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Minerals Yearbook

U.S.
DEPARTMENT
OF THE
INTERIOR

BUREAU OF
MINES

1988

UNITED STATES DEPARTMENT OF THE INTERIOR • Manuel Lujan, Jr., Secretary

BUREAU OF MINES • T S Ary, Director

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

U.S. GOVERNMENT PRINTING OFFICE

WASHINGTON : 1990

Foreword

This edition of the Minerals Yearbook discusses the performance of the worldwide minerals industry during 1988 and provides background information to assist in interpreting that performance. Content of the individual yearbook volumes follows:

Volume I, Metals and Minerals, contains chapters on virtually all metallic and industrial mineral commodities important to the U.S. economy. In addition, it includes a survey methods and statistical summary of nonfuel minerals chapter, and a chapter on mining and quarrying trends.

Volume II, Area Reports: Domestic, contains chapters on the minerals industry of each of the 50 States, and Puerto Rico, Northern Marianas, Island Possessions, and Trust Territory. This volume also has a survey methods and statistical summary of nonfuel minerals chapter.

Volume III, Area Reports: International, contains the latest available mineral data on more than 150 foreign countries and discusses the importance of minerals to the economies of these nations. A separate chapter reviews the international minerals industry in general and its relationship to the world economy.

The Bureau of Mines continually strives to improve the value of its publications to users. Therefore, constructive comments and suggestions by readers of the Yearbook will be welcomed.

T S Ary, *Director*

Acknowledgments

The chapters of this volume were written by the State Mineral Officers of the Bureau of Mines, located throughout the country. Preparation of the chapters was coordinated by the Office of State Activities, Division of Mineral Commodities.

The Survey Methods and Statistical Summary of Nonfuel Minerals chapter and the tabular material covering total State mineral production and mineral production by county, were prepared in the Division of Mineral Commodities.

Compilations contained in this volume were based largely on statistics and other data provided by the minerals industries. The Bureau gratefully acknowledges the willing contribution of these essential data by both companies and individuals.

In the collection of statistical and other mineral-industry information, the Bureau of Mines was also assisted by various State agencies through cooperative agreements. Many of the chapters in Volume II were reviewed by staff members of these agencies; in some instances the staff members collaborated in preparing the chapters and are shown as coauthors. Our sincere appreciation for this assistance is extended to the following cooperating organizations:

Alabama: Geological Survey of Alabama.
Alaska: Division of Geological and Geophysical Surveys, Alaska Department of Natural Resources.
Arizona: Arizona Department of Mines and Mineral Resources.
Arkansas: Arkansas Geological Commission.
California: California Department of Conservation, Division of Mines and Geology.
Colorado: Colorado Geological Survey.
Connecticut: State Geological and Natural History Survey of Connecticut, Department of Environmental Protection.
Delaware: Delaware Geological Survey.
Florida: Florida Bureau of Geology.
Georgia: Georgia Geologic Survey, Environmental Protection Division, Georgia Department of Natural Resources.
Hawaii: Department of Land and Natural Resources of the State of Hawaii.
Idaho: Idaho Geological Survey.
Illinois: State Geological Survey, Illinois Department of Energy and Natural Resources.
Indiana: Geological Survey, Indiana Department of Natural Resources.
Iowa: Geological Survey Bureau, Division of Energy and Geological Resources, Iowa Department of Natural Resources.
Kansas: Kansas Geological Survey.
Kentucky: Kentucky Geological Survey.
Louisiana: Louisiana Geological Survey.
Maine: Maine Geological Survey.
Maryland: Maryland Geological Survey.
Massachusetts: Commonwealth of Massachusetts, Executive Office of Environmental Affairs.
Michigan: Geological Survey Division, Michigan Department of Natural Resources.
Minnesota: Mineral Resources Research Center, University of Minnesota.
Mississippi: Bureau of Geology and Energy Resources, Mississippi Department of Natural Resources.
Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey.
Montana: Montana Bureau of Mines and Geology.
Nebraska: Conservation and Survey Division of the University of Nebraska (Nebraska Geological Survey).
Nevada: Nevada Bureau of Mines and Geology.
New Hampshire: New Hampshire Department of Environmental Services.
New Jersey: Geological Survey, Division of Water Resources, New Jersey Department of Environmental Protection.
New Mexico: New Mexico Bureau of Mines and Mineral Resources.
New York: New York State Education Department, New York Geological Survey.

North Carolina: Division of Land Resources, North Carolina Department of Environment, Health, and Natural Resources.
North Dakota: North Dakota Geological Survey.
Oklahoma: Oklahoma Geological Survey.
Pennsylvania: Pennsylvania Bureau of Topographic and Geologic Survey, Department of Environmental Resources.
Puerto Rico: Department of Natural Resources, Commonwealth of Puerto Rico.
Rhode Island: Rhode Island Department of Environmental Management.
South Carolina: South Carolina Geological Survey, State Division of Research and Statistical Services.
South Dakota: South Dakota Geological Survey.
Tennessee: Tennessee Division of Geology.
Texas: Bureau of Economic Geology, The University of Texas at Austin.
Utah: Utah Geological and Mineral Survey.
Vermont: Office of the State Geologist, Agency of Environmental Conservation.
Virginia: Virginia Division of Mineral Resources.
Washington: Washington Division of Geology and Earth Resources.
West Virginia: West Virginia Geological and Economic Survey.
Wisconsin: Wisconsin Geological and Natural History Survey.
Wyoming: Geological Survey of Wyoming.

Donald S. Colby, Chief, *Office of State Activities*

Contents

SURVEY METHODS AND STATISTICAL SUMMARY OF NONFUEL MINERALS

By Gloria L. Walker[1] and Stephen D. Smith[2]

SURVEY METHODS

The Bureau of Mines Information and Analysis Directorate collects worldwide data on virtually every commercially important nonfuel mineral commodity. These data form the base for tracking and assessing the health of the minerals sector of the U.S. economy.

This data collection activity was instituted by the 47th Congress in an appropriations act of August 7, 1882 (22 Stat. 329), to place the collection of mineral statistics on an annual basis. The most recent authority for the Bureau of Mines Information and Analysis activity is the National Materials and Minerals Policy, Research and Development Act of 1980 (Public Law 96–479, 96th Congress), which strengthens protection for proprietary data provided to the U.S. Department of the Interior by persons or firms engaged in any phase of mineral or mineral-material production or consumption.

Data Collection Surveys

The Bureau begins the collection of domestic nonfuel minerals and materials statistics by appraising the information requirements of Government and private organizations of the United States. Information needs that can be satisfied by data from the minerals industries are expressed as questions on Bureau of Mines survey forms. Figure 1 shows a typical survey form, "Alumina" (6–1013–A). Specific questions about the production, consumption, shipments, etc., of mineral commodities are structured in the survey forms to provide meaningful aggregated data. Thus, the entire mineral economic cycle from production through consumption is covered by 169 monthly, quarterly, semiannual, and annual surveys.

After the survey form has been designed, a list of the appropriate establishments to be canvassed is developed. Many sources are used to determine which companies, mines, plants, and other operations should be included on the list to produce meaningful National and State totals for the survey. Bureau of Mines State Mineral Officers, State geologists, Federal organizations (e.g., Mine Safety and Health Administration), trade associations, and industry publications and directories are some of the sources that are explored to develop and update survey listings. With few exceptions, a complete canvass of the entire list of establishments is employed rather than a random sample. The iron and steel scrap industry is an example of one of the exceptions where a sampling plan is used rather than a complete canvass of the population.

Before mailing, the survey form must be approved by the Office of Management and Budget (OMB). Under the Paperwork Reduction Act of 1980, OMB approves the need to collect the data and protects industry from unwarranted Government paperwork.

The Bureau publishes a "Survey Forms Catalog," which describes the content of each form. Copies of the catalog may be obtained by contacting the Office of Statistical Standards, U.S. Bureau of Mines, 2401 E Street, N.W., Mail Stop 9701, Washington, DC 20241.

Survey Processing

Approximately 26,000 establishments yield more than 53,000 responses to 169 surveys annually. Each completed survey form returned to the Bureau undergoes extensive scrutiny to ensure the highest possible accuracy of the mineral data. The statistical staff investigates all surveys to certify that no error is introduced by reporting in units other than those specified on the survey form. Relationships between related measures, such as produced crude ore and marketable crude ore, are analyzed for consistency. Internal numerical relationships of column and row totals are validated, and currently reported data are checked against prior reports to detect possible errors or omissions.

For the majority of the surveys, which are automated, the forms are reviewed to certify that data are complete and correct before entering into the computer. The computer is programmed to conduct a series of automated checks to verify mathematical consistency and to identify discrepancies between the data reported and logically acceptable responses.

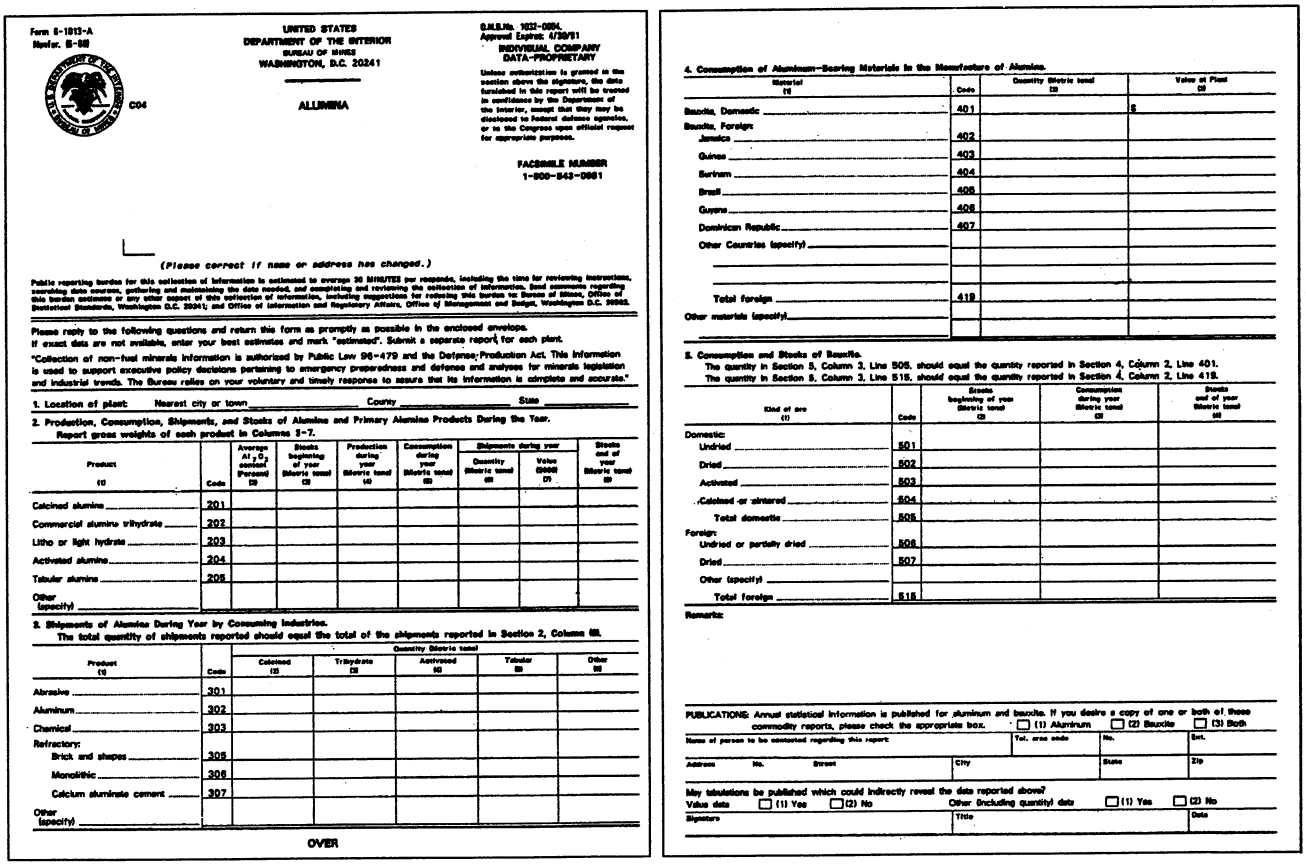
The Bureau of Mines is modernizing and automating all of its survey processing and data dissemination methods. Automation of the commodity data systems supports the processing of individual surveys and the preparation of statistical tables for publication. A central data base includes the minerals data gathered through surveys and pertinent data accumulated from other sources. The data base allows Bureau personnel to retrieve the data required for analysis of mineral problems and for answering specific user questions.

Survey Responses.—To enable the reader to better understand the basis on which the statistics are calculated, each commodity chapter of the "Minerals Yearbook" includes a section entitled "Domestic Data Coverage." This section briefly describes the data sources, the number of establishments surveyed, the response percentage, and the method of estimating the production or consumption for nonrespondents.

To produce reliable aggregated data, the Bureau employs efficient procedures for handling instances of nonresponse. Failure to return the initial survey form results in a second mailing of the form. If the second form is not returned, telephone calls are made to the nonrespondents. These followup calls provide the necessary data to complete the survey forms, to verify questionable entries, and to encourage nonrespondents to either complete and return survey forms or to provide the information orally. Periodic visits to important minerals establishments are also made by Bureau commodity specialists or State Mineral Officers in order to gather missing data and indi-

FIGURE 1

A TYPICAL SURVEY FORM



Form E-1813-A
Revised: 6-88

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON, D.C. 20241

O.M.B.No. 1032-0004
Approval Expires: 4/30/91

INDIVIDUAL COMPANY DATA-PROPRIETARY

Unless authorization is granted in the section above the signature, the data furnished in this report will be treated in confidence by the Department of the Interior, except that they may be disclosed to Federal defense agencies, or to the Congress upon official request for appropriate purposes.

C04

ALUMINA

FACSIMILE NUMBER
1-800-543-0881

(Please correct if name or address has changed.)

Public reporting burden for this collection of information is estimated to average 30 MINUTES per response, including the time for reviewing instructions, searching data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to: Bureau of Mines, Office of Statistical Standards, Washington D.C. 20241; and Office of Information and Regulatory Affairs, Office of Management and Budget, Washington D.C. 20503.

Please reply to the following questions and return this form as promptly as possible in the enclosed envelope.
If exact data are not available, enter your best estimates and mark "estimated". Submit a separate report for each plant.

"Collection of non-fuel minerals information is authorized by Public Law 96-479 and the Defense Production Act. This information is used to support executive policy decisions pertaining to emergency preparedness and defense and analyses for minerals legislation and industrial trends. The Bureau relies on your voluntary and timely response to assure that its information is complete and accurate."

1. Location of plant: Nearest city or town _____ County _____ State _____

2. Production, Consumption, Shipments, and Stocks of Alumina and Primary Alumina Products During the Year.
Report gross weights of each product in Columns 1-7.

Product (1)	Code	Average Al_2O_3 content Percent (2)	Stocks beginning of year Metric tons (3)	Production during year Metric tons (4)	Consumption during year Metric tons (5)	Shipments during year: Quantity Metric tons (6)	Shipments during year: Value (000) (7)	Stocks end of year Metric tons (8)
Calcined alumina	201							
Commercial alumina trihydrate	202							
Litho or light hydrate	203							
Activated alumina	204							
Tabular alumina	205							
Other (specify)								

3. Shipments of Alumina During Year by Consuming Industries.
The total quantity of shipments reported should equal the total of the shipments reported in Section 2, Column (6).

Product (1)	Code	Quantity Metric tons: Calcined (2)	Trihydrate (3)	Activated (4)	Tabular (5)	Other (6)
Abrasive	301					
Aluminum	302					
Chemical	303					
Refractory:						
Brick and shapes	305					
Monolithic	306					
Calcium aluminate cement	307					
Other (specify)						

OVER

4. Consumption of Aluminum-Bearing Materials in the Manufacture of Alumina.

Material (1)	Code	Quantity Metric tons (2)	Value at Plant (3)
Bauxite, Domestic	401		$
Bauxite, Foreign:			
Jamaica	402		
Guinea	403		
Surinam	404		
Brazil	405		
Guyana	406		
Dominican Republic	407		
Other Countries (specify)			
Total foreign	419		
Other materials (specify)			

5. Consumption and Stocks of Bauxite.
The quantity in Section 5, Column 3, Line 505, should equal the quantity reported in Section 4, Column 2, Line 401.
The quantity in Section 5, Column 3, Line 518, should equal the quantity reported in Section 4, Column 2, Line 419.

Kind of ore (1)	Code	Stocks beginning of year Metric tons (2)	Consumption during year Metric tons (3)	Stocks end of year Metric tons (4)
Domestic:				
Undried	501			
Dried	502			
Activated	503			
Calcined or sintered	504			
Total domestic	505			
Foreign:				
Undried or partially dried	506			
Dried	507			
Other (specify)				
Total foreign	518			

Remarks:

PUBLICATIONS: Annual statistical information is published for aluminum and bauxite. If you desire a copy of one or both of these commodity reports, please check the appropriate box. ☐ (1) Aluminum ☐ (2) Bauxite ☐ (3) Both

Name of person to be contacted regarding this report | Tel. area code | No. | Ext.

Address | No. | Street | City | State | Zip

May tabulations be published which could indirectly reveal the data reported above?
Value data ☐ (1) Yes ☐ (2) No Other (including quantity) data ☐ (1) Yes ☐ (2) No

Signature | Title | Date

cate the importance of the establishment's reports in producing accurate National, State, and county statistics. By describing the use of these statistics and showing the impact of nonresponse, the Bureau hopes to encourage respondents to give a complete and accurate reply.

The OMB "Guidelines for Reducing Reporting Burden" stipulates that the minimum acceptable response rate shall be 75% of the panel surveyed. In addition, the Bureau strives for a minimum reporting level of 75% of the quantity produced or consumed (depending on the survey) for certain key statistics. Response rates are periodically reviewed. For those surveys not meeting the minimum reporting level, procedures are developed and implemented to improve response rates.

Estimation for Nonresponse.—When efforts to obtain a response to a survey fail, it becomes necessary to employ estimation or imputation techniques to account for the missing data. These techniques prove to be most effective when the response rate is relatively high. Some of the estimation methods depend upon knowledge of prior establishment reporting, while other techniques rely on external information to estimate the missing data. Survey forms received after publication cutoff dates are edited and necessary imputations are made for missing data. The data base is updated, and these revisions are reflected in later publications.

Protection of Proprietary Data.—The Bureau of Mines relies on the cooperation of the U. S. minerals industry to provide the mineral data that are presented in this and other Bureau publications. Without a strong response to survey requests, the Bureau would not be able to present reliable statistics. The Bureau in turn respects the proprietary nature of the data received from the individual companies and establishments. To insure that proprietary rights will not be violated, the Bureau analyzes each of the aggregated statistics to determine if the statistics of an individual establishment can be deduced from the aggregated statistics. For example, if there are only two significant producers of a commodity in a given State, the Bureau will not publish that total because either producer could readily estimate the production of the other. It is this obligation to protect proprietary information that results in the "Withheld" or "W" entries in the "Minerals Yearbook" tables. However, if a company gives permission in writing, the Bureau may release data otherwise withheld because of proprietary considerations as long as the data from other producers in an aggregated cell are protected from disclosure.

International Data

Each commodity chapter in Volume I of the "Minerals Yearbook" contains a "World Review" section that usually includes a world production table. These tables are prepared by country specialists in the Bureau of Mines Division of International Minerals. The data are gathered from various sources, including published reports of foreign government mineral and statistical agencies, international organizations, the U.S. Department of State, the United Nations, the Organization of Petroleum Exporting Countries, and personal contact by specialists traveling abroad. Each February an annual "Minerals Questionnaire" is sent through the Department of State to more than 130 U.S. Embassies asking them to provide by May estimates of mineral production for the host country for the preceding year. Missing data are estimated by Bureau country specialists based upon historical trends and specialists' knowledge of current production capabilities in each country.

Publications

The "Minerals Yearbook" provides the definitive historical record for mineral statistics used by Government and industry in assessing U.S. mineral supply and the characteristics of U.S. mineral demand. Also, it provides worldwide information on the production and consumption of minerals in foreign countries. Beginning with the 1988 edition, the "Minerals Yearbook" format has been enlarged to an 8.5″ × 11″ size with each chapter published as an individual report.

Volume I of the "Minerals Yearbook" provides annual data on nonfuel mineral commodities in an authoritative and complete reference source.

Volume II of the "Minerals Yearbook" contains information organized by State.

Volume III of the "Minerals Yearbook" contains information organized by country and regions. It includes the mineral supply and trade position of each country, details on mineral development and foreign investment policies, structure of the mining industry, infrastructure, and industry outlook.

"Mineral Facts and Problems," last published in 1985, is a one-volume reference source containing worldwide production information and demand forecasts for all nonfuel minerals. Each commodity chapter covers the structure of the industry, uses of the commodity, reserves and resources, technology, supply-demand relationships, byproducts and coproducts, strategic considerations, economic and operating factors, and forecasts. Each chapter also compares the United States and world reserves with cumulative demands to appraise the adequacy of world mineral supplies. "Mineral Facts and Problems" is particularly useful in educating new people in the industry and in familiarizing people with a new commodity. Its commodity forecasts provide unique insight into future developments for each commodity.

"Mineral Industry Surveys" provide periodic data designed to give timely statistical information on production, distribution, stocks, and consumption of significant mineral commodities. These reports are issued monthly for 22 commodities and quarterly for 11 com-

modities. Annual surveys are issued periodically throughout the year as information becomes available. Electronic publication has been initiated for several commodities on an experimental basis to enhance timeliness.

"Mineral Commodity Summaries," an up-to-date summary of about 85 nonfuel mineral commodities, is the earliest Government publication to furnish estimates covering the previous year's nonfuel mineral industry data. It contains information on the domestic industry structure, Government programs, tariffs, and 5-year salient statistics.

"State Mineral Summaries" combine the preliminary annual area reports into a single volume and is a companion publication to "Mineral Commodity Summaries." These summaries have been prepared in cooperation with State geological surveys or related agencies. Individual State summaries are published separately as State Mineral Industry Surveys each February for the preceding year. Copies can be obtained from the appropriate State Activities field office.

"Mineral Perspective" is an intermittent series issued to inform the Bureau's audience of developments in the mineral industries and markets of a foreign country or region of the world. Recent publications in this series include country-by-country reviews of Latin America, the Far East, and South Asia.

"Minerals and Materials/A Bimonthly Survey" is being replaced by a new publication called "Minerals Today" that will continue to provide timely information on mineral commodities in terms of major economic variables—consumption, production, imports, exports, inventories, and prices—and on other current issues such as the environment and land use.

"Information Circulars" are primarily concerned with Bureau economic reviews and interpretative analyses. The series also includes surveys of mining and operating activities, guides to marketing of mineral commodities, and compilations of historical or statistical and economic data of minerals.

To purchase Volumes I, II, and III of the "Minerals Yearbook," "Mineral Facts and Problems," and "Minerals Today" contact the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. For free publications of individual chapters of the "Minerals Yearbook," the "Mineral Industry Surveys," the "Mineral Commodity Summaries," the "State Mineral Summaries," the "Mineral Perspective," and "Information Circulars" contact Publications Distribution, Bureau of Mines, Cochrans Mill Road, P.O. Box 18070, Pittsburgh, PA 15236.

STATISTICAL SUMMARY

This chapter summarizes data on crude nonfuel mineral production for the United States, its island possessions, and the Commonwealth of Puerto Rico. Also included are tables that show the principal nonfuel mineral commodities exported from and imported into the United States and that compare world and U.S. mineral production. The detailed data from which these tables were derived are contained in the individual commodity chapters of Volume I and in the State chapters of Volume II of this edition of the Minerals Yearbook.

Although crude mineral production may be measured at any of several stages of extraction and processing, the stage of measurement used in this chapter is what is termed "mine output." It usually refers to minerals or ores in the form in which they are first extracted from the ground, but customarily includes the output from auxiliary processing at or near the mines.

Because of inadequacies in the statistics available, some series deviate from the foregoing definition. For copper, gold, lead, silver, tin, and zinc, the quantities are recorded on a mine basis (as the recoverable content of ore sold or treated). However, the values assigned to these quantities are based on the average selling price of refined metal, not the mine value. Mercury is measured as recovered metal and valued at the average New York price for the metal.

The weight or volume units shown are those customarily used in the particular industries producing the commodities. Values shown are in current dollars, with no adjustments made to compensate for changes in the purchasing power of the dollar.

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[1] Operations Research Analyst, Office of Statistical Standards, author of "Survey Methods."

[2] Mineral data assistant, Section of Ferrous Metal Data. The author was assisted in the preparation of the "Statistical Summary" by Barbara M. Carrico, Chief, Section of Nonferrous Metals Data; Sarah P. Guerrino, Chief, Section of Ferrous Metals Data; Barbara E. Gunn, Chief, Section of Industrial Minerals Data; William L. Zajac, Chief, Branch of Geographic Data.

TABLE 1

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
METALS							
Bauxite	metric tons, dried equivalent	510,074	$10,361	575,574	r$10,916	587,889	$10,566
Beryllium concentrates	short tons	W	W	W	W	5,851	6
Copper (recoverable content of ores, etc.)	metric tons	1,147,277	1,670,660	r1,243,638	r2,261,833	1,419,645	3,771,570
Gold (recoverable content of ores, etc.)	troy ounces	3,739,015	1,376,855	r4,947,040	r2,216,027	6,459,539	2,831,281
Iron ore (includes byproduct material)[2]	thousand metric tons	41,991	1,472,511	47,983	1,503,087	57,113	1,716,661
Iron oxide pigments, crude	short tons	40,987	2,908	42,773	3,598	43,774	3,815
Lead (recoverable content of ores, etc.)	metric tons	339,793	165,150	r311,381	r246,720	384,983	315,222
Magnesium metal	short tons	138,493	423,788	137,123	381,914	156,509	469,767
Manganiferous ore (5% to 35% Mn)	short tons, gross weight	14,320	W	rW	W	W	W
Molybdenum (content of ore and concentrate)	thousand pounds	95,006	240,484	69,868	179,286	99,738	266,899
Nickel (content of ore and concentrate)	short tons	1,175	W	—	—	—	—
Silver (recoverable content of ores, etc.)	troy ounces	34,523,896	188,846	r39,896,541	r279,675	53,415,677	349,339
Tungsten (content of ore and concentrate)	metric tons	817	5,774	W	W	W	W
Zinc (recoverable content of ores, etc.)	do.	202,983	170,050	r216,327	r199,924	244,314	324,249
Combined value of antimony (1986), mercury, platinum-group metals (1987–88), rare-earth metal concentrates, tin, titanium concentrates (ilmenite and rutile), vanadium, zircon concentrates, and values indicated by symbol W		XX	r96,394	XX	r139,596	XX	159,409
Total[3]		**XX**	**r5,824,000**	**XX**	**r7,423,000**	**XX**	**10,219,000**
INDUSTRIAL MINERALS (EXCEPT FUELS)							
Abrasives[4]	short tons	W	W	12,773	957	14,675	1,183
Asbestos	metric tons	51,437	17,367	50,600	17,198	W	W
Barite	thousand short tons	297	12,326	448	15,810	445	15,512
Boron minerals	do.	1,251	426,086	1,385	475,092	1,267	429,667
Bromine[e]	thousand pounds	310,000	93,000	335,000	107,000	360,000	144,000
Cement:							
Masonry	thousand short tons	3,525	231,551	3,680	259,926	3,574	243,941
Portland	do.	75,181	3,759,942	74,868	3,646,561	74,074	3,575,906
Clays	short tons	44,619,581	1,095,179	47,657,286	1,202,284	49,069,375	1,400,820
Diatomite	thousand short tons	628	128,362	658	134,239	693	143,774
Emery	short tons	2,878	W	1,945	W	W	W
Feldspar	do.	735,000	26,100	720,000	26,100	715,484	28,082
Fluorspar	do.	e78,000	W	68,839	11,725	W	W
Garnet (abrasive)	do.	32,296	2,603	42,277	4,350	46,855	4,707
Gem stones		NA	9,247	NA	21,389	NA	43,508
Gypsum	thousand short tons	15,403	99,570	15,612	106,977	16,390	109,205

See footnotes at end of table.

TABLE 1—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS (EXCEPT FUELS)—Continued							
Helium:							
Crude	million cubic feet	432	$9,504	730	$16,068	W	W
Grade-A	do.	1,941	72,788	2,230	82,540	2,574	$95,238
Iodine	pounds	W	W	W	W	2,238,152	W
Lime	thousand short tons	14,474	757,867	15,733	786,125	17,293	828,007
Mica (scrap)	do.	148	7,108	161	8,201	143	6,793
Peat	do.	1,038	23,988	958	r21,020	929	19,933
Perlite	do.	507	15,646	533	16,494	576	17,652
Phosphate rock	metric tons	40,320,000	897,131	40,954,000	793,280	45,389,000	887,809
Potassium salts (K_2O equivalent)	thousand metric tons	1,147	152,000	1,485	195,700	1,427	240,300
Pumice	thousand short tons	554	5,756	392	4,493	389	4,129
Salt	do.	36,663	665,400	36,493	684,170	37,997	680,174
Sand and gravel:							
Construction	do.	883,000	2,747,200	e895,200	e3,002,500	923,400	3,126,000
Industrial	do.	27,420	359,300	28,010	364,100	28,480	388,000
Sodium carbonate (natural)	do.	W	W	8,891	593,685	9,632	644,973
Sodium sulfate (natural)	do.	396	34,102	382	33,086	398	31,377
Stone:[5]							
Crushed	do.	e1,023,200	e4,255,000	1,200,100	5,248,600	e1,247,800	e5,558,000
Dimension	short tons	e1,163,347	e173,269	1,183,849	190,153	e1,189,333	e196,289
Sulfur, Frasch process	thousand metric tons	4,180	508,512	3,610	386,834	4,341	430,814
Talc and pyrophyllite	short tons	1,302,179	31,227	r1,281,789	r28,872	1,376,560	29,444
Tripoli	do.	117,174	918	114,926	975	110,152	864
Vermiculite	do.	317,000	34,400	302,926	33,105	303,544	33,948
Combined value of aplite, asphalt (native, 1986), calcium chloride (natural), graphite (natural, 1988), kyanite, lithium minerals, magnesite, magnesium compounds,[6] marl (greensand), olivine, pyrites, staurolite, wollastonite, and values indicated by symbol W		XX	994,446	XX	r374,832	XX	442,620
Total[3]		**XX**	**17,647,000**	**XX**	**r18,894,000**	**XX**	**19,803,000**
Grand total[3]		**XX**	**r23,471,000**	**XX**	**r26,317,000**	**XX**	**30,022,000**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Shipments are not comparable to those of previous years owing to the inclusion of byproduct material in the new series.

[3] Data may not add to totals shown because of independent rounding.

[4] Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

[5] Excludes abrasive stone and bituminous limestone and sandstone; all included elsewhere in table.

[6] Excludes values that must be concealed to avoid disclosing company proprietary data.

TABLE 2

NONFUEL MINERALS PRODUCED IN THE UNITED STATES AND PRINCIPAL PRODUCING STATES IN 1988

Mineral	Principal producing States, in order of quantity	Other producing States
Abrasives[1]	OH, AR, IN, WI.	
Antimony (content of ores, etc.)	ID.	
Aplite	VA.	
Asbestos	CA and VT.	
Barite	NV, GA, MO, CA	TN.
Bauxite	AR, AL, GA.	
Beryllium concentrate	UT.	
Boron minerals	CA.	
Bromine	AR and MI.	
Calcium chloride (natural)	MI, CA, WA.	
Cement:		
Masonry	FL, IN, PA, AL	All other States except AK, CT, DE, MA, MN, NV, NH, NJ, NC, ND, RI, VT, WI.
Portland	CA, TX, PA, MI	All other States except CT, DE, MA, MN, NH, NJ, NC, ND, RI, VT, WI.
Clays	GA, OH, NC, TX	All other States except AK, DE, HI, NH, RI, VT, WI.
Copper (content of ores, etc.)	AZ, NM, UT, MT	CA, CO, ID, IL, MI, MO, NV, TN.
Diatomite	CA, NV, WA, OR	AZ.
Emery	NY.	
Feldspar	NC, CT, CA, GA	OK, SD.
Fluorspar	IL and NV.	
Garnet (abrasive)	ID, NY, ME.	
Gold (content of ores, etc.)	NV, CA, SD, UT	AZ, AK, CO, ID, MI, MT, NM, OR, SC, WA.
Graphite (natural)	MT.	
Gypsum	OK, IA, MI, TX	AR, AZ, CA, CO, IN, KS, LA, MT, NV, NM, NY, OH, SD, UT, VA, WA, WY.
Helium	KS, WY, TX, NM.	
Iodine	OK.	
Iron ore (includes byproduct)	MN, MI, MO, UT	CA, MT, NM, NY, SD, TX.
Iron oxide pigments (crude)	MI, GA, MO, VA.	
Kyanite	VA.	
Lead (content of ores, etc.)	MO, ID, CO, MT	AZ, IL, NV, NY, NM, TN.
Lime	OH, MO, PA, AL	All other States except AK, CT, DE, FL, GA, KS, ME, MS, NH, NJ, NM, NY, NC, RI, SC, VT.
Lithium minerals	NC and NV.	
Magnesite	NV.	
Magnesium compounds	MI, CA, UT, FL	DE, TX.
Magnesium metal	TX, WA, UT.	
Manganiferous ore	SC.	
Marl (greensand)	NJ and DE.	
Mercury	NV, UT, CA.	
Mica (scrap)	NC, SD, GA, SC	CT, NM, PA.
Molybdenum	AZ, CO, MT, UT	CA.

See footnote at end of table.

TABLE 2—Continued

NONFUEL MINERALS PRODUCED IN THE UNITED STATES AND PRINCIPAL PRODUCING STATES IN 1988

Mineral	Principal producing States, in order of quantity	Other producing States
Olivine	NC and WA.	
Peat	MI, FL, IN, IL	CA, CO, GA, IA, MA, MD, MN, MT, NJ, NC, OH, PA, SC, WA, WI, WV.
Perlite	NM, AZ, CA, ID	CO, NV.
Phosphate rock	FL, NC, ID, UT	MT, TN.
Platinum-group metals	MT.	
Potassium salts	MN, CA, UT.	
Pumice	OR, NM, ID, CA	AZ, HI, KS.
Pyrites (ore and concentrate)	AZ.	
Rare-earth metal concentrate	CA and FL.	
Salt	LA, TX, NY, OH	AL, AZ, CA, KS, MI, NV, NM, ND, OK, UT, WV.
Sand and gravel:		
Construction	IL, MI, CA, NJ	All other States.
Industrial	CA, MI, TX, OH	All other States except AK, DE, HI, IA, KY, ME, NH, NM, ND, OR, SD, VT, WY.
Silver (content of ores, etc.)	NV, ID, MT, AZ	AK, CA, CO, IL, MI, MN, MO, NY, OR, SC, SD, TN, UT.
Sodium carbonate (natural)	WY and CA.	
Sodium sulfate (natural)	CA, TX, UT.	
Staurolite	FL.	
Stone:		
Crushed	PA, FL, TX, VA	All other States except DE.
Dimension	IN, GA, VT, NH	All other States except AK, DE, FL, HI, KY, LA, MS, NE, NV, NJ, ND, OR, RI, WV, WY.
Sulfur (Frasch)	TX and LA.	
Talc and pyrophyllite	MT, VT, TX, NY	AL, AR, CA, GA, NC, VA, OR.
Tin	AK and AZ.	
Titanium concentrates	FL.	
Tripoli	IL, OK, AR, PA.	
Tungsten (content of ores, etc.)	CA.	
Vanadium (content of ores, etc.)	ID, CO, UT.	
Vermiculite (crude)	SC, MT, VA.	
Wollastonite	NY.	
Zinc (content of ores, etc.)	TN, NY, MO, MT	CO, ID, IL, KY.
Zircon concentrate	FL, NJ, AL.	

[1] Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

TABLE 3

VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 1988

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$459,495	21	1.53	Cement (portland), stone (crushed), lime, sand and gravel (construction).
Alaska	118,694	40	.40	Gold, sand and gravel (construction), stone (crushed), cement (portland).
Arizona	2,773,411	1	9.24	Copper, molybdenum, sand and gravel (construction), cement (portland).
Arkansas	306,789	29	1.02	Bromine, stone (crushed), cement (portland), sand and gravel (construction).
California	2,708,768	2	9.02	Sand and gravel (construction), cement (portland), boron minerals, gold.
Colorado	364,005	25	1.21	Molybdenum, gold, sand and gravel (construction), cement (portland).
Connecticut	118,116	41	.39	Stone (crushed), sand and gravel (construction), feldspar, sand and gravel (industrial).
Delaware[1]	5,999	50	.02	Magnesium compounds, sand and gravel (construction), marl (greensand), gem stones.
Florida	1,391,881	6	4.64	Phosphate rock, stone (crushed), cement (portland), sand and gravel (construction).
Georgia	1,373,825	7	4.58	Clays, stone (crushed), cement (portland), sand and gravel (construction).
Hawaii	74,932	45	.25	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry).
Idaho	290,616	31	.97	Phosphate rock, silver, gold, sand and gravel (construction).
Illinois	587,626	16	1.96	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial).
Indiana	406,389	24	1.35	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry).
Iowa	290,256	32	.97	Stone (crushed), cement (portland), sand and gravel (construction), gypsum (crude).
Kansas	291,713	30	.97	Cement (portland), stone (crushed), salt, helium (Grade-A).
Kentucky	344,979	28	1.15	Lime, cement (portland), sand and gravel (construction), clays.
Louisiana	434,536	23	1.45	Sulfur (Frasch), salt, sand and gravel (construction), stone (crushed).
Maine	67,760	46	.23	Sand and gravel (construction), cement (portland), stone (dimension), stone (crushed).
Maryland	362,921	26	1.21	Stone (crushed), sand and gravel (construction), cement (portland), cement (masonry).
Massachusetts	192,238	37	.64	Stone (crushed), sand and gravel (construction), stone (dimension), lime.
Michigan	1,587,561	4	5.29	Iron ore (includes byproduct material), cement (portland), sand and gravel (construction), magnesium compounds.
Minnesota	1,267,499	8	4.22	Iron ore (includes byproduct material), sand and gravel (construction), stone (crushed), stone (dimension).
Mississippi	103,400	42	.34	Sand and gravel (construction), clays, cement (portland), stone (crushed).
Missouri	967,949	12	3.22	Lead, cement (portland), stone (crushed), lime.

See footnote at end of table.

TABLE 3—Continued

VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 1988

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Montana	$548,161	18	1.83	Copper, gold, platinum-group metals, silver.
Nebraska	91,192	43	.30	Cement (portland), sand and gravel (construction), stone (crushed), lime.
Nevada	1,944,566	3	6.48	Gold, silver, sand and gravel (construction), cement (portland).
New Hampshire[1]	53,060	47	.18	Sand and gravel (construction), stone (dimension), stone (crushed), clays.
New Jersey	241,832	34	.81	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), zircon concentrates.
New Mexico	1,018,532	10	3.39	Copper, potassium salts, sand and gravel (construction), silver.
New York	695,700	15	2.32	Stone (crushed), cement (portland), salt, sand and gravel (construction).
North Carolina	529,434	19	1.76	Stone (crushed), phosphate rock, lithium minerals, sand and gravel (construction).
North Dakota	18,807	48	.06	Sand and gravel (construction), lime, salt, clays.
Ohio	737,252	13	2.46	Stone (crushed), sand and gravel (construction), salt, lime.
Oklahoma	220,137	35	.73	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial).
Oregon	178,188	38	.59	Stone (crushed), sand and gravel (construction), cement (portland), lime.
Pennsylvania	1,042,493	9	3.47	Stone (crushed), cement (portland), sand and gravel (construction), lime.
Rhode Island[1]	17,248	49	.06	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), gem stones.
South Carolina	357,802	27	1.19	Cement (portland), stone (crushed), clays, gold.
South Dakota	285,719	33	.95	Gold, cement (portland), stone (crushed), sand and gravel (construction).
Tennessee	585,649	17	1.95	Stone (crushed), zinc, cement (portland), clays.
Texas	1,468,818	5	4.89	Cement (portland), stone (crushed), magnesium metal, sulfur (Frasch).
Utah	1,014,847	11	3.38	Copper, gold, magnesium metal, sand and gravel (construction).
Vermont	76,945	44	.26	Stone (dimension), stone (crushed), sand and gravel (construction), talc and pyrophyllite.
Virginia	494,512	20	1.65	Stone (crushed), sand and gravel (construction), cement (portland), lime.
Washington	459,334	22	1.53	Magnesium metal, gold, sand and gravel (construction), stone (crushed).
West Virginia	127,455	39	.42	Stone (crushed), cement (portland), sand and gravel (industrial), sand and gravel (construction).
Wisconsin	204,873	36	.68	Stone (crushed), sand and gravel (construction), lime, sand and gravel (industrial).
Wyoming	709,812	14	2.36	Sodium carbonate (natural), clays, helium (Grade-A), stone (crushed).
Undistributed	7,812	—	.03	
Total[2]	**30,022,000**	**XX**	**100.00**	

XX Not applicable.

[1] Partial total, excludes values that must be concealed to avoid disclosing company proprietary data. Concealed values included with "Undistributed" figure.

[2] Data may not add to totals shown because of independent rounding.

TABLE 4

VALUE OF NONFUEL MINERAL PRODUCTION PER CAPITA AND PER SQUARE MILE IN 1988, BY STATE

State	Area (square miles)	Population (thousands)	Total (thousands)	Per square mile		Per capita	
				Dollars	Rank	Dollars	Rank
Alabama	51,705	4,102	$459,495	8,887	26	112	19
Alaska	591,004	524	118,694	201	50	227	10
Arizona	114,000	3,489	2,773,411	24,328	4	795	3
Arkansas	53,187	2,395	306,789	5,768	32	128	15
California	158,706	28,314	2,708,768	17,068	12	96	25
Colorado	104,091	3,301	364,005	3,497	41	110	20
Connecticut	5,018	3,233	118,116	23,538	6	37	45
Delaware	2,044	660	[1]5,999	2,935	44	9	50
Flordia	58,664	12,335	1,391,881	23,726	5	113	18
Georgia	58,910	6,342	1,373,825	23,321	7	217	11
Hawaii	6,471	1,098	74,932	11,580	20	68	33
Idaho	83,564	1,003	290,616	3,478	42	290	9
Illinois	56,345	11,614	587,626	10,429	23	51	40
Indiana	36,185	5,556	406,389	11,231	22	73	32
Iowa	56,275	2,834	290,256	5,158	36	102	22
Kansas	82,277	2,495	291,713	3,545	40	117	17
Kentucky	40,409	3,727	344,979	8,537	27	93	26
Louisiana	47,751	4,408	434,536	9,100	25	99	24
Maine	33,265	1,205	67,760	2,037	46	56	39
Maryland	10,460	4,622	362,921	34,696	1	79	31
Massachusetts	8,284	5,889	192,238	23,206	8	33	46
Michigan	58,527	9,240	1,587,561	27,125	3	172	13
Minnesota	84,402	4,307	1,267,499	15,017	13	294	8
Mississippi	47,689	2,620	103,400	2,168	45	39	43
Missouri	69,697	5,141	967,949	13,888	17	188	12
Montana	147,046	805	548,161	3,728	37	681	4
Nebraska	77,355	1,602	91,192	1,179	48	57	38
Nevada	110,561	1,054	1,944,566	17,588	11	1,845	1
New Hampshire	9,279	1,085	[1]53,060	5,718	33	49	41
New Jersey	7,787	7,721	241,832	31,056	2	31	47
New Mexico	121,593	1,507	1,018,532	8,377	28	676	5
New York	49,107	17,909	695,700	14,167	15	39	44
North Carolina	52,669	6,489	529,434	10,052	24	82	30
North Dakota	70,703	667	18,807	266	49	28	48
Ohio	41,330	10,855	737,252	17,838	10	68	35
Oklahoma	69,956	3,242	220,137	3,147	43	68	36
Oregon	97,073	2,767	178,188	1,836	47	64	37
Pennsylvania	45,308	12,001	1,042,493	23,009	9	87	28
Rhode Island	1,212	993	[1]17,248	14,231	14	17	49
South Carolina	31,113	3,470	357,802	11,500	21	103	21
South Dakota	77,116	713	285,719	3,705	38	401	7
Tennessee	42,144	4,895	585,649	13,896	16	120	16

See footnote at end of table.

TABLE 4—Continued

VALUE OF NONFUEL MINERAL PRODUCTION PER CAPITA AND PER SQUARE MILE IN 1988, BY STATE

State	Area (square miles)	Population (thousands)	Total (thousands)	Per square mile		Per capita	
				Dollars	Rank	Dollars	Rank
Texas	266,807	16,841	$1,468,818	5,505	34	87	27
Utah	84,899	1,690	1,014,847	11,954	19	601	6
Vermont	9,614	557	76,945	8,003	29	138	14
Virginia	40,767	6,015	494,512	12,130	18	82	29
Washington	68,138	4,648	459,334	6,741	31	99	23
West Virginia	24,231	1,876	127,455	5,260	35	68	34
Wisconsin	56,153	4,855	204,873	3,648	39	42	42
Wyoming	97,809	479	709,812	7,257	30	1,482	2
Undistributed	XX	XX	7,812	XX	XX	XX	XX
Total[2] or average	**3,618,700**	**245,190**	**[3]30,022,000**	**8,296**	**XX**	**122**	**XX**

XX Not applicable.

[1] Partial total, excludes values that must be concealed to avoid disclosing company proprietary data. Concealed values included with "Undistributed" figure.

[2] Excludes Washington, DC (which has no mineral production), with an area of 69 square miles and a population of 617,000.

[3] Data do not add to total shown because of independent rounding.

TABLE 5

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ALABAMA							
Cement:							
Masonry	thousand short tons	267	$18,165	291	$17,626	273	$16,457
Portland	do.	3,477	153,629	3,600	160,878	3,524	157,214
Clays[2]	short tons	2,077,427	14,828	2,238,971	16,217	2,516,210	16,039
Gem stones		NA	1	NA	7	NA	5
Lime	thousand short tons	1,180	50,377	1,232	52,200	1,450	66,576
Sand and gravel:							
Construction	do.	10,781	30,807	e10,300	e35,600	11,742	41,417
Industrial	do.	433	3,388	580	5,025	871	8,507
Stone:							
Crushed	do.	e24,000	e120,500	30,018	146,247	e29,700	e140,100
Dimension	short tons	e7,797	e968	W	W	W	W
Combined value of bauxite, clays (bentonite), salt, talc and pyrophyllite (1988), zircon concentrates (1988), and values indicated by symbol W		XX	12,553	XX	12,843	XX	13,180
Total		**XX**	**405,216**	**XX**	**446,643**	**XX**	**459,495**
ALASKA							
Gem stones		NA	$25	NA	$86	NA	$50
Gold (recoverable content of ores, etc.)	troy ounces	48,271	17,775	86,548	38,769	135,340	59,320
Sand and gravel (construction)	thousand short tons	27,762	61,954	e27,200	e73,400	17,200	48,749
Silver (recoverable content of ores, etc.)	troy ounces	W	W	r15,812	r111	20,589	135
Stone (crushed)	thousand short tons	e2,000	e8,500	2,033	8,945	e1,800	e8,400
Combined value of cement (portland), tin, and value indicated by symbol W		XX	3,226	XX	4,010	XX	2,040
Total		**XX**	**91,480**	**XX**	**r125,321**	**XX**	**118,694**
ARIZONA							
Clays	short tons	201,110	$1,366	218,151	$1,905	185,620	$1,590
Copper (recoverable content of ores, etc.)	metric tons	789,175	1,149,193	r751,073	r1,365,994	845,445	2,246,093
Diatomite	thousand short tons	—	—	—	—	8	1,208
Gem stones		NA	2,533	NA	3,000	NA	3,300
Gold (recoverable content of ores, etc.)	troy ounces	W	W	r57,592	r25,798	146,259	64,106
Gypsum	thousand short tons	260	1,820	W	W	W	W
Lime	do.	505	21,016	546	21,932	674	29,637
Molybdenum	thousand pounds	29,382	75,607	W	W	W	W
Perlite	thousand short tons	W	W	49	1,361	W	W
Pumice	do.	2	30	1	7	1	7
Sand and gravel:							
Construction	do.	40,468	140,004	e38,100	e141,300	32,399	123,854
Industrial	do.	W	W	W	W	119	3,045
Silver (recoverable content of ores, etc.)	troy ounces	4,506,197	24,649	r3,661,277	r25,666	4,888,951	31,974
Stone:							
Crushed	thousand short tons	e5,600	e25,100	7,712	33,999	e7,400	e33,000
Dimension	short tons	W	W	—	—	W	e1
Combined value of cement, lead (1988), pyrites (1987–88), salt, tin (1988), and values indicated by symbol W		XX	118,505	XX	r129,398	XX	235,596
Total		**XX**	**1,559,823**	**XX**	**r1,750,360**	**XX**	**2,773,411**

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ARKANSAS							
Abrasives[3]	short tons	W	W	W	W	1,235	$429
Clays	do.	[2]974,373	[2]$8,998	908,394	$8,651	930,863	15,376
Gem stones		NA	522	NA	1,800	NA	2,300
Sand and gravel:							
Construction	thousand short tons	8,571	26,999	[e]7,200	[e]23,900	7,722	26,201
Industrial	do.	400	3,975	505	5,147	669	6,784
Stone:							
Crushed	do.	[e]15,500	[e]58,500	15,234	63,847	[e]17,100	[e]70,100
Dimension	short tons	[e]5,145	[e]305	10,541	629	[e]10,541	[e]629
Combined value of bauxite, bromine,[e] cement, clays (fire clay, 1986), gypsum, lime, talc and pyrophyllite, tripoli, and values indicated by symbol W		XX	[r]163,708	XX	160,188	XX	184,970
Total		**XX**	**[r]263,007**	**XX**	**264,162**	**XX**	**306,789**
CALIFORNIA							
Boron minerals	thousand short tons	1,251	$426,086	1,385	$475,092	1,267	$429,667
Cement:							
Masonry	do.	W	W	W	W	8	730
Portland	do.	9,490	578,502	9,937	593,859	10,423	601,152
Clays	short tons	[2]2,449,136	[2]33,289	2,296,332	33,045	2,221,693	31,620
Gem stones		NA	418	NA	3,367	NA	3,365
Gold (recoverable content of ores, etc.)	troy ounces	425,617	156,729	602,605	269,937	721,512	316,246
Gypsum	thousand short tons	1,378	10,777	1,468	11,719	1,490	11,222
Lime	do.	371	24,187	465	25,745	699	30,356
Mercury	76 pound flasks	—	—	([4])	([4])	W	W
Peat	thousand short tons	W	W	W	W	2	119
Pumice	do.	46	1,263	42	1,539	35	1,245
Sand and gravel:							
Construction	do.	128,407	498,456	[e]141,600	[e]561,300	141,946	622,074
Industrial	do.	2,364	44,813	2,241	41,472	2,444	42,078
Silver (recoverable content of ores, etc.)	troy ounces	155,176	849	121,817	854	481,376	3,148
Stone:							
Crushed	thousand short tons	[e]38,500	[e]159,300	44,315	186,504	[e]49,100	[e]275,000
Dimension	short tons	[e]22,749	[e]2,582	33,335	4,554	[e]42,048	[e]5,991
Talc and pyrophyllite	thousand short tons	64	1,528	W	W	W	W
Combined value of asbestos, barite (1987–88), calcium chloride (natural), cement (masonry 1987–88), clays (ball clay, 1986), copper (1986, 1988), diatomite, feldspar, iron ore (includes byproduct material, 1988), magnesium compounds, molybdenum, perlite, potassium salts, rare-earth metal concentrates, salt, sodium carbonate (natural), sodium sulfate (natural), tungsten ore and concentrate, wollastonite (1986–87), and values indicated by symbol W		XX	330,638	XX	342,298	XX	334,755
Total		**XX**	**2,269,417**	**XX**	**2,551,285**	**XX**	**2,708,768**

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
COLORADO							
Clays	short tons	242,333	$1,523	292,050	$1,763	272,790	$1,890
Copper (recoverable content of ores, etc.)	metric tons	W	W	W	W	898	2,386
Gem stones		NA	100	NA	100	NA	100
Gold (recoverable content of ores, etc.)	troy ounces	120,347	44,317	178,795	80,091	164,809	72,237
Sand and gravel (construction)	thousand short tons	23,233	70,095	e22,800	e84,300	21,566	69,882
Silver (recoverable content of ores, etc.)	troy ounces	644,574	3,526	860,562	6,033	854,413	5,588
Stone:							
Crushed	thousand short tons	e8,000	e30,700	8,045	33,465	e10,600	e42,400
Dimension	short tons	e3,600	e255	3,000	133	e3,450	e143
Combined value of cement, gypsum, lead, lime, molybdenum, peat, perlite, pyrites (1987), sand and gravel (industrial), tungsten ore and concentrate (1986), vanadium, zinc, and values indicated by symbol W		XX	219,492	XX	167,104	XX	169,379
Total		**XX**	**370,008**	**XX**	**372,989**	**XX**	**364,005**
CONNECTICUT							
Clays	short tons	156,680	$975	W	W	W	W
Gem stones		NA	2	NA	$2	NA	$2
Sand and gravel (construction)	thousand short tons	7,254	25,984	e8,400	e37,000	8,275	32,102
Stone:							
Crushed	do.	e7,700	e45,800	11,412	76,668	e11,400	e76,900
Dimension	short tons	e24,425	e1,653	18,140	1,646	e19,718	e1,914
Combined value of feldspar, mica (scrap), sand and gravel (industrial), and values indicated by symbol W		XX	6,040	XX	6,959	XX	7,198
Total		**XX**	**80,454**	**XX**	**122,275**	**XX**	**118,116**
DELAWARE							
Gem stones		NA	$1	NA	$1	NA	$1
Marl (greensand)	short tons	1,068	12	W	W	750	10
Sand and gravel (construction)	thousand short tons	1,547	4,156	e2,300	e6,400	1,933	5,988
Total[5]		**XX**	**4,169**	**XX**	**6,401**	**XX**	**5,999**
FLORIDA							
Cement:							
Masonry	thousand short tons	352	$21,269	390	$24,069	411	$25,892
Portland	do.	3,189	147,643	3,565	165,944	3,682	168,719
Clays	short tons	725,903	43,261	597,187	39,496	591,855	44,423
Peat	thousand short tons	365	5,743	363	6,068	266	5,091
Sand and gravel:							
Construction	do.	28,233	67,898	e30,000	e74,900	18,654	53,083
Industrial	do.	1,467	14,930	1,884	19,713	636	6,928
Stone (crushed)	do.	e69,000	e288,200	e6,78,992	e6,350,537	e6,83,200	e6,374,400
Combined value of gem stones, lime (1986), magnesium compounds (1988), phosphate rock, rare-earth metal concentrates, staurolite, stone (crushed marl, 1987–88), titanium concentrates, (ilmenite and rutile), and zircon concentrates		XX	700,919	XX	665,510	XX	713,345
Total		**XX**	**1,289,863**	**XX**	**1,346,237**	**XX**	**1,391,881**

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
GEORGIA							
Clays	short tons	9,826,662	$669,200	10,454,740	$756,093	11,325,528	$908,771
Gem stones		NA	20	NA	20	NA	20
Sand and gravel (construction)	thousand short tons	8,126	23,222	e9,000	e26,900	9,526	30,185
Stone:							
Crushed	do.	e56,700	e293,100	60,834	318,903	e57,400	e317,200
Dimension	short tons	e198,905	e20,678	179,207	21,683	e190,472	e27,768
Talc and pyrophyllite	do.	8,800	61	20,100	286	26,000	260
Combined value of barite, bauxite (1987–88), cement, feldspar, iron oxide pigments (crude), kyanite (1986), mica (scrap), peat, sand and gravel (industrial), and values indicated by symbol W		XX	85,174	XX	88,485	XX	89,621
Total		**XX**	**1,091,455**	**XX**	**1,212,370**	**XX**	**1,373,825**
HAWAII							
Cement:							
Masonry	thousand short tons	7	$1,078	10	$1,559	10	$1,531
Portland	do.	287	24,253	324	26,550	354	28,880
Gem stones		NA	25	NA	25	NA	W
Lime	thousand short tons	3	W	3	W	W	W
Sand and gravel (construction)	do.	605	2,666	e700	e3,500	652	3,173
Stone (crushed)	do.	e7,100	e42,100	5,732	41,548	e5,700	e41,000
Combined value of other industrial minerals and values indicated by symbol W		XX	290	XX	297	XX	348
Total		**XX**	**70,412**	**XX**	**73,479**	**XX**	**74,932**
IDAHO							
Clays[2]	short tons	1,644	W	21,781	$229,835	9,391	W
Copper (recoverable content of ores, etc.)	metric tons	W	W	W	W	2,269	$6,028
Gem stones		NA	$305	NA	507	NA	500
Gold (recoverable content of ores, etc.)	troy ounces	70,440	25,938	97,773	43,797	103,463	45,349
Lead (recoverable content of ores, etc.)	metric tons	9,951	4,836	W	W	W	W
Lime	thousand short tons	89	4,729	97	5,149	W	W
Phosphate rock	metric tons	4,235,000	82,332	3,411,000	47,072	4,706,000	81,011
Sand and gravel:							
Construction	thousand short tons	5,708	14,830	e7,200	e28,000	6,914	19,897
Industrial	do.	W	W	W	W	483	5,089
Silver (recoverable content of ores, etc.)	troy ounces	11,206,851	61,301	W	W	10,934,631	71,512
Stone (crushed)	thousand short tons	e3,700	e12,700	3,852	15,346	e3,400	e13,100
Zinc (recoverable content of ores, etc.)	metric tons	351	294	W	W	W	W
Combined value of antimony (1986, 1988), cement, clays (bentonite, common, fire clay (1986), kaolin), garnet (abrasive), molybdenum (1986–87), perlite, pumice, stone (dimension), vanadium, and values indicated by symbol W		XX	66,783	XX	129,272	XX	48,130
Total		**XX**	**274,048**	**XX**	**269,373**	**XX**	**290,616**

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ILLINOIS							
Cement (portland)	thousand short tons	2,118	$83,783	2,119	$86,210	2,307	$101,760
Clays[2]	short tons	282,993	1,092	232,949	977	180,306	704
Gem stones		NA	15	NA	15	NA	30
Sand and gravel:							
Construction	thousand short tons	27,867	82,523	e28,300	e93,300	30,098	93,504
Industrial	do.	4,039	52,133	4,346	45,547	4,328	56,142
Stone:							
Crushed	do.	e44,200	e179,600	52,102	216,212	e57,900	e251,200
Dimension	short tons	e1,750	e107	W	W	e1,175	e129
Combined value of cement (masonry), clays (fuller's earth), copper, fluorspar, lead, lime, peat, silver, tripoli, zinc, and value indicated by symbol W		XX	70,272	XX	74,945	XX	84,157
Total		**XX**	**469,525**	**XX**	**517,206**	**XX**	**587,626**
INDIANA							
Cement:							
Masonry	thousand short tons	395	$22,936	422	$32,299	405	$27,442
Portland	do.	2,136	92,327	2,320	103,177	2,315	107,179
Clays	short tons	743,859	3,044	2 1,036,669	2 4,056	1,141,813	4,630
Gem stones		NA	1	NA	10	NA	10
Peat	thousand short tons	79	W	44	W	54	W
Sand and gravel:							
Construction	do.	19,642	61,232	e18,900	e65,200	25,923	79,985
Industrial	do.	193	1,490	230	1,357	362	1,829
Stone:							
Crushed	do.	e 6 22,600	e 6 76,500	31,067	106,770	e36,600	e130,000
Dimension	short tons	e190,995	e20,252	183,609	23,115	e195,444	e24,956
Combined value of abrasives, clays (fire clay, 1987), gypsum, lime, stone (crushed marl, 1986), and values indicated by symbol W		XX	27,566	XX	27,881	XX	30,358
Total		**XX**	**305,348**	**XX**	**363,865**	**XX**	**406,389**
IOWA							
Cement:							
Masonry	thousand short tons	48	$3,199	W	W	W	W
Portland	do.	1,819	86,984	2,139	$104,457	2,029	$98,930
Clays	short tons	486,309	1,421	472,788	1,495	445,248	1,588
Gem stones		NA	20	NA	W	NA	W
Gypsum	thousand short tons	1,826	12,602	1,874	12,887	2,047	13,710
Peat	do.	14	381	24	W	14	433
Sand and gravel (construction)	do.	14,511	40,418	e19,000	e63,800	11,880	36,087
Stone:							
Crushed	do.	e23,400	e98,000	25,991	110,106	e29,200	e128,500
Dimension	short tons	W	W	W	W	W	e588
Combined value of other industrial minerals and values indicated by symbol W		XX	5,707	XX	12,332	XX	10,420
Total		**XX**	**248,732**	**XX**	**305,077**	**XX**	**290,256**

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986 Quantity	1986 Value (thousands)	1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)
KANSAS							
Cement:							
Masonry	thousand short tons	51	$3,264	52	$3,150	50	$2,988
Portland	do.	1,763	91,110	1,697	81,045	1,569	72,805
Clays	short tons	903,448	5,295	[2]603,680	[2]2,576	[2]612,597	[2]2,632
Gem stones		NA	3	NA	3	NA	3
Salt[7]	thousand short tons	1,656	68,887	1,689	70,148	1,284	55,753
Sand and gravel:							
Construction	do.	15,609	33,721	e15,600	e37,800	10,760	25,329
Industrial	do.	132	1,155	127	1,400	W	W
Stone:							
Crushed	do.	e16,600	e60,300	19,319	69,628	e17,300	e72,700
Dimension	short tons	W	W	11,423	445	e6,889	e219
Combined value of clays (bentonite, 1987–88), gypsum, helium (crude and Grade-A), pumice, salt (brine), and values indicated by symbol W		XX	53,910	XX	53,409	XX	59,284
Total		**XX**	**317,645**	**XX**	**319,604**	**XX**	**291,713**
KENTUCKY							
Clays[2]	short tons	721,111	$3,450	1,030,518	$8,821	840,317	$3,217
Gem stones		NA	3	NA	3	NA	3
Sand and gravel (construction)	thousand short tons	7,194	16,986	e7,100	e15,200	6,325	15,243
Stone (crushed)	do.	e [6]38,400	e [6]137,000	43,330	173,222	e50,700	e207,900
Zinc (recoverable content of ores, etc.)	metric tons	W	W	10	9	W	W
Combined value of cement, clays (ball clay, fire clay), lime, sand and gravel (industrial, 1986–87), stone (crushed sandstone, 1986), and values indicated by symbol W		XX	109,826	XX	r98,508	XX	118,616
Total		**XX**	**267,265**	**XX**	**290,335**	**XX**	**344,979**
LOUISIANA							
Clays	short tons	331,982	$7,670	356,904	$9,192	[2]375,778	[2]$9,535
Gem stones		NA	1	NA	1	NA	3
Salt	thousand short tons	11,608	103,611	12,498	108,999	14,274	108,982
Sand and gravel:							
Construction	do.	14,292	46,134	e12,200	e43,600	14,233	52,820
Industrial	do.	256	4,225	289	3,997	318	4,786
Stone (crushed)[6]	do.	e5,400	e25,300	4,390	36,514	e3,700	e29,200
Sulfur (Frasch)	thousand metric tons	1,602	W	1,458	W	1,719	W
Combined value of cement (masonry (1987–88), portland), gypsum (1987–88), lime, stone (crushed miscellaneous), and values indicated by symbol W		XX	259,857	XX	221,918	XX	229,210
Total		**XX**	**446,798**	**XX**	**424,221**	**XX**	**434,536**

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MAINE							
Clays	short tons	46,000	$90	W	W	W	W
Gem stones		NA	200	NA	$1,172	NA	$150
Sand and gravel (construction)	thousand short tons	8,572	22,843	e8,600	e22,100	10,183	33,007
Stone:							
Crushed	do.	e1,600	e4,400	2,010	7,532	e1,400	e5,300
Dimension	short tons	W	W	7,512	5,924	e7,512	e5,924
Combined value of cement, garnet (abrasive), peat (1986), and values indicated by symbol W		XX	25,326	XX	28,729	XX	23,379
Total		**XX**	**52,859**	**XX**	**65,457**	**XX**	**67,760**
MARYLAND							
Cement (portland)	thousand short tons	1,785	$89,799	1,829	$90,020	1,808	$89,083
Clays	short tons	2361,729	2$1,757	383,054	1,940	394,443	2,016
Gem stones		NA	5	NA	5	NA	5
Lime	thousand short tons	10	546	9	486	6	329
Peat	do.	W	W	W	W	7	W
Sand and gravel (construction)	do.	18,173	86,925	e19,600	e92,900	19,266	95,169
Stone:							
Crushed	do.	e26,400	e126,000	30,136	151,579	e32,700	e167,000
Dimension	short tons	e20,505	e1,286	22,843	1,516	e20,729	e1,515
Combined value of cement (masonry), clays (ball clay, 1986), sand and gravel (industrial), and values indicated by symbol W		XX	7,027	XX	6,688	XX	7,804
Total		**XX**	**313,345**	**XX**	**345,134**	**XX**	**362,921**
MASSACHUSETTS							
Clays	short tons	139,995	$871	W	W	W	W
Gem stones		NA	W	NA	$1	NA	$1
Sand and gravel:							
Construction	thousand short tons	19,200	60,464	e21,800	e75,300	22,168	79,364
Industrial	do.	45	739	56	922	W	W
Stone:							
Crushed	do.	e10,000	e50,000	14,907	78,969	e17,500	e91,900
Dimension	short tons	e78,728	e14,928	76,579	12,747	W	W
Combined value of lime, peat, and values indicated by symbol W		XX	7,395	XX	8,583	XX	20,973
Total		**XX**	**134,397**	**XX**	**176,522**	**XX**	**192,238**
MICHIGAN							
Cement:							
Masonry	thousand short tons	257	$17,026	263	$23,004	265	$22,915
Portland	do.	4,713	216,120	4,755	207,332	5,253	231,141
Clays	short tons	1,402,446	5,684	1,333,498	5,338	1,375,816	4,432
Gem stones		NA	25	NA	25	NA	25
Gypsum	thousand short tons	1,979	11,052	1,977	12,190	1,958	11,630

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MICHIGAN—Continued							
Iron ore	thousand metric tons	11,133	W	12,509	W	14,623	W
Lime	thousand short tons	556	$27,257	569	$30,320	714	$36,088
Peat	do.	324	6,599	281	5,290	342	6,256
Sand and gravel:							
Construction	do.	42,514	91,886	e42,800	e105,300	53,508	138,171
Industrial	do.	3,343	29,493	2,792	22,451	3,045	27,150
Stone:							
Crushed	do.	e27,800	e83,900	37,909	109,514	e38,800	e120,300
Dimension	short tons	e5,863	e148	W	W	W	W
Combined value of bromine,[e] calcium chloride (natural), copper, gold, iron oxide pigments (crude), magnesium compounds, salt, silver, and values indicated by symbol W		XX	750,393	XX	844,846	XX	989,453
Total		**XX**	**1,239,583**	**XX**	**1,365,610**	**XX**	**1,587,561**
MINNESOTA							
Gem stones		NA	$5	NA	$40	NA	$40
Iron ore	thousand metric tons	29,241	1,017,261	r34,274	1,012,788	40,735	1,134,539
Peat	thousand short tons	W	W	30	W	29	1,027
Sand and gravel (construction)	do.	24,055	53,116	e25,200	e67,400	33,769	72,678
Stone:							
Crushed	do.	e8,300	e26,300	8,995	29,246	e8,300	e28,200
Dimension	short tons	e27,973	e10,507	41,354	12,967	e45,000	e13,000
Combined value of clays, lime, sand and gravel (industrial), and values indicated by symbol W		XX	20,438	XX	20,308	XX	18,015
Total		**XX**	**1,127,627**	**XX**	**1,142,749**	**XX**	**1,267,499**
MISSISSIPPI							
Clays[2]	short tons	927,716	$13,538	1,123,325	$26,933	1,093,316	$24,564
Gem stones		NA	1	NA	1	NA	1
Sand and gravel (construction)	thousand short tons	15,080	42,809	e14,700	e47,000	13,314	38,806
Stone (crushed)	do.	e1,600	e4,400	1,492	9,621	e1,500	e9,000
Combined value of cement, clays (ball clay and fuller's earth, 1986), and sand and gravel (industrial)		XX	40,347	XX	26,524	XX	31,029
Total		**XX**	**101,095**	**XX**	**110,079**	**XX**	**103,400**
MISSOURI							
Barite	thousand short tons	W	W	27	$2,030	26	$1,930
Cement:							
Masonry	do.	167	$7,816	167	10,027	153	6,310
Portland	do.	4,642	179,184	5,110	185,317	4,679	184,755
Clays[2]	short tons	1,320,767	6,650	1,475,837	10,415	1,581,864	12,171
Iron ore	thousand metric tons	816	W	756	W	816	W
Lead (recoverable content of ores, etc.)	metric tons	319,900	155,481	W	W	353,194	289,194

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MISSOURI—Continued							
Sand and gravel:							
Construction	thousand short tons	9,746	$24,065	e10,900	e$30,400	11,217	$32,941
Industrial	do.	517	6,230	622	7,786	744	9,876
Silver (recoverable content of ores, etc.)	troy ounces	1,459,185	7,982	1,180,584	8,276	1,460,271	9,550
Stone:							
Crushed	thousand short tons	e51,200	e170,500	54,910	184,824	e52,100	e183,000
Dimension	short tons	W	W	3,212	454	e3,644	e547
Zinc (recoverable content of ores, etc.)	metric tons	37,919	31,767	34,956	32,306	41,322	54,842
Combined value of clays (fuller's earth), copper, gem stones, iron oxide pigments (crude), lime, and values indicated by symbol W		XX	158,910	XX	391,206	XX	182,833
Total		**XX**	**748,585**	**XX**	**863,041**	**XX**	**967,949**
MONTANA							
Clays	short tons	221,819	$5,882	[2]28,879	[2]$98	[2]101,194	[2]$1,416
Gem stones		NA	480	NA	1,302	NA	1,602
Gold (recoverable content of ores, etc.)	troy ounces	W	W	234,365	104,984	294,976	129,291
Gypsum	thousand short tons	W	W	24	W	27	W
Lead (recoverable content of ores, etc.)	metric tons	W	W	W	W	8,266	6,768
Sand and gravel (construction)	thousand short tons	8,066	19,391	e6,800	e18,800	7,984	20,225
Silver (recoverable content of ores, etc.)	troy ounces	4,773,264	26,110	r5,937,155	r41,619	6,186,074	40,457
Stone (crushed)	thousand short tons	e [6]2,200	e [6]6,200	1,463	3,585	e1,800	e4,500
Talc and pyrophyllite	short tons	W	W	r356,231	r11,334	377,789	11,309
Zinc (recoverable content of ores, etc.)	metric tons	—	—	W	W	18,935	25,130
Combined value of barite (1987), cement, clays (fire clay, 1987–88), copper, graphite (natural, 1988), iron ore, lime, molybdenum, peat, phosphate rock, platinum-group metals, (1987–88), sand and gravel (industrial), stone (crushed traprock, 1986, dimension), vermiculite, zinc, and values indicated by symbol W		XX	179,870	XX	186,456	XX	307,463
Total		**XX**	**237,933**	**XX**	**r368,178**	**XX**	**548,161**
NEBRASKA							
Clays	short tons	221,153	$668	223,728	$721	237,459	$786
Gem stones		NA	10	NA	10	NA	10
Sand and gravel (construction)	thousand short tons	9,675	23,912	e10,300	e26,300	11,229	28,928
Stone (crushed)	do.	e4,000	e17,900	4,316	19,461	e4,900	e22,000
Combined value of cement, lime, and sand and gravel (industrial)		XX	51,598	XX	43,256	XX	39,468
Total		**XX**	**94,088**	**XX**	**89,748**	**XX**	**91,192**

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NEVADA							
Barite	thousand short tons	184	$3,005	308	$4,778	319	$5,053
Clays[2]	short tons	10,313	584	r11,799	r810	28,865	2,143
Gem stones		NA	213	NA	280	NA	280
Gold (recoverable content of ores, etc.)	troy ounces	2,098,980	r772,928	2,679,470	1,200,269	3,675,526	1,611,020
Gypsum	thousand short tons	1,236	8,221	W	W	W	W
Perlite	do.	4	122	W	W	5	142
Sand and gravel:							
Construction	do.	12,197	35,692	e10,600	e30,700	15,729	50,928
Industrial	do.	518	W	578	W	602	W
Silver (recoverable content of ores, etc.)	troy ounces	6,408,783	35,056	r12,186,692	r85,429	19,535,223	127,760
Stone (crushed)	thousand short tons	e1,500	e7,000	6 1,264	6 5,700	e 6 1,300	e 6 5,700
Combined value of cement (portland), clays (fuller's earth (1986–87), kaolin), copper (1986, 1988), diatomite, fluorspar, iron ore (1986), lime, lithium minerals, magnesite, mercury, salt, stone (crushed dolomite, 1987–88), and values indicated by symbol W		XX	114,529	XX	r118,825	XX	141,540
Total		**XX**	**977,350**	**XX**	**r1,446,791**	**XX**	**1,944,566**
NEW HAMPSHIRE							
Gem stones		NA	W	NA	$310	NA	$100
Sand and gravel (construction)	thousand short tons	8,418	$26,089	e9,100	e33,300	9,089	32,614
Stone:							
Crushed	do.	e1,800	e5,900	2,479	10,386	e2,400	e9,800
Dimension	short tons	e82,294	e6,451	67,479	10,684	e73,393	e10,546
Combined value of other industrial minerals and value indicated by symbol W		XX	137	XX	(8)	XX	(8)
Total		**XX**	**38,577**	**XX**	**5 54,680**	**XX**	**5 53,060**
NEW JERSEY							
Clays	short tons	132,524	$2,066	2 5,985	2 $140	2 16,484	2 $368
Gem stones		NA	3	NA	3	NA	3
Peat	thousand short tons	W	542	32	614	43	797
Sand and gravel:							
Construction	do.	13,999	53,746	e15,200	e61,200	18,318	74,183
Industrial	do.	2,341	29,878	2,112	27,872	1,860	25,437
Stone (crushed)	do.	e15,300	e95,400	6 17,576	6 111,951	e 6 19,300	e 6 123,500
Combined value of other industrial minerals		XX	4,613	XX	12,444	XX	17,544
Total		**XX**	**186,248**	**XX**	**214,224**	**XX**	**241,832**
NEW MEXICO							
Clays	short tons	60,184	$170	51,248	$141	31,476	$83
Copper (recoverable content of ores, etc.)	metric tons	W	W	r246,532	r448,373	258,660	687,182
Gem stones		NA	200	NA	200	NA	200
Gold (recoverable content of ores, etc.)	troy ounces	39,856	14,677	W	W	W	W

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NEW MEXICO—Continued							
Lead (recoverable content of ores, etc.)	metric tons	10	5	W	W	W	W
Perlite	thousand short tons	433	13,727	437	13,611	458	14,294
Potassium salts	thousand metric tons	987	132,900	1,323	174,200	1,271	213,800
Pumice	thousand short tons	255	2,370	87	991	84	852
Sand and gravel (construction)	do.	8,471	25,862	e8,600	e31,000	8,787	31,367
Stone:							
Crushed	do.	e3,900	e15,300	4,503	15,919	e3,500	e13,900
Dimension	short tons	e21,615	e378	21,893	626	e21,893	e626
Combined value of cement, gypsum, helium (Grade-A), iron ore (includes byproduct material), mica (scrap), molybdenum, pyrites (1987), salt, silver, and values indicated by symbol W		XX	r406,723	XX	r52,783	XX	56,228
Total		**XX**	**r612,312**	**XX**	**r737,844**	**XX**	**1,018,532**
NEW YORK							
Clays	short tons	618,968	$3,075	672,635	$3,562	607,786	$3,654
Emery	do.	2,878	W	1,945	W	W	W
Gem stones		NA	100	NA	135	NA	200
Peat	thousand short tons	W	W	1	34	W	W
Salt	do.	5,071	122,601	4,918	119,962	4,614	127,994
Sand and gravel:							
Construction	do.	31,172	103,748	e31,400	e112,900	33,884	124,341
Industrial	do.	59	1,164	58	651	53	625
Stone:							
Crushed	do.	e40,600	e196,600	38,103	188,694	e39,900	e193,500
Dimension	short tons	e15,637	e3,002	38,553	5,822	e30,751	e4,333
Combined value of cement, garnet (abrasive), gypsum, iron ore (includes byproduct material, 1988), lead, silver, talc and pyrophyllite, wollastonite, zinc, and values indicated by symbol W		XX	247,272	XX	218,620	XX	241,053
Total		**XX**	**677,562**	**XX**	**650,380**	**XX**	**695,700**
NORTH CAROLINA							
Clays	short tons	2,657,679	$10,970	3,229,053	$15,282	3,174,766	$16,349
Feldspar	do.	526,672	15,568	512,386	15,562	507,986	17,312
Gem stones		NA	551	NA	550	NA	688
Gold (recoverable content of ores, etc.)	troy ounces	12	4	—	—	—	—
Mica (scrap)	thousand short tons	89	4,641	100	5,607	87	4,512
Peat	do.	15	W	W	W	21	W
Sand and gravel:							
Construction	do.	7,543	23,127	e8,600	e30,100	11,076	38,459
Industrial	do.	1,464	16,656	1,184	15,329	1,246	15,953
Stone:							
Crushed	do.	e43,500	e206,500	48,847	237,181	e50,500	e250,000
Dimension	short tons	e41,418	e6,633	32,669	5,128	e31,977	e5,026
Talc and pyrophyllite	do.	82,694	1,552	W	W	W	W
Combined value of lithium minerals, olivine, phosphate rock, and values indicated by symbol W		XX	180,528	XX	152,178	XX	181,135
Total		**XX**	**466,730**	**XX**	**476,917**	**XX**	**529,434**

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NORTH DAKOTA							
Clays	short tons	W	W	50,101	$100	84,787	$147
Gem stones		NA	$2	NA	2	NA	2
Lime	thousand short tons	74	7,359	127	11,912	108	7,094
Sand and gravel (construction)	do.	5,135	10,741	e4,900	e10,200	3,772	8,079
Combined value of peat, salt, sand and gravel (industrial, 1986–87), stone (crushed miscellaneous), and value indicated by symbol W		XX	2,700	XX	4,097	XX	3,485
Total		**XX**	**20,802**	**XX**	**26,311**	**XX**	**18,807**
OHIO							
Cement:							
Masonry	thousand short tons	138	$11,540	139	$11,964	129	$11,140
Portland	do.	1,706	79,383	1,748	83,661	1,424	70,816
Clays	short tons	2,832,785	11,515	3,187,270	12,714	3,709,454	14,423
Gem stones		NA	10	NA	10	NA	10
Lime	thousand short tons	1,648	81,103	1,926	93,108	2,065	87,431
Peat	do.	6	W	W	W	W	W
Salt	do.	4,115	126,757	3,276	104,099	3,795	115,860
Sand and gravel:							
Construction	do.	36,806	126,747	e36,400	e136,900	46,104	156,318
Industrial	do.	1,221	21,183	1,249	21,292	1,361	23,441
Stone:							
Crushed	do.	e39,300	e147,300	51,590	300,096	e48,000	e252,000
Dimension	short tons	e35,698	e2,708	47,816	2,427	e38,300	e3,137
Combined value of abrasives, gypsum, and values indicated by symbol W		XX	1,738	XX	2,510	XX	2,676
Total		**XX**	**609,984**	**XX**	**768,781**	**XX**	**737,252**
OKLAHOMA							
Cement:							
Masonry	thousand short tons	50	$3,198	41	$2,436	W	W
Portland	do.	1,579	69,075	1,415	54,870	1,432	$42,131
Clays	short tons	992,702	2,329	797,301	1,783	754,054	1,803
Gem stones		NA	2	NA	8	NA	18
Gypsum	thousand short tons	1,683	9,855	1,828	13,336	2,173	13,393
Iodine	pounds	W	W	W	W	2,238,152	W
Sand and gravel:							
Construction	thousand short tons	10,366	24,585	e10,500	e24,200	9,273	22,654
Industrial	do.	1,203	16,454	1,243	17,078	1,268	17,381
Stone:							
Crushed	do.	e30,900	e102,100	625,155	683,732	e 626,300	e 692,000
Dimension	short tons	e18,503	e913	8,311	861	e7,746	e785
Combined value of feldspar, lime, pumice (1986), salt, stone (crushed dolomite, 1987–88), tripoli, and values indicated by symbol W		XX	18,504	XX	24,915	XX	29,972
Total		**XX**	**247,015**	**XX**	**223,219**	**XX**	**220,137**

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
OREGON							
Clays	short tons	203,596	$289	267,824	$986	248,021	$1,049
Gem stones		NA	350	NA	350	NA	894
Nickel (content of ores and concentrates)	short tons	1,175	W	—	—	—	—
Sand and gravel (construction)	thousand short tons	13,441	42,597	e13,000	e42,200	14,880	52,657
Stone (crushed)	do.	e15,100	e53,400	20,663	73,902	e22,200	e77,600
Talc and pyrophyllite	short tons	58	41	150	14	W	W
Combined value of cement, diatomite, gold, lime, pumice, silver (1987–88), stone (dimension, 1986, 1988), and values indicated by symbol W		XX	29,755	XX	43,544	XX	45,988
Total		**XX**	**126,432**	**XX**	**160,996**	**XX**	**178,188**
PENNSYLVANIA							
Cement:							
Masonry	thousand short tons	391	$26,683	397	$30,464	391	$28,713
Portland	do.	6,290	324,187	6,325	334,709	6,309	329,634
Clays[2]	short tons	1,233,791	5,061	1,206,121	4,751	1,375,836	5,843
Gem stones		NA	5	NA	5	NA	5
Lime	thousand short tons	1,417	81,234	1,574	93,430	1,641	91,214
Peat	do.	19	532	18	513	21	736
Sand and gravel:							
Construction	do.	15,373	68,880	e14,800	e72,900	19,826	91,966
Industrial	do.	688	10,091	W	W	W	W
Stone:							
Crushed	do.	e63,700	e317,100	97,213	458,676	e104,600	e470,700
Dimension	short tons	e72,352	e8,100	60,118	10,177	e59,022	e9,584
Combined value of clays (kaolin), mica (scrap), tripoli and values indicated by symbol W		XX	1,185	XX	r10,872	XX	14,098
Total		**XX**	**843,058**	**XX**	**r1,016,497**	**XX**	**1,042,493**
RHODE ISLAND							
Gem stones		NA	W	NA	$1	NA	$1
Sand and gravel:							
Construction	thousand short tons	2,269	$8,252	e2,700	e10,900	1,853	7,847
Industrial	do.	22	143	W	W	W	W
Stone (crushed)	do.	e61,000	e65,700	1,228	7,797	e1,500	e9,400
Combined value of other industrial minerals and values indicated by symbol W		XX	101	XX	(8)	XX	(8)
Total		**XX**	**14,196**	**XX**	**518,698**	**XX**	**517,248**

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
SOUTH CAROLINA							
Cement (portland)	thousand short tons	2,306	$109,529	2,567	$117,878	2,533	$118,670
Clays	short tons	[2]1,986,253	[2]37,980	[2]2,193,540	[2]38,244	2,058,927	40,541
Gem stones		NA	10	NA	10	NA	10
Manganiferous ore	short tons	14,320	W	rW	W	W	W
Sand and gravel:							
Construction	thousand short tons	7,200	19,783	e7,500	e19,500	7,529	20,751
Industrial	do.	800	14,081	844	15,188	859	15,271
Stone:							
Crushed	do.	e18,200	e76,700	[6]24,278	[6]105,387	e [6]23,500	e [6]105,800
Dimension	short tons	e7,550	e533	2,319	312	e353	e31
Combined value of cement (masonry), clays (fuller's earth, 1986–87), gold, mica (scrap), peat, silver, stone (crushed shell, 1987–88), vermiculite, and values indicated by symbol W		XX	37,273	XX	44,806	XX	56,728
Total		**XX**	**295,889**	**XX**	**341,325**	**XX**	**357,802**
SOUTH DAKOTA							
Cement:							
Masonry	thousand short tons	4	W	4	W	4	W
Portland	do.	635	W	519	W	490	W
Clays[2]	short tons	118,718	$375	W	W	W	W
Gem stones		NA	100	NA	$100	NA	$100
Gold (recoverable content of ores, etc.)	troy ounces	W	W	W	W	449,514	197,026
Gypsum	thousand short tons	31	268	W	W	W	W
Sand and gravel (construction)	do.	9,713	19,853	e9,600	e19,100	7,929	18,681
Silver (recoverable content of ores, etc.)	troy ounces	W	W	W	W	84,398	552
Stone:							
Crushed	thousand short tons	e3,600	e12,600	5,070	18,515	e5,500	e20,600
Dimension	short tons	e54,934	e18,399	50,718	18,209	e43,297	e16,472
Combined value of beryllium concentrates (1986–87), clays (bentonite, 1986, common, 1987–88), iron ore (1988), lime, mica, (scrap), and values indicated by symbol W		XX	181,291	XX	206,968	XX	32,288
Total		**XX**	**232,886**	**XX**	**262,892**	**XX**	**285,719**
TENNESSEE							
Clays[2]	short tons	1,164,290	$25,228	1,260,873	$25,480	1,285,002	$27,696
Phosphate rock	metric tons	1,231,000	21,191	W	W	W	W
Sand and gravel:							
Construction	thousand short tons	7,360	24,592	e7,900	e28,900	6,836	23,343
Industrial	do.	488	5,523	W	W	W	W
Stone:							
Crushed	do.	e [6]40,700	e [6]175,600	51,406	227,263	e52,200	e235,000
Dimension	short tons	e5,598	e1,553	3,360	573	e3,942	e567
Zinc (recoverable content of ores, etc.)	metric tons	102,118	85,550	115,699	106,926	119,954	159,201
Combined value of barite, cement, clays (bentonite, 1988, fuller's earth), copper, gem stones, lead (1987–88), lime, pyrites (1986–87), silver, stone (crushed granite, 1986), and values indicated by symbol W		XX	136,610	XX	138,670	XX	139,842
Total		**XX**	**475,847**	**XX**	**527,812**	**XX**	**585,649**

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
TEXAS							
Cement:							
Masonry	thousand short tons	209	$15,790	172	$11,283	136	$10,800
Portland	do.	8,883	412,697	7,318	319,996	7,000	292,256
Clays[2]	short tons	2,514,546	11,724	r3,315,424	r14,825	2,992,166	17,468
Gem stones		NA	297	NA	345	NA	340
Gypsum	thousand short tons	2,131	14,982	1,874	14,254	1,943	15,790
Lime	do.	1,173	62,670	1,140	59,027	1,192	55,935
Salt	do.	8,520	62,996	7,810	60,857	7,802	62,925
Sand and gravel:							
Construction	do.	59,562	209,855	e48,200	e178,600	50,370	171,167
Industrial	do.	1,302	18,274	1,509	22,843	1,631	26,645
Stone:							
Crushed	do.	e84,200	e301,500	84,347	276,477	e82,000	e271,300
Dimension	short tons	e49,457	e15,407	75,426	10,030	e66,354	e8,310
Sulfur (Frasch)	thousand metric tons	2,506	W	2,152	W	2,622	W
Talc and pyrophyllite	short tons	282,744	6,456	255,039	4,380	260,950	4,466
Combined value of asphalt (native, 1986), clays (ball clay, fuller's earth, 1986–87, kaolin), fluorspar (1986), helium (crude and Grade-A), iron ore, magnesium compounds, magnesium metal, sodium sulfate (natural), and values indicated by symbol W		XX	579,340	XX	r457,814	XX	531,416
Total		**XX**	**1,711,988**	**XX**	**r1,430,731**	**XX**	**1,468,818**
UTAH							
Beryllium concentrates	short tons	6,533	$7	6,062	$6	5,851	$6
Cement (portland)	thousand short tons	1,014	58,431	935	50,565	772	39,664
Clays	short tons	304,547	2,048	315,154	1,959	340,156	2,469
Gem stones		NA	96	NA	105	NA	370
Gypsum	thousand short tons	284	2,478	W	W	W	W
Lime	do.	232	13,079	562	17,894	365	17,252
Salt	do.	1,112	31,830	1,108	34,264	1,006	35,294
Sand and gravel:							
Construction	do.	16,452	39,763	e21,000	e56,700	17,843	49,796
Industrial	do.	6	123	6	11	3	60
Stone:							
Crushed	do.	e4,500	e14,100	7,989	23,606	e7,300	e20,600
Dimension	short tons	W	W	2,004	93	e2,004	e93
Vermiculite	do.	W	153	—	—	—	—
Combined value of asphalt (native, 1986), cement (masonry), copper, gold, iron ore, magnesium compounds, magnesium metal, mercury, molybdenum (1987–88), phosphate rock, potassium salts, silver, sodium sulfate (natural, 1986, 1988), stone (dimension, 1986), vanadium, and values indicated by symbol W		XX	212,330	XX	514,661	XX	849,243
Total		**XX**	**374,438**	**XX**	**699,864**	**XX**	**1,014,847**

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
VERMONT							
Gem stones		NA	W	NA	$10	NA	$10
Sand and gravel (construction)	thousand short tons	4,834	$11,226	e4,700	e10,800	6,047	17,478
Stone:							
Crushed	do.	e1,600	e7,600	62,159	620,400	e 62,000	e 618,000
Dimension	short tons	e104,610	e27,075	103,923	30,074	e105,000	e30,500
Combined value of asbestos, stone (crushed granite, 1987–88), talc and pyrophyllite, and value indicated by symbol W		XX	9,310	XX	r12,160	XX	10,957
Total		**XX**	**55,211**	**XX**	**r73,444**	**XX**	**76,945**
VIRGINIA							
Clays	short tons	899,977	$7,700	21,174,442	2$6,291	21,113,459	2$6,614
Gem stones		NA	20	NA	20	NA	20
Lime	thousand short tons	624	27,362	699	29,435	741	33,875
Sand and gravel (construction)	do.	11,670	46,488	e12,100	e43,400	12,551	42,573
Stone:							
Crushed	do.	e52,000	e224,700	60,376	295,903	e66,000	e326,700
Dimension	short tons	e9,542	e3,128	9,077	2,720	e10,000	e2,900
Combined value of aplite, cement, clays (fuller's earth, 1987–88), gypsum, iron oxide pigments (crude), kyanite, sand and gravel (industrial), talc and pyrophyllite (1987–88), and vermiculite		XX	83,639	XX	83,673	XX	81,830
Total		**XX**	**393,037**	**XX**	**461,442**	**XX**	**494,512**
WASHINGTON							
Cement:							
Masonry	thousand short tons	6	$530	W	W	W	W
Portland	do.	1,212	59,091	1,282	$63,600	979	$48,233
Clays	short tons	252,145	1,560	415,593	2,356	415,487	2,235
Gem stones		NA	200	NA	200	NA	200
Peat	thousand short tons	W	W	7	191	5	142
Sand and gravel:							
Construction	do.	26,342	76,387	e25,300	e78,900	31,170	94,402
Industrial	do.	W	W	294	5,186	W	W
Stone:							
Crushed	do.	e9,000	e34,100	14,754	49,618	e13,900	e48,700
Dimension	short tons	e1,223	e69	297	42	e697	e60
Combined value of calcium chloride (natural), copper (1987), diatomite, gold, gypsum, lime, magnesium metal, olivine, silver, and values indicated by symbol W		XX	204,688	XX	r238,341	XX	265,362
Total		**XX**	**376,625**	**XX**	**r438,434**	**XX**	**459,334**

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
WEST VIRGINIA							
Clays	short tons	214,980	$470	266,037	$565	263,973	$586
Gem stones		NA	1	NA	1	NA	1
Sand and gravel (construction)	thousand short tons	1,501	5,365	e1,000	e3,200	1,653	6,099
Stone (crushed)	do.	e9,800	e37,500	12,458	50,947	e11,600	e47,600
Combined value of cement, lime (1987–88), peat (1987–88), salt, and sand and gravel (industrial)		XX	86,473	XX	89,308	XX	73,169
Total		**XX**	**129,809**	**XX**	**144,021**	**XX**	**127,455**
WISCONSIN							
Gem stones		NA	$15	NA	$15	NA	$15
Lime	thousand short tons	350	19,715	393	21,733	452	23,986
Peat	do.	9	W	9	r237	11	270
Sand and gravel:							
Construction	do.	24,913	59,325	e23,900	e57,000	25,048	60,080
Industrial	do.	1,194	12,399	1,314	15,168	1,351	15,458
Stone:							
Crushed	do.	e18,700	e57,600	6,22,757	6,71,776	e 6,28,500	e 6,98,300
Dimension	short tons	e22,912	e2,878	36,903	3,697	e49,900	e6,200
Combined value of abrasives, cement (masonry, 1986–87, portland, 1986–87), stone (crushed traprock, 1987–88), and value indicated by symbol W		XX	12,600	XX	r16,846	XX	564
Total		**XX**	**164,532**	**XX**	**r186,472**	**XX**	**204,873**
WYOMING							
Clays	short tons	1,761,635	$51,823	2,127,645	2$62,031	2,357,616	2$72,174
Gem stones		NA	225	NA	150	NA	150
Lime	thousand short tons	25	1,689	29	1,560	26	1,640
Sand and gravel (construction)	do.	3,377	10,977	e2,600	e9,000	3,413	11,351
Stone (crushed)	do.	e 61,700	e 65,900	3,171	15,049	e2,500	e11,400
Combined value of beryllium concentrates (1986), cement, clays (common, 1987–88), gypsum, helium (Grade-A), sodium carbonate (natural), and stone (crushed granite, 1986)		XX	484,196	XX	557,265	XX	613,097
Total		**XX**	**554,810**	**XX**	**645,055**	**XX**	**709,812**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data, value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" figure.

[3] Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

[4] Less than 1/2 unit.

[5] Partial total, excludes values that must be concealed to avoid disclosing company proprietary data.

[6] Excludes certain stones; kind and value included with "Combined value" figure.

[7] Excludes salt in brines; value included with "Combined value" figure.

[8] Value excluded to avoid disclosing company proprietary data.

TABLE 6

MINERAL PRODUCTION[1] IN THE ISLANDS ADMINISTERED BY THE UNITED STATES

Mineral		1986[e]		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
American Samoa: Stone (crushed)	thousand short tons	([2])	$400	W	W	—	—
Guam: Stone (crushed)	do.	700	3,300	354	$2,289	—	—
Virgin Islands: Stone (crushed)	do.	200	1,500	345	2,741	—	—

[e] Estimated. W Withheld to avoid disclosing company proprietary data.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Less than 1/2 unit.

TABLE 7

MINERAL PRODUCTION[1] IN THE COMMONWEALTH OF PUERTO RICO

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	W	W	1,296	$106,185	1,397	$113,966
Clays	short tons	110,997	$223	148,029	318	163,382	365
Lime	thousand short tons	24	3,291	25	3,558	25	3,802
Salt	do.	40	880	40	900	40	900
Sand and gravel (industrial)	do.	31	624	67	W	31	624
Stone (crushed)	do.	[e]5,400	[e]26,000	8,480	41,299	[e]9,350	[e]47,400
Total[2]		**XX**	**31,018**	**XX**	**152,260**	**XX**	**167,057**

[e] Estimated. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Total does not include value of items not available or withheld.

TABLE 8

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS					
Aluminum:					
Ingots, slabs, crude	metric tons	ʳ281,816	ʳ$415,013	400,057	$925,572
Scrap	do.	ʳ368,510	ʳ409,712	486,615	774,277
Plates, sheets, bars, etc.	do.	251,572	647,890	334,395	995,767
Castings and forgings	do.	6,902	65,504	16,964	111,168
Aluminum sulfate	do.	1,857	1,535	3,492	1,982
Other aluminum compounds	do.	46,419	40,587	57,931	57,158
Antimony, metal and alloys, crude	short tons	876	2,817	688	1,793
Bauxite including bauxite concentrate	thousand metric tons	201	ʳ15,230	63	10,451
Beryllium	pounds	170,408	5,013	82,889	6,894
Bismuth, metals and alloys	do.	83,685	641	323,604	1,213
Cadmium metal	metric tons	241	660	613	3,697
Chromium:					
Ore and concentrate:					
Exports	thousand metric tons	1	707	4	1,430
Reexports	do.	5	352	1	320
Chromium ferroalloys	do.	5	5,730	8	12,503
Cobalt (content)	thousand pounds	806	7,007	1,197	10,131
Copper:					
Ore, concentrate, composition metal, unrefined (copper content)	metric tons	ʳ143,087	ʳ182,627	248,864	496,257
Scrap	do.	108,535	104,920	119,773	164,933
Refined copper and semimanufactures	do.	114,721	427,843	197,995	891,910
Other copper manufactures	do.	3,723	9,511	2,350	7,861
Ferroalloys not elsewhere listed:					
Ferrophosphorous	short tons	34,699	4,334	21,363	3,434
Ferroalloys, n.e.c.	do.	19,073	14,938	12,871	18,981
Gold:					
Ore and base bullion	troy ounces	1,557,794	674,658	1,829,432	776,340
Bullion, refined	do.	2,288,404	1,304,186	8,723,623	3,882,757
Iron ore	thousand metric tons	5,093	198,254	5,286	193,796
Iron and steel:					
Pig iron	short tons	50,072	4,897	71,454	7,790
Iron and steel products (major):					
Steel mill products	do.	1,093,982	949,597	2,065,955	1,702,286
Other steel products	do.	225,587	482,464	380,741	723,111
Iron and steel scrap: Ferrous scrap including rerolling materials, ships, boats, other vessels for scrapping	thousand short tons	10,670	996,145	10,470	1,402,833

See footnotes at end of table.

TABLE 8—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS—Continued					
Lead:					
Ore and concentrate	metric tons	8,764	$3,333	20,902	$10,678
Pigs, bars, cathodes, sheets, etc.	do.	10,116	11,945	13,594	15,919
Scrap	do.	52,823	15,670	81,910	23,212
Magnesium, metal and alloys, scrap, semimanufactured forms, n.e.c.	short tons	r48,702	r130,730	54,897	145,312
Manganese:					
Ore and concentrate	do.	63,270	4,225	67,991	5,496
Ferromanganese	do.	2,851	2,144	3,442	2,950
Silicomanganese	do.	697	493	7,467	4,975
Metal	do.	5,775	9,748	9,859	16,242
Molybdenum:					
Ore and concentrate (molybdenum content)	thousand pounds	40,514	98,381	51,807	148,237
Metal and alloys, crude and scrap	do.	513	3,504	995	6,686
Wire	do.	573	9,043	839	12,984
Semimanufactured forms, n.e.c.	do.	282	8,167	451	9,362
Powder	do.	2,145	8,866	1,340	5,889
Ferromolybdenum	do.	161	605	113	382
Compounds	do.	2,696	11,146	8,350	21,828
Nickel: [1]					
Primary (unwrought commercially pure, cathodes, ferronickel, powder and flakes)	short tons	2,507	19,165	2,721	29,146
Wrought (bars, rods, angles, shapes, sections, plates, sheets, strip; tubes, pipes, blanks, fittings hollow bar; wire)	do.	9,887	87,595	12,741	135,560
Compound catalysts and waste and scrap	do.	15,525	34,213	17,594	57,824
Platinum-group metals:					
Ore and scrap	troy ounces	276,727	84,578	272,835	88,651
Palladium, rhodium, iridium, osmiridium, ruthenium, osmium (metal and alloys including scrap)	do.	341,362	93,626	396,382	97,830
Platinum (metal and alloys)	do.	90,208	46,765	256,319	123,541
Rare-earth metals: Ferrocerium and alloys	metric tons	82	653	38	341
Selenium	kilograms	162,217	1,686	243,096	3,197
Silicon:					
Ferrosilicon	short tons	15,049	11,647	28,912	25,379
Silicon carbide, crude and in grains (including reexports)	do.	5,254	7,825	3,542	4,867
Silver:					
Ore, concentrate, waste, sweepings	thousand troy ounces	15,853	113,182	17,833	112,057
Bullion, refined	do.	11,240	79,123	14,269	94,029
Tantalum:					
Ore, metal, other forms	thousand pounds	r516	18,665	701	25,872
Powder	do.	193	16,129	278	23,758

See footnotes at end of table.

TABLE 8—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS—Continued					
Tin:					
Ingots, pigs, bars, etc.: Exports	metric tons	1,318	$9,456	1,209	$9,838
Tinplate and terneplate	do.	209,526	106,156	297,629	295,002
Titanium:					
Ore and concentrate	short tons	4,435	1,395	10,326	3,729
Unwrought and scrap metal	do.	5,922	12,721	6,922	25,428
Intermediate mill shapes and mill products, n.e.c.	do.	4,704	84,737	5,249	105,270
Pigments and oxides	do.	133,057	210,185	135,474	234,122
Tungsten (tungsten content):					
Ore and concentrate	metric tons	2	31	153	1,815
Carbide powder	do.	383	9,063	618	15,340
Alloy powder	do.	669	13,319	759	17,616
Vanadium:					
Pentoxide, etc.	thousand pounds	2,922	5,566	2,440	8,604
Ferrovanadium	do.	872	4,081	1,258	6,732
Zinc:					
Slabs, pigs, or blocks	metric tons	1,082	2,114	482	933
Sheets, plates, strips, other forms, n.e.c.	do.	1,732	2,337	3,814	4,416
Waste, scrap, dust (zinc content)	do.	90,204	49,482	105,953	69,981
Semifabricated forms, n.e.c.	do.	7,096	12,534	7,764	12,792
Ore and concentrate	do.	16,921	8,304	33,590	19,699
Zirconium:					
Ore and concentrate	do.	20,054	6,802	21,794	12,339
Oxide	do.	1,206	3,948	1,809	5,464
Metals, alloys, other forms	do.	1,225	62,892	1,257	62,646
INDUSTRIAL MINERALS					
Abrasives (includes reexports):					
Industrial diamond, natural or synthetic:					
Powder or dust	thousand carats	56,792	92,858	74,533	115,430
Other	do.	2,542	27,592	2,994	29,342
Diamond grinding wheels	do.	493	5,964	537	6,759
Other natural and artificial metallic abrasives and products		XX	[2]124,984	XX	[2]149,322
Asbestos:					
Exports:					
Unmanufactured	metric tons	59,136	15,818	31,334	8,410
Products		XX	178,953	XX	192,846
Reexports:					
Unmanufactured	metric tons	948	331	210	58
Products		XX	1,649	XX	2,012
Barite: Natural barium sulfate	short tons	9,083	716	226	353

See footnotes at end of table.

TABLE 8—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS—Continued					
Boron:					
Boric acid	short tons	66,614	$34,180	62,186	$35,301
Sodium borates, refined	do.	608,893	243,600	601,857	240,800
Bromine compounds	thousand pounds	48,300	18,000	30,700	13,000
Calcium:					
Other calcium compounds including precipitated calcium carbonate	short tons	49,978	40,705	18,306	10,703
Chloride	do.	34,718	6,657	18,710	5,532
Dicalcium phosphate	do.	83,362	53,456	114,496	78,411
Cement: Hydraulic and clinker	do.	52,009	9,563	101,000	8,907
Clays:					
Kaolin and china clay	thousand short tons	2,026	340,475	2,362	334,931
Bentonite	do.	539	40,596	626	48,409
Other	do.	761	131,897	909	133,226
Diatomite	do.	139	33,075	162	39,374
Feldspar, leucite, nepheline syenite	short tons	9,634	691	13,712	769
Flourspar	do.	2,860	340,315	3,457	381,572
Gem stones (including reexports):					
Diamonds	thousand carats	2,530	968,100	2,135	1,227,900
Pearls		XX	1,860	XX	14,500
Other		XX	140,300	XX	175,500
Graphite, natural	short tons	12,897	6,218	12,200	5,815
Gypsum:					
Crude, crushed, or calcined	thousand short tons	127	15,629	271	19,362
Manufactured, wallboard and plaster articles		XX	16,432	XX	17,051
Helium	million cubic feet	494	18,278	663	24,863
Lime	short tons	12,644	2,971	14,908	3,113
Lithium compounds:					
Lithium carbonate	thousand pounds	12,750	16,751	15,627	21,061
Lithium hydroxide	do.	6,930	11,033	8,352	15,069
Other lithium compounds	do.	2,688	7,062	3,404	7,291
Magnesium compounds:					
Magnesite, dead-burned	short tons	14,131	3,240	40,516	9,262
Magnesite, crude, caustic-calcined, lump or ground	do.	22,396	14,167	23,203	13,322
Mica:					
Waste, scrap, ground	thousand pounds	11,154	1,534	13,870	1,990
Block, film, splittings	do.	170	145	138	228
Manufactured, cut or stamped, built-up	do.	NA	4,748	NA	6,148
Mineral-earth pigments, iron oxide, natural and synthetic	short tons	22,249	31,689	24,213	33,014
Nitrogen compounds (major)	thousand short tons	10,901	NA	11,250	NA
Phosphate rock	thousand metric tons	8,454	194,691	8,092	206,984

See footnotes at end of table.

TABLE 8—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS—Continued					
Phosphatic fertilizers:					
Phosphoric acid	thousand metric tons	500	$85,912	434	NA
Superphosphates	do.	1,160	192,308	917	NA
Diammonium phosphates	do.	5,647	890,801	5,954	NA
Elemental phosphorous	metric tons	20,302	30,796	18,642	$27,539
Pigments and compounds: Zinc oxide (metal content)	do.	265	531	530	822
Potash:					
Potassium chloride	do.	511,590	NA	400,831	NA
Potassium sulfate	do.	230,899	NA	178,498	NA
Quartz crystal:					
Cultured	thousand pounds	448	6,954	417	7,162
Natural	do.	139	708	95	431
Salt:					
Crude and refined	thousand short tons	541	8,217	884	10,858
Shipments to noncontiguous territories	do.	NA	NA	NA	NA
Sand and gravel:					
Construction:					
Sand	do.	593	7,610	506	7,476
Gravel	do.	544	2,923	459	3,572
Industrial sand	do.	758	21,253	1,060	30,843
Sodium compounds:					
Sodium carbonate	do.	2,224	253,200	2,467	286,945
Sodium sulfate	do.	122	10,554	85	8,737
Stone:					
Crushed	do.	3,320	26,063	3,642	30,413
Dimension	do.	NA	20,470	NA	32,219
Sulfur, crude	thousand metric tons	1,242	139,431	1,223	131,863
Talc, crude and ground	thousand short tons	318	21,040	421	29,091
Total		**XX**	**13,426,441**	**XX**	**19,596,526**

[r] Revised. NA Not available. XX Not applicable.

[1] Not comparable to prior years owing to regrouping of nickel forms.

[2] Silicon carbide (crude and refined) has been deducted and is shown separately elsewhere in this table.

TABLE 9

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS					
Aluminium:					
Metal	metric tons	ᵣ1,245,638	ᵣ$1,852,304	1,027,246	$2,197,785
Scrap	do.	ᵣ188,667	ᵣ202,333	200,517	318,015
Plates, sheets, bars, etc.	do.	415,211	840,409	392,459	1,028,213
Aluminium oxide (alumina)	thousand metric tons	4,068	581,864	4,634	851,851
Antimony:					
Ore and concentrate (antimony content)	short tons	5,634	5,732	8,867	4,109
Sulfide including needle or liquated	do.	102	112	179	432
Metal	do.	9,701	18,171	18,303	34,837
Oxide	do.	ᵣ11,325	20,024	12,731	20,164
Arsenic:					
White (As_2O_3 content)	metric tons	26,843	16,800	28,056	16,461
Metallic	do.	631	3,471	600	2,642
Bauxite, crude	thousand metric tons	9,156	NA	9,944	NA
Beryllium ore	short tons	2,302	1,944	975	911
Bismuth, metals and alloys (gross weight)	pounds	3,484,713	8,769	3,618,727	18,354
Cadmium metal	metric tons	2,701	7,818	2,482	31,081
Calcium metal	pounds	776,225	1,918	1,464,794	3,024
Cesium compounds and chloride	do.	73,892	4,033	49,867	1,583
Chromium:					
Ore and concentrate (Cr_2O_3 content)	thousand metric tons	208	ᵣ23,775	270	42,317
Ferrochromium (gross weight)	do.	295	150,269	422	353,053
Ferrochromium-silicon	do.	7	4,920	10	5,461
Metal	do.	4	24,096	4	29,656
Cobalt:					
Metal	thousand pounds	18,612	122,791	14,683	105,547
Oxide (gross weight)	do.	795	5,293	743	5,692
Salts and compounds (gross weight)	do.	903	2,004	937	2,772
Columbium ore	do.	4,581	6,612	3,723	7,561
Copper (copper content):					
Ore and concentrate	metric tons	2,339	2,013	2,776	7,917
Matte	do.	6,869	9,339	5,462	10,399
Blister	do.	24,084	41,976	98,453	197,621
Refined in ingots, etc.	do.	ᵣ469,159	ᵣ734,647	331,671	810,495
Scrap	do.	33,123	ᵣ45,121	37,152	87,124
Ferroalloys not elsewhere listed, including spiegeleisen	short tons	3,940	22,722	4,859	26,792
Gallium	kilograms	12,490	4,874	12,160	4,341
Germanium	do.	17,498	10,491	19,291	13,539

See footnotes at end of table.

TABLE 9—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS—Continued					
Gold:					
Ore and base bullion	troy ounces	1,420,200	$580,025	1,124,328	$469,417
Bullion, refined	do.	2,423,053	1,052,941	1,851,748	799,901
Hafnium	short tons	1	180	4	764
Indium	thousand troy ounces	1,522	9,796	1,224	13,386
Iron ore (usable)	thousand metric tons	16,849	408,783	20,183	484,543
Iron and steel:					
Pig iron	short tons	354,712	52,500	652,555	85,730
Iron and steel products (major):					
Steel mill products	do.	20,350,816	8,567,164	20,774,712	8,932,276
Other products	do.	1,020,073	1,143,999	1,219,974	1,585,904
Scrap including tinplate	thousand short tons	843	82,016	1,038	133,577
Lead:					
Ore, flue dust,matte (lead content)	metric tons	873	308	20,606	11,224
Base bullion (lead content)	do.	10,827	7,239	4,046	2,743
Pigs and bars (lead content)	do.	185,673	123,157	148,604	107,484
Reclaimed scrap, etc. (lead content)	do.	6,587	3,128	7,289	3,339
Sheets, pipe, shot	do.	2,793	5,301	3,445	3,280
Magnesium:					
Metal and scrap	short tons	6,832	16,223	8,713	19,330
Alloys (magnesium content)	do.	2,921	8,624	4,638	12,702
Sheets, tubing, ribbons, wire, other forms (magnesium content)	do.	2,208	6,117	2,530	7,225
Manganese:					
Ore (35% or more contained manganese)	do.	340,539	15,079	511,695	29,074
Ferromanganese	do.	367,675	113,630	531,281	212,221
Ferrosilicon-manganese (manganese content)	do.	124,315	58,461	152,884	91,928
Metal	do.	8,925	9,600	11,730	14,946
Mercury:					
Compounds	pounds	475,015	2,136	658,195	4,194
Metal	76-pound flasks	18,451	3,860	9,558	2,798
Molybdenum:					
Ore and concentrate (molybdenum content)	thousand pounds	1,264	3,109	169	349
Waste and scrap		NA	2,545	NA	3,276
Metal:					
Unwrought (molybdenum content)	do.	174	2,308	296	3,752
Wrought (gross weight)	do.	158	2,801	119	3,457
Ferromolybdenum (gross weight)	do.	3,815	8,042	3,704	8,504
Material in chief value molybdenum (molybdenum content)	do.	5,248	15,497	965	2,863
Compounds (gross weight)	do.	6,711	13,407	7,361	15,015

See footnotes at end of table.

TABLE 9—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS—Continued					
Nickel:					
Cathodes, pellets, briquets, and shot	short tons	113,249	$455,126	112,576	$1,024,106
Plates, bars, etc.	do.	5,444	54,861	5,337	62,421
Slurry	do.	5,241	24,754	9,067	51,512
Scrap	do.	7,567	25,133	9,261	58,037
Powder and flakes	do.	11,977	60,406	10,984	100,743
Ferronickel	do.	45,398	57,481	44,576	116,990
Oxide	do.	2,278	4,277	3,397	26,009
Platinum-group metals:					
Unwrought:					
Grains and nuggets (platinum)	troy ounces	821	368	19,345	8,601
Sponge (platinum)	do.	1,124,018	621,321	1,371,704	710,520
Sweepings, waste, scrap	do.	624,916	106,920	410,270	84,257
Iridium	do.	11,814	4,319	18,288	6,132
Palladium	do.	1,529,161	210,670	1,487,740	198,924
Rhodium	do.	211,466	249,811	230,331	236,879
Ruthenium	do.	84,399	6,269	120,381	7,680
Other platinum-group metals	do.	17,620	6,204	4,266	1,732
Semimanufactured:					
Platinum	do.	45,804	24,840	113,187	62,314
Palladium	do.	151,499	22,312	212,369	27,387
Rhodium	do.	829	649	6,261	2,696
Other platinum-group metals	do.	4,200	925	2,954	805
Rare-earth metals:					
Ferrocerium and other cerium alloys	kilograms	94,829	1,294	100,662	1,348
Monazite	metric tons	1,121	627	1,924	1,154
Metals including scandium and yttrium	kilograms	13,490	1,350	20,087	907
Rhenium:					
Metal including scrap	pounds	7,436	2,072	6,821	3,161
Ammonium perrhenate (rhenium content)	do.	7,225	2,122	5,979	3,414
Selenium and selenium compounds (selenium content)	kilograms	495,862	10,108	474,234	11,140
Silicon:					
Metal (over 96% silicon content)	short tons	36,930	74,298	62,030	108,717
Ferrosilicon	do.	230,658	108,749	230,897	158,176
Silver:					
Ore and base bullion	thousand troy ounces	2,681	18,019	6,151	35,508
Bullion, refined	do.	67,959	460,235	72,662	476,181
Sweepings, waste, doré	do.	11,186	76,372	9,825	65,835
Tantalum ore	thousand pounds	697	5,186	1,410	15,027
Tellurium (gross weight)	kilograms	26,700	808	76,890	2,689

See footnotes at end of table.

TABLE 9—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS—Continued					
Thallium	pounds	3,138	$89	1,780	$98
Tin:					
Concentrate (tin content)	metric tons	2,953	9,509	2,837	7,913
Dross, skimmings, scrap, residure, tin alloys, n.s.p.f.	do.	2,270	9,241	1,542	6,054
Tinfoil, powder, flitters, etc.		XX	1,854	XX	1,013
Tin compounds	metric tons	838	5,162	838	5,439
Titanium:					
Ilmenite[1]	short tons	789,585	94,987	913,608	112,378
Rutile	do.	218,188	72,113	254,770	93,949
Metal	do.	4,521	29,759	7,339	52,288
Ferrotitanium and ferrosilicon-titanium	do.	1,425	2,521	1,711	6,180
Pigments	do.	192,043	236,945	204,443	291,832
Tungsten ore and concentrate (tungsten content)	metric tons	4,414	23,964	8,045	48,265
Vanadium (vanadium content):					
Ferrovanadium	thousand pounds	685	3,777	238	2,271
Pentoxide	do.	457	2,210	482	2,948
Vanadium-bearing materials	do.	4,528	5,903	4,465	7,107
Zinc:					
Ore and concentrates (zinc content)	metric tons	46,464	12,322	62,966	25,746
Blocks, pigs, slabs	do.	705,985	581,221	749,133	833,531
Sheets, etc.	do.	960	1,384	4,100	5,395
Fume (zinc content)	do.	16	18	100	27
Waste and scrap	do.	4,025	1,928	5,727	3,615
Dross and skimmings	do.	6,711	3,443	6,246	4,252
Dust, powder, flakes	do.	7,001	7,940	7,652	11,958
Manufactured		XX	1,570	XX	1,416
Zirconium:					
Ore including zirconium sand	metric tons	67,917	10,243	76,331	20,004
Metal, scrap, compounds	do.	4,233	25,592	4,207	23,286
INDUSTRIAL MINERALS					
Abrasives:					
Diamond (industrial)	thousand carats	48,877	r95,535	71,147	130,300
Other		XX	329,105	XX	371,407
Asbestos	metric tons	93,763	22,022	85,326	21,528
Barite:					
Crude and ground	thousand short tons	837	29,519	1,263	83,634
Witherite	short tons	436	144	1,377	253
Chemicals	do.	42,537	22,072	66,360	22,506

See footnotes at end of table.

TABLE 9—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS—Continued					
Boron:					
Boric acid (contained boric oxide)	short tons	2,240	$2,899	3,030	$2,020
Colemanite (contained boron oxide)	thousand short tons	8	2,763	19	7,790
Ulexite	do.	52	20,597	34	7,480
Bromine (contained in compounds)	thousand pounds	25,326	19,237	43,358	43,392
Calcium chloride:					
Crude	short tons	229,964	20,917	221,926	21,216
Other	do.	1,282	706	3,530	1,797
Cement: Hydraulic and clinker	thousand short tons	17,726	r606,588	17,488	616,107
Clays	short tons	37,679	9,392	36,208	8,835
Cryolite	do.	13,605	7,693	9,735	7,310
Feldspar:					
Crude	do.	344	4	75	8
Ground and crushed	do.	r4,455	r442	6,752	657
Fluorspar	do.	585,901	48,429	759,646	71,678
Gem stones:					
Diamond	thousand carats	9,121	3,423,094	10,397	4,305,762
Emeralds	do.	2,075	141,575	2,216	174,632
Other		XX	524,851	XX	582,949
Graphite, natural	short tons	47,768	17,654	59,378	23,238
Gypsum:					
Crude, ground, calcined	thousand short tons	9,719	59,555	9,681	59,836
Manufactured		XX	104,026	XX	98,333
Iodine, crude	thousand pounds	2,542	17,595	2,771	21,944
Lime:					
Hydrated	short tons	39,734	3,021	54,419	4,031
Other	do.	138,171	7,558	155,497	8,541
Lithium:					
Ore	do.	18,174	3,987	15,830	3,489
Compounds	do.	2,309	6,485	3,595	7,629
Magnesium compounds:					
Crude magnesite	do.	3,318	733	9,006	1,728
Lump or ground caustic-calcined magnesia	do.	42,011	4,575	22,850	2,371
Refractory magnesia, dead-burned, fused magnesite dead-burned dolomite	do.	223,555	43,539	278,008	46,667
Compounds	do.	70,746	20,593	104,782	25,881

See footnotes at end of table.

TABLE 9—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS—Continued					
Mica:					
Waste, scrap, ground	thousand pounds	21,142	$3,928	26,732	$5,561
Block, film, splittings	do.	2,460	1,230	3,535	2,083
Manufactured, cut or stamped, built-up	do.	1,645	5,125	1,657	5,679
Mineral-earth pigments, iron oxide:					
Ocher, crude and refined	short tons	59	99	371	34
Siennas, crude and refined	do.	289	177	99	30
Umber, crude and refined	do.	6,123	1,058	4,974	849
Vandyke brown	do.	1,576	342	1,633	314
Other natural and refined	do.	1,598	769	1,429	906
Synthetic	do.	32,679	18,235	34,405	24,996
Nepheline syenite:					
Crude	do.	3,720	142	2,882	111
Ground, crushed, etc.	do.	304,965	11,259	306,962	11,122
Nitrogen compounds (major) including urea	thousand short tons	7,065	582,553	7,904	796,087
Peat:					
Fertilizer-grade	short tons	500,142	69,076	577,177	73,072
Poultry- and stable-grade	do.	14,373	1,890	12,469	1,493
Phosphates, crude and apatite	thousand metric tons	464	18,816	673	25,911
Phosphatic fertilizers:					
Fertilizer and fertilizer materials	do.	55	7,820	27	6,802
Elemental phosphorous	do.	4	6,609	249	NA
Other	do.	53	8,514	106	16,515
Pigments and salts:					
Lead pigments and compounds	metric tons	21,213	21,145	19,442	22,291
Zinc pigments and compounds	do.	68,672	60,078	88,227	97,454
Potash	do.	6,706,200	432,700	6,963,900	622,900
Pumice:					
Crude and unmanufactured	short tons	17,353	2,414	30,722	4,386
Wholly or partly manufactured	do.	1,201	380	2,080	631
Manufactured, n.s.p.f.		XX	899	XX	704
Quartz crystal (Brazilian lacas)	thousand pounds	146	157	215	180
Salt	thousand short tons	5,716	66,936	5,474	77,357
Sand and gravel:					
Industrial sand	do.	104	1,071	43	1,900
Other sand and gravel	do.	283	2,367	351	3,163
Sodium compounds:					
Sodium carbonate	do.	150	18,334	133	15,999
Sodium sulfate	do.	138	10,363	150	11,943

See footnotes at end of table.

TABLE 9—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS—Continued					
Stone:					
Crushed	thousand short tons	3,595	$12,500	3,244	$14,815
Dimension		XX	439,278	XX	517,835
Calcium carbonate fines	thousand short tons	263	1,524	358	1,973
Strontium:					
Minerals	short tons	42,469	3,670	45,462	3,502
Compounds	do.	10,004	7,307	14,434	9,313
Sulfur and compounds, sulfur ore and other forms, n.e.s.	thousand metric tons	1,599	152,096	1,996	185,864
Talc, unmanufactured	thousand short tons	53	10,348	87,514	12,268
Total[2]		**XX**	**28,534,000**	**XX**	**33,904,000**

[r] Revised. NA Not available. XX Not applicable.

[1] Includes titanium slag averaging about 70% TiO_2. For details, see "Titanium" chapter.

[2] Data may not add to totals shown because of independent rounding.

TABLE 10

COMPARISON OF WORLD AND U.S. PRODUCTION OF SELECTED NONFUEL MINERAL COMMODITIES

(Thousand short tons unless otherwise specified)

Mineral		1987			1988[p]		
		World production[1]	U.S. production	U.S. percent of world production	World production[1]	U.S. production	U.S. percent of world production
METALS, MINE BASIS							
Antimony (content of ore and concentrate)	short tons	76,112	—	—	78,196	W	NA
Arsenic trioxide[2]	metric tons	53,696	—	—	55,103	—	—
Bauxite[3]	thousand metric tons	93,969	576	1	98,859	588	1
Beryl	short tons	9,303	6,062	65	9,143	5,858	64
Bismuth	thousand pounds	6,372	W	NA	6,106	W	NA
Chromite	thousand metric tons	10,917	—	—	11,666	—	—
Cobalt (content of ore and concentrate)	thousand pounds	100,870	—	—	96,781	—	—
Columbium-tantalum concentrate (gross weight)	do.	49,570	—	—	85,834	—	—
Copper (content of ore and concentrate)	thousand metric tons	8,328	1,244	15	8,453	1,420	17
Gold (content of ore and concentrate)	thousand troy ounces	53,034	4,947	9	58,454	6,460	11
Iron ore (gross weight)	thousand metric tons	888,050	47,568	5	916,574	57,515	6
Lead (content of ore and concentrate)	do.	3,429	319	9	3,426	394	12
Manganese ore (gross weight)		26,160	—	—	26,303	—	—
Mercury	thousand 76-pound flasks	172	W	NA	167	W	NA
Molybdenum (content of ore and concentrate)	thousand pounds	196,537	75,117	38	208,880	94,911	45
Nickel (content of ore and concentrate)		896	—	—	920	—	—
Platinum-group metals[3]	thousand troy ounces	8,593	W	NA	8,668	W	NA
Silver (content of ore and concentrate)	do.	443,050	39,790	9	443,330	53,416	12
Tin (content of ore and concentrate)	metric tons	177,205	W	NA	200,798	W	NA
Titanium concentrates (gross weight):							
Ilmenite		4,274	W	NA	4,345	W	NA
Rutile		485	W	NA	480	W	NA
Tungsten (content of ore and concentrate)	metric tons	42,174	34	([4])	43,236	W	NA
Vanadium (content of ore and concentrate)	short tons	31,315	W	NA	33,660	W	NA
Zinc (content of ore and concentrate)	thousand metric tons	7,242	233	3	6,977	256	4
METALS, SMELTER BASIS							
Aluminum (primary)	do.	16,378	3,343	20	17,304	3,944	23
Cadmium	metric tons	18,996	1,515	8	19,823	1,885	10
Cobalt	thousand pounds	59,188	—	—	55,696	—	—
Copper (primary and secondary)[5]	thousand metric tons	8,914	1,249	14	9,023	1,363	15
Iron, pig		566,520	48,308	9	593,949	55,745	9
Lead (primary and secondary)[6]	thousand metric tons	5,687	1,084	19	5,716	1,129	20
Magnesium (primary)		361	137	38	372	157	42
Nickel[7]		840	—	—	889	—	—
Selenium[8]	kilograms	1,228,632	W	NA	1,502,671	285,600	19
Steel, raw		808,198	89,151	11	856,973	99,924	12
Tellurium[8]	kilograms	73,762	W	NA	63,681	W	NA
Tin	metric tons	187,373	[9]3,927	2	204,340	[9]1,467	1
Zinc (primary and secondary)	thousand metric tons	7014	344	5	7,109	330	5

See footnotes at end of table.

TABLE 10—Continued

COMPARISON OF WORLD AND U.S. PRODUCTION OF SELECTED NONFUEL MINERAL COMMODITIES

(Thousand short tons unless otherwise specified)

Mineral		1987			1988[P]		
		World production[1]	U.S. production	U.S. percent of world production	World production[1]	U.S. production	U.S. percent of world production
INDUSTRIAL MINERALS							
Asbestos	thousand metric tons	4,256	51	1	4,361	18	([4])
Barite		5,197	[10]448	9	5,844	[10]445	8
Boron minerals		2,975	1,385	47	3,043	1,267	42
Bromine	thousand pounds	857,530	[10]335,000	39	892,230	[10]360,000	40
Cement, hydraulic		1,151,060	[11]79,501	7	1,212,724	[11]78,252	6
Clays:							
Bentonite[2]		9,734	[10]2,806	29	10,016	[10]3,165	32
Fuller's earth[8]		2,658	[10]2,057	77	2,832	[10]2,175	77
Kaolin[2]		26,455	[10]8,827	33	28,365	[10]9,891	35
Diamond, natural	thousand carats	87,615	—	—	93,999	—	—
Diatomite		2,003	658	33	2,036	693	34
Feldspar		4,705	720	15	4,728	715	15
Fluorspar		5,461	70	1	5,709	70	1
Graphite	short tons	728,904	—	—	741,220	—	—
Gypsum		99,634	15,612	16	104,923	16,390	16
Iodine, crude	thousand pounds	27,748	W	NA	32,222	2,200	7
Lime		124,776	[10] [11]15,758	13	131,212	[10] [11]17,318	13
Magnesite, crude		13,370	W	NA	13,358	W	NA
Mica (including scrap and ground)	thousand pounds	637,984	321,100	50	595,960	286,400	48
Nitrogen: N content of ammonia		103,944	13,230	13	109,022	13,930	13
Peat		207,779	955	([4])	207,597	900	([4])
Perlite		1,927	[10]533	28	2,037	[10]576	28
Phosphate rock (gross weight)	thousand metric tons	144,228	40,954	28	163,673	45,389	28
Potash (K_2O equivalent)	do.	30,470	1,262	4	31,429	1,521	5
Pumice[8]		11,888	[10]392	3	11,945	[10]389	3
Salt		196,956	[10] [11]36,532	19	202,905	[10] [11]38,037	19
Sodium compounds, n.e.s. (natural and manufactured):							
Carbonate		33,330	8,891	27	34,258	9,632	28
Sulfate		5,101	814	16	5,080	788	16
Strontium[8]	short tons	199,993	—	—	211,185	—	—
Sulfur, all forms	thousand metric tons	56,940	10,538	19	58,396	10,746	18
Talc and pyrophyllite		8,435	1,349	16	8,432	1,377	16
Vermiculite[8]		598	[10]303	51	596	[10]304	51

[P] Preliminary. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in world total.

[1] The reporting of world production of natural corundum was dropped from the 1987 edition of the Minerals Yearbook, therefore, corundum no longer appears in this table. For those commodities for which U.S. data are withheld to avoid disclosing company proprietary data, the world total excludes U.S. output and the U.S. percent of world production cannot be reported.

[2] World total does not include an estimate for China.

[3] U.S. figures represent dried bauxite equivalent of crude ore; to the extent possible, individual country figures that are included in the world total are also on the dried bauxite eqiuivalent basis, but for some countries available data are insufficient to permit this adjustment.

[4] Less than 0.5%.

[5] Primary and secondary blister and anode copper, including electrowon refined copper that is not included as blister or anode.

[6] Includes bullion.

[7] Refined nickel plus nickel content of ferronickel and nickel oxide.

[8] World total does not include estimates for output in the U.S.S.R. or China.

[9] Includes tin content of alloys made directly from ore.

[10] Quantity sold or used by producers.

[11] Includes Puerto Rico.

THE MINERAL INDUSTRY OF ALABAMA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Geological Survey of Alabama for collecting information on all nonfuel minerals.

By Doss H. White, Jr.[1]

In 1988, Alabama's nonfuel mineral output was valued at a record $459 million, exceeding the previous record set in 1987 by $12 million. Production increased for clays, sand and gravel, and lime, but decreased for cement and crushed stone. Many of Alabama's nonfuel mineral commodities—common clay, cement, sand and gravel, and stone—were used by the construction industry. Construction activity remained strong during the year.

Alabama ranked 21st nationally in total nonfuel mineral production. The State's mineral producers ranked in the top 10 in the production of several mineral commodities: bauxite (second), bentonite (third), fire clay (third), masonry cement (fourth), and lime (fifth).

TRENDS AND DEVELOPMENTS

During the 1980's, the three leading mineral commodities, in terms of tonnage, have been crushed stone, construction sand and gravel, and portland cement. These three commodities were the principal raw materials of Alabama's construction industry, and the strength of this mineral industry sector was reflected favorably in the State's economy over the 8-year period.

One trend has been a significant increase in foreign ownership of Alabama's mineral producers. Foreign ownership was almost nonexistent in the mid-1970's, but, by 1988, foreign concerns had purchased five cement plants, three clay plants, two stone operations, one aluminum plant, one concrete company, and one precious metals recovery operation.[2]

Developments during 1988 reflected the growth of the State's industrial minerals sector. The Geological Survey of Alabama reported 3 new and 11 expanding industrial minerals operations. The total capital investment for these 14 firms was $26.6 million. The cement-concrete sector, a major user of crushed stone and sand, had 1 new operation and 12 expanded operations with a total investment of $26.9 million. The primary metals industry had 2 new operations and 51 expansions with a capital investment of $284.8 million.[3]

For 1988, the Alabama Geological Survey estimated the value of oil production at $124.8 million, condensate at $145.6 million, natural gas at $196.9 million, and coal at $1,076.2 million.

The Port of Mobile handled 32.8 million short tons of cargo in 1988, an

TABLE 1

NONFUEL MINERAL PRODUCTION IN ALABAMA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	267	$18,165	291	$17,626	273	$16,457
Portland	do.	3,477	153,629	3,600	160,878	3,524	157,214
Clays[2]	short tons	2,077,427	14,828	2,238,971	16,217	2,516,210	16,039
Gem stones		NA	1	NA	7	NA	5
Lime	thousand short tons	1,180	50,377	1,232	52,200	1,450	66,576
Sand and gravel:							
Construction	do.	10,781	30,807	e10,300	e35,600	11,742	41,417
Industrial	do.	433	3,388	580	5,025	871	8,507
Stone:							
Crushed	do.	e24,000	e120,500	30,018	146,247	e29,700	e140,100
Dimension	short tons	e7,797	e968	W	W	W	W
Combined value of bauxite, clays (bentonite), salt, talc and pyrophyllite (1988), zircon concentrates (1988), and values indicated by symbol W		XX	12,553	XX	12,843	XX	13,180
Total		**XX**	**405,216**	**XX**	**446,643**	**XX**	**459,495**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

increase of 3.4 million tons over that of 1987.[4] Several mineral commodities processed by Alabama and Mississippi industries were included among the imports. Among these were gypsum, ilmenite, iron ore, manganese, potash, rutile, salt, and talc. Minerals exported were primarily aggregates shipped to other gulf ports.

EMPLOYMENT

Monthly reports issued by the Alabama Department of Industrial Relations (Alabama Labor Market News) noted that the average unemployment rate for 1988 was 7.1%, down about 12% from that of 1987. The 6.7% unemployment rate for September was the lowest in the State in more than 10 years. Many of the mineral-related labor sectors contributed to the decline in the unemployment rate as the demand for mineral products escalated. Mining employment increased nearly 9%, primary metals employment increased nearly 14%, and stone, clay, and glass employment increased nearly 2%. However, in the construction sector, which had the most effect on mineral aggregates, employment decreased nearly 3%.

REGULATORY ISSUES

A Livingston, AL, company received a State permit for a trial burn of hazardous waste as kiln fuel for lightweight aggregate manufacture. If tests were successful, waste would be purchased from four suppliers, including Chemical Waste Management, Inc., operator of a hazardous waste landfill at Emelle.[5]

LEGISLATION AND GOVERNMENT PROGRAMS

During 1988, no bills were introduced that directly affected the State's mineral producers.

The Geological Survey of Alabama, an independent State agency that reported directly to the Legislature and the Governor, continued projects to better define the State's geology and mineral resources. During the year, the Survey worked in cooperation with the U.S. Minerals Management Service to assess offshore minerals, including sand, gravel, oyster shell, and heavy minerals. Work continued on the Piedmont mapping program to develop a geologic data base for Piedmont minerals exploration. The energy resources program continued to collect coal samples for analysis and to estimate coal resources by quadrangle and county. Water resources programs continued to collect data on water movement, quality, and use.

The State of Alabama, through the University of Alabama at Tuscaloosa, continued construction of a $20 million Energy and Mineral Research complex. The 145,000-square-foot complex was to house the School of Mines and Energy Development and the research activities of the Mineral Engineering and Geology Departments. Physics and metallurgical engineering research also was to be conducted at the new facility. A simulated mine was to be constructed in the basement of the complex to be used for mine ventilation studies. The U.S. Department of Energy funded a $7.7 million grant for the complex. Remaining funds were allocated from a State bond issue, University of Alabama capital campaign funds, and other Federal and private sources.[6]

The State Lands Division of the Department of Conservation and Natural Resources managed State-owned lands, including land leased to private firms for mineral extraction. The Division supervised leases on coal, coal gas, oil, natural gas, and sand and gravel properties. In fiscal year 1988, the State received over $57 million from the mineral leases.

The U.S. Bureau of Mines funded $138,000 to the Alabama Mining and Mineral Resources Institute (MMRI) at the University of Alabama to support mineral resource investigations. An additional $80,000 contract was negotiated with MMRI to measure the extent of coalbed gas drainage at a large vertical borehole test facility.

The U.S. Bureau of Mines Research Center at Tuscaloosa conducted several studies of interest to the mineral industry in Alabama and other States. This work fell into three broad categories: (1) the recovery of phosphate values from phosphate waste, (2) the improvement of fine-particle recovery during froth flotation beneficiation, and (3) the development of new composite ceramic materials with super strength properties.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Industrial minerals accounted for more than 99% of the value of Alabama's nonfuel mineral production. Fourteen industrial minerals were either mined or manufactured in 1988.

Cement.—Alabama ranked 7th nationally among the 39 portland cement-producing States. Portland and masonry cement sales accounted for more than 37% of the State's mineral value. Cement output, 3.8 million tons valued at $174 million, decreased below the level reported in 1987 by 94,000 tons and $4.7 million, respectively. The decrease was due to a slowdown in construction activity in Alabama and surrounding States.

Alabama's cement industry consisted of six plants; five used the dry process for cement manufacture, while the sixth used the wet process. The six plants, located in Birmingham, Demopolis, Mobile, and Montevallo, operated eight kilns. Materials used in clinker manufacture were limestone, chalk, clay, gypsum, iron ore, sand, and shale.

During 1988, Ideal Basic Industries

reactivated its $347 million plant in Mobile, opened in 1981 and closed in 1984. The 1.5-million-ton-annual-capacity plant was plagued by excessive moisture in limestone shipped from the company's Alabama mines. A $3.1 million program modified the raw materials-processing and fuel-firing sections of the plant. In addition, the company purchased a quarry in the Dominican Republic and began work on a new quarry on Florida's west coast. From 1984 to 1988, the facility ground imported clinker.[7]

Allied Products Co. announced plans to close its 350,000-short-ton-per-year wet-kiln plant in Birmingham. Beginning in 1989, Allied was to purchase cement from Ideal Basic's newly restarted plant in Theodore. Allied's closure was motivated, in part, by Ideal's plans to market cement in north Alabama.[8]

Clays.—The State ranked 6th among the 44 clay-producing States. Clay sales accounted for 3% of Alabama's nonfuel mineral value. Alabama's 23 clay-producing companies mined bentonite, common clay, fire clay, and kaolin. The output of these clays decreased 164,000 tons below the figures reported by the industry in 1987. Value from clay sales decreased $77,000 from that reported in 1987.

Bentonite.—One firm, American Colloid Co. in Lowndes County, mined bentonite, a clay with absorbent properties, at its Sandy's Ridge Mine. Most of the output, which decreased below the 1987 level, was sold to the foundry and agricultural industries.

Common Clay and/or Shale.—Common clay or shale was mined by 16 companies operating 19 mines in 15 counties. The principal clay-producing counties were Jefferson, Russell, and Sumter. These three counties accounted for 49% of the State's common clay output. Most of the clay was processed into brick at plants in the vicinity of the mines. Other end uses included concrete block and highway surfacing.

One firm, Livlite Corp., mined clay for a 1.2 million-cubic-yard lightweight aggregate plant at Livingston. In 1988, the company applied for a permit to construct an additional coal-fired kiln adjacent to the present facility. The new kiln would raise the facility's annual capacity to 1.8 million cubic yards.

Fire Clay.—Fire clay, a clay containing low percentages of iron oxide, lime, magnesia, and alkalies was mined by four companies at four mines in Calhoun, St. Clair, and Shelby Counties in the northeast quarter of the State. The production of fire clay was more than 113,000 short tons valued at $3.4 million. Fire clay, which can withstand temperatures to 1,500° C, was sold to the refractory industry for the manufacture of fire and insulating brick.

Kaolin.—Barbour and Henry Counties in southwest Alabama were the center of the State's kaolin industry. Kaolin, a light-colored, clay-like material containing the mineral kaolinite, was marketed for use in the refractories, heavy clay products, and chemical materials industries. Output and value increased over that reported in 1987.

Lime.—Alabama ranked fourth among the 34 lime-producing States, and the value of lime sales accounted for approximately 14% of the State's mineral value. Lime was produced at four plants in Shelby County; output increased 218,000 tons over that produced in 1987. All four lime-mining firms mined a local limestone for kiln feed. Both quicklime and hydrated lime were produced.

Salt.—Alabama ranked 10th nationally in salt production. One firm, Olin Corp., produced salt from brine wells developed in the McIntosh salt dome in Washington County in the southwestern part of the State. Principal salt sales were to the paper and pulp, water purification, and sewage treatment industries. Production and value decreased from that reported for the previous year.

Sand and Gravel.—The State continued as a producer of both construction and industrial sand and gravel. Alabama's reported output in 1988, 12.6 million tons valued at almost $50 million, ranked the State third among the seven southeastern sand and gravel-producing States. Sand and gravel sales accounted for approximately 11% of Alabama's mineral value in 1988.

Construction.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and

TABLE 2

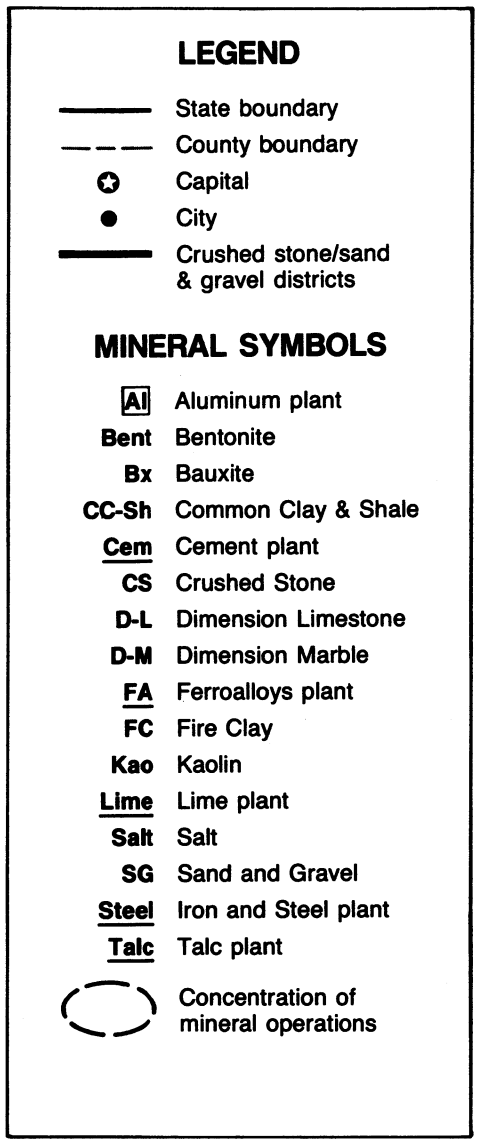
ALABAMA: LIME SOLD OR USED BY PRODUCERS, BY USE

Use	1987		1988	
	Quantity (Short tons)	Value (Thousands)	Quantity (Short tons)	Value (Thousands)
Paper and pulp	365,256	$15,232	473,682	$21,823
Water purification	212,251	8,959	255,990	9,998
Sewage treatment	64,986	2,950	W	W
Other[1]	589,255	25,059	720,069	34,755
Total	**1,231,748**	**52,200**	**1,449,741**	**66,576**

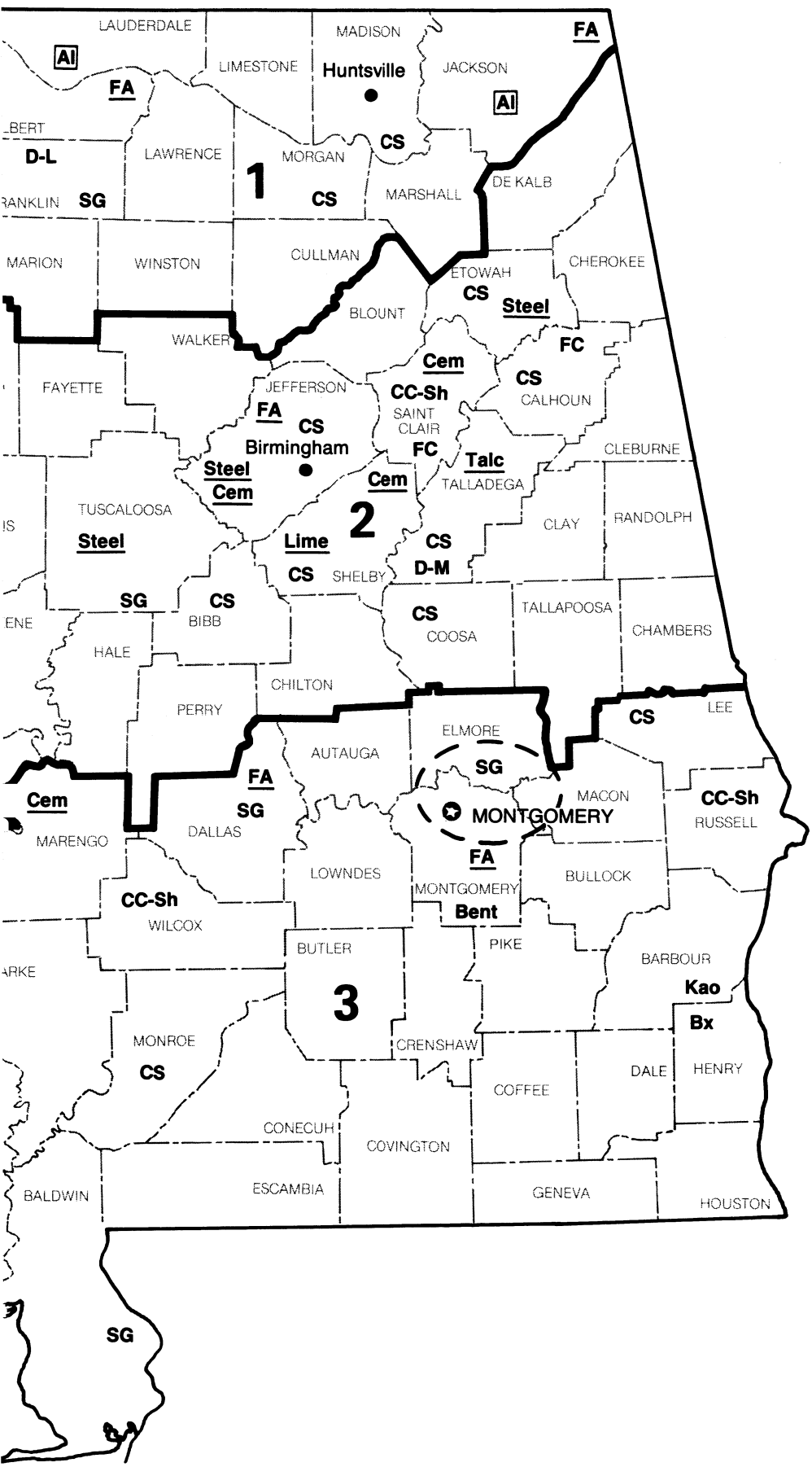
W Withheld to avoid disclosing company proprietary data; included with "Other."

[1] Includes acid water neutralization, agriculture, alkalies, aluminum and bauxite, animal and human food, basic oxygen steel, electric steel, mason's lime, open hearth steel, ore concentration, other chemical and industrial, other construction, other metallurgy, petroleum refining, road stabilization, sugar refining, tanning, and use indicated by symbol W.

ALABAMA



Principal Mineral-Producing Localities


LAUDERDALE
AI
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LIMESTONE
MADISON
Huntsville
JACKSON
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LBERT
D-L
LAWRENCE
MORGAN
CS
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CS
MARSHALL
DE KALB
RANKLIN
SG
MARION
WINSTON
CULLMAN
ETOWAH
CS
Steel
CHEROKEE
BLOUNT
WALKER
FC
Cem
CS
FAYETTE
JEFFERSON
CC-Sh
CALHOUN
FA
CS
SAINT
CLAIR
Birmingham
FC
Talc
CLEBURNE
Steel
Cem
Cem
TALLADEGA
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RANDOLPH
Lime
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LEE
ELMORE
AUTAUGA
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Cem
SG
MONTGOMERY
RUSSELL
MARENGO
DALLAS
FA
LOWNDES
MONTGOMERY
BULLOCK
CC-Sh
Bent
WILCOX
BUTLER
PIKE
BARBOUR
ARKE
Kao
3
Bx
MONROE
CRENSHAW
DALE
HENRY
CS
COFFEE
CONECUH
COVINGTON
BALDWIN
ESCAMBIA
GENEVA
HOUSTON
SG

estimates for 1987.

Alabama construction sand and gravel statistics are compiled by geo graphical districts as depicted in the centerfold map. Table 3 presents end-use data for the State's three districts.

Construction sand and gravel production in 1988 was 1.4 million short tons over the estimate for 1987. The increase was primarily due to the continued demand by the construction industry. In 1988, the industry was composed of 48 companies operating 67 pits in 25 counties. Leading producing counties were Clinton, Macon, and Montgomery. Principal end uses reported to the Bureau of Mines were concrete aggregate, asphaltic concrete, and fill.

Industrial.—Production increased 291,000 short tons over that reported by the industry in 1987. Foundries purchased most of the output for mold making.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on an

TABLE 3

ALABAMA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	4,123	$11,938	$2.90
Plaster and gunite sands	170	711	4.18
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	4.15
Asphaltic concrete aggregates and other bituminous mixtures	1,203	7,369	6.13
Road base and coverings	493	991	2.01
Fill	215	299	1.39
Snow and ice control	W	W	4.00
Railroad ballast	12	35	2.92
Other[1]	247	910	3.68
Unspecified:[2]			
Actual	4,249	16,412	3.86
Estimated	1,030	2,753	2.67
Total or average	**11,742**	**[3]41,417**	**3.53**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes roofing granules.
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data do not add to total shown because of independent rounding.

TABLE 4

ALABAMA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	996	2,232	726	2,962	2,631	7,703
Asphaltic concrete aggregates and road base and coverings[2]	352	1,974	145	362	1,413	6,323
Snow and ice control	W	W	—	—	—	—
Railroad ballast	—	—	—	—	12	35
Other miscellaneous[3]	2	11	42	131	143	520
Other unspecified[4]	14	40	1,063	3,286	4,202	15,839
Total[5]	**1,364**	**4,258**	**1,976**	**6,741**	**8,401**	**30,419**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for plaster and gunite sands.
[2] Includes sand and gravel for fill.
[3] Includes sand and gravel for roofing granules.
[4] Includes sand and gravel reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

nual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—In 1988, the estimated value of crushed stone was approximately 30% of Alabama's mineral value. The 1988 estimate, $140 million, was a $6 million decrease over the value reported by the State's stone producers in 1987. The State's stone producers mined and crushed a variety of stone types; these included chalk, chert, dolomite, granite, limestone, marble, and marl.

The last year for which complete data were reported for crushed stone was 1987. Limestone, including chalk and marl, was the leading stone type produced that year; 21 companies operated 21 quarries in 14 counties to produced more than 22 million tons of stone, approximately 74% of Alabama's total. Dolomite was produced by five companies operating five quarries in Calhoun, Jefferson, Madison, Shelby, and Talladega Counties. Output totaled almost 5 million tons, approximately 16% of the total rock crushed. Two companies operated two marble quarries in Talladega County and one firm, Rock Granite Inc., mined and crushed granite in Coosa County. Chert, which is not included in table 1, was mined for road-base use in several counties. Of the end uses reported for crushed stone, three leading categories were concrete aggregate (14%), cement manufacture (13%), and graded road base (9%).

E.C.C. America Inc., which acquired Sylacauga Calcium Products Division from Moretti-Harrah Marble Co. in 1986, purchased Cyprus Mineral Co.'s calcium carbonate mine and mill at Sylacauga in 1988. The purchase price, which included a mill in Georgia, was $73.4 million.[9]

Pfizer Inc. of New York announced plans to build a precipitated calcium carbonate plant in Selma to supply the International Paper Co.'s Hammermill plant. The facility was scheduled for completion in 1989.[10]

Hoover Inc., which opened a new quarry in Huntsville in 1987, applied for permits to open a quarry west of Decatur. Some of the stone would be transported by barge on the Tennessee River.

Vulcan Materials Co. continued development of its quarry in the Yucatan Peninsula of Mexico despite environmental protests. Shipments of crushed limestone at a rate of 65,000 short tons per week will begin in 1989 to gulf coast ports in Alabama, Florida, Louisiana, and Texas.[11]

Dimension.—Two firms, Alabama Limestone Co. Inc. in Franklin County and Lamb Stone Co. in Blount County, reported dimension stone production. Alabama Limestone produced rough blocks and cut and veneer stone from an oolitic zone in the Bangor Formation. The company operated one of two underground limestone quarries in the United States. Lamb operated a surface quarry to produce sandstone blocks and sawed and dressed stone and flagging. Production increased 7% over that reported by the two firms in 1987.

Sulfur (Recovered).—Alabama ranked 6th among the 26 sulfur-producing States. Five companies reported sulfur recovery from natural gas processing plants and/or petroleum refineries. Production totaled 372,000 metric tons valued at $33.6 million, an increase of 53,000 tons and $3 million over the 1987 output and sales.

In April, Mobil Oil began gas processing and sulfur recovery at its new facility in Mobile. The gas was piped to the plant from wells developed in Mobile Bay. Exxon Co. and Shell Offshore Inc. planned similar gas processing and sulfur recovery plants for the Mobile area.[12]

Talc.—Cyprus Minerals Co. began development work on the Winterboro Mine at Alpine in June 1987, and the mine reached full production in 1988. The thickness of overburden varied from 20 to 70 feet with the ore thickness ranging from 20 to 40 feet. This ore, in addition to ore obtained from Montana and Australia,[13] was ground at a plant adjacent to the mine. Sales were to the cosmetic and pharmaceutical industries.

Other Industrial Minerals.—Norton Co., in Huntsville, manufactured artificial abrasives at its facility in Madison County. The Company produced abrasive-grade, high-purity fused aluminum oxide and aluminum zirconium oxide. International Minerals & Chemical Corp. operated a fluosilicic acid plant at Florence. Tennessee Valley Authority and U.S.S. Agri-Chemical Inc. produced anhydrous ammonia at plants in north Alabama. W.R. Grace & Co. and Armstrong World Industries expanded perlite from ore shipped in from the western United States. W.R. Grace also exfoliated vermiculite at its plant in Irondale, near Birmingham.

Metals

In the 1800's, most of Alabama's mineral output was from metals, primarily iron and gold, with one copper mine in operation. Ore depletion and unfavorable economics depressed the State's extractive metals industry until, in 1988, only a small tonnage of iron ore and bauxite was mined. However, the State has maintained a primary metals industry using scrap and foreign ores for plant feed.

Aluminum.—Two companies, Revere Copper & Brass Inc. and Reynolds Metals Co., both with their smelter operations shut down, maintained facilities for sheet and plate manufacture.

Reynolds announced plans to invest $125 million in a new aluminum casting facility at its Listerhill alloys plant near Sheffield. Construction was scheduled for early 1989 with completion by late 1991. The new plant, which was to replace the existing casting facility, would cast aluminum ingots for Rey-

nolds' adjacent rolling mill, whose primary output was sheet products for beverage cans. Annual capacity was scheduled to increase from 800 million pounds to more than 1 billion pounds.[14]

Bauxite.—Alabama was one of three States reporting bauxite production. Two companies mined bauxite in Barbour and Henry Counties. Output increased almost 50% while value decreased only slightly. Most of the bauxite was calcined and sold to refractory products manufacturers.

Ferroalloys.—In 1988, Alabama ranked 4th among the 15 States with ferroalloy production. The State produced 105,000 short tons of ferroalloys valued at $109.8 million. Compared with 1987, production decreased by 13,500 short tons; however, value increased by more than $12 million. Both ferrosilicon and silicon metal were produced by four companies with plants in Montgomery County.

One of the companies, Ohio Ferro-Alloys Corp. (OFA), received approval of its financial reorganization plan from the U.S. Bankruptcy Court. The plan permitted the company to emerge from Chapter 11 protection after 2 years. The company's name change to SiMetco indicated its only product was silicon metal. OFA completed refurbishing work on a silicon metal furnace at the Montgomery plant. The furnace was one of three at the Montgomery facility.[15]

Iron Ore.—The Alabama Department of Industrial Relations reported that Pickett Machine & Welding (Pickett Mine) and North Star Materials Inc. (Rockwood Mine) recovered more than 60,000 short tons of iron ore fines in Franklin County.

Iron and Steel.—Gulf States Steel Corp. and USX Corp. operated the only integrated steel mills in the State. Minimills were operated by Birmingham Steel Corp., Commercial Metals Co., and SMI Steel Inc. Tuscaloosa Steel Corp. operated a platemill.

In June, Gulf States Steel in Gadsden broke ground for a new slab caster and began improvements on its blast furnace. The $55 million project was part of a 5-year, $165 million investment plan to upgrade the facility. When the $55 million expansion is completed, production is scheduled to increase from 72,000 short tons per month to approximately 90,000 tons.[16]

The Fairfield Works of USX resumed production late in 1988 following a shutdown of more than 2 years. The resumption in production followed the completion of a 10-year, $1 billion renovation and modernization program. The largest of the blast furnaces, rated at 5,000 short tons per day, was brought on-line followed by the startup of the renovated hot strip mill. The new continuous slab caster also went on line late in the year. USX announced a $15.3 million renovation of its six-stand cold reduction mill, scheduled for completion late in 1989. Citing unprofitability, USX closed its tin mill at mid-year. Fairfield Works had the capacity to produce 1 million tons of sheet and 640,000 tons of finished seamless pipe.

Other Metals.—Manganese and chromite were ground by Prince Mfg. Co. (Phenix City) for use in brick colorization. Kerr-McGee Chemical Corp. operated a synthetic rutile plant near Mobile with output shipped to its Hamilton, MS, plant for titanium dioxide pigments. Ilmenite from Australia was used as feed; nearly 180,000 short tons was imported through the Port of Mobile, up from 150,000 tons imported in 1987.

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[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL.

[2] Alabama Business. Who Owns What, Where. July 1988, pp. 30-31.

[3] Dean, Lewis S. (ed.). Minerals in Alabama, 1988. Geol. Surv. of AL, Information Series 64G, 1989.

[4] Port of Mobile. Increased Coal Movements Through Port of Mobile. Aug. 1988.

[5] The Birmingham News. Livingston Plant Trying Chemical Waste Fuel. Mar. 6, 1988.

[6] SOMED News. School of Mines and Energy Development, University of Alabama Tuscaloosa, AL. V. 8, No. 1, Spring 1987, pp. 1-2.

[7] The Denver Post. Ideal Basic to Crank Up Idled Plant. Jan. 13, 1988.

[8] Rock Products. Allied Products Will Close Plant; Will Buy From Ideal. Dec. 1988, p. 9.

[9] The Wall Street Journal. Cyprus Minerals To Sell Unit to British Firm. May 10, 1988.

[10] Birmingham Post-Herald. Pfizer Announces Plant Slated Next to International Paper. Oct. 7, 1988.

[11] Minneapolis Star Tribune. Quarrying Mexican Rock for U.S. Roads Raises Ecological Concerns. Dec. 15, 1988.

[12] Birmingham Post-Herald. Natural Gas From Alabama Coast Reaches Processing Plant. Apr. 15, 1988.

[13] Port of Mobile. Bulk Plant Handles Talc Movement. May 1988, pp. 10-11.

[14] Birmingham Post-Herald. Reynolds To Expand Facility. Oct. 25, 1988.

[15] American Metal Market. Ferrosilicon Demand Raises Prices. Feb. 23, 1988.

[16] Port of Mobile. Steel Industry and Alabama's Seaports Mean Big Business for Alabama. Aug. 1989, pp. 5-9.

TABLE 5

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum (smelters):			
Revere Copper & Brass Inc.	Box 191 Rome, NC 13440	Plant	Jackson.
Reynolds Metals Co.	Reynolds Metals Bldg. Richmond, VA 23218	do.	Colbert.
Bauxite:			
A. P. Green Refractories Co.,[1] a subsidiary of USG Corp.	Mexico, MO 65265	Mine and plant	Barbour.
Harbison-Walker Refractories Co. Inc.,[2] a division of Dresser Industries Inc.	Dale Rd. Route 1, Box 58 Eufaula, AL 36027	do.	Barbour and Henry.
Mullite Co. of America	901 East 8th Ave. King of Prussia, PA 19406	Mines	Do.
Cement:			
Allied Products Co.[3]	Box 36130 Birmingham, AL 35236	Plants	Jefferson and Shelby.
Blue Circle Inc.[4]	Box 182 Calera, AL 35040	Plant	Shelby.
Citadel Cement Corp.	2959 Paces Ferry Rd., Suite 7 Atlanta, GA 30339	do.	Marengo.
Ideal Basic Industries Inc.[4]	950 17th St. Box 8789 Denver, Co 80201	Plants	Mobile.
Lehigh Portland Cement Co.	Box 1882 718 Hamilton Mall Allentown, PA 18105	Plant	Jefferson.
National Cement Co. Inc.	Box 7348 Mountain Brook Station Birmingham, AL 35223	do.	St. Clair.
Clays:			
Bickerstaff Clay Products Co. Inc.	Box 517 Bessemer, AL 35020	Mines	Jefferson and Russell.
Blue Circle Inc.	Box 182 Calera, AL 35040	Mine	Shelby.
Jenkins Brick Co.	Box 91 Montgomery, AL 37101	Mines	Chilton, Elmore, Montgomery.
Livlite Corp.	Drawer V Livingston, AL 35470	Mine	Sumter.
Ferroalloys:			
Interlake Inc., Globe Metallurgical Div.	Box 348 Selma, AL 36701	Electric Furnace	Dallas.
International Minerals & Chemical Corp.,	Garner Rd. Bridgeport, AL 35740	do.	Jackson.
Ohio Ferro-Alloys Corp.	Box 68 Montgomery, AL 36057	do.	Montgomery.
Reynolds Metals Co.	Box 191 Sheffield, AL 35660	do.	Colbert.
Lime:			
Allied Products Co.	Box 268 Alabaster, AL 35007	Plant	Shelby.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Dravo Lime Co.	One Gateway Center Seventh Floor Pittsburgh, PA 15222	Plant	Shelby.
Pig iron:			
Gulf States Steel Corp.	174 South 26th St. Gadsden, AL 35901	Furnaces and mills.	Etowah and Jefferson.
USX Corp.	Box 599 Fairfield, AL 35064	do.	Jefferson.
Jim Walter Resources Inc.	330 1st Ave., North Birmingham, AL 35202	Furnaces	Do.
Salt:			
Olin Corp.	120 Long Ridge Rd. Stamford, CT 06904	Brine wells	Washington.
Sand and gravel:			
Holland and Woodward Co. Inc.	Box 19147 Decatur, AL 35601	Surface mine and plant.	Franklin.
R & S Materials Inc.	Box 3547 Montgomery, AL 36109	do.	Autauga, Elmore, Montgomery.
Southern Industries, Radcliff Materials	Box 2068 Mobile, AL 36601	do.	Mobile and Montgomery.
C.T. Thackston Sand & Gravel Inc.	Box 3211 Montgomery, AL 36109	do.	Montgomery.
Stone (1987):			
Allied Products Co.	Box 628 Alabaster, AL 35007	Quarries	Jefferson and Shelby.
Dolcito Quarry Co.	Box 6566 Birmingham, AL 35217	Quarry	Jefferson.
Ideal Basic Industries Inc.	950 17th St. Box 8789 Denver, CO 80201	do.	Monroe.
Southern Stone Co. Inc.[5]	Box C-200 Birmingham, AL 35283	Quarries	Jefferson, Lee, Shelby.
Vulcan Materials Co.[6]	Box 7324-A Birmingham, AL 35253	do.	Calhoun, Colbert, Etowah, Franklin, Jackson, Jefferson, Madison, Morgan, Shelby.
Talc:			
Cyprus Industrial Minerals Co.	Alpine, AL 35014	do.	Talladega.

[1] Also kaolin.
[2] Also kaolin and synthetic mullite.
[3] Also lime.
[4] Also clays and stone.
[5] Also sand and gravel.
[6] Also clays and sand and gravel.

THE MINERAL INDUSTRY OF ALASKA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of Interior, and the Division of Geological and Geophysical Surveys, Alaska Department of Natural Resources, for collecting information on all nonfuel minerals.

By Tom L. Pittman[1]

The value of nonfuel mineral production reported in Alaska in 1988 was $118.7 million; in 1987, the value was $141.4 million. Alaska ranked 40th in the value of nonfuel mineral production in 1987 and 1988. The decline in value was due to reduced construction sand and gravel production from that estimated for 1987, partially offset by increased gold output. The increased gold production was due to expanded operations at several of the larger placer mines and two hard-rock gold mines. About 208 mechanized placer mines and three lode gold mines operated in 1988. Construction at the Greens Creek silver-gold-zinc-lead mine approached completion and the 1,000-ton-per-day operation is scheduled to start in February 1989. The Red Dog zinc-lead-silver mine was scheduled to start production in early 1990; construction was about 60% completed at yearend.

The U.S. Bureau of Land Management (BLM) had prepared three draft environmental impact statements (EIS) and a final EIS for the four areas ordered in court actions. Mining was allowed on operations disturbing less than 5 acres, but larger placer mines were still closed under a court injunction. A 1985 suit against the National Park Service (NPS) stopped all mining in Alaska's National Parks and Preserves until NPS prepared the several EIS documents and issued individual mine operating plans. Court action mandating a change from the location system of mineral entry on State lands to a lease, rental, and royalty procedure posed a major problem to the legislature and unknown ramifications to holders of mining claims on State lands. The Environmental Protection Agency (EPA) issued guidelines to require 100% recycling of placer mine effluents in 1989. The Alaska Department of Environmental Conservation (DEC) adopted regulations establishing mixing zones for effluent discharges into receiving waters, which were to be tested in 1989 and adopted in 1990. The mixing zones may help industrial water users meet the State's stringent turbidity standards. There had been exemplary improvement by placer operators in meeting suspended solids regulations and progress in complying with the water turbidity standards.

TRENDS AND DEVELOPMENTS

There were 11,484 new mining claims filed in 1988, a significant increase over the 8,276 claims filed in 1987. Total active claims increased to 75,542 in 1988 from 68,348 in 1987, according to State records. Most of the new claims were for precious metals and over 90% of the exploration expenditures reported were for gold, silver, and platinum-group metals. The number of mechanized gold placer mines remained almost the same as in 1987, but the larger mines increased their proportion of total production. Eight placer mines and two lode mines produced 59% of the Statewide gold production listed in the State surveys.

Operation of the offshore bucketline dredge BIMA near Nome has caused a resurgence of interest in offshore mining for gold and platinum-group metals. The U.S. Minerals Management Service (MMS) scheduled a public hearing in Nome on the draft EIS for a proposed outer Continental Shelf mining lease sale in Norton Sound. The draft EIS was issued November 23, 1988, and covered some 178,000 acres offshore in the Sound. The sale was tentatively scheduled for late 1989.

The results of State surveys of the mining industry were published in Alaska's Mineral Industry, 1988—Special Report 43.[2] That report was produced and distributed by the Alaska Department of Natural Resources Division of Geologi-

TABLE 1

NONFUEL MINERAL PRODUCTION IN ALASKA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	$25	NA	$86	NA	$50
Gold (recoverable content of ores, etc.)	troy ounces	48,271	17,775	r122,548	r54,895	135,340	59,320
Sand and gravel (construction)	thousand short tons	27,762	61,954	e27,200	e73,400	17,200	48,749
Silver (recoverable content of ores, etc.)	troy ounces	W	W	r15,812	r111	20,589	135
Stone (crushed)	thousand short tons	e2,000	e8,500	2,033	8,945	e1,800	e8,400
Combined value of cement (portland), tin, and value indicated by symbol W		XX	3,226	XX	4,010	XX	2,040
Total		**XX**	**91,480**	**XX**	**141,447**	**XX**	**118,694**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

cal and Geophysical Surveys (DGGS) and Division of Mining (DOM), and by the Division of Business Development of the Department of Commerce and Economic Development. State surveys showed exploration expenditures in 1988 were $45.5 million, almost triple the expenditures in 1987. Southeastern Alaska was the most active region in the State, absorbing about 45% of the Statewide totals of exploration money and labor on gold and silver properties. There was increased precious metal exploration activity in the Nome area of the western region, and in the eastern interior, southwestern, and south-central regions.

An estimated $274.9 million was spent on development in 1988. Expenditures at the Greens Creek and Red Dog Mines totaled about $269 million for the construction of roads, ports, camps, mine developments, and various infrastructure facilities. State surveys estimated nonfuel mineral production at $187.5 million in 1988, an increase of about 17% over 1987 production. Gold and construction sand and gravel values increased moderately and the 1988 production value of crushed and broken stone was more than double the value produced in 1987.

ENVIRONMENTAL ISSUES

Lead-, zinc-, and copper-bearing ores and flotation concentrates had been shipped from mines in Canada to the Alaskan port at Skagway for marine transport to various smelters. The old railroad and the present highway run through the town to the port terminal. Skagway is in a very windy location and, over the years, concentrations of lead-sulfide-bearing dusts have accumulated adjacent to the railroad and the new highway route to the port. There was a very high concentration of lead in soils at the shipping terminal and in the marine sediments near the conveyor belt shiploading facility. Steps were taken by the current trucking and port operators to try to prevent additional contamination. Blood tests given to residents indicated that there was no immediate health threat from extensive lead-sulfide contamination. DEC said it would require cleanup of contaminated soil. There had been preliminary investigations of possible contamination by petroleum products, milling chemicals and reagents, and metal-bearing ores and dusts at several old mining sites. Notable among these sites were possible environmental contaminations at the old Red Devil mercury mine and retort plant and at the amalgamation and retorting facility formerly used by a dredging company near Nome.

Placer miners improved their water quality performance and reclamation activities over previous years. DEC inspected 158 active placer mining sites in 1988; 43 sites had no detectable water discharge and 153 met the Federal settleable solids standard (0.2 milliliter per liter). Turbidity measurements at 59 discharge sites fell within the range of 6–20 NTU (nephelometric turbidity units). Hydrogeologic studies by DGGS show lowered turbidity in Birch, Goldstream, and Faith Creeks. These streams were of particular concern to environmentalists. Inspections by DEC showed significant and continued improvements in downstream water quality in various placer districts. DEC also worked with the new heap-leach operators in developing practical and effective cyanidation regulations.

EPA issued guidelines for placer mining effluents that were to be included in 1989 water discharge permits. Included were 100% recycling of mining process waters, restrictions on hydraulic mining methods, and recommended use of certain so-called "best practice" mining methods. Mineral industry representatives did not agree with EPA's economic justification model. The U.S. Department of the Interior formally objected to parts of the EPA economic analysis, requesting that the gold content in troy ounces per cubic yard be lowered for the average placer deposit and that certain costs of the required reclamation and water recycling be included. The U.S. Army Corps of Engineers (Corps) began requiring permits for placer mines affecting wetlands under Section 404 of the Clean Water Act. Permits issued included requirements for stream reconstruction, settling pond design, land reclamation, and the location of mine infrastructure and roads.

EMPLOYMENT

The State surveys estimated that there were 4,231 people employed in the nonfuel mineral industry in 1988, a 32% increase over the 3,177 employed in 1987. Mineral development employed 1,294 and exploration, 280. Construction at the Greens Creek and Red Dog Mines and statewide exploration occupied over one-third of the total employees. In 1988, an estimated 2,657 persons were employed in the operation of nonfuel mines and quarries. Placer mining employed 1,206 persons; lode mining, 99 persons; sand and gravel operations, 752; stone quarries, 210; tin, jade, and soapstone mining, 40; and recreational mining enterprises, 350 persons.

Employees at lode gold operations generally work year round. Employees at gold placers, sand and gravel pits, stone quarries, and other operations usually work on a seasonal basis (an average of 5½ months per year). The State figures for lode mining largely represent year-round employment, but the other production sector figures represent a combination of seasonal and year-round employment. The figures for the mineral and exploration sectors have been converted from reported and estimated seasonal and year-round employment into full-time employment equivalents. General construction employment for mine roads and facilities was included in the development sector to estimate total employment in Alaska created by the mining industry.

EXPLORATION ACTIVITIES

Total reported expenditures for nonfuel exploration were $42.7 million in 1988, up from about $14.6 million in 1987, according to State surveys. Over 95% of the exploration effort was on precious metals. Over 75% of the exploration money was from Canadian companies and their U.S. subsidiaries or from funds raised through Canadian venture capital markets.

Of the $41.4 million spent on precious metal exploration, about $39.3 million was spent on lode deposits. Work in the southeastern region accounted for about $20.1 million of the lode exploration expenditures. About $5.9 million was expended in the eastern interior, $5.5 million in the south-central, and lesser amounts in each of the other regions. Lode exploration expenditures were greater than usual because of the driving of underground workings, several intensive drilling projects, and road building. Base metal exploration was reported to be $1.2 million, with $0.59 million in the northern, $0.44 million in the southeastern, and lesser amounts in the south-central and eastern interior regions.

Drilling totaled 794,750 feet on nonfuel mineral projects in Alaska in 1988, up from 295,300 feet in 1987. Placer drilling accounted for about 452,000 feet, 57% of the total, and a significant increase over the 1987 total of 180,000 feet. About 300,000 feet of placer drilling was at Alaska Gold Co.'s dredge thaw fields. Western Gold Exploration and Mining Co. (WestGold) drilled over 98,000 feet on its offshore placer leases near Nome. Giant Bay drilled over 7,000 feet, exploring its offshore State leases in Norton Sound. Valdez Creek Mining Co. drilled over 36,000 feet of exploratory holes at its opencut placer operation east of Cantwell. Hard-rock drilling reported in 1989 was 342,750 feet, more than double the 115,100 feet reported in 1987. The State survey determined there were 33 major drilling programs on hard-rock properties and 3 on placer properties. Only two companies reported drilling on base metal deposits. The total footages of diamond drilling and rotary drilling were almost equal, a first for rotary drilling in Alaska. In 1989, 27 companies conducted major drilling programs, up from 16 companies in 1987.

LEGISLATION AND GOVERNMENT PROGRAMS

The U.S. Supreme Court refused to hear the State of Alaska's appeal from the decision of the Alaska Supreme Court ruling requiring a change from the current location system of mineral entry on State lands to a lease, rental, and royalty system. The State court ruling resulted from its interpretation of Section 6(i) in the statehood act when considering a suit brought against the State. The 1989 legislature was to formulate and pass legislation that would satisfy the court ruling. The ramifications to current and future claims and lease holders on State lands were largely unknown. Although reclamation was covered by State and Federal laws and regulations, some proponents of the new mineral entry system for State lands believed reclamation provisions should also be included in the enabling legislation. The new mixing zone water quality regulations adopted by DEC may help miners and other industrial water users meet the State's turbidity and other water standards. The regulations and guidelines were to be tested in 1989 and enforced in 1990. The placer mining effluent guidelines issued by the EPA on May 24, 1988, have been discussed in the section on Environmental Issues.

Four bills of interest to the mineral industry, passed by the 1988 session of the State legislature, were signed by the Governor to become Chapters of the Session Laws of Alaska (Ch., SLA). More than 21 bills of interest were introduced into this first session of the 16th Legislature. Bills not passed in that session were to remain for consideration in the second session in 1989. The State Mineral Policy Act (Ch. 138, SLA 88) stipulated that equitable consideration be given to mineral exploration and development in multiple-use management of State lands. Marketing had to be considered in developing infrastructure and transportation systems. There were also other provisions. The effectiveness of the act would depend on the regulations to implement it and its administration. The Workman's Compensation Act (Ch. 79, SLA 88) guaranteed a nominal reduction in rates charged to the employer and should slow the rate of premium increases in high-risk industries. Creation of the Minto Flats Game Reserve (Ch. 18, SLA 88) withdrew 507,136 acres of land from mineral entry and strictly regulated activities on valid inholdings. The System of Recreational Rivers (Ch. 122, SLA 88) withdrew land along rivers yet to be named and placed restrictions on valid inholdings. Activities on valid mining claims were to be strictly regulated by management plans to be prepared by fish and game and recreational agencies.

In 1987, BLM lost an action brought by the Sierra Club in the U.S. District Court for Alaska resulting in an injunction that prohibited BLM from permitting any mining operations that would disturb more than 5 acres in the Beaver Creek, Birch Creek, Chatanika River, and Fortymile River drainages. The agency was to prepare a cumulative EIS for each of the areas and satisfy the court before reopening the areas to large-scale mining. One final EIS and three draft EIS documents were completed in 1988. A final EIS was to go to the Secretary of the Interior for a record of decision.

NPS had halted all mining in Alaska's National Parks and Preserves under an injunction resulting from an adverse court action but had not prepared any of

the required EIS documents in 1988. The Corps began requiring permits from placer mining operations that would impact wetlands and that needed either individual or standard nationwide permits. These permits were issued under the authority of Section 404 of the Clean Water Act. MMS completed the draft EIS for its proposed offshore lease sale. The resulting preferred alternative identified 178,282 acres of Federal land in Norton Sound near Nome, and contiguous to State leases being mined by West-Gold's dredge BIMA. The lease sale was scheduled for January 1990. The EIS suggested surveys be made to find out if mercury levels in local residents required attention. These people consumed large amounts of seafood that was relatively high in mercury because of widespread, naturally occurring mercury sulfide (cinnabar) in the Nome area.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Gold.—Gold production reported to the U.S. Bureau of Mines in 1988 was 135,340 troy ounces valued at $59.3 million. This production was reported by 14 placer and 2 lode operators and was probably about 50% of the 1988 production. State surveys estimated gold production at about 265,000 troy ounces valued at $112.8 million, up from 229,700 troy ounces valued at $104.5 million in 1987.

In 1988, State production surveys were based "on data compiled from 229 questionnaires returned by mining companies, municipalities, and individuals; responses to a telephone survey of 35 companies and Government agencies that mine or lease sand, gravel, and stone deposits; Alaska DOM field notes on 1988 placer mining operations; and information provided by the U.S. Bureau of Mines, University of Alaska, Alaska Department of Transportation and Public Facilities (DOTPF), and precious metal refiners," according to Special Report 43.[2] About 59% of the gold production was produced by 10 operations. The eight placer operations were Alaska Gold Co., Anvil Mining Inc., GHD Resources Partners Ltd., Polar Mining Inc., Sphinx America Inc., Valdez Creek Mining Co., Western Gold Exploration and Mining Co., and Windfall Gold Mining Co. They produced 142,940 ounces of gold. Two lode operations produced 13,515 ounces of gold from 21,500 ounces of dore bullion. They were Citygold Alaska Inc. and Tricon Mining Inc.

The western region produced about 37% of the gold from an estimated 48 placer operators, compared to 44% of the statewide gold from 46 operators in 1987. Alaska Gold Co. operated its No. 5 dredge on the upland 3rd Beach deposit northeast of Nome and No. 6 dredge on the so-called Submarine Beach about 1½ miles west of the Nome airport. The two 9-cubic-foot bucketline dredges processed about 1.6 million cubic yards of gravels during the 1988 season and operated at 80% to 85% efficiency in 1988, according to the State survey. In 1987, Alaska Gold started winter-mechanized stripping of frozen overburden ahead of the dredges and used cold-water thawing to loosen the pay gravels. This was to cut down on the necessity for the dredges to mine and process overburden.

Windfall Gold Mining Corp. continued opencut placer mining at Cooper Gulch on the 3rd Beach deposit, east of Dredge No. 5. Windfall mined about 910,000 cubic yards of gravel in 1988, using hauling scrapers, loaders, and sluice boxes. Reserves in the Copper Gulch area were nearly depleted and the company is looking for other ground to work in the future. Windfall reclaimed about 30 acres of mined ground, contoured it, and reseeded it. A large-scale opencut placer was operated by Anvil Mining Co. about 2 miles east of Windfalls's mine, on Anvil Mountain.

The largest operation in the western region was the Western Gold Exploration and Mining Co. offshore dredge BIMA, working State leases in Norton Sound near Nome. This 33-cubic-foot bucketline dredge mined 2.9 million cubic yards of pay material in the season running from June 10 to November 14, 1988. It was the largest gold producer in the Western region and ranked second in Alaska. The production season required 108 people, 40 of whom were employed for maintenance and exploration work during the winter.

GHD Resources Partners Ltd. mined in the Kiwalik River drainages with Berg-Wetlesen Co. and AU Mining Co. Engstrom Dredging Co. ran a 1½-cubic-foot dredge on Basin Creek and N.B. Tweet and Sons operated a 2-cubic-foot dredge on the Kougarok River. Several other fairly large-scale placers and many smaller mines operated on the Seward Peninsula and in the Kaiyuh Hills, Ruby, Ruby-Poorman, Tolstoi, and other areas of the Western region.

Exploration activity was widespread in the western region. Reported expenditures were $3.9 million, up from $1.2 million in 1987. Placer Dome U.S. Inc. continued large-scale work in the Rock Creek and Anvil Creek areas north of Nome on ground held by Nome Gold J.V. The major drilling program used rotary and diamond drills. Other work included geochemical and geophysical surveys, mapping, and trenching on an extensive quartz vein lode system.

BHP-Utah International explored a 14,000-acre lease on the Nome plain, but dropped the lease in the fall. Solomon Gold Corp. headed a joint venture that drilled 12,200 feet of core in 91 holes at the Big Hurrah Mine. It announced potential open pit reserves of 436,000 short tons grading 0.28 ounce gold per ton, diluted. The stripping ratio would be 8:1 waste to ore. Battle Mountain Exploration Co. examined, drilled, and carried out other activities at Nixon Fork and near McGrath. Giant Bay Resources drilled 190 holes from atop winter ice to depths of 30 to 50 feet into bottom sediments on its State offshore leases near Nome.

Placer development expenditures reported to the State by five operators in the western region were about $5.3 million, over 91% of the State's total.

The eastern interior region reported 89 producers that accounted for about 29% of statewide production. The State reported 24 mechanized sluicing plants and 11 development projects working in the Circle area. The largest producers were GHD on Eagle Creek, Helen Warner Mining on Porcupine Creek, Greenhorn Mining on Crooked Creek, and Paul and Company on Deadwood Creek. Alaska Placer Development Inc. was the main producer in the Livengood-Tolovana area. This operation used hydraulic methods for stripping overburden and mining and recycled all of the water used. Underground drift mining was stopped by Mammoth Mines on Wilbur Creek in 1988. There were nine active placers reported in the Fortymile area. Most of the operations were small mechanized mines and floating suction dredges. This area suffered from closures due to Federal agency management problems. Several operations in the Eureka-Tofty and the Rampart districts were hindered or closed by the summer drought, water recycling improvement, or reclamation requirements. Shoreham Resources, a subsidiary of GHD, was preparing a large-scale opencut placer on the Sullivan Bench-Tofty area, to produce gold and some tin in 1989.

There were 22 placer and 3 lode mines in the Fairbanks area; of the 214 employees, 127 were at placers and 87 worked at lode mines. Polar Mining Inc., on Sheep Creek and Sphinx America Inc., near the junction of Fish and Fairbanks Creeks, were the largest operators in the eastern interior region and the Fairbanks area. They processed 1.3 million cubic yards of placer gravel. Each stripped overburden in the winter, using D–10 tractors with rippers, some drilling and blasting, and backhoes. Both companies operated on patented claims owned by Alaska Gold Co. The other operators mined on about 13 other creeks.

The Grant Mine, on Ester Dome, was operated all year by Tricon Mining Inc., a subsidiary of Silverado Mines (U.S.) Inc. Most of the mill feed came from the Elmes vein and from the Ethel and Silver Dollar shear zones. Some ore was custom-milled for mines in the Cleary Hill and Tenderfoot Creek areas, and a small test lot from Democrat Creek was milled for Tri-Valley Mining Co. The mill contained gravity concentration and batch-leach cyanidation circuits. Citigold Alaska Inc. recovered gold and silver from two heap leach pads at the Ryan Lode Mine on Ester Dome. Almost one-half of the gold and silver produced was recovered from the 1987 pad, and the balance from the 100,000 tons of ore crushed and agglomerated and placed on the 1988 pad. The Moore and Voytilla heap leach experiment at the Adler vein deposit was abandoned as a technical success but not an economic one.

There was limited placer activity in the Tenderfoot area. The Bonnifield district hosted 17 placer operations in 1988. Various operators mined on California, Gold King, Iron, Saint George, and Tatlanika Creeks, and the Tatlanika River.

Exploration expenditures increased about 90% in the region in 1988 to $6.3 million. The State reported more than 3,000 mining claims filed in the Fairbanks recording district from July through October, compared with 627 in the same period in 1987. Most of the claims were filed on gold lode prospects. Fairbanks Gold Ltd. drilled at the Fort Knox property near Gilmore Dome and reported the potential for a deposit containing 15 million tons averaging about 0.06 ounce gold per ton, using a 0.02 ounce per ton cutoff. The deposit is in a granodioritic intrusive, unusual in the Fairbanks area. WGM Inc. was the project operator.

BP Minerals America Inc. conducted drilling and other exploration activities at the Cleary Summit property of Fairbanks Exploration Inc., but withdrew from the joint venture at the end of the season. Nerco Exploration Co., which completed an exploration drilling and trenching project at the Liberty Bell Mine, was reported to have outlined an important arsenical gold-silver lode deposit. Nerco also did exploration work at the Monzulla-Gil properties near Fairbanks, and at other localities, in partnerships with Cominco Alaska Exploration and Western Mining Corp. of Australia. Placer Dome, American Copper and Nickel Co. Inc., and many lesser companies explored lode and placer prospects on Federal, State, Native, and private lands.

An estimated 26% of the State's 1988 gold production came from the southcentral region. About 68,300 ounces of gold from about 30 mechanized placers employing 315 people was reported. Valdez Creek Mining Co. produced 44,494 ounces of gold from its all-year opencut placer operation about 50 miles east of Cantwell. It was the largest gold producer in the State, as it was in 1987. Valdez Creek Mining Co. was owned by Camindex Mines Ltd., Cambior Mines Ltd., and American Barrick Corp.; all were Canadian companies. In 1988, about 370,780 cubic yards of the 20-foot-thick pay streak was sluiced, and about 6.5 million cubic yards of overburden was stripped and discarded, according to State reports. The average recovery from the material sluiced was 0.12 ounce of gold per cubic yard. The stripping ratio exceeds 20:1. Since starting in 1984, this operation had mined two newly discovered paleo channels and the old, deeply buried Tammany channel of Valdez Creek that was originally worked by opencuts and drift mining.

Chesna Gold Co. (Chesna) leased ground formerly worked by Ranchers Exploration Co. on Slate Creek in the Chistochina district. Chesna mined for a short time late in the season but spent most of the season testing tailings and exploring new ground. Gold Dust Mines, formerly in the Fairbanks area, mined and used its IHC jig recovery unit nearby on the Chisana Discovery

Claim, but lacked economic reserves at the end of the season. TC Mining and many small-scale placers worked in the Cache Creek district west of Talkeetna, on 10 or more other creeks, on the Chunilna and Kahiltna Rivers, and on the Kenai Peninsula. The Mrak Placer Mine continued its longtime operation in the Hatcher Pass mining district North of Palmer. The State reported that the Hardrock Mining Co. mined 2,000 tons of telluride gold-silver ore, averaging 0.85 ounce of gold per ton, from the Independence Mine near Hatcher Pass.

Exploration expenditures in the south-central region were over $9 million, more than double the level of 1987. Cominco Alaska Exploration explored its Mount Estelle gold prospect near Rainy Pass by diamond drilling and other methods. Platinova Resources Ltd. had an interest in this property. Exploration at the Golden Zone Mine included diamond drilling, some closely spaced reverse circulation drilling, and the driving of a 1,600-foot crosscut. Golden Zone Resources Inc. announced reserves of 208,500 ounces of gold, in 1.1 million tons of ore containing 0.179 ounce of gold per ton. The State reported that United Pacific Gold Ltd., a joint venturer during most of 1988, had dropped out of the project. The Johnson River gold-zinc-copper-lead prospect was leased from the Cook Inlet Regional Corp., and diamond drilling was managed by Hunt Ware and Proffet for the lease holder. WGM continued rehabilitation of workings, dewatering, and sampling at the old Cliff Mine for the Hayes Resources-Dasher Resources Joint Venture, west of Valdez. Several other companies and individuals explored lode and placer deposits in the region.

In the southwestern region, 33 placer mines employed 108 people and produced 14,800 ounces of gold, about two-thirds of the region's 1987 production. Tuluksak Dredging Co. was denied a permit to continue operating its bucketline dredge on Bear Creek, above Nyac. Cumulative effects on the environment of mining subsequent to the early 1950's were to be studied prior to project approval by BLM. The company continued operating its opencut placer mine on California Creek and increased the capacity of its hydroelectric power plant from 450 kilowatts to about 750 kilowatts. Lyman Resources in Alaska Inc. continued mining at Quartz Gulch and also leased ground from Calista Corp. Misco-Walsh Mining Co. continued mining the Golden Horn residual placer and producing tungsten and gold. The Fullerton Brothers continued mining on Flat Creek. Other placer operators mined and explored on various creeks in the Aniak, Iditarod, Innoko, and Marshall districts and furnished badly needed employment for local Natives and other people.

Exploration expenditures in the region, reported at $2.63 million, were about four times the amount reported in 1987. Small to moderate exploration projects for placer and lode gold deposits ranged from efforts by placer miners to extend placer reserves and find lode sources of their gold to modest drilling and other programs by major companies. Battle Mountain Exploration Co. examined gold prospects near the George River and performed other regional work. Fairbanks Gold Ltd. explored Doyon Ltd. lands near Flat. American Copper and Nickel Co. worked at mapping, geochemical, and geophysical surveys on Doyon land in the Stone Mountains and on Doyon and State claims in the Candle Hills, north and south of McGrath. A gold and tin prospect in the Taylor Mountain quadrangle was drilled by the partnership of Cominco American Exploration Co. and American Ultramer Ltd. WestGold explored gold prospects on Calista Corp. lands near Donlin Creek and located gold-silver claims in the Gaines-Yankee Creek area southwest of McGrath.

Gold production in the northern region was estimated at 6,500 ounces in 1988, down from 7,260 ounces in 1987. Lack of water in the Koyukuk-Nolan area, near Wiseman, caused problems for placer miners not prepared to recycle water effectively. Mines were active on the Hammond River and its South Fork, and on Bear, Boulder, Eagle, Emma, and Nolan Creeks. Paradise Valley Mining Co. ran a mechanized placer and also a handmining venture for tourists. The State reported the economic value of the tourist venture exceeded the gross value from the mechanized mine.

In the Chandalar district, Tobin Creek Mining Co. worked placer on Tobin Creek and Little Squaw Gold Mining Co. reported some sampling and trenching on its lode claims. Alminco Inc. explored its Eldorado claims and BTW Mining and Exploration Corp. sampled and mapped other deposits.

The southeastern and Alaska Peninsula regions had an estimated gold production of only 850 ounces in 1988, down from 3,400 ounces in 1987. The Big Nugget placer mine in the Porcupine mining district and several recreational miners recovered gold from Porcupine, McKinley, and Nugget Creeks, northwest of Haines. Charter Resources Inc. mined beach placer sands at Icy Bay, using a backhoe and an elevated sluice. Icy Bay is east of Cape Yakataga. The Cusac Ltd. beach placer at Cape Yakataga was idle in 1988.

Southeastern region exploration expenditures were $20.64 million, up from $5.85 million in 1987, and over 45% of the reported exploration funds in the State. Echo Bay Exploration Inc., as operator, continued an extensive exploration program at the Alaska Juneau Mine. Echo Bay held an 85% interest in the project and WGM held a 15% carried interest. According to a State report, 1988 work included about 50,000 feet of diamond drilling, 2,700 feet of underground decline and crosscuts, rehabilitating 18,000 feet of old underground workings, cutting 9,000 feet of channel samples, mining 500 tons of ore for metallurgical testing,

geotechnical and mine openings design work, and testing blasting and cratering techniques.

The general mining plan envisaged an underground mine and underground gravity and flotation mill with surface facilities and concentrate cyanide plant at the portal of an 11,000-foot, 20 by 20-foot access adit situated about ½ mile south of Juneau. All mill tailings would be pumped to an impound area behind a dam in Sheep Creek Canyon. The project would cost about $180 million and produce about 250,000 ounces of gold yearly when operating at 22,500 tons of ore milled per day. Power would be supplied by a 4.5-megawatt hydroelectric plant near the mouth of Sheep Creek, a standby diesel-electric installation, and purchases from the local power company.

The old Kensington gold mine, about 50 miles north of Juneau, was being developed by an Echo Bay-Coeur Alaska Inc. joint venture, with Echo Bay as operator. Coeur Alaska is a subsidiary of Coeur d'Alene Mines Inc. Using Southcoast Constructors as contractors, a 2½-mile road was built from Comet, on Lynn Canal, to camp and portal sites. A 5,200-foot adit was driven at an elevation of 800 feet that intersected the Kensington vein about 1,200 feet below the old adit level and 600 feet below the deepest prior drill information. The Kensington vein was 70 feet wide as apparently minable ore; all assays had not been received by yearend. Drifting, drilling, and other exploratory work was to continue in 1989, and a 250-ton sample of ore from the drifts was to be shipped to eastern Canada for metallurgical testing. A company news release announced that previously calculated probable reserves contained just over 1 million ounces of gold from the surface down to an elevation of 1,450 feet. The average grade was 0.142 ounce of gold per ton, using a cutoff of 0.05 ounce per ton, in a 60-foot-wide steeply dipping structure.

Curator American Inc., a subsidiary of International Curator Resources Ltd., had been exploring the Jualin Mine, a former gold producer south of the Kensington Mine that was owned by Hyak Mining Co. of Juneau. Granges Exploration had entered the project on a buy in basis. Curator built a 5½-mile road from Berners Bay to the property and drilled about 12,500 feet of core holes at Jualin, increasing the core hole footage to 30,000 feet. The company listed proven reserves of 238,000 tons averaging 0.309 ounce gold per ton and probable and possible reserves at 1.04 million tons averaging 0.30 ounce gold per ton. An 800-foot decline and additional surface and underground drilling were planned for 1989. The Big Lake vein, a new target area, was discovered about 1 mile southeast of and parallel to the Jualin vein. Chip samples along about 1,200 feet of an estimated 3,000 feet of strike averaged 0.445 ounce gold per ton.

Curator completed a preliminary evaluation of the Dream massive sulfide prospect about 15 miles south of Haines and west of Lynn Canal. The mapping and reconnaissance work identified three distinct zones of mineralization in similar stratigraphic positions over a strike length of 3 miles: the gold-cobalt Discovery Zone, the copper-enriched CP Zone, and the zinc-lead EUX-125 Zone, according to a company announcement. This prospect, discovered by a Bureau geologist during work on the Juneau Gold Belt project, was the subject of a public announcement. Assays of rock chip samples were very encouraging, and more detailed exploratory work and some drilling were scheduled for 1989. Curator did preliminary exploration work on the Clark claim group east of Juneau and planned a drilling program in 1989.

Golden Sitka Resources Inc. abandoned its lease of the Hirst-Chichagof Mine after an underground drilling program failed to find a downward extension of the Kay ore shoot below the lower level of the old workings. The company was reopening old underground mine workings at the Chichagof Mine and extending drifts on vein structures when the camp facilities were destroyed by fire. The project was shut down because of impending winter weather. These properties were about 40 miles north of Sitka, on the west coast of Chichagof Island.

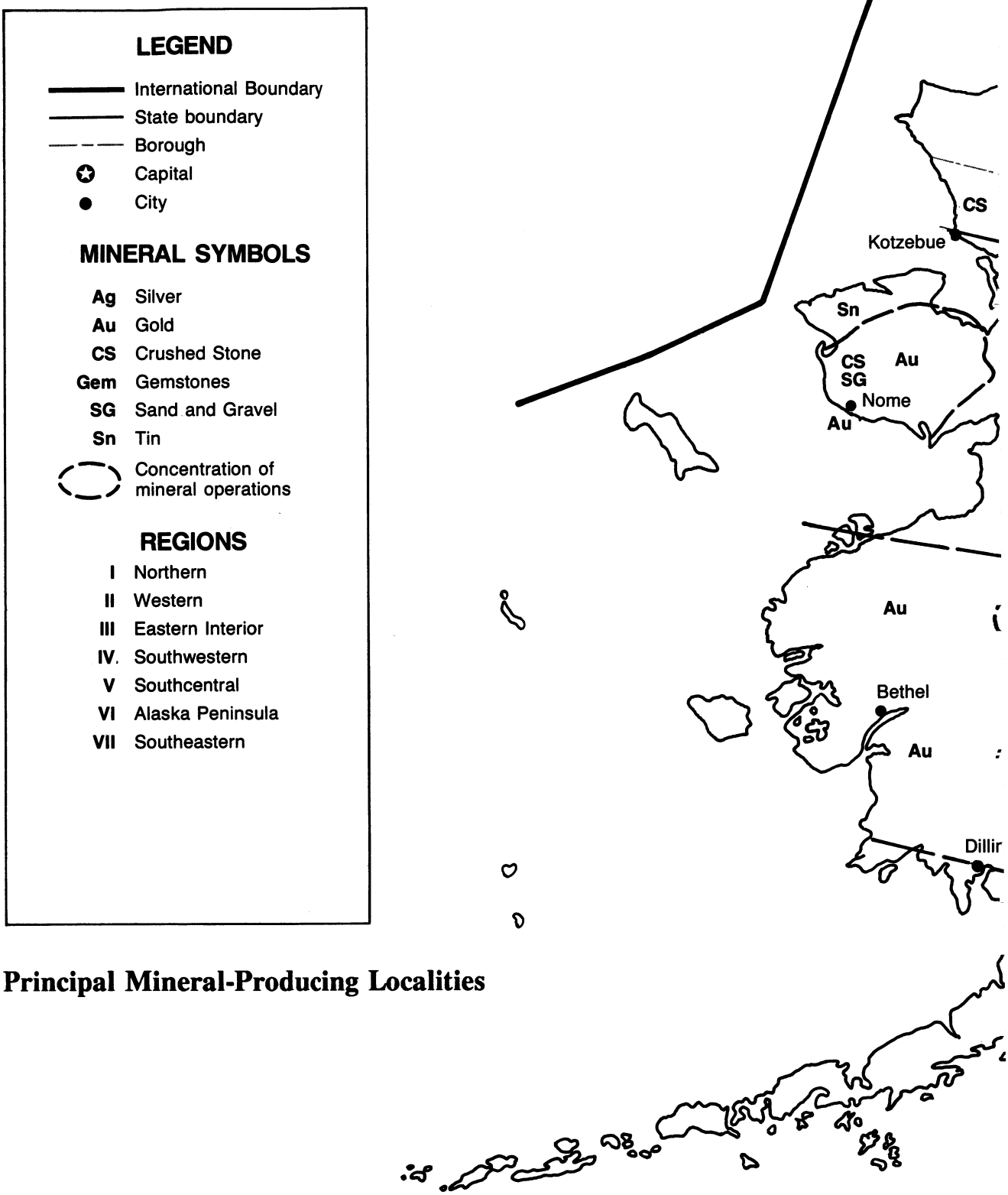
Lac Minerals (USA) Inc. continued exploration of the Niblack and Ruby Tuesday gold-silver-base-metal massive sulfide deposits on Prince of Wales Island. It prepared drill sites and did other work at the Kaigani deposit on Dall Island. Lac was operator on the claims held jointly with Noranda Exploration Inc.

Orbex Metals Ltd. and American Platinum Inc. continued basic exploration at the Salt Chuck and the Rush and Brown properties to delineate gold, copper, and platinum-group metals. Other exploration projects were conducted in the southeast region by BP Minerals, Cominco Alaska Exploration, FMC Gold Co., Nerco Exploration Co., Newmont Exploration Ltd., WGM Inc., and several other companies and individuals.

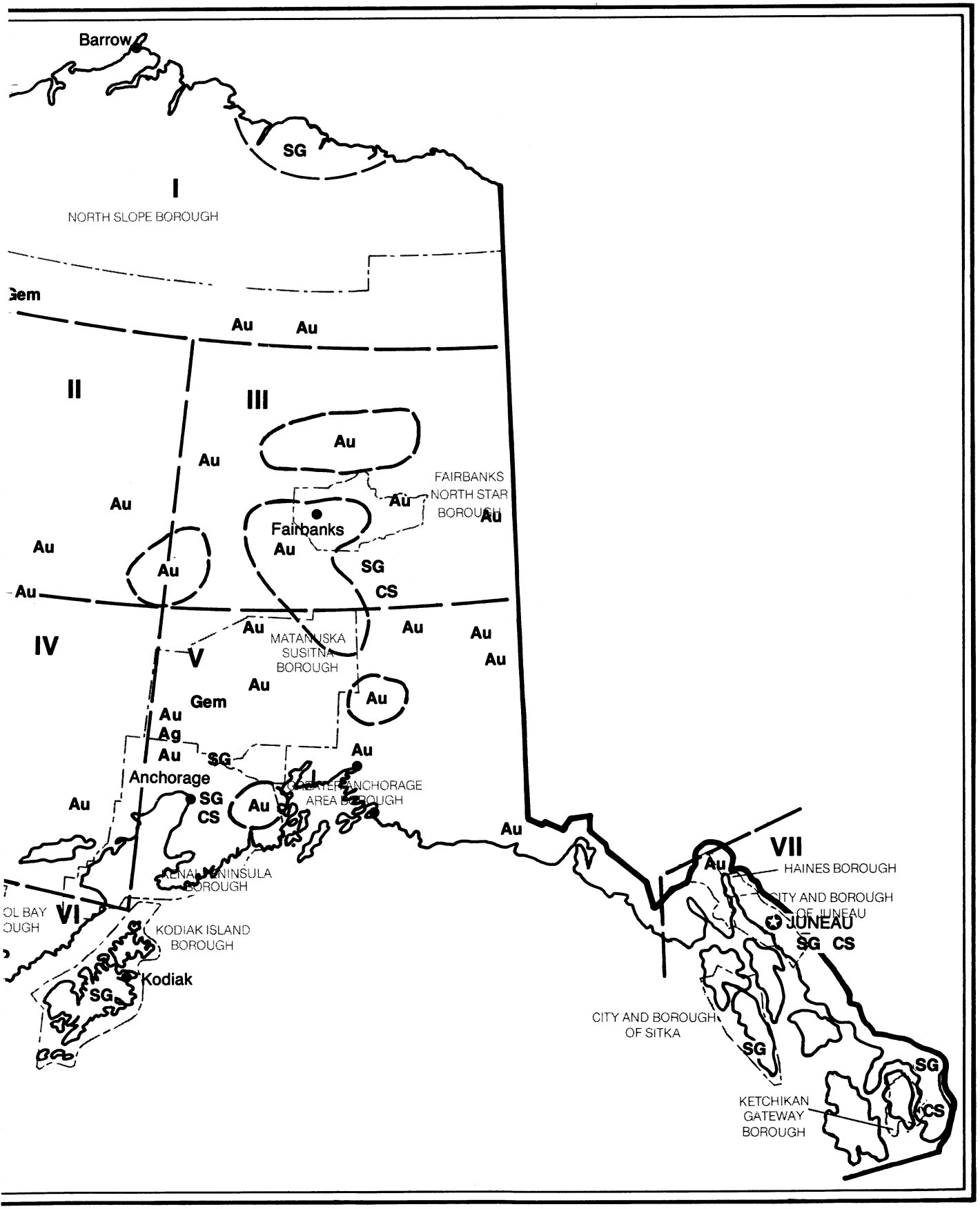
In the Alaska Peninsula region, Alaska Apollo Gold Mines Ltd. constructed a new camp and improved the road at the Apollo and Sitka Mines and to the Shumagin prospect. The company reported reserves of about 278,200 tons averaging 0.524 ounce gold and 2.47 ounces silver per ton at the Shumagin prospect. Battle Mountain Exploration Co. explored for precious metals on Aleut Native Corp. lands in the Cold Bay, False Pass, Port Moller, and Stepovak Bay Quadrangles, according to the State survey. Bristol Bay Native Corp. looked for precious metals on some of its lands.

Silver.—Silver production reported to the U.S. Bureau of Mines in 1988 was 20,589 troy ounces valued at $135,000, an increase from 15,812 ounces reported in 1987. State surveys reported 1988 production at 47,790 ounces, down from 54,300 ounces of silver recovered in 1987.

ALASKA



Principal Mineral-Producing Localities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SUSITNA
BOROUGH
Au
Au
Au
Au
Au
Gem
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Ag
Au
SG
Au
Anchorage
SG
CS
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VII
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HAINES BOROUGH
JUNEAU
SG CS
VI
KODIAK ISLAND
BOROUGH
Kodiak
SG
CITY AND BOROUGH
OF SITKA
SG
SG
KETCHIKAN
GATEWAY
BOROUGH
CS

All of the silver produced was recovered as a coproduct from placer and lode gold mining.

The Greens Creek Mining Co. continued its mine, mill, and plant construction program and was scheduled to start production at the rate of 1,000 tons of ore per day early in February, 1989. Annual output was expected to be 6.4 million ounces of silver, 36,000 ounces of gold, 24,800 tons of zinc, and 9,000 tons of lead contained in about 85,000 tons of zinc and lead flotation concentrates and a gravity gold product. Concentrates were scheduled to be shipped by ocean freight to European and Asiatic smelters. Concentrates were to be trucked to the company's port at Hawk Inlet. Announced reserves were 3.5 million tons of ore averaging 23.8 ounces of silver and 0.18 ounce of gold per ton, 9.7% zinc, and 3.9% lead. Favorable geology indicates additional reserves may be developed. Trackless haulage and mining equipment were to operate through a 6,000-foot-long haulage adit and interior ramps were to provide access to stoping areas. Drift-and-fill mining was developed as the usual production method, with cut-and-fill mining in steeper sections of the vein system. Stopes were to be backfilled with deslimed and filtered mill tailings emplaced by slinger trucks.

Work in 1988 brought the total amount of underground workings up to 17,000 linear feet, and added extensive diamond drilling and test stoping to refine mine development. The roads from the Youngs Bay ferry landing to Hawk Inlet and from Hawk Inlet to the mine were improved, and concentrate and supply storage and handling facilities at Hawk Inlet were completed. The mill, equipment shop, change-room and mine offices, and a 6.6-megawatt diesel electric-generating plant were constructed at the mine. The operating crew of about 230 people were to commute from Auke Bay, north of Juneau, by company ferry to Youngs Bay on Admiralty Island, thence by company crew buses about 13 miles to the mine and mill. Startup cost estimates were increased from an original $79 million to $112.6 million. Greens Creek Mining Co. is owned by BP Minerals America (53.1% and operator), Hecla Mining Co. (28%), CSX Oil and Gas Corp. (12.6%), and Exalas Resources Corp. (6.3%). In December 1988, it was announced that BP Minerals was considering selling its mineral interests in the United States and most of its worldwide mineral holdings to RTZ Corp., one of the world's largest mining companies.

Tin.—State surveys reported tin production in 1988 was 300,000 pounds, valued at $950,000, up from 288,000 pounds valued at $460,000 in 1987. The recorded production was by Lost River Mining from its Cape Creek placer mine on the Seward Peninsula. About 200 tons of cassiterite concentrates were shipped to Asiatic smelters and the resulting tin "shakes" were then marketed on consignment to American and European buyers. The mine faced closure if new reserves were not identified and developed.

Shoreham Resources was exploring placer property near Tofty and planned to produce gold and a coproduct tin concentrate in 1989. Cominco Alaska Exploration and American Ultramar Ltd. core-drilled a tin and precious metal prospect in the Taylor Mountain quadrangle.

Exploration on several promising lode tin deposits was not expected to resume until there was a substantial and sustained increase in the price of tin.

Zinc and Lead.—Construction at the Red Dog open pit mining and milling project, about 90 miles north of Kotzebue, was reported to be about 60% completed at the end of 1988. When completed in 1990, the operation was scheduled to mine and mill about 6,000 tons of ore per day and produce about 580,000 tons of zinc concentrate, 120,000 tons of lead concentrate, and 50,000 tons of zinc-lead concentrate that would be suitable feed for an Imperial type smelter. Published open pit reserves were 85 million tons averaging 17.1% zinc, 5% lead, and 2.4 ounces silver per ton. The property was owned by Alaska Natives as the NANA Regional Corp. and was to be equipped and operated by Cominco Alaska Inc.

The 52-mile road from the port on the Chukchi Sea to the mine was completed. The road was 30 feet wide and had passing turnouts, each 300 feet long, every 2 miles. At the port site, four large double-walled fuel tanks were installed, foundation work was completed for the very large concentrate storage building, and steel erection was started. A support cell for the 1,500-foot offshore concentrate conveyor was completed and another cell was being built. A construction camp was moved from the port to the mine in January and made operational. At the mine, Green Construction Co. started construction of a diversion dam and the tailings dam. The initial 65-foot lift on the tailings dam was completed. The accommodations building was prefabricated as 300 modules in Boise, Idaho, and constructed onsite as a single building by Pacific Construction Inc. Pacific Construction was also building the services complex to contain offices, warehousing, and the maintenance shops and facilities. Mill foundations were being constructed to support the mill modules being built in the Philippine Islands and due at the mine site in the summer of 1989.

Cominco Alaska Exploration drilled and performed other exploration and annual maintenance work on various zinc-lead claims in the region.

Other Metals.—A small amount of mercury production was reported to the State, but the source and amount was not disclosed. About 25 ounces of platinum was recovered with placer gold and marketed. Tungsten and gold were recovered by the Miscovich-Walsh operation in working the residual placer at the Golden Horn lode mine near

Flat. The State reported 1988 production at 240 short ton units of tungsten, up from 160 short ton units in 1987. Copper exploration activity was mainly confined to the annual work required to hold a few of the most valuable deposits. Cominco Alaska Exploration worked on claims on the Sun and Smucker deposits in the Ambler area. Nickel-copper-cobalt deposits on Yakobi Island and at Mirror Harbor, on Chichagof Island, were maintained by Andromeda Resources Inc., a subsidiary of Galactic Resources Ltd. Touchstone Resources was a joint venture partner with Galactic Resources in these claims.

Industrial Minerals

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1987. Data for odd-numbered years are based on annual company estimates. Construction sand and gravel production reported in 1988 was 17.2 million tons valued at $48.7 million; this was down from 27.2 million tons valued at $73.4 million estimated production in 1987. The State survey reported production in 1988 at 17.2 million tons valued at $48.8 million, up from 16.7 million tons valued at $42.7 million in 1987. There was no reported production of industrial sand and gravel in Alaska.

State surveys provide information on the production and uses of sand and gravel in various regions in Alaska. About 5.45 million tons of sand and gravel were produced in the eastern interior region by 10 operators. Major users were construction projects for the U.S. Army Light Infantry Division at Fort Wainwright, near Fairbanks, Alyeska Pipeline maintenance, a George Parks Highway project at Fairbanks, and repairs along the Richardson Highway. Some of the top producers, according to the State surveys, were Fairbanks Sand and Gravel Co., Eveco Inc., Alaska Basic Industries, H&H Contractors Inc., Earth Movers, and Rogers and Babler.

TABLE 2

ALASKA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	116	$694	$5.98
Plaster and gunite sands	17	140	8.24
Concrete products (blocks, bricks, pipe, decorative, etc.)	9	50	5.56
Asphaltic concrete aggregates and other bituminous mixtures	148	939	6.34
Road base and coverings	14,998	38,806	2.59
Fill	W	W	2.92
Snow and ice control	32	221	6.91
Other	277	594	2.14
Unspecified:[1]			
Actual	222	888	4.00
Estimated	1,381	6,417	4.65
Total or average	**17,200**	**48,749**	**2.83**

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.

The south-central region reported the production of about 4.19 million tons of sand and gravel. The Anchorage area used about 2.5 million tons of sand and gravel in each of the last 3 years, about 40% of the consumption in 1984 and 1985. The Alaska Railroad Co. hauled 1.7 million tons of sand and gravel from the Palmer-Wasilla area during the construction season, using two 80-car unit trains. Major producers were Alaska Aggregate Co. (540,000 tons) and Anchorage Sand and Gravel Co. (500,000 tons). Reconstruction on the Seward Highway just south of Anchorage used about 2.7 million tons of sand and gravel, mostly from local sites. Other major users were a new Federal Express center, the Ship Creek development project, and the new Anchorage landfill and dump site.

The northern region produced 3.77 million tons of sand and gravel in 1988. About 722,300 tons of sand and gravel was mined by Arco Alaska Inc. and BP Exploration. Most of it was used in the oilfields for construction of a new drill pad at Kuparuk, repairs to the Endicott Causeway and Duck Island and Endeavor Island projects, and road maintenance. The amounts of sand and gravel used in the oilfields in the last 3 years was less than 15% of the statewide total. That was the lowest recorded since oil was discovered at Prudhoe Bay in 1968, according to State surveys. Red Dog Mine and port site construction used most of the sand and gravel, aggregate, and broken or crushed rock produced in the northern region. These materials were derived mostly from quarrying, sizing, and crushing rock to produce riprap, coarse aggregate, finer aggregate, gravel, and sand as needed, so it is difficult to clarify the consumption of sand and gravel. The State Survey said: "During 1988, road and port construction required 617,000 tons of surface (coarse) aggregate and 103,000 tons of finer crushed aggregate. Additional fill and riprap requirements called for

1,330,000 tons and 11,000 tons, respectively, for road and millsite construction; 750,000 tons of crushed rock and gravel were used to construct the starter dam for impoundment of mill tailings."[2]

The southeast region produced about 2.9 million tons of construction sand and gravel, about triple the production in 1987. The U.S. Forest Service reported about a million tons of sand and gravel used by various contractors for road construction in the Stikine area of the Tongass National Forest. Hildre Sand and Gravel Co. produced sand and gravel for the Juneau area and supplied bank-run material and washed sand to the Greens Creek Mine project for construction pads and foundation concrete for the mill and other facilities. Construction of roads at the Kensington and the Jualin Mines projects used considerable amounts of sand and gravel. The western region produced close to 1 million tons of sand and gravel; most of it was used for road construction and maintenance. The Alaska Peninsula and southwestern regions each produced a few thousand tons of sand and gravel.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; therefore, this chapter contains only estimates for 1988. Data for even-numbered years are based on annual company estimates made before yearend.

Crushed and broken stone production in 1988 was estimated at 1.8 million tons valued at $8.4 million, a decrease from 2.0 million tons valued at $8.9 million in 1987. State surveys estimated stone production at 3.6 million tons valued at $24.65 million, more than double the production in 1987. About one-half of the stone reported by the State was quarried in the southeast region. The U.S. Forest Service reported that several contractors produced about 1 million tons of rock that was used in road construction in the Stikine area. Substantial amounts of shot rock and aggregate were used by contractors constructing roads from Comet to the Kensington Mine and from Berners Bay to the Jualin Mine projects. Significant amounts of shot rock products were used in the northern region for construction on the Red Dog Mine project, as noted in the section on sand and gravel. Yutan Construction Co. quarried 315,000 tons of basalt, valued at $1.2 million near Fairbanks. This was about 75% of normal production for each of the last 3 years. About 600,000 tons of riprap and quarry stone, valued at $2.5 million, were produced from three quarries in the eastern interior region.

Other Industrial Minerals.—Portland cement was produced by Anchorage Sand and Gravel Co. using domestic clinker and gypsum shipped into Anchorage. Limestone was produced at the Cantwell quarry of Alaska Limestone Co. and processed to supply local markets with agricultural limestone. Sherman "Red" Smith and Ed Martin continued exploration of a travertine deposit on the Kenai Peninsula for agricultural limestone. Gemstone production reported to the U.S. Bureau of Mines was valued at about $50,000, down from $86,000 in 1987. Jade was produced by the NANA Regional Corp. in the Kobuk area, and carving-grade soapstone was mined in other areas. The State estimated horticultural peat production at 55,000 cubic yards valued at $375,000, up from 46,000 cubic yards worth $299,000 in 1987.

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[1]State Mineral Officer, Bureau of Mines, Juneau, AK.

[2]Green, C. B., T. K. Bundtzen, R. J. Peterson, A. F. Seward, J. R. Deagen, and J. E. Burton. Alaska's Mineral Industry, 1988. Div. of Geol. and Geophys. Surv. Spec. Rep. 43, 1989, 79 pp.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement (portland):			
Alaska Basic Industries	1813 East First Ave. Anchorage, AK 99501	Grind and blend	Cook Inlet-Susitna.
Gold:			
Alaska Gold Co.	Box 640 Nome, AK 99762	Placer-dredge	Seward Peninsula.
Alaska Placer Development Inc. (Hanneman-Knaebel Partnership)	Box 81467 Fairbanks, AK 99708	Placer	Yukon River.
GHD Resources Partners Ltd.	Box 10499 Fairbanks, AK 99710	do.	Do.
Valdez Creek Mining Co. Inc.	610 East 4th Ave. Anchorage, AK 99507	do.	Do.
Western Gold Exploration and Mining Co.	Box 1210 Nome, AK 99762	Placer-dredge	Seward Peninsula.
Windfall Gold Mining Corp.	Box 1920 Nome, AK 99762	Placer	Do.
Sand and gravel (construction):			
Anchorage Sand and Gravel Co.	1813 East First Ave. Anchorage, AK 99501	Pit	Cook Inlet-Susitna.
Central Paving Products	1301 East 64th Ave. Anchorage, AK 99501	Pit	Do.
Fairbanks Sand and Gravel Co.	Box 686 Fairbanks, AK 99707	Pit	Yukon River.
Juneau Ready Mix Hildre Sand and Gravel	Box 270 Juneau, AK 99802	Pit	Southeastern Alaska.
U.S. Bureau of Land Management	Box 13, 701 C St. Anchorage, AK 99513	Pit	Various.
Stone:			
Alaska Railroad Corp.	Box 107500 Anchorage, AK 99510	Pit	Do.
Aleutian Constructors	3909 Arctic Blvd. Anchorage, AK 99501	Quarries	Cook Inset-Susitna.
Associated Sand & Gravel Co. Inc.	Box 3699 Juneau, AK 99803	do.	Southeastern Alaska.
U.S. Forest Service, Region 10	Box 1628 Juneau, AK 99802	do.	Various.
South Coast Inc.	Box 8620 Ketchikan, AK 99901	Quarry	Southeastern Alaska.
Yutan Construction Co.	Box 1775 Fairbanks, AK 99707	do.	Yukon River.
Tin:			
Lost River Mining	Box 411 Nome, AK 99672	Placer	Seward Peninsula.

THE MINERAL INDUSTRY OF ARIZONA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Arizona Department of Mines and Mineral Resources for collecting information on all nonfuel minerals.

By Michael N. Greeley[1] and Leroy E. Kissinger[2]

Arizona led the United States in the production of nonfuel minerals in 1988. The total value of output, $2.8 billion, was an increase of about $1 billion over that of the previous year.

The State led the Nation in copper production and was also among the top producers of gem stones, lime, molybdenum, rhenium, sand and gravel, and sulfuric acid. Metal output valued at $2.49 billion represented 89% of all nonfuel mineral production in the State. Industrial mineral production for the year was $287 million, or about 11% of the total mineral value.

TRENDS AND DEVELOPMENTS

The major increase in the value of nonfuel mineral production was primarily due to strong metal prices and to increased production, particularly of copper, gold, and molybdenum. Within this group of metals, copper had the highest value; prices received rose 46%, from an average of $.825 per pound in 1987 to an average of $1.205 per pound in 1988.

The value of industrial mineral production for 1988 decreased by about 4% from the previous year. Although impressive gains were registered in lime, perlite, salt, and industrial sand and gravel, equally significant losses were recorded in clays and construction sand and gravel.

EMPLOYMENT

During 1988, the Arizona mining industry, including mineral fuels, increased its employment about 8% over that of 1987 to an average of 12,000 workers.[3] Most of this increase was a result of additional employment in the copper industry. The average number of copper exploration and production employees inccreased from 8,900 in 1987 to

TABLE 1

NONFUEL MINERAL PRODUCTION IN ARIZONA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	201,110	$1,366	218,151	$1,905	185,620	$1,590
Copper (recoverable content of ores, etc.)	metric tons	789,175	1,149,193	r751,073	r1,365,994	845,445	2,246,093
Diatomite	thousand short tons	—	—	—	—	8	1,208
Gem stones		NA	2,533	NA	3,000	NA	3,300
Gold (recoverable content of ores, etc.)	troy ounces	W	W	r57,592	r25,798	146,259	64,106
Gypsum	thousand short tons	260	1,820	W	W	W	W
Lime	do.	505	21,016	546	21,932	674	29,637
Molybdenum	thousand pounds	29,382	75,607	W	W	W	W
Perlite	thousand short tons	W	W	49	1,361	W	W
Pumice	do.	2	30	1	7	1	7
Sand and gravel:							
Construction	do.	40,468	140,004	e38,100	e141,300	32,399	123,854
Industrial	do.	W	W	W	W	119	3,045
Silver (recoverable content of ores, etc.)	troy ounces	4,506,197	24,649	r3,661,277	r25,666	4,888,951	31,974
Stone:							
Crushed	thousand short tons	e5,600	e25,100	7,712	33,999	e7,400	e33,000
Dimension	short tons	W	W	—	—	W	e1
Combined value of cement, lead (1988), pyrites (1987–88), salt, tin (1988), and values indicated by symbol W		XX	118,505	XX	r129,398	XX	235,596
Total		**XX**	**1,559,824**	**XX**	**1,750,360**	**XX**	**2,773,411**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

9,500 in 1988. The number of miners and other workers in the copper sector represented more than 79% of all employees in the State's mineral industry.

Total income earned in all mining sectors of the State was $498.7 million in 1988, an increase of almost 18% over that of the previous year. The copper industry increased its payroll by more than $120 million over the payroll of 1987, to $374.7 million, and contributed more than 75% of the total wages paid to all mineral industry employees.

During the year, the average weekly earnings of all workers (including management) in Arizona's mining industry was $684. The average weekly earnings of an employee in the State's copper sector was $758, a sharp rise of 38% over the average weekly income of $549 in 1987. Much of the dramatic increase in wages was due to voluntary bonuses or contract-mandated bonuses paid by the copper companies. More than $50.9 million in bonuses was distributed to approximately 8,000 workers in 1988.

REGULATORY ISSUES

In 1988, the State continued to monitor development of Federal regulation of solid waste disposal under the Resource Conservation and Recovery Act (RCRA). The Arizona Department of Environmental Quality and the environmental committee of the Arizona Mining Association (AMA) cooperated in the analysis and evaluation of RCRA proposals that would affect the mineral industry. The AMA also continued to provide assistance and information to the State as it prepared regulations governing aquifer protection.

EXPLORATION ACTIVITIES

According to the U.S. Bureau of Land Management, the State ranked third in the Nation for the number of unpatented mining claims considered active during 1988.

Interest continued in Arizona's potential for the discovery of additional copper and gold deposits. Most of the interest in copper exploration focused on locating deposits that would be amenable to low-cost production by solvent extraction-electrowinning technology. The State was generally recognized as the leader in proven and probable reserves of acid-soluble copper.

Exploration for gold was widespread in southern and western Arizona, with activity generally centered around properties in Cochise, La Paz, Maricopa, Mohave, Pinal, and Yavapai Counties. Several targets within each of these counties were drilled.

LEGISLATION AND GOVERNMENT PROGRAMS

In Senate bill 1310, the Arizona State Legislature established new laws and regulations governing mineral leases on State trust lands. The bill set the minimum annual land rental at 75 cents per acre and the minimum royalty at 2% of gross value. The land commissioner may charge higher rents and royalties to ensure that the trust receives fair value. The commissioner may also deny a prospecting permit or a mineral lease whenever exploration or mineral production is deemed not to be the "highest and best use" of the trust lands.

State officials authorized major reductions in the 1989–1990 fiscal year budgets of the State Mine Inspector and the Arizona Department of Mines and Mineral Resources (ADMMR). Both agencies were to receive budget reductions of 22% and staff reductions of more than 25%.

In 1988, the University of Arizona began to implement plans to establish the Center for Advanced Studies for Copper Recovery and Utilization. The U.S. Congress approved $4 million in seed money to help found the research facility, also known as the Copper Research Center, in Tucson. During the year, policy and technical advisory boards were organized and proposals for research were solicited.

During 1988, the U.S. Bureau of Mines completed its examination of several Arizona sites proposed for a field research project designed to evaluate in situ copper mining. The Bureau signed an agreement to conduct the research in cooperation with the Santa Cruz Joint Venture (a mining partnership formed between ASARCO Santa Cruz Inc., a subsidiary of ASARCO Incorporated and Freeport Copper Co., a subsidiary of Freeport-McMoRan Gold Co.). The venture partners provided the Santa Cruz site in Pinal County, 7 miles west of Casa Grande, for the in situ project. Late in the year, the Bureau began drilling the first core hole to obtain mineralized samples and fracture orientation data from the buried oxide copper deposit.

The U.S. Bureau of Mines continued to supervise the administration of the Arizona Mining and Mineral Resources Research Institute (MMRRI) during 1988. The Institute, housed at the University of Arizona, was administered by a faculty member of the Department of Materials Science and Engineering. Total funds allocated by the Bureau to the MMRRI was $138,000.

During the year, the Bureau issued eight open-file reports addressing mineral land assessments in Arizona. These reports summarized mineral evaluations of wilderness study areas under the U.S. Bureau of Land Management jurisdiction.

In 1988, the Bureau of Mines released a special publication, Availability of Federally Owned Minerals for Exploration and Development in Western States: Arizona, 1986. This report compared the availability of federally owned minerals in the State with lands considered favorable for discovery of mineral resources. The study was made

to determine the extent to which Federal lands with mineral potential in Arizona have been withdrawn by legal action or restricted by management practice.

Late in the year, the Bureau of Mines established a southwest regional office in Tucson. The new office was opened to facilitate information gathering and to increase Bureau representation in the southwestern states.

During 1988, the ADMMR published three annual directories: (1) Directory of Active Mines in Arizona, (2) Exploration Offices, and (3) Arizona Mining Consultants. A map of current mining operations accompanied the mines directory.

During the year, the Arizona Geological Survey (AGS) published a new Geologic Map of Arizona (Map 26) at a scale of 1:1,000,000. This map superseded the out-of-print 1969 State geologic map. Among several open-file reports issued by the AGS were OFR 88-16, Index to Published Geologic Maps of Arizona, and OFR 88-22, Additions to Bibliographies for Metallic Mineral Districts in Cochise, Graham, Greenlee, La Paz, Mohave, Pima, Santa Cruz, and Yuma Counties, Arizona.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Copper.—Arizona continued as the Nation's leading copper producer in 1988. The combined output of mines in the State was nearly 60% of the total domestic production. Seven of the top 10 copper-producing mines in the United States were in Arizona.

There were 15 principal copper mine operations in the State during the year. These facilities produced more than 1.8 billion pounds of copper, an increase of about 13% over that of 1987. Tight supplies, strong demand, and production disruptions in several foreign countries resulted in an increase in the average domestic price of copper during 1988. Increased production and high prices increased the total value of the metal produced in the State by more than 64% compared to the previous year. The total value of copper, about $2.2 billion, represented nearly 81% of the value of all nonfuel mineral production in Arizona.

Almost 25% of all copper produced in the State was recovered by leaching oxide ores and low-grade dumps. Eighty-eight percent of this copper was recovered by electrowinning.

The Morenci Mine in Greenlee County, 85% owned by the Phelps Dodge Corp., was the Nation's largest producer of copper during 1988. According to Phelps Dodge's 1988 annual report, approximately 17% of the copper produced at the mine for the company's account was electrowon. The new solvent extraction-electrowinning (SX-EW) plant at Morenci, in its first full year of production, enabled the company to increase its electrowon copper sixfold over that of 1987.

Phelps Dodge and its minority partner, Sumitomo Metal Mining Arizona, Inc., continued a program to modernize the conventional mining and processing facilities at Morenci. The $48 million project, begun in September 1987, was to install an in-pit crushing and conveying (IPCC) system that would allow the partners to phase out rail haulage in the mine.

Net income of $420.2 million reported by Phelps Dodge for 1988 represented the company's highest earnings ever. The principal reasons cited by the firm for the high income were record copper production and sales at high spot prices. Toward yearend, the company announced the creation of two operating divisions: the Phelps Dodge Mining Co., which, was the mineral exploration, mining and marketing arm, and Phelps Dodge Industries, the manufacturing and specialty chemicals arm.

At the Mission Mine complex in Pima County, Asarco continued a $13 million project to expand production capacity from about 54,000 metric tons of copper per year to approximately 79,000. Most of this expansion consisted of enlargement and improvement of the Mission concentrator.

During late 1988, Asarco began a $12 million project to expand mill capacity at the Ray Mine in Pinal County. The mill expansion was initiated to offset the anticipated effects of increasing ore hardness as the pit deepened and to maintain production capacity of copper in concentrates at about 68,000 tons per year. Also during the year, the company began construction of a holding furnace at its Hayden copper smelter in Gila County to improve the plant's operating rate.

Asarco purchased the Helvetia property about 15 miles southeast of the Mission area to provide more copper reserves and greater flexibility in company planning. The Helvetia deposit, largely defined by its former owner, the defunct Anamax Mining Co., is located in the Santa Rita Mountains in Pima County and was reported in Asarco's annual report for 1988 to contain 254 million tons of 0.62% sulfide copper and 21 million tons of 0.78% oxide copper. The cost of acquisition from a real estate trust was $1 million plus 1,200 acres of surplus land.

Near yearend, Asarco and the Freeport-McMoRan Gold Co. jointly purchased the Casa Grande deposit in Pinal County, originally discovered by the Getty Minerals Co. and the M.A. Hanna Co. The companies paid about $14 million plus certain call provisions on some of the purchased property.[4] According to its 1980 annual report, Getty reported the Casa Grande reserves to be 319 million tons at 1% copper.

Continuing its aggressive expansion program, Cyprus Minerals Co. acquired two copper properties in Arizona. Early in 1988 the company obtained a 15-year lease on the Twin Buttes Mine in Pima County and began

mining high-grade copper ore. The ore was hauled by truck to Cyprus' nearby mill at the Sierrita Mine in Pima County. The company also considered producing electrowon copper in the existing SX-EW plant at Twin Buttes. Reserves reported by Cyprus included approximately 37 million tons of 0.92% sulfide copper and 10 million tons of 0.73% acid-soluble copper.[5]

At midyear, Cyprus purchased the Arizona copper assets of Inspiration Consolidated Copper Co. near Miami in Gila County for $125 million.[6] The operation, renamed Cyprus Miami Mining Corp., consisted of an open pit mine producing acid soluble copper, an SX-EW plant, a smelter, a refinery, and a rod mill. One reason for the acquisition was the company's desire to have its own smelter, thereby eliminating its dependence on short-term smelting contracts. The company also wanted its own rod plant capable of producing high-value wire that would enable the company to broaden its customer base.

With these acquisitions, Cyprus increased its copper operations in the State to six. These properties combined produced approximately 208,000 tons of copper according to the Cyprus 1988 Form 10-K, making Cyprus the second leading producer of copper in Arizona.

At the San Manuel smelter (Pinal County), owned by the Magma Copper Co., construction of a new flash furnace and associated facilities was completed by late 1988. Designed for a capacity of 2,700 tons of concentrates per day, the furnace was the largest copper smelting furnace in the world. The smelter would process concentrates, supplied by the company and by toll customers, totaling approximately 910,000 tons per year. The new smelting system, including a sulfuric acid plant and oxygen plant, cost $150 million and replaced three reverberatory furnaces that had been in operation since the San Manuel smelter was started in 1956.

Magma's smelter construction was the largest component of a $253 million expansion and modernization program begun in 1986 and substantially completed in 1988. Additional components of the program at San Manuel included expansion of the SX-EW plant and the refinery, modernization of the mill, development of in situ leaching of the San Manuel ore body, and development of the deep Kalamazoo deposit. However, development of the Kalamazoo deposit was suspended in October. Part of the expenditure also included costs to expand an SX-EW plant operated by the Pinto Valley division and to recover copper from concentrator tailings.

In terms of production, the San Manuel Mine was one of the world's largest underground copper mines. According to Magma's annual report for 1988, ore production from the mine averaged slightly more than 40,000 tons per day.

The design capacity of the SX-EW plant at San Manuel was doubled to 100 million pounds of cathode copper annually. Magma expanded to accommodate copper-bearing solutions recovered from heap-leach pads and from in situ ores. Oxide copper ore placed on leach pads was mined from a pit situated above the caved San Manuel deposit. Rubbled oxide ore, overlying the area adjacent to worked-out portions of the deposit, was subjected to in situ leaching. Although Magma reported that the in situ program was adversely affected by continued ground movement in 1988, the company projected that this program alone would contribute 70 million pounds of cathode copper annually by the end of 1991.

Early in 1988, Magma initiated development of its Miami No. 2 tailings-leach project in Gila County. This $20 million project was designed to hydraulically mine mill tailings associated with the old Miami underground mine and to process the resulting copper-bearing solutions in an enlarged SX-EW plant. The operation was expected to begin in early 1989.

The Kocide Chemical Co. began in situ leaching at the Van Dyke Mine (Gila County) during 1988. Copper-bearing solutions were pumped to the surface from underground and were processed to recover cement copper. The copper precipitates were converted to copper sulfate for agricultural products at a company facility in Casa Grande.

Gold.—The production of gold in Arizona rose sharply in 1988 to more than 2½ times that of 1987. The State's output was the highest since 1965. About 57% of the gold was recovered either on-site at primary lode mines or from primary ores shipped to copper smelters. Most of the remaining gold was recovered as a byproduct of copper ores.

Largest among the primary gold producers was the Copperstone Mine (La Paz County) owned by Cyprus. According to the firm's 1988 Form 10-K, the open pit mine produced 62,800 troy ounces in its first full year of operation. During the second half of 1988, the company began construction of a decline as part of a plan to develop an underground mine beneath the existing surface operation. The company anticipated that this deeper ore would yield an additional 40,000 ounces of gold per year.

Operations at Copperstone experienced problems during the year. Mill throughput was sharply curtailed for about a month while repairs were made, and costly efforts were required to prevent waterfowl from landing on the cyanide-bearing tailings ponds. Moreover, the ore grades encountered that were lower than expected.

Echo Bay Mines Ltd. began operating the Congress Mine in Yavapai County in March 1988. High-silica gold ore was shipped from the underground mine to the Phelps Dodge Hidalgo copper smelter in New Mexico. Echo Bay's 1988 annual report credited the mine with a production of 16,176 ounces during the year.

Queenstake Resources Ltd. continued development at the Gold Prince Mine in Cochise County during 1988. The company's annual report for 1988 stated that 500 short tons of silica flux, averaging 0.338 ounce of gold per ton, was shipped as a test lot to the Hidalgo smelter.

The Stan West Mining Corp. completed construction of a 500-short-ton-per-day mill at the McCabe Mine in Yavapai County and began mine production in September. The mine was expected to produce approximately 50,000 ounces of gold and 140,000 ounces of silver annually.[7]

Two other gold properties operated in Maricopa County in 1988. The J. Devins Resource Group continued mining and leaching ore heaps at the U.S. Mine, and A.F. Budge (Mining) Ltd. began operations at the historic Vulture Mine. Budge heap leached old tailings at the site and planned to produce approximately 7,000 ounces of gold within about 1 year.[8]

Late in the year, the Gladiator-War Eagle Mine in Yavapai County was closed by Nor-Quest Arizona. The underground mine had been in production since 1986.

Molybdenum.—In 1988, Arizona became the largest producer of molybdenum in the United States. Production more than quadrupled over that of the previous year. The increase was due to strong demand, increased prices, and expanded markets.

As in the recent past, all molybdenum produced in the State during 1988 was mined as a byproduct or coproduct of primary copper ores. Molybdenite concentrates were recovered at five mines. The Sierrita Mine (Pima County), owned and operated by Cyprus, was the largest producer. This property was also the only one in Arizona that operated a molybdenum sulfide roaster to produce molybdenum oxide.

According to the Cyprus Form 10-K for 1988, the company produced 23.8 million pounds of molybdenum from its Arizona mines. Approximately 73% of this total originated at the Sierrita Mine. Cyprus was the largest domestic producer of molybdenum in 1988, and its output of the metal in Arizona was approximately 25% of the Nation's total production. Magma's annual report for the year announced its total molybdenum production was 4.3 million pounds.

Silver.—Arizona ranked fourth in the United States in silver output in 1988. More than 4.8 million ounces, an amount greater than 9% of total domestic output, was produced by the State's mines.

Five properties in Arizona placed among the 25 leading silver-producing mines in the Nation. These five operations plus two others, all primary copper producers, were responsible for more than 97% of the State's output. Asarco's Mission complex was the single largest producer of byproduct silver. The complex produced 1,248,000 ounces in 1988, according to the firm's annual report for that year. The company-owned Ray Mine produced 439,000 ounces. Magma reported in its 1988 annual report that the combined output of the Pinto Valley and San Manuel divisions was 623,000 ounces of silver.

Most of the balance of silver production in the State was recovered from silicious ores shipped to copper smelters. The largest of these producers was the underground Ash Peak Mine operated by Arizona Flux Mines Inc. in Greenlee County. Other major sources of silver-bearing flux were the Commonwealth tailings in Cochise County, the Mammoth tailings in Pinal County, and the Congress lode mine in Yavapai County.

Other Metals.—Arizona was the only State in which rhenium was mined in 1988. It was produced by Cyprus at the Sierrita Mine. The metal, occurring as a trace element in molybdenite, was recovered as ammonium perrhenate by roasting the molybdenum concentrates.

Approximately 32% of the Nation's domestically produced uranium was mined in Arizona. In 1988, six uranium mines in Arizona, located in Coconino and Mohave Counties, were either in production or under development by Energy Fuels Nuclear Inc.

A relatively small amount of lead was produced as a byproduct at the Mission copper complex, and lode tin was recovered at the Cheops (formerly Apache) property in Graham County. There was no recorded production during the year of other metals in the State except trace metals recovered at copper refineries.

Industrial Minerals

Cement.—Arizona ranked in the top half of all cement-producing States during 1988. While production of masonry cement in the State declined, portland cement production increased by about 1.5%. However, the average price of both types of cement declined.

Arizona Portland Cement Co., a subsidiary of the Calmat Co., was the largest producer of cement in the State. The company modernized equipment in the finish grinding mill circuit of its Rillito plant in Pima County. Calmat's 1988 annual report indicated that this improvement significantly increased production while it decreased energy consumption. Rubber tire chips were burned successfully on an experimental basis as an alternate energy source in kilns at the cement plant.

Clays.—During the year, the State's total production of clay decreased approximately 15% compared to 1987 figures. Most of this decline was due to a major reduction of common clay and shale output used to manufacture building materials. However, bentonite production increased slightly from 28,530 short tons in 1987 to 28,733 short tons in 1988. Arizona was the seventh largest producer of bentonite among the 14 producing States.

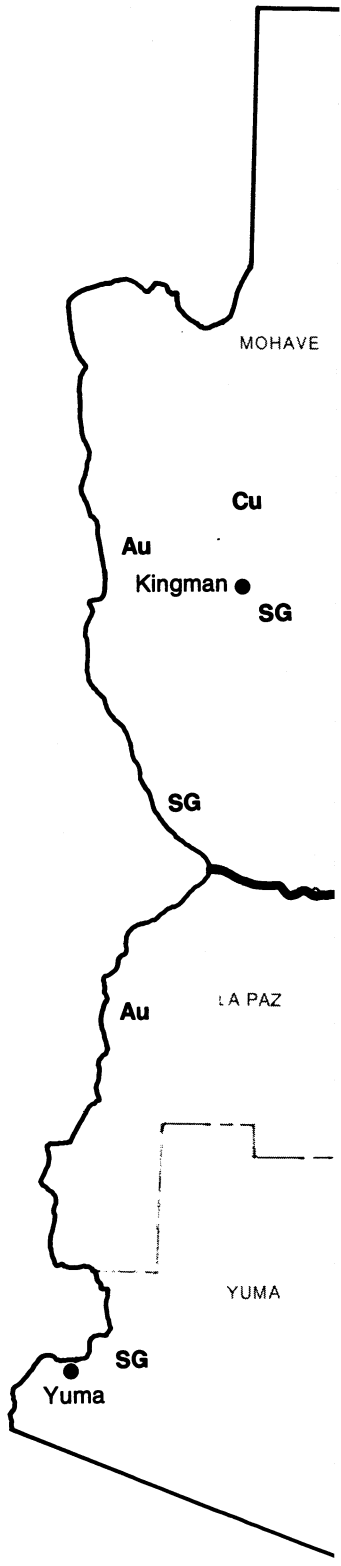
ARIZONA

LEGEND

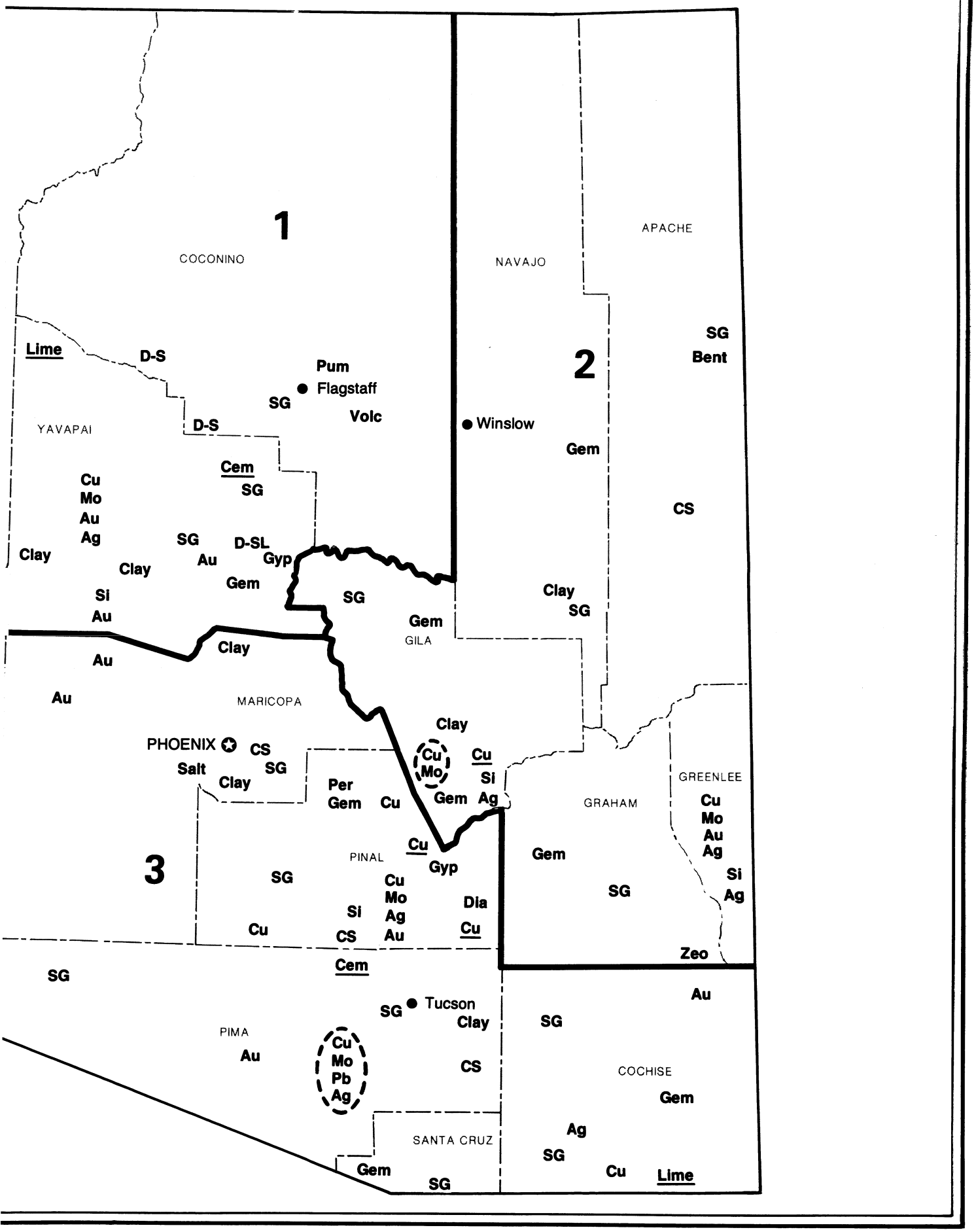
- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Ag	Silver
Au	Gold
Bent	Bentonite
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper
Cu	Copper plant
D-S	Dimension Sandstone
D-SL	Dimension Slate
Dia	Diatomite
Gem	Gemstones
Gyp	Gypsum
Lime	Lime plant
Mo	Molybdenum
Pb	Lead
Per	Perlite
Pum	Pumice
Salt	Salt
SG	Sand and Gravel
Si	Silica
Volc	Volcanic cinder
Zeo	Zeolite
	Concentration of mineral operations



Principal Mineral-Producing Localities


1
COCONINO
NAVAJO
APACHE
2
3
Lime
D-S
Pum
Flagstaff
SG
Volc
D-S
YAVAPAI
Winslow
SG
Bent
Gem
CS
Cem
SG
Cu
Mo
Au
Ag
SG
D-SL
Clay
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CS
Cu
Zeo
Cem
SG
Au
SG
Tucson
Clay
SG
PIMA
Cu
Mo
Pb
Ag
Au
CS
COCHISE
Gem
Ag
SANTA CRUZ
SG
Gem
Cu
Lime
SG

Gem Stones.—Arizona continued as the third leading producer of gem stones in the United States. The State ranked second in the Nation as a source of mined gem materials. The total value was estimated to have risen about 10% over that of 1987. Principal gem stones included agate, malachite, blue opal, peridot, petrified wood, and turquoise.

Gypsum.—Arizona's gypsum production placed it in the top half of all the producing States in 1988. Mine production of gypsum in the State increased by about 8% over that of 1987. Average prices rose slightly.

Three companies operated four mines during the year and supplied agricultural, cement, and wallboard customers. Most of the production was from Pinal County.

According to its Form 10-K for 1988, the National Gypsum Co. produced 165,000 short tons of gypsum at the Feldman Mine in Pinal County. Through its Gold Bond Building Products division, the firm calcined gypsum and manufactured wallboard at its plant in Phoenix.

Lime.—Domestically, the State continued to rank 11th in lime production. Arizona's output increased by more than 23% over that of 1987, and average prices increased by almost 12%. The entire output was produced by Chemstar Inc. at its two plants, one at Paul Spur in Cochise County and one at Nelson in Mohave County.

Chemstar, a privately owned company, was the largest producer of hydrated lime and quicklime in the western United States. The Nelson facility, one of the firm's largest, had a rated capacity of 1,800 short tons of high-calcium quicklime per day. The Paul Spur facility was rated at 1,000 tons per day.

Perlite.—Nationally, Arizona was the second leading producer of perlite during 1988. Two mining firms operated surface pits near Superior (Pinal County) and supplied a variety of markets. Expanded perlite was produced primarily for horticultural purposes by Therm-O-Rock Industries in Maricopa County.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

For some States, construction sand and gravel statistics are compiled by districts. Table 3 presents end-use data for this commodity in Arizona in the districts depicted in the centerfold map.

In 1988, the State ranked seventh nationally in the domestic production of construction sand and gravel. Compared to the estimated production figure for 1987, Arizona's output in 1988 decreased by 15%. Average prices increased during the year and the total value of production, $124 million, contributed significantly to the combined value of all nonfuel mineral commodities in the State. District 3 sand and gravel mines, encompassing the two principal population centers of Phoenix and Tucson, produced more than 88% of the total production in Arizona.

Industrial.—Production of industrial sand in Arizona continued at the Houck Mine in Apache County. This relatively valuable commodity, consisting of well-rounded and well-sorted quartz grains, sold for an average price of about $25.60 per short ton in 1988.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

During 1988, production of crushed stone in Arizona was estimated to have decreased slightly. The estimated value, however, was significant at $33 million. Six companies quarried dimension stone in Arizona and supplied various users. A diversity of products, including onyx marble, sandstone, and schist, were mined during 1988.

TABLE 2

ARIZONA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	3,914	$14,819	$3.79
Plaster and gunite sands	166	772	4.65
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	4.30
Asphaltic concrete aggregates and other bituminous mixtures	1,914	9,663	5.05
Road base and coverings[1]	3,980	10,037	2.52
Fill	408	1,032	2.53
Other	243	1,028	4.23
Unspecified:[2]			
Actual	18,513	75,417	4.07
Estimated	3,262	11,085	3.40
Total[3] or average	**32,399**	**123,854**	**3.82**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

TABLE 3

ARIZONA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	236	869	236	1,405	3,443	12,544
Plaster and gunite sands	33	165	11	67	121	540
Concrete products (blocks, bricks, etc.)	—	—	—	—	W	W
Asphaltic concrete aggregates and other bituminous mixtures	W	W	W	W	1,714	8,596
Road base and coverings[1]	879	2,162	438	1,423	2,664	6,452
Fill	23	38	54	128	331	865
Other miscellaneous	14	88	187	979	243	1,028
Other unspecified[2]	1,433	5,305	209	736	20,133	80,461
Total[3]	**2,617**	**8,628**	**1,135**	**4,739**	**28,648**	**110,487**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

Other Industrial Minerals.—Several other industrial minerals were mined or produced in Arizona during 1988. Included among these commodities were diatomite, pumice, pyrite, salt, sulfuric acid, and zeolite.

Arizona was one of only five States in which diatomite was produced in 1988. The Whitecliffs Mine in Pinal County was the State's sole source of this relatively high-valued product.

A small amount of pumice was produced in the State during the year, and the State was the only source of marketed pyrite concentrates in the Nation. Pumice was mined in Graham and Coconino Counties, and pyrite was recovered at the Magma property in Pinal County.

Solution mining and processing of salt continued at the Luke facility owned by Morton Salt in Maricopa County. Production in 1988 increased by approximately 27% over that of the previous year.

Sulfuric acid as a byproduct of metal smelters and roasters was produced in greatest quantity in the United States at Arizona's copper facilities. Total production for the State, 1.3 million short tons, increased by approximately 12% over that of 1987. In 1988, this output was 45% of the total sulfuric acid produced domestically in this manner.

Exfoliated vermiculite was produced by Therm-O-Rock Industries and W.R. Grace and Co. at their plants in Maricopa County. The companies shipped crude vermiculite to the processing facilities from out of the State.

Limited amounts of zeolite, as raw chabazite, were mined from a deposit near Bowie. In 1988, five mining firms shipped the commodity from this deposit, which straddles the Cochise-Graham County line, to processing plants in other States.

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[1] State Mineral Officer, Bureau of Mines, Tucson, AZ.

[2] Director, Arizona Department of Mines and Mineral Resources, Phoenix, AZ.

[3] Leaming, G. F. The Copper Industry's Impact on the Arizona Economy 1988. West. Econ. Anal. Cent. (Marana, AZ) Mar. 1989, 32 pp.

[4] Epler, B. Santa Cruz Joint Venture Buys Casa Grande Copper Deposit. Pay Dirt, Southwestern Edition, Feb. 1989, p. 16A.

[5] Walenga, K. Cyprus Plans June Start-Up of Twin Buttes Copper Production. Pay Dirt, Southwestern Edition, Apr. 1988, p. 3A.

[6] Walenga, K. Cyprus Gets Inspiration for $125 Million in Cash. Pay Dirt, Southwestern Edition, June 1988, pp. 4A-5A.

[7] Walenga, K. Gold and Silver Are There—but Are Tough to Get. Pay Dirt, Southwestern Edition, Jan. 1989, pp. 4A-6A.

[8] Walenga, K. Budge Mining Preparing to Reprocess Tailings at Vulture Mine. Pay Dirt, Southwestern Edition, May 1988, p. 21A.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Arizona Portland Cement Co., division of California Portland Cement Co., a subsidiary of CalMat Co.[1 2]	Box 338 Rillito, AZ 85654	Quarry and dry-process, 4-rotary-kiln plant	Pima.
Salt River Pima-Maricopa Community (formerly Phoenix Cement Co.)[1 2]	Box 428 Clarkdale, AZ 86324	Quarry and dry-process, 3-rotary-kiln plant	Yavapai.
Cinder (volcanic):			
Flagstaff Cinder Sales Inc.	Old Highway 66, Box 2796 Flagstaff, AZ 86003	Quarry	Coconino.
Superlite Builders Supply, a subsidiary of U.S. Industries Inc.	Box 40159 Flagstaff, AZ 86004	Open pit mine and crushing plant	Do.
Clays:			
Building Products Co.	4850 West Buckeye Rd. Phoenix, AZ 85043	Open pit mines	Navajo and Yavapai.
Clinton-Campbell Contracting Inc. (formerly Phoenix Brick Yard)	1814 South 7th Ave. Phoenix, AZ 85007	do.	Maricopa and Pima.
Harshaw/Filtrol Partnership of Kaiser Aluminum & Chemical Corp. and Chevron Corp.	Box 155 Sanders, AZ 86512	Surface strip mine	Apache.
McKusick Mosaic Co.	Route 1, Box 35-D Globe, AZ 85501	Surface mine	Gila.
United Desiccants, a division of United Catalyst Inc.	Box 32370 Louisville, KY 40232	Surface strip mine	Apache.
Copper:			
ASARCO Incorporated			
Hayden Unit	Box 98 Hayden, AZ 85235	Smelter and acid plant	Gila.
Mission Complex[3 4 5]	Box 111 Sahuarita, AZ 85629	Open pit mines and mill	Pima.
Ray Unit[3 5 6]	Box 9 Hayden, AZ 85235	Open pit mine, dump and heap leach, precipitation, SX-EW plants	Gila and Pinal.
Silver Bell Unit	Marana, AZ 85653	Leach dumps and precipitation plant	Pima.
Cyprus Metals Co., a division of Cyprus Minerals Co.:			
Cyprus Bagdad Copper Co.[5 6]	Box 245 Bagdad, AZ 86321	Open pit mine, mill, leach dump, SX-EW plant	Yavapai.
Cyprus Casa Grande	Box C-9 Casa Grande, AZ 85222	In situ mine and SX-EW plant	Pinal.
Cyprus Miami	Box 1559 Claypool, AZ 85532	Dump and heap leach, precipitation plant, SX-EW, smelter, refinery, rod mill	Gila.
Cyprus Mineral Park	Box 6249 Kingman, AZ 86401	Leach dump and precipitation plant	Mohave.
Cyprus Sierrita Corp.[3 5 6]	Box 527 Green Valley, AZ 85622	Open pit mine, mill, leach dumps, precipitation plant, SX-EW plant	Pima.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Copper—Continued			
Cyprus Twin Buttes[3 5 6]	1855 La Canada Green Valley, AZ 85622	Open pit, leach dumps, SW–EX plant.	Pima.
Magma Copper Co.:			
Pinto Valley Div.[3 5 6]	Box 100 Miami, AZ 85539	Open pit mine, mill, leach dumps, in situ leach, SX–EW plant.	Gila.
San Manuel Div.[1 3 5 6 7]	Box M San Manuel, AZ 85631	Underground mine, mill, in situ and heap leaching, SX–EW plant, acid plant, smelter, refinery, rod mill.	Pinal.
Phelps Dodge Corp.:			
Corporate Headquarters	2600 North Central Ave. Phoenix, AZ 85004–3015		Maricopa.
Copper Queen Branch	Highway 92 Bisbee, AZ 85603	Leach dumps, in situ leaching, precipitation plant.	Cochise.
Morenci Branch[3 5 6]	Morenci, AZ 85540	Open pit mine, mills, leach dump, precipitation and SX–EW plants.	Greenlee.
Diatomite:			
Whitecliffs Industries	460 West Roger Rd., Suite 101 Tucson, AZ 85705	Surface mine and plant	Pinal.
Gold:			
Cyprus Copperstone Gold Corp.	Box A1 Parker, AZ 85344	Open pit mine, agitation leach.	La Paz.
Echo Bay Mines Ltd.	Box 361 Congress, AZ 85332	Underground mine	Yavapai.
J. Devins Resource Group	Box 2406 Wickenburg, AZ 85358	Open pit mine and heap leach	Maricopa.
Nor-Quest Arizona Inc.	Box 416 Crown King, AZ 86343	Underground mine and concentrator.	Yavapai.
Stan West Mining Corp.	Box 460 Humboldt, AZ 86329	Underground mine and mill	Do.
Gypsum:			
National Gypsum Co:			
Gold Bond Building Products Div.	Box 20863 Phoenix, AZ 85036	Plant	Maricopa.
Pinal Gypsum Co.	Box 99 Coolidge, AZ 85228	Open pit mine	Pinal.
Superior Companies[1 2]	1700 North 7th St., No. 5 Phoenix, AZ 85005	Quarries and plant	Apache, Pinal, Yavapai.
Winkelman Gypsum Pit	Star Route, Box 3990 Winkelman, AZ 85292	Open pit mine and crushing plant.	Pinal.
Lime:			
Chemstar Inc.	Box 197 Peach Springs, AZ 86434	Quarries and plant	Yavapai.
Can-Am Corp., Paul Lime Div., a subsidiary of Chemstar Inc.[2]	Drawer T Douglas, AZ 85607	Quarry and three lime kilns	Cochise.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Perlite:			
Harborlite Inc.	Box 960 Superior, AZ 85273	Open pit mine and plant	Pinal.
Nord-Sil Flo Inc., a subsidiary of Nord Resources Corp.	Box 127 Superior, AZ 85273	do.	Do.
Therm-O-Rock Industries, Inc.	6732 West Willis Rd. Chandler, AZ 85226	Plant	Maricopa.
Pumice:			
Arizona Tufflite Inc.	2432 West Peoria Phoenix, AZ 85029	Open pit mine	Coconino.
Gila Valley Block Co.	Box 465 Safford, AZ 85546	do.	Graham.
Salt:			
Morton Salt Div., a subsidiary of Morton Thiokol Inc.	13000 West Glendale Ave. Glendale, AZ 85307–2408	Solution mining and solar evaporation	Maricopa.
Sand and gravel:			
Construction:			
Arizona Crushers Inc.	Box 9129 Phoenix, AZ 85068	Pits	Do.
Baseline Materials Inc.	38353 Schneph Rd. Queen Creek, AZ 85242	Pits	Do.
Blue Circle West Inc.	2625 South 19th Ave. Phoenix, AZ 85009	do.	Do.
CalMat Co. of Arizona, a subsidiary of California Portland Cement Co., a subsidiary of CalMat Co.	1801 East University Dr. Box 52012 Phoenix, AZ 85036	Pits and plants	Do.
Earth Products Inc.	Box 278 Humboldt, AZ 86329	do.	Yavapai.
Mesa Materials Inc.	3410 North Higley Rd. Mesa, AZ 85205	Pits	Maricopa.
Phoenix Redi-Mix Co.	3635 South 43rd Ave. Phoenix, AZ 85009	do.	Do.
Salt River Sand & Rock	Box 728 Mesa, AZ 85211	do.	Do.
The Tanner Companies	3640 South 19th Ave. Box 52124 Phoenix, AZ 85072	Pits and plants	Coconino, La Paz, Maricopa, Pima, Pinal, Yavapai, Yuma.
Union Rock & Materials Corp.	2800 South Central Ave., Box 8007 Phoenix, AZ 85006	do.	Maricopa, Pima.
Industrial:			
Arizona Silica Sand Co.	Box 108 Houck, AZ 86506	Open pit mine	Apache.
Stone:			
Crushed:			
Andrada Marble Co.	4901 East Drexel Rd. Tucson, AZ 85706	Quarry	Pima.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Arizona Granite	7401 West Villa Rita Dr. Peoria, AZ 85345	Quarry	Maricopa.
Madison Granite Supplies	7050 Grand Ave. Glendale, AZ 85301	Quarry and plant	Do.
Red Mountain Mining Inc.	4250 North Bush Hwy. Mesa, AZ 85205	do.	Do.
Scala Granite	East Canyon Dr. Apache Junction, AZ 85220	do.	Pinal.
Dimension:			
Dunbar Stone Co.	Box 246 Ash Fork, AZ 86320	Quarries and plant	Coconino, Maricopa, Mohave, Yavapai.
Western States Stone Co.	2830 Grand Ave. Phoenix, AZ 85017	do.	Coconino, La Paz, Maricopa, Mohave, Yavapai.
Stone (Smelter flux):			
Arizona Flux Mines Inc.	Box 26707 Tucson, AZ 85727	Underground mine	Greenlee.
Little Hill Mines Inc.	Box 332 Oracle, AZ 85623	Open pit mine	Pinal.
Triple Nichol Inc.	R.R. 1, Box N123 Globe, AZ 85501	Surface and underground mines	Gila, Pinal.
Vermiculite (exfoliated):			
W. R. Grace & Co., Construction Products Div.	4220 West Glenrosa Phoenix, AZ 85019	Plant	Maricopa.
Therm-O-Rock Industries	6732 West Willis Rd. Chandler, AZ 85226	do.	Do.
Zeolite:			
GSA Resources	Box 16509 Cortaro, AZ 85652	Surface strip mine	Cochise.
Union Carbide Corp.	Box 1029 Grand Junction, CO 81502	do.	Do.

[1] Also clays.
[2] Also limestone.
[3] Also gold.
[4] Also lead.
[5] Also silver.
[6] Also molybdenum.
[7] Also lime.

THE MINERAL INDUSTRY OF ARKANSAS

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Arkansas Geological Commission for collecting information on all nonfuel minerals.

By Doss H. White, Jr.,[1] and William V. Bush[2]

In 1988, the value of nonfuel mineral production in Arkansas, as reported by the State's mineral producers, increased to a record high of $307 million, a $43 million increase over 1987. This value exceeded the previous record high established in 1979 by almost $2 million. Nationally, Arkansas ranked 29th in the total value of nonfuel mineral production.

Fifteen nonfuel mineral commodities, 14 industrial minerals, and 1 metallic mineral were produced during the year; 8 exceeded 1987 production levels, 5 declined below the levels reported in 1987, and 1 remained at the previous year's figure. Production data were not available for gemstones. A significant increase in the value of bromine, clays, construction sand and gravel, and crushed stone accounted for the new State record; the value of these four commodities exceeded the 1987 level by almost $46 million.

TRENDS AND DEVELOPMENTS

During the past 10 years (1979–88), Arkansas' annual mineral value has exhibited two distinct trends. During the initial half of the 10-year period (1979–83), value declined from a record high of $305 million in 1979 to $246 million in 1983; the decline resulted from the nationwide recession in the early 1980's. In 1984, however, the trend of declining value reversed and, with a minor exception in 1985–86, sales increased to the record high of $307 million reported in 1988.

During the year there was activity, including openings, sales, and plant transfers, in both the industrial minerals and metals sectors. In the industrial minerals sector, the State's talc industry developed new markets, which resulted in increased sales. Several bromine producers completed expansions. Dow Chemical U.S.A. sold its Magnolia clear brine fluids plant and reserves to Tetra Technologies Inc. Tri States Sand and Gravel Co. sold its Delight plant and reserves to Gifford-Hill and Co. Inc., and Silica Products Co. Inc. sold its mining and processing facility at Guion to Unimin Corp. of New Canaan, CT.

In the metals sector, Nucor-Yamato Steel Co. began production at its new minimill at Blytheville, the Stratcor vanadium roasting plant at Hot Springs resumed operations, and Reynolds Metals Inc. donated its closed reduction plant at Jones Mill to Hot Springs County.

EMPLOYMENT

According to records issued by the Arkansas Employment Security Divi-

TABLE 1

NONFUEL MINERAL PRODUCTION IN ARKANSAS[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Abrasives[2]	short tons	W	W	W	W	1,235	$429
Clays	do.	[3]974,373	[3]$8,998	908,394	$8,651	930,863	15,376
Gem stones		NA	522	NA	1,800	NA	2,300
Sand and gravel:							
Construction	thousand short tons	8,571	26,999	e7,200	e23,900	7,722	26,201
Industrial	do.	400	3,975	505	5,147	669	6,784
Stone:							
Crushed	do.	e15,500	e58,500	15,234	63,847	e17,100	e70,100
Dimension	short tons	e5,145	e305	10,541	629	e10,541	e629
Combined value of bauxite, bromine, cement, clays (fire clay 1986), gypsum, lime, talc and pyrophyllite, tripoli, and values indicated by symbol W		XX	r163,708	XX	160,188	XX	184,970
Total		**XX**	**263,007**	**XX**	**264,162**	**XX**	**306,789**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

[3] Excludes certain clays; kinds and values included with "Combined value" data.

sion, primary metals employment in 1988 was up 19% as the new steel mill came on-line near Blytheville. Employment in the stone, clay, and glass sector was up 5.1%. Mining employment increased 6.1%.

LEGISLATION AND GOVERNMENT PROGRAMS

The Arkansas Legislature meets biennially and thus did not convene in 1988. In 1987, the Legislature passed Act 793, which created a Diamond Mining Advisory Task Force to study the feasibility of commercial mining at the Crater of Diamonds State Park. Late in 1988, the Task Force recommended that geologic testing be carried out to determine whether or not mining on a commercial scale was feasible.

The Geology and Land Survey Divisions of the Arkansas Geological Commission (AGC) responded to over 4,000 requests for geologic-related information during the year. The AGC continued cooperative work with the U.S. Geological Survey on several projects, including the Gamma Ray and Neutrino Detector program (GRANDE), Conterminous United States Mineral Assessment Program (CUSMAP), and the Cooperative Geologic Mapping Program (COGEOMAP).

The abandoned Chamberland Creek barite mine near Hot Springs was selected as the site for the world's largest gamma ray and neutrino detector. The AGC conducted a hydrological study of the site and ordered a magnetic survey of the mine to develop data for design purposes.

AGC staff continued to add to the State's well sample library, and efforts were underway to obtain funding to expand the facility. Work continued on the CUSMAP program to evaluate the mineral resources of the Harrison 1 degree by 2 degree quadrangle. Maps were also prepared for the Midcontinent Strategic and Critical Minerals project.

Hydrogeology studies on ground and surface water quality and quantity were ongoing as the demand for water quality information increased. Work continued on the COGEOMAP program to evaluate the economic potential of the Ouachitas in Arkansas. In 1988, emphasis was placed on geological mapping.

Commission geologists were involved in several activities, including chairing the Arkansas Earthquake Advisory Council and acting as advisors for various regulatory agencies. Advisory work included reviewing mine and reclamation plans and landfill permits and providing counsel to the Arkansas representative to the Central Low Level Radioactive Waste Compact Commission.

U.S. Bureau of Mines employees reviewed several environmental impact statements prepared by Federal and State agencies concerning planned construction in the State. The reviews were undertaken to ensure that existing mining operations and mineral reserves would not be adversely affected by additional construction activity.

The U.S. Office of Surface Mining funded a $164,000 project to reclaim mined land for Franklin County. Work on the project, which was completed at yearend, included "partially filling a large water-filled pit . . . constructing an earthern dam . . . fencing portions of the highwall . . . smoothing spoil piles." Topsoil was spread on the smoothed areas and vegetation planted.[3]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Arkansas' industrial minerals sector mined or manufactured 14 industrial mineral commodities. The annual report of the Arkansas Department of Labor noted 225 mines and quarries active in 1988; 215 of these produced industrial minerals.[4]

Abrasives (Natural).—Arkansas ranked second among the four States producing natural silica abrasives in 1988. Novaculite, a dense, hard, fine- grained, high-silica stone, was mined in Garland and Hot Springs Counties. Several grades of novaculite were produced. Run-of-mine material was cut into 2-, 4-, or 6-inch blocks by diamond saw and then cut into smaller sizes and shaped for final finishing. The final finishing step was done on iron laps, producing whetstones, hones, scrapers, and files. Uncut novaculite was marketed in Europe and Japan, and several Arkansas firms purchased run-of-mine stone to produce finished products. Output increased significantly; there was a modest increase in value.

During the year, Smith Whetstones Inc. expended $200,000 on its facilities in Hot Springs.

Bromine.—Arkansas continued as the Nation's leading bromine producer. In terms of value bromine was the leading mineral commodity produced in-State. Bromine occurs as sodium bromine in brines underlying the south-central part of Arkansas in Columbia and Union Counties. The Arkansas brines, which occur at depths of approximately 8,000 feet, contain up to 5,000 parts-per-million of extractable bromide. The bromine-bearing brines are recovered through wells drilled to the brine horizons. Both output and value increased substantially over that reported for 1987.

Columbia County producers included the Ethyl Corp., the largest bromine producer in the Nation, and Dow Chemical U.S.A. Union County producers included Arkansas Chemicals Inc. and Great Lakes Chemical Corp.

Bromine industry expansions included $1.1 million by Arkansas Chemicals Inc. in El Dorado, $12.5 million by Ethyl Corp. at two plants in Magnolia, and $50.5 million by Great Lakes Chemical Corp. at both its plants in El Dorado.

Dow's clear brine fluids business was

acquired by Tetra Technologies Inc. at midyear. Included in the sale were a 120-million-pound-per-year calcium bromide plant in Magnolia; all patents, technology, and production expertise; and brine reserves projected to last 15 years. Clear brine fluids were used in the oil and gas industries as drilling and completion media. Tetra planned to supplement the calcium bromide capacity of the plant with zinc, sodium and potassium salts, and custom-formulated clear brine fluids. The clear brine fluids operation was part of a 1987 consent decree under which the U.S. Department of Justice allowed Ethyl Corp. to purchase other bromine assets of Dow.

Cement.—Two companies produced both masonry and portland cement at plants in Saratoga and Foreman. The two companies operated a total of five kilns and used the wet process to manufacture cement from materials mined locally. Masonry shipments and value declined below the 1987 level; the output of portland cement increased, but value was below that reported for the previous year. Portland cement value ranked third among the 15 mineral commodities produced in Arkansas.

Clays.—Arkansas ranked 18th among the 46 clay-producing states; both common clay and/or shale and kaolin were mined. Output of both clay types increased over 22,000 short tons, and value rose almost $7 million over the levels reported by the State's clay producers in 1987.

Common clay was mined by 7 companies from 14 pits in 9 counties. The leading counties, Hot Springs, Crittenden, and Montgomery, accounted for almost 59% of the total common clay and shale production. End uses reported by the industry were primarily heavy clay products, such as facebricks, and expanded lightweight aggregate materials.

Kaolin was mined by three companies at six pits in Pulaski County. Sales included both unprocessed and calcined kaolin used by the refractories and chemical industries, respectively.

During the year Acme Brick in Malvern completed an $800,000 plant expansion.

Gem Stones.—Park authorities at the Crater of Diamonds State Park in Pike County reported that, in 1988, visitors found 1,280 diamonds, as compared with 959 diamonds found in 1987. Total weight amounted to 185 carats. Of the diamonds found, 17 weighed over 1 carat. The colors of the diamonds collected during the year included white (762), yellow (247), brown (246), and others (25).

During the year, the State's Diamond Mining Advisory Task Force continued to consider the feasibility of opening a commercial diamond-mining operation at the Crater of Diamonds Park. The Task Force recommended, and the State Parks, Recreation, and Travel Commission accepted, a plan to proceed with the first phase of a drilling program to test the geology of the area. Costs of the exploration would not exceed $350,000 and would be borne by mining companies in exchange for test results and the opportunity to bid on any resulting contract to mine. In 1989, before testing, the State Parks Division would seek approval from the U.S. Department of the Interior, because Federal funds were used for park development. Further action was not expected until approval was received.

Gypsum.—Arkansas was 1 of 21 States reporting gypsum production; in 1988, the State ranked ninth. Two companies, Weyerhaeuser Co. and Harrison Gypsum Co. Inc., produced gypsum from surface mines; the former calcined gypsum for wallboard manufacture, and the latter sold gypsum for use in cement manufacture. A third company, Temple Inland Forest Products Corp., purchased gypsum mined in Okalahoma for use in wallboard manufacture. Production and value of gypsum mined in-State decreased for the second consecutive year.

Lime.—One company, Arkansas Lime Co., located in Independence County, produced both hydrate and quicklime using local limestone as a raw material. Production had been on a gradual decline since the mid-1970's; newer plants in surrounding States manufactured and shipped lime to Arkansas' industries at a lower cost.

Quartz.—Quartz crystals were mined by many small operators for gem collections and for use as "transmitters of tranquillity" and "basic good luck." Demand remained strong even though increased imports from South America depressed prices. By late in the year, high-grade material, which represented 10% to 20% of mine run, remained at $100 per pound. Prices for medium to low-grade crystals, however, fell from about $25 per pound to $10 per pound.[5]

To simplify mining operations while maintaining environmental protection, quartz crystals in the Ouachita National Forest were designated a salable mineral under Section 325 of the Interior Appropriations Act. The mineral will now be administered by the Forest Service, as is the case with other common-variety materials.[6]

Sand and Gravel.—Both construction and industrial sand and gravel were produced in Arkansas in 1988. Production increased 686,000 short tons over that estimated for 1987.

Construction.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

Compared with 1986, the last year the U.S. Bureau of Mines conducted a full national survey of construction

sand and gravel companies, 1988 production and value in Arkansas both decreased. However, production increased 500,000 short tons and the value rose $2.3 million when compared with 1987 estimates. The industry consisted of 51 companies operating 67 pits in 35 counties. Production was centered in Little River, Ouachita, and Pulaski Counties.

Tri States Sand and Gravel Co. was sold to Gifford-Hill and Co. Inc. Included in the sale was the plant in Delight, AR.[7]

Arkansas construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data for this commodity in the three Arkansas districts. District 2 accounted for over 60% of the value of production.

Industrial.—The State ranked sixth nationally among the 37 States reporting industrial sand and gravel output. Production increased 164,000 tons over the 1987 level, and value was $1.6 million above the previous year's sales.

TABLE 2

ARKANSAS: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	3,631	$12,211	$3.36
Plaster and gunite sands	2	W	W
Concrete products (blocks, bricks, pipe, decorative, etc.)	90	253	2.81
Asphaltic concrete aggregates and other bituminous mixtures	329	1,170	3.56
Road base and coverings	516	1,432	2.78
Fill	84	221	2.63
Snow and ice control	W	W	4.90
Other	72	237	3.29
Unspecified:[1]			
Actual	1,813	7,094	3.91
Estimated	1,184	3,584	3.03
Total[2] or average	**7,722**	**26,201**	**3.39**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[2] Data may not add to totals shown because of independent rounding.

TABLE 3

ARKANSAS: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	1,145	3,048	2,435	9,064	144	361
Asphaltic concrete aggregates and other bituminous mixtures	105	274	224	896	—	—
Road base and coverings	234	827	176	330	106	275
Fill	W	W	W	W	—	—
Snow and ice control	W	W	—	—	—	—
Railroad ballast	—	—	—	—	—	—
Other miscellaneous	135	407	21	41	—	—
Other unspecified[2]	145	574	1,964	6,183	889	3,921
Total[3]	**1,764**	**5,130**	**4,819**	**16,513**	**1,138**	**4,558.00**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for plaster and gunite sands.
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

The State's industrial sand industry consisted of five companies operating five pits in five counties. Principal sales were to the foundry, glassmaking, and blasting (abrasive) industries.

Silica Products Inc., which produced sand for the glass and foundry industries, sold its mining and processing facility at Guion to Unimin Corp., the Nation's largest silica producer, with 20 operations in 13 States.[8]

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—In 1988, Arkansas ranked 26th among the 48 States, in crushed stone production. The value ranked 2d among the mineral commodities produced within the State during the year. In 1987, the last year that complete production data were reported by industry, 36 companies operated 49 quarries to produce 15.2 million short tons of stone valued at $63.8 million. The 1988 estimated production exceeded that of 1987 by almost 2 million tons and $6 million.

The leading stone types produced in descending tonnage were as follows: granite, 5.8 million short tons (38%); sandstone, 4 million short tons (27%); limestone, 3.7 million short tons (24%); and dolomite, slate, and "other" stone types, which accounted for the remainder.

Granite was produced by six companies in Pulaski and Pope Counties. Sandstone was produced by 15 firms operating 15 quarries in 13 counties; Crawford, Sebastian, and Pulaski were the leading counties. Limestone was produced by 15 companies operating 24 quarries in 14 counties. The leading sandstone-producing counties were Little River, Independence, and Pope. Dolomite output was reported from Lawrence County, slate from Saline, and "other" stone from Crawford, Garland, Montgomery, and Saline Counties.

The five major end uses for crushed stone reported in 1987 were (1) graded road base (2,338 million short tons), (2) cement manufacture (tonnage withheld), (3) rip rap and jetty stone (749,000 short tons), (4) bituminous aggregates (710,000 short tons), and (5) concrete aggregates (561,000 short tons).

Dimension.—The production of dimension sandstone was reported by three companies with three quarries in Independence, Logan, and Sebastian Counties. The only end use reported was cut and veneer stone. Output and value were estimated to be the same as in 1987, when 10,500 short tons valued at $629,000 was produced.

Sulfur (Recovered).—Arkansas was 1 of 26 States with sulfur recovered as a byproduct of other industrial processes. MKP Operating Co. in Lafayette County recovered sulfur as part of the petroleum refining process at its McKamie facility. The Ethyl Corp. recovered sulfur during bromine extraction from brine obtained from deep wells in Columbia County.

Talc.—The Milwhite Co. mined talc from the Congo surface mine in Saline County near Benton in central Arkansas. Ore was trucked to the Bryant mill where it was processed for sales to the ceramics and paper industries. There was a four-fold increase in tonnage mirrored by a similar but slightly smaller increase in value. The increase in output and value was due to a shift in major markets; previously, the company had sold to the roofing and insulation industries.

Tripoli.—Tripoli, a microcrystalline silica, was produced in Arkansas, Illinois, Oklahoma, and Pennsylvania. The Arkansas deposit, located in the northwest corner of the State, was mined by openpit methods by Malvern Minerals Co. The output, generally finer grained than tripoli occurring in other States, was used primarily as a filler and an abrasive. Production and value fell slightly below the 1987 levels.

Other Industrial Minerals.—Arkansas ranked seventh among the 13 States with synthetic graphite production. Two companies, Great Lakes Carbon Group and Superior Graphite Co., manufactured graphite electrodes at plants in Ozark and Russellville. Petroleum coke, obtained from oil refining, was the principal raw material used in electrode manufacture. Perlite was expanded by Strong-Lite Products Corp. at a plant in Pine Bluff utilizing raw material shipped in from New Mexico. Output and value decreased below the 1987 level. Principal sales were for concrete aggregate and horticultural applications. Vermiculite was exfoliated by two companies, Strong-Lite at Pine Bluff and W. R. Grace & Co. at North Little Rock, from material mined in South Carolina and other States. Exfoliated vermiculite was used for texturing paints and in aggregates, insulation, agriculture, and fireproofing.

METALS

The State's primary metals industry, which had expanded in recent years, remained a relatively small part of the State's industrial base. Recent growth in the iron and steel sector was offset by shutdowns in the aluminum industry.

Aluminum.—Reynolds Metal Co.'s Jones Mill reduction plant, closed in 1985, was donated to Hot Springs County for use as an industrial site. The plant, once a major producer of aluminum, was closed because of economic conditions.[9]

Bauxite.—Arkansas continued as the Nation's leading State in bauxite production. In 1988, output decreased slightly, though value was reported above the 1987 level. Two operations in Saline County mined bauxite for chemical purposes. Aluminum Co. of America (Alcoa) announced the closing of its

ARKANSAS

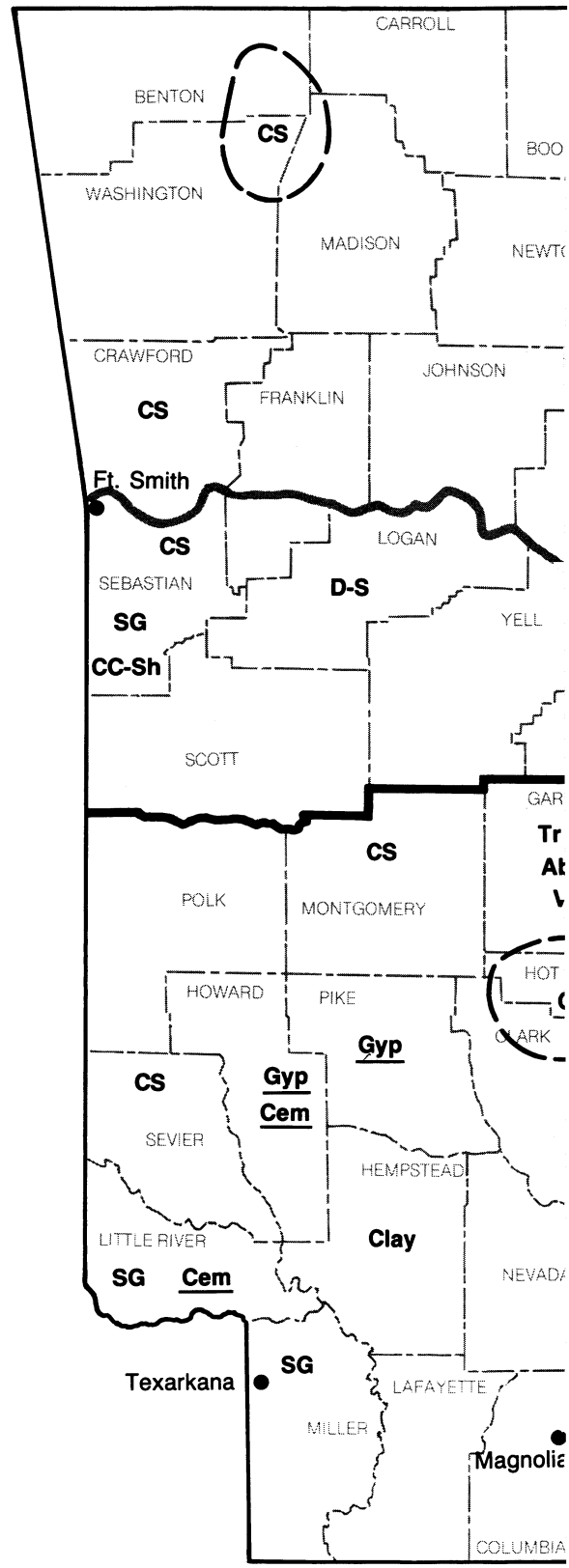
LEGEND

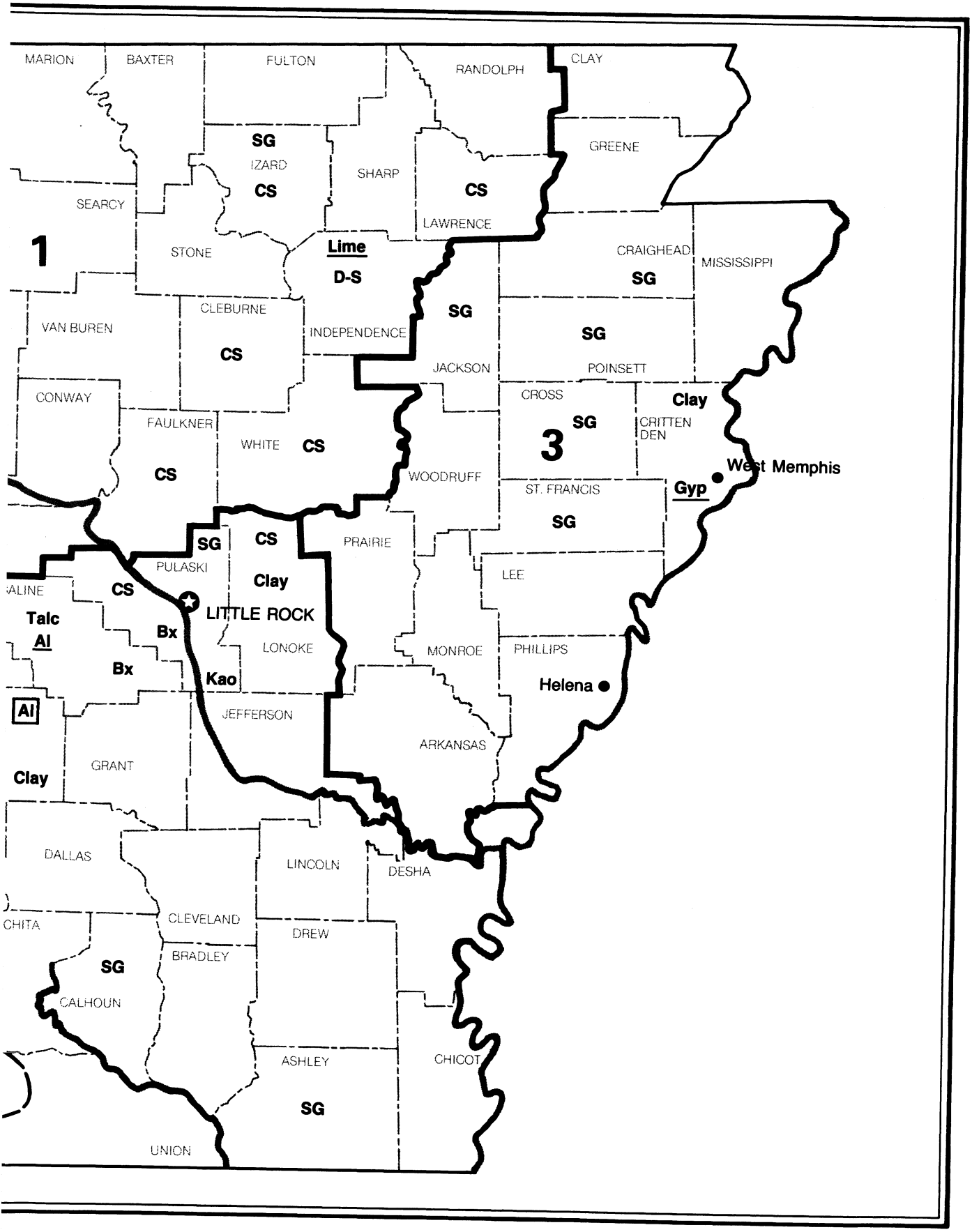
- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Abr	Abrasives
Al	Alumina plant
Al	Aluminum plant
Br	Bromine plant
Bx	Bauxite
CC-Sh	Common Clay & Shale
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-S	Dimension Shale
Gyp	Gypsum plant
Kao	Kaolin
Lime	Lime plant
SG	Sand and Gravel
Talc	Talc minerals
Trip	Tripoli
V	Vanadium
	Concentration of mineral operations

Principal Mineral-Producing Localities

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CRAIGHEAD
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MISSISSIPPI
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JACKSON
POINSETT
CONWAY
CROSS
Clay
FAULKNER
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CRITTEN
DEN
WHITE
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WOODRUFF
West Memphis
ST. FRANCIS
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PRAIRIE
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LITTLE ROCK
Talc
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LONOKE
MONROE
PHILLIPS
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DALLAS
LINCOLN
DESHA
CLEVELAND
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BRADLEY
SG
CALHOUN
ASHLEY
CHICOT
SG
UNION

bauxite mining and alumina refining operations by October.[10] Late in the year, Alcoa delayed the shutdown until early 1989. The company retained a small mining and refining operation to supply the Norton Alcoa plant at Fort Smith. Alcoa's alumina chemical operation will continue, using alumina from Alcoa's facility at Point Comfort, TX.

Gold.—Developments were limited to exploration activities centered in the west-central part of Arkansas. During the year, one company reportedly held about 8,000–9,000 claims in the Ouachita National Forest in Polk and Montgomery Counties near Mena.[11] Geologists with the Arkansas Geological Commission were unable to verify gold in any samples collected in the area.

Iron and Steel.—Nucor-Yamato Steel Co. completed construction of its $175 million, 600,000-short-ton-per-year minimill near Blytheville on the Mississippi River.[12] The furnaces at the 700,000-square-foot mill were fired at midyear. Rolling of blooms into I-beams, flats, channels, and angles began in September. Full production was achieved by yearend.

Vanadium.—Strategic Minerals Corp. (Stratcor) resumed operation of its vanadium-roasting facility in Hot Springs. Roasting-plant feed consisted of stockpiled ore, refinery residue, fly ash, slags, and spent catalysts processed to produce a vanadium oxide. The company announced plans to reopen its vanadium mine early in 1989 to meet increased market conditions. The mine, closed for 3 years, was the only primary vanadium operation in the Nation.[13]

[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL.

[2] Assistant State geologist, Arkansas Geological Commission, Little Rock, AR.

[3] Paris Express Progress. Groundbreaking Set for Mining Reclamation Project. Mar. 21, 1988.

[4] Arkansas Dept. of Labor. 1988 Annual Report, 17 pp.

[5] USDA Forest Service Memorandum. Update to Quartz Crystals Market Conditions. Aug. 1, 1988, pp. 1–2.

[6] Hot Springs Village LaVilla. Federal Regulations Simplify Quartz Mining. Jan. 9, 1989.

[7] Pit and Quarry. Gifford-Hill purchased Tri State S & G Assets. Aug. 1988, p. 10.

[8] White River Current (Calico Rock). Silica Products Inc. Sold. Aug. 18, 1988.

[9] Pine Bluff Commercial. Reynolds Donates Aluminum Plant. Oct. 9, 1988.

[10] Aluminum Company of America News Release. Alcoa to Phase Out Mining and Refining Operations in Arkansas. Jan. 14, 1988.

[11] Evening Star (Mena). Questions Raised in Gold Operation Near Mena. Apr. 17, 1988.

[12] News-Times (El Dorado). Nucor Steel Plant Fires Up Furnaces. July 4, 1988.

[13] American Metal Market. Stratcor to Reopen Vanadium Mine. Dec. 22, 1988.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Abrasives:			
Oilstones and whetstones:			
Hiram A. Smith Whetstone Co. Inc.	1500 Sleepy Valley Rd. Hot Springs, AR 71901	Quarry	Garland.
Tripoli:			
Malvern Minerals Co. Inc.	Box 1246 Hot Springs, AR 71901	Mine	Do.
Bauxite:			
Aluminum Co. of America[1]	1501 Alcoa Bldg. Pittsburgh, PA 15219	Mine and plant	Saline.
American Cyanamid Co.	Berdan Ave. Wayne, NJ 07470	do.	Do.
Bromine:			
Arkansas Chemicals Inc.	Route 6, Box 98 El Dorado, AR 71730	Brine wells and plant	Union.
Dow Chemical U.S.A.	2030 Dow Center Midland, MI 48640	do.	Columbia.
Ethyl Corp., Arkansas Div.	Box 729 Magnolia, AR 71753	do.	Do.
Great Lakes Chemical Corp.	Box 2200 West Lafayette, IN 47906	do.	Union.
Cement:			
Arkansas Cement Corp., a subsidiary of Ash Grove Cement Co.[1]	Box 25900 Overland Park, KS 66225	Plant	Little River.
Ideal Cement Co., a subsidiary of Ideal Basic Industries Inc.[1]	Box 8789 Denver, CO 80201	do.	Howard.
Clays:			
Acme Brick Co., a division of Justin Industries Inc.	Box 425 Fort Worth, TX 76101	Pits and plants	Hot Springs and Sebastian.
Arkansas Lightweight Aggregate Corp.	El Dorado, AR 71730	Pit and plant	Crittenden.
Eureka Brick and Tile Co.	Box 379 Clarksville, AR 72830	Mine	Johnson.
A. P. Green Refractories Co., a subsidiary of USG Corp.	Box 6057 Little Rock, AR 77216	Pit and plant	Pulaski.
Gypsum:			
Harrison Gypsum Co. Inc.	Box 336 Lindsay, OK 73052	Mine	Pike.
Weyerhaeuser Co., Dierks Div.	Route 4, Box 78 Nashville, AR 71852	Mine and plant	Howard.
Lime:			
Arkansas Lime Co., a subsidiary of Rangaire Corp.[1]	Box 2356 Batesville, AR 72501	Quarry and plant	Independence.
Perlite:			
Strong-Lite Products Corp.	Box 8029 Pine Bluff, AR 71611	Plant	Jefferson.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Construction:			
The Beaver Group	Box 6657 Shreveport, LA 71136	Plants	Litte River, Pike, and Ouachita.
Boorhem-Fields Inc.	Box 2196 Little Rock, AR 72203	Pits and Plants	Calhoun, Craighead, Poinsett, St. Francis.
Jeffrey Sand Co.	4401 S 16th Circle Fort Smith, AR 72901	Pit and Plants	Faulkner, Pulaski, Sebastian.
Industrial:			
Gifford-Hill and Co. Inc.[2]	Box 6615 Shreveport, LA 71136	Pits	Miller.
Unimin Corp.	258 Elm St. New Canaan, CT 06840	do.	Izard.
Stone (1987):			
Granite:			
Freshour Construction Co. Inc.	Drawer AF Cabot, AR 72023	Quarry	Pulaski.
McGeorge Contracting Co. Inc.	Box 7008 Pine Bluff, AR 71611	Quarries	Do.
Minnesota Mining and Manufacturing Co.	3M Center, 223-4N-05 St. Paul, MN 55144	Quarry	Do.
Limestone:			
McClinton-Anchor Co., a subsidiary of Ashland Oil Inc.	Box 756 Fayetteville, AR 72701	Quarries	Benton, Madison, Washington.
Midwest Lime Co.	Box 2608 Batesville, AR 72501	Quarry	Independence.
Sandstone:			
Arkhola Sand and Gravel Co.,[1] a subsidiary of Ashland Oil Inc.	Box 1627 Fort Smith, AR 72901	Quarries	Crawford and Sebastian.
H M B Construction Co.	Box 5606 Texarkana, TX 75501	Quarry	Sevier.
Ben M. Hogan Co. Inc.[1]	Box 2860 Little Rock, AR 72203	Quarries	White.
M and M Rock Co. Inc.	Box 1190 Conway, AR 72032	do.	Faulkner, Perry, White.
Slate:			
Bird and Son Inc.	Drawer 151 Glenwood, AR 71943	Quarry	Montgomery.
Sulfur (recovered):			
Ethyl Corp., Arkansas Div.	Box 729 Magnolia, AR 71753	Sulfur recovered in bromine extraction.	Columbia.
Phillips Petroleum Co.	724 Adams Bldg. Bartlesville, OK 74004	Sulfur recovered as a byproduct of petroleum refining.	Lafayette.
Talc:			
The Milwhite Co. Inc.	Box 15038 Houston, TX 77020	Mine and plant	Saline.
Vanadium:			
Strategic Minerals Corp.	Route 6, Box 943 Hot Springs, AR 71901	Mine and mill	Garland.
Vermiculite (exfoliated):			
W. R. Grace and Co.	62 Whittemore Ave. Cambridge, MA 02140	Plant	Pulaski.
Strong-Lite Products Corp.	Box 8029 Pine Bluff, AR 71611	do.	Jefferson.

[1] Also produced limestone.
[2] Also produced construction sand and gravel in Ouachita County.

THE MINERAL INDUSTRY OF CALIFORNIA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the California Department of Conservation, Division of Mines and Geology, for collecting information on all nonfuel minerals.

By Fred V. Carrillo,[1] Brian E. Tucker,[2] and J. L. Burnett[3]

California ranked second among the States in the value of nonfuel minerals produced in 1988, just over 9% of the U.S. total. The value of the commodities produced increased by 6% to $2.709 billion, continuing the steady growth in the State's mineral industries since 1982. California led all States in the production of asbestos, boron minerals, portland cement, diatomite, calcined gypsum, construction sand and gravel, rare-earth metal concentrates, and tungsten ore and concentrates. The State ranked second nationally in the production of natural calcium chloride, byproduct gypsum, magnesium compounds from seawater, sodium compounds, and gold.

No-growth regulations and opposition to new mining permits impeded mining operations throughout the State. Activities of gold mining operations, sand and gravel quarries, and cement plants were halted or delayed. Initiatives to prohibit surface mining operations were proposed in El Dorado, Mariposa, and Tuolumne Counties, but were narrowly defeated in the fall elections.

TABLE 1

NONFUEL MINERAL PRODUCTION IN CALIFORNIA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Boron minerals	thousand short tons	1,251	$426,086	1,385	$475,092	1,267	$429,667
Cement:							
Masonry	do.	W	W	W	W	8	730
Portland	do.	9,490	578,502	9,937	593,859	10,423	601,152
Clays	short tons	[2]2,249,136	[2]33,289	2,296,332	33,045	2,221,693	31,620
Gem stones		NA	418	NA	3,367	NA	3,365
Gold (recoverable content of ores, etc.)	troy ounces	425,617	156,729	602,605	269,937	721,512	316,246
Gypsum	thousand short tons	1,378	10,777	1,468	11,719	1,490	11,222
Lime	do.	371	24,187	465	25,745	699	30,356
Mercury	76-pound flasks	—	—	[3]	[3]	W	W
Peat	thousand short tons	W	W	W	W	2	119
Pumice	do.	46	1,263	42	1,539	35	1,245
Sand and gravel:							
Construction	do.	128,407	498,456	e141,600	e561,300	141,946	622,074
Industrial	do.	2,364	44,813	2,241	41,472	2,444	42,078
Silver (recoverable content of ores, etc.)	troy ounces	155,176	849	121,817	854	481,376	3,148
Stone:							
Crushed	thousand short tons	e38,500	e159,300	44,315	186,504	e49,100	e275,000
Dimension	short tons	e22,749	e2,582	33,335	4,554	e42,048	e5,991
Talc and pyrophyllite	thousand short tons	64	1,528	W	W	W	W
Combined value of asbestos, barite (1987–88), calcium chloride (natural), cement (masonry 1987–88), clays (ball clay 1986), copper (1986, 1988), diatomite, feldspar, iron ore (includes byproduct material, 1988), magnesium compounds, mercury 1988, molybdenum, perlite, potassium salts, rare-earth metal concentrates, salt, sodium carbonate (natural), sodium sulfate (natural), tungsten ore and concentrates, wollastonite (1986–87), and values indicated by symbol W		XX	330,638	XX	342,298	XX	334,755
Total		**XX**	**2,269,417**	**XX**	**2,551,285**	**XX**	**2,708,768**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

[3] Less than 1/2 unit.

TRENDS AND DEVELOPMENTS

Industrial minerals comprised 87% of the State's nonfuel mineral production value. In 1988, 36 mineral commodities, including 8 metals, were produced in California. A rising trend continued in mineral production and value as the State continued its economic expansion from a 1982 low.

Gold production increased by over 20% from that of 1987 to 721,512 troy ounces, continuing California's ranking as the second largest State among U.S. gold producers. Despite a drop in average annual price to $439, the value of gold produced in the State was $316.3 million. This figure was up $76.3 million from the value of 1987 gold production because most of the State's producers increased their output from the previous year. Most gold production continued to be from open pit projects in low-grade disseminated ore.

Construction sand and gravel, portland cement, and boron minerals were the State's most important mineral commodities in terms of value. Boron production declined by 9% from its 1987 record high, while portland cement and construction sand and gravel increased slightly, reflecting the continued, although slowing, growth of California's economy and the construction industry in particular.

EMPLOYMENT

According to the California Employment Development Department, approximately 9,600 workers were employed in nonfuel mining in California in 1988. Of these, 2,300 were employed in metal mining and 7,300 in industrial minerals mining.

REGULATORY ISSUES

Special elections held during the year in various areas of the California Mother Lode included ballot initiatives to ban or restrict surface mining operations. Mariposa County voters defeated "Measure B," which proposed to eliminate "strip and open pit mining" by establishing a 10,000-foot buffer zone adjacent to homes, hospitals, and schools. Voters in Amador City voted to ban surface mining operations and to require permits for all exploration.

LEGISLATION AND GOVERNMENT PROGRAMS

Legislation was passed (AB 747) requiring all existing surface mining operations with vested rights to have an approved reclamation plan by July 1, 1990. Also passed was Senate bill 2295, requiring joint multicounty hearings to appeal the tax assessment for mines located in more than one county.

The Bureau of Land Management (BLM) authorized construction of six major gold mining operations on public lands and reported a 32% increase in gold production from public lands, mostly from the southern California desert. BLM, with the assistance of the Bureau of Mines and Geological Survey mineral reports, completed wilderness reviews of more than 7 million acres in the State and recommended 2.3 million acres for wilderness designation and the release of 4.8 million acres for other multiple uses. BLM also reported 16,266 new mining claims filed during the year, bringing the total number of claims in the State to 150,000. Leasable mineral royalties in California (sodium, potash, boron) netted BLM $6 million in 1988.

The California State Mining and Geology Board and the Department of Conservation formed a task force to develop recommendations for more effective coordination of mining activities on Federal lands. The Board completed the designation of aggregate resources in the Fresno Production-Consumption Region and began the designation process for the Stockton-Lodi and Palm Springs Production-Consumption Regions. Four new Surface Mining and Reclamation Act (1975) (SMARA) classification reports were reviewed and transmitted to affected lead agencies.

The California Division of Mines and Geology prepared a comprehensive file of mines in California that are producing and intermittently producing. The objectives of the file were to create a mineral property data base and indexing system and to provide accurate data for assessing compliance with the SMARA. The file, named MOSS-FILE (Mining Operations Subject to SMARA) included approximately 1,100 active mines.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Asbestos.—Although California remained the Nation's leading asbestos producer, 1988 production decreased by 74%, continuing a 15-year downward national trend. Production was reported only from KCAC Inc.'s Joe Asbestos Mine near King City in San Benito County. Calaveras Asbestos Corporation's Copperopolis Mine in Calaveras County was closed during the latter part of 1987 and remained closed during the year.

Boron Minerals.—Sales of boron minerals valued at more than $429 million declined by 10% from those of 1987. Production of 1,267,000 short tons was reported from three operations during 1988. California continued to be the only domestic supplier of boron minerals, principally in the form of sodium borate.

The majority of the boron production continued to be from Kern County, with the balance from San Bernardino and Inyo Counties. United States Bo-

rax and Chemical Corp., a subsidiary of RTZ Corp. PLC of London, United Kingdom, continued to be California's largest producer and the primary world supplier of sodium borates. U.S. Borax mined and processed crude and refined hydrated sodium borates, their anhydrous derivatives, and anhydrous boric sodium acid at Boron in Kern County. A second plant at Boron produced technical-grade boric acid from U.S. Borax's extensive kernite ore reserves. The boric acid was produced to compete with imported colemanite used in glass manufacture. The majority of boron material was shipped to U.S. Borax's storage facility in Wilmington, CA, which also produced some boron specialty chemicals and borated soap products. Other boron compounds were used in fertilizers, herbicides, and wood preservatives.

Kerr-McGee Chemical Corp. produced borax and boric acid products from mineral-rich lake brines at the Trona and Westend Plants at Searles Lake in San Bernardino County. The Trona plant used a differential evaporative process to produce pentahydrate borax and anhydrous borax and a solvent extraction process to produce boric acid. The Westend plant continued production of sodium borates by a carbonation process that also produced lime, sodium carbonate, and sodium sulfate.

Mountain States Mineral Enterprises Inc. in Tucson, AZ, studied the boron market to determine if commercial development of the Fort Cody colemanite deposit in San Bernardino County would be feasible.

Cement.—Portland cement was California's second most valuable mineral commodity in 1988, with a reported value of more than $601 million. California's 10,423,000 short tons ranked first among States in the production of finished portland cement, furnishing 14% of the U.S. total. Although the national production of portland cement declined slightly in 1988, the State reported a 5% increase and continued to lead all other regions of the country in portland cement consumption because of the sustained level of construction in southern California. A small amount of masonry cement was also produced in the State during 1988. Eight of the eleven plants that continued to report cement production were in the southern half of the State. California continued to lead all States in clinker production, accounting for approximately 14% of the total. More than two-thirds of the clinker came from eight southern California plants.

CalMat Co. reached an agreement with Onoda USA, a subsidiary of Onoda Cement Co. Ltd. of Japan, giving Onoda an option to acquire CalMat's cement and ready-mix concrete operations in the Los Angeles metropolitan area. Kaiser Cement Co., a subsidiary of Hanson Trust PLC of the United Kingdom, sold its Lucerne Valley plant to Mitsubishi Mining and Cement Co. of Japan. Lone Star Industries formed a joint venture with RMC Group PLC of the United Kingdom to operate its Davenport plant. Monolith Portland Cement Co. sold its Monolith plant to Cimentaries CBR of Belgium.

Clays.—Production of 2,221,693 short tons of clay and shale valued at more than $31 million was reported in 1988 from 28 companies in 18 counties. Common clay and shale comprised the bulk of the clays produced, with nine companies reporting ball clay, bentonite, or kaolin deposits.

Diatomite.—California continued to lead all other States in diatomite production during 1988. As in previous years, the major producer was Manville Products Corp. from its operations near Lompoc in Santa Barbara County. Grefco Inc., Decalite Division, was the second largest producer with production from the Lompoc area supplemented with diatomite from its Burney plant in Shasta County.

Feldspar.—California ranked third nationally in the production of feldspar and feldspar-silica mixtures. Compared with 1987, feldspar quantity declined slightly while its value increased slightly. The production of feldspar-silica mixture was reported from U.S. Silica Company's San Diego County plant and California Silica Products Co.'s Orange County plant. Calspar Division of Steelhead Resources handcobbed feldspar at their San Bernardino operation.

Gypsum.—California continued to rank first nationally in the production of calcined gypsum, with a total 1988 output of 1,950,000 short tons, a slight increase from that of 1987. However, the State's total mined output of crude gypsum, 1,490,000 short tons, was ranked only fifth among the States.

Lime.—Lime production of almost 700,000 short tons in 1988 was 50% more than that of the previous year. Value increased by only 18% to $30,356,000. Chemstar Inc.'s Richmond plant in Contra Costa County was the State's largest producer, followed by National Refractories and Minerals Corp.'s Natividad quicklime plant in Monterey County. Production was reported from 11 plants in 9 different counties throughout the State.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

California construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. At the request of the State, the districts have been increased from 3 to 12, beginning in 1988. This redistricting will reflect better local markets and thus assist local governments in planning for and managing sand and gravel production activities and growth in their areas.

California remained the Nation's number one construction sand- and gravel-producing State with 1988 production of 141,946,000 short tons. Sand and gravel, valued at more than $622 million, was California's leading commodity in value, accounting for 23% of the State's 1988 total nonfuel mineral production value. CalMat Co., California Portland Cement, and Beazer/Gifford-Hill Inc. were the State's largest producers among the 168 companies reporting construction sand and gravel production.

RMC Industries Corp. of Decautur, GA, a subsidiary of RMC Group PLC of Seltham, United Kingdom, entered into a joint venture with Lone Star Industries and formed RMC LONESTAR of Pleasanton, CA. The new company operated eight sand and gravel pits in California.

Center Corp. acquired exclusive rights from Yuba Natural Resources, Inc. to mine aggregates from a deposit near Marysville. Center planned to build an aggregate plant on the site initially to serve the Sacramento market. Opposition to new permits for aggregate operations developed throughout the State, principally from nearby homeowners. The following operations were affected: Pleasanton Gravel Co.'s Livermore Quarry in Alameda County; the Azusa Rock Inc. Quarry in Fish Canyon, Los Angeles County; Granite Rock's Logan Quarry extension in Monterey County; the Rocklin Quarry in Placer County; Teichert Aggregates Blue Ravine aggregate and crushing plant east of Folsom in Sacramento County; Tri-City Aggregates Santa Ana River deposit in San Bernardino County; Palomar Aggregates Inc.'s Rice Canyon quarry in San Diego County; the North River Road Gravel Mine in San Luis Obispo County; Raisch Paving Company's San Bruno Canyon Quarry in Santa Clara County; and the Cache Creek deposit in Yolo County.

Industrial.—Industrial sand production of 2,444,018 short tons was reported from 11 operations in 9 counties. Four companies each produced more than 200,000 tons. Owens-Illinois Inc. was the State's largest producer. Industrial sand was used primarily in blasting, fiberglass manufacture, glass containers, and roofing granules.

Sodium Compounds.—California led the nation in natural sodium sulfate production during 1988 and was second in the production of sodium carbonate. Sodium sulfate production was from Kerr-McGee Chemical Corp.'s Westend plant. The company produced soda ash from its Arsus facility in San Bernardino County, where natural brines were pumped from Searles Lake. The nameplate capacity of the soda ash industry was reduced by 150,000 tons in January with the closure of the soda ash portion of Kerr-McGee's Westend facility.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data from 1987.

A comparison of the reported 1987 and estimated 1988 crushed stone production indicated a 5.9% growth in the Pacific region in which California is the major State. California's estimated crushed stone production of 49 million short tons was 11% higher than that of 1987.

English China Clay (ECC) of Exeter, United Kingdom, acquired Cyprus Minerals Co. of Denver, CO, and its calcium carbonate operations in the southern States. Included in this acquisition were significant California stone reserves.

Other Industrial Minerals.—California was the fourth largest barite-producing State, with all of its production reported from one stockpile operation near Sacramento. Natural calcium chloride production was reported from three operations

TABLE 2

CALIFORNIA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	47,607	$220,272	$4.63
Plaster and gunite sands	3,425	19,360	5.65
Concrete products (blocks, bricks, pipe, decorative, etc.)	1,355	7,177	5.30
Asphaltic concrete aggregates and other bituminous mixtures	19,822	96,830	4.88
Road base and coverings[1]	23,041	88,808	3.85
Fill	7,477	20,943	2.80
Snow and ice control	71	270	3.80
Railroad ballast	62	245	3.95
Other	2,464	12,933	5.25
Unspecified:[2]			
Actual	29,420	129,889	4.41
Estimated	7,201	25,348	3.52
Total[3] or average	**141,946**	**622,074**	**4.38**

[1] Includes road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

TABLE 3

CALIFORNIA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	246	1,174	440	1,926	1,663	7,176	5,863	27,198
Plaster and gunite sands	W	10	W	W	35	133	406	2,270
Concrete products (blocks, bricks, etc.)	W	15	—	—	W	W	W	W
Asphaltic concrete aggregates and other bituminous mixtures	347	2,867	248	1,566	351	1,581	4,572	22,757
Road base and coverings[1]	570	3,013	593	2,067	1,195	3,914	5,244	18,091
Fill	27	95	104	307	630	2,083	415	1,310
Snow and ice control	—	—	(2)	1	—	—	—	—
Railroad ballast	W	W	4	18	—	—	—	—
Other miscellaneous	15	5	33	235	239	980	151	445
Other unspecified[3]	163	518	400	1,393	1	13	1,683	7,215
Total[4]	**1,367**	**7,697**	**1,823**	**7,513**	**4,115**	**15,881**	**18,335**	**79,285**
	District 5		District 6		District 7		District 8	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	934	4,625	5,619	27,226	1,382	7,100	4,545	19,579
Plaster and gunite sands	W	W	W	W	W	W	126	616
Concrete products (blocks, bricks, etc.)	—	—	—	—	W	W	W	W
Asphaltic concrete aggregates and other bituminous mixtures	W	W	3,515	17,513	328	2,099	1,491	7,388
Road base and coverings[1]	547	2,421	1,698	7,622	401	613	3,643	13,554
Fill	W	W	1,043	2,474	800	1,771	374	897
Snow and ice control	W	W	—	—	—	—	W	W
Railroad ballast	12	43	W	W	—	—	W	W
Other miscellaneous	364	1,755	284	1,714	760	4,406	607	2,824
Other unspecified[3]	631	2,456	92	162	658	2,309	2,142	7,966
Total[4]	**2,487**	**11,299**	**12,251**	**56,711**	**4,330**	**18,297**	**12,928**	**52,825**
	District 9		District 10		District 11		District 12	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	11,598	50,817	460	1,639	13,507	62,366	1,349	9,446
Plaster and gunite sands	1,421	7,107	52	102	668	4,294	W	W
Concrete products (blocks, bricks, etc.)	371	1,554	W	W	W	W	121	1,547
Asphaltic concrete aggregates and other bituminous mixtures	3,258	11,250	370	1,478	4,255	22,082	977	5,655
Road base and coverings[1]	3,085	10,206	875	3,096	3,764	16,111	1,427	8,099
Fill	931	2,973	101	199	2,474	6,855	494	1,717
Snow and ice control	—	—	W	W	—	—	—	—
Railroad ballast	—	—	W	W	W	W	—	—
Other miscellaneous	700	3,177	22	68	201	864	977	6,658
Other unspecified[3]	10,651	41,616	720	2,293	14,592	62,092	4,889	27,205
Total[4]	**32,015**	**128,701**	**2,601**	**8,876**	**39,460**	**174,663**	**10,234**	**60,326**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."

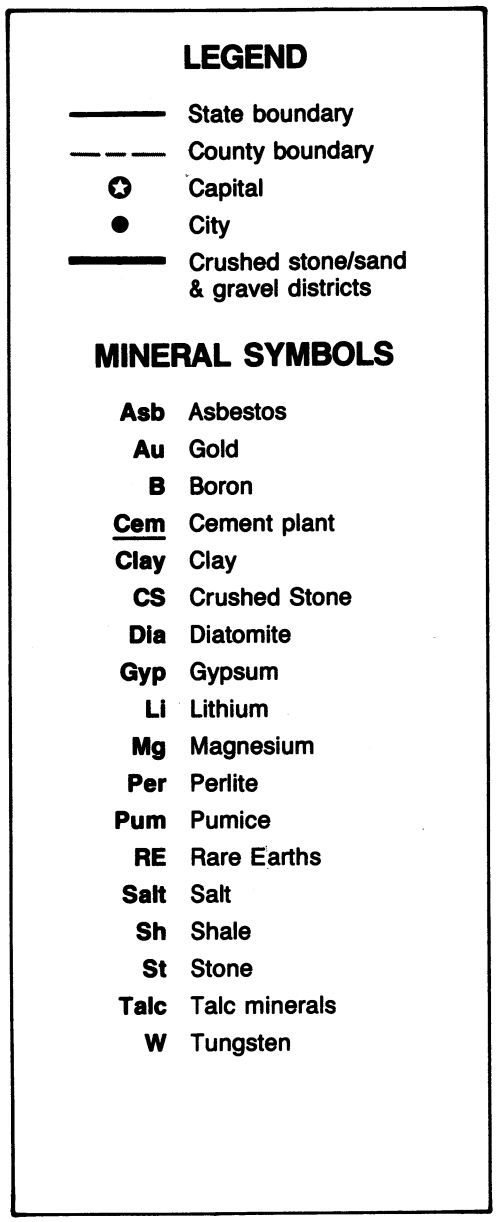
[1] Includes sand and gravel for road and other stabilization (cement).

[2] Less than one-half of a unit.

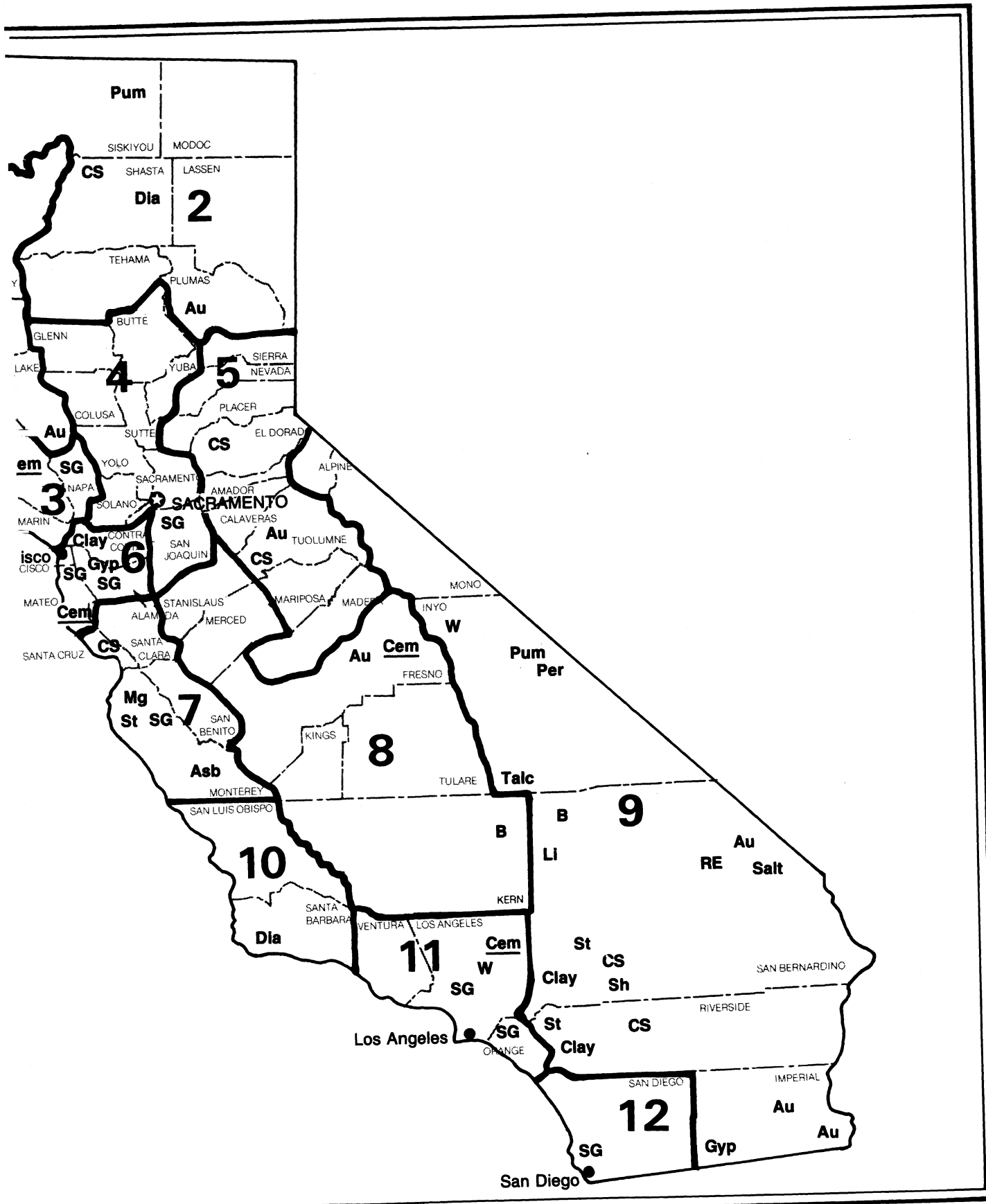
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.

[4] Data may not add to totals shown because of independent rounding.

CALIFORNIA



Principal Mineral-Producing Localities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in San Bernardino County. Two plants in Los Angeles County and one plant in Sacramento County produced synthetic graphite for cloth and fibers. Magnesium compounds were obtained from seawater magnesia operations in Monterey and San Mateo Counties.

Radel Inc., in Modoc County, was the only peat producer. Processed perlite production was reported from plants in Los Angeles, San Bernardino, and San Diego Counties. Kerr-McGee produced muriate of potash (60% K_2O) and sulfate of potash (50% K_2O) from plants in San Bernardino County.

California remained the third largest pumice-producing State despite a continuing slide in production to 35,000 short tons of pumice and pumicite (volcanic ash) sold in 1988. The State ranked sixth among the nine States reporting talc and pyrophyllite production from five mines in four counties.

Byproduct sulfur was recovered at 15 oil refineries in Contra Costa, Kern, Los Angeles, and Solano Counties.

Metals

Gold.—California produced 11% of the Nation's primary gold in 1988, making it the second largest producer in the Nation with 721,512 troy ounces of gold valued at $316,246,000. Although the rate of new mine openings slowed from the last few years, exploration and mine development continued in many of the State's historic gold-producing districts, especially in the Mother-Lode area and the southern desert regions.

Homestake Mining Company's McLaughlin Mine, near Clear Lake, at the junction of Napa, Yolo, and Lake Counties, was California's largest gold producer, with a record 205,257 ounces of gold. This production represented an 8% increase over that of 1987, reflecting the addition of new equipment and a 95% recovery rate. Installation of a new parallel oxide ore processing circuit at the McLaughlin mill was nearing completion at yearend.

Gold Fields Mining Corp.'s Mesquite Mine in Imperial County completed a $20 million expansion project with three new open pits. The opening of the Vista, Cherokee, and Rainbow pits, collectively called the VCR Project, was expected to increase ore throughput by 50%. A new heap-leaching area, completed near yearend, was also constructed as part of the expansion project.

Expansion at Cactus Gold Mines property in Kern County was expected to double gold production to 60,000 ounces annually. Royal Gold Inc.'s Sixteen-to-One Mine in Sierra County began commercial production in January, following completion of scheduled mine development and the renovation of the mill. Mother Lode Goldmines Consolidated began construction of a new 2,750-ton-per-day mill at the Royal Mountain King Mine near Copperopolis in Calaveras County. Construction at the Royal Mountain King project began in January with preliminary stripping at one of three open pits to be used to extract the gold by Meridian Minerals. Western Mining Corporation, a leading Australian nickel producer, bought and reopened the Carson Hill Gold Mine near Angels Camp in Calaveras County.

Gold exploration in the State increased as rising production encouraged further exploration. AMAX Gold Inc. and U.S. Gold Corp. entered into a joint venture agreement to explore and develop the Hayden Hill property in Lassen County. CoCa Mines Inc. explored additional targets at the Cactus Gold property in Kern County. Billiton Minerals U.S.A. Inc. conducted exploration work on properties controlled by Amerigold Inc. in San Bernardino County. Golconda Resources, Ltd. and Galactic Services, two Canadian companies, were granted permits for exploration drilling in Mono County. Drilling permits were also approved by the Mono County planning department for locations in the White Mountains and for the Masonic Mountain area. Queenstake Resources Ltd. explored the Davenport vein at their Argus gold project near Bakersfield. Amador United Gold Mines explored in four underground mines near Sutter Creek in Amador County.

Rare-Earth Metal Concentrates.—Rare-earth concentrate production from Molycorp Inc.'s Mountain Pass bastnasite mine in San Bernardino County declined to slightly over 1986 levels during 1988. Despite the decreased production, California remained the major U.S. producing State of rare-earth concentrates. Molycorp was the only domestic producer of the rare-earth, fluocarbonate-mineral bastnasite. Production of bastnasite concentrates decreased substantially in 1988, but remained the principal source of rare-earth production in the United States. Molycorp reported increased sales of almost all refined rare-earth and yttrium products, with the strongest demand coming from the permanent magnet and electronics industries. Molycorp completed installation of new facilities to produce high-purity cerium oxide and neodymium oxide at Mountain Pass as part of its continuing modernization and expansion program.

Silver.—Mined silver recovered in California during 1988 totaled 481,376 troy ounces, about 1% of the Nation's total mine production. The value of California's 1988 mined silver production increased by more than 200% from that of 1987 to about $3.15 million. The large increase resulted from additional byproduct silver from California's new gold producers.

Cactus Gold Mines Company began commercial production at its Kern County Shumake Mine in December. The mine was expected to produce about 40,000 gold-equivalent ounces of silver and gold.

Tungsten.—Strategic Minerals Corp. (Stratcor), a subsidiary of U.S. Tungsten Corp., reopened the Pine Creek Mine near Bishop in May. The mine had been closed for 2 years due to weak markets. Production from Stratcor's

Pine Creek plant remained the principal source of U.S. tungsten during 1988, with most of the ore continuing to be imported. The Curtis Mining Company's Andrew Mine in Los Angeles County began construction of processing facilities and anticipated production startup in 1989.

Other Metals.—Limited copper production, principally from the Iron Mountain Mine in Shasta County, resumed in 1988 after a 1-year hiatus. Byproduct copper from U.S. Tungsten Corp.'s Pine Creek tungsten operation in Inyo County was also reported. No lead or zinc production was reported in 1988.

[1] State Mineral Officer, Bureau of Mines, Reno, NV.

[2] Acting state geologist, California Department of Conservation, Division of Mines and Geology, Sacramento, CA.

[3] Geologist, California Department of Conservation, Division of Mines and Geology, Sacramento, CA.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Asbestos:			
Calaveras Asbestos Corp.	Box 127 Copperopolis, CA 95228	Surface mine and plant	Calaveras.
KCAC Inc.	Box K King City, CA 93930	do.	San Benito.
Boron minerals:			
Kerr-McGee Chemical Corp.[1]	Kerr-McGee Center Oklahoma City, OK 73125	Evaporators and plant	San Bernardino.
United States Borax & Chemical Corp.	Box 75128 Sanford Station Los Angeles, CA 90010	Surface mine and plant	Kern.
Calcium chloride:			
Leslie Salt Co., a subsidiary of Cargill Inc.[2]	Box 5621 Minneapolis, MN 55440	Solar evaporators	San Bernardino.
National Chloride Co. of America	Box 604 Norwalk, CA 90650	do.	Do.
Cement:			
CalMat Co.[3]	3200 San Fernando Rd. Los Angleles, CA 90065	Plants	Various.
Kaiser Cement Corp. (Mitsubishi Mining & Cement Co.)	300 Lakeside Dr. Oakland, CA 94612	do.	Do.
Southwestern Portland Cement Co.[4]	Box 937 Victorville, CA 93292	Plant	San Bernardino.
Clays:			
Excel Minerals Co.	Box 878 111 South La Patera Ln. Goleta, CA 93116	Pits	Kern.
Gifford-Hill & Co. Inc., Riverside Cement Co.[5]	Box 832 Riverside, CA 92592	do.	Various.
Lightweight Processing Co.	715 North Central Ave. Suite 321 Glendale, CA 91203	do.	Ventura.
Lincoln Clay Products Co.	Box 367 Lincoln, CA 95648	Pit	Placer.
Lone Star Industries Inc., Pacific Region, Santa Cruz plant[5]	11555 Dublin Canyon Rd. Pleasanton, CA 94566	Pit	Santa Cruz.
Port Costa Materials Inc.	Box 5 Port Costa, CA 94569	Pit	Contra Costa.
Diatomite:			
Grefco Inc.	3435 Lomita Blvd. Torrance, CA 90509	Surface mine and plant	Santa Barbara and Shasta.
Manville Products Corp.	2500 Miguelito Rd. Lompoc, CA 93436	do.	Santa Barbara.
Feldspar:			
California Silica Products Co.[6]	Box 249 31302 Ortega Highway San Juan Capistrano, CA 92693	do.	Orange.
U. S. Silica Co.	3231 Oceanside Drive Oceanside, CA 92054	Mine and plant	San Diego.
Gold:			
Gold Fields Mining Corp.[7]	HCR 75 Glamis 100 Brawley, CA 92227	Surface mine	Imperial.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Homestake Mining Co.[7]	650 California St. San Francisco, CA 94108	Surface mine and plant	Napa.
Gypsum:			
U.S. Gypsum Co.	Plaster City, CA 92269	do.	Imperial.
Lime:			
Chemstar Inc.[8]	901 Mariners Island Blvd. Suite 425 San Mateo, CA 94404	do.	Monterey.
National Refractories & Minerals Corp.	Box 1938 Salinas, CA 95039	do.	Do.
Perlite:			
American Perlite Co.	11831 Vose St. North Hollywood, CA 91605	Surface mine and mill	Los Angeles.
Pumice:			
U.S. Pumice Co.	20219 Bahama St. Chatsworth, CA 91311	Mine and mill	Mono.
Rare earths:			
Molycorp Inc.	Union Oil Center 461 South Boylston St. Los Angeles, CA 91017	Surface mine	San Bernardino.
Sand and gravel (construction):			
Beazer/Gifford-Hill Inc.	Box 832 Riverside, CA 92502	Pits	Do.
CalMat Co.	3200 San Fernando Rd. Los Angeles, CA 90065	do.	Various.
Granite Construction Co.	Box 900 Watsonville, CA 95077	do.	Do.
Owl Rock Products Co.	Box 330 Arcadia, CA 91006	do.	Do.
A. Teichert & Sons Inc., Teichert Aggregates	Box 15002 Sacramento, CA 95851	do.	Do.
Sand and gravel (industrial):			
Corona Industrial Sand Company	20125 Temescal Canyon Rd. Corona, CA 91719	Mill and mine	Riverside.
Owens-Illinois Inc.	Box 427 Ione, CA 95640	do.	Amador.
Unimin Corporation	258 Elm St. New Canaan, CT 06840	do.	Contra Costa.
Sodium compounds:			
Kerr-McGee Chemical Corporation	Box 367 Trona, CA 93562	Plant	San Bernardino.
Talc and pyrophyllite:			
Western Source Inc.	Box 280 San Andreas, CA 95249	Surface mine and mill	Calaveras.
Tungsten ore and concentrate:			
U.S. Tungsten Corp., a subsidiary of Strategic Minerals Corp. (Stratcor)[9]	Route 2 Bishop, CA 93514	Underground mine and plant	Inyo.
Vermiculite (exfoliated):			
W. R. Grace & Co.	1114 Avenue of the Americas New York, NY 10036	Plants	Alameda and Orange.

[1] Also lime, potassium salts, sodium carbonate, and sodium sulfate.
[2] Also salt.
[3] Also clays, gypsum, and iron ore.
[4] Also clays.
[5] Also cement and industrial sand.
[6] Also industrial sand.
[7] Also silver.
[8] Also magnesium compounds.
[9] Also molybdenum.

THE MINERAL INDUSTRY OF COLORADO

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Colorado Geological Survey for collecting information on all nonfuel minerals.

By Jane P. Ohl[1] and Mark W. Davis[2]

The value of nonfuel minerals produced in Colorado in 1988 was $364 million, a 2.4% decline from the value of production in 1987, according to the Bureau of Mines, U.S Department of the Interior. The State ranked 25th in the Nation and accounted for slightly more than 1% of the total U.S. nonfuel mineral value. Between 1985 and 1988, the reopening of several old precious-metals mines increased Colorado gold output 280%. Gold production in 1988, however, when compared with that of 1987, fell nearly 8% to about 165,000 troy ounces. Silver output declined less than 1%. Raw material treated at gold mines amounted to 3.8 million short tons in 1988, compared with 4.3 million short tons in 1987, largely because of reduced output at the Summitville and Sunnyside Mines.

TRENDS AND DEVELOPMENTS

Events in Colorado's mining industry during 1988 signified a general rising confidence in sustainable and profitable activities in both metal and industrial mineral mining. At mid-1988, AMAX Incorporated expressed confidence in a stronger molybdenum market by rehiring 15 employees at its Henderson facility. Some gold-mining firms, however, were limiting their participation in the economic upswing to development work and were forgoing production mining until gold prices rose. Copper, lead, vanadium, and zinc, none of them large-value commodities in the State, showed moderate-to-significant increases in price per unit. Average unit prices for gold and silver were down, due mainly to enlarged inventories and lower demand in the world market. Molybdenum was an exception to that price trend; inventories were down and the unit price had increased very slightly, so production was being revived to meet demand.

Denver once again was becoming a gold capital. More than 50% of U.S. gold production in 1988 was controlled by the three dozen companies of local, national, and international standing whose headquarters or major offices were in, or were moving to, the Denver metropolitan area. These firms included Newmont Mining Corp. (from New York City), Gwalia Resources Ltd. (of Perth, Australia), Nevada Goldfields Corp. (from Reno, NV), Placer Dome Inc. (of Vancouver, Canada), and Bond International Gold Inc. (of Australia), which relocated its exploration group from Tucson, AZ. These companies, found in Denver, desirable low-cost office space and a superior mining support structure, including research libraries, laboratories, air transportation facilities, and Federal Government offices related to mining and land management. Other major gold-mining companies with established offices in Colorado included AMAX Gold Inc., Homestake Mining Co., FMC Corp., and Echo Bay Mines Ltd.

International bidding for promising gold-mining companies involved Newmont Mining in a corporate takeover attempt of Britain's Consolidated Gold Fields PLC (a 49.3% owner of Newmont) by the Luxembourg-based Minorco S.A. (61% owned by Anglo

TABLE 1

NONFUEL MINERAL PRODUCTION IN COLORADO[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	242,333	$1,523	292,050	$1,763	272,790	$1,890
Copper (recoverable content of ores, etc.)	metric tons	W	W	W	W	898	2,386
Gem stones		NA	100	NA	100	NA	100
Gold (recoverable content of ores, etc.)	troy ounces	120,347	44,317	178,795	80,091	164,809	72,237
Sand and gravel (construction)	thousand short tons	23,233	70,095	e22,800	e84,300	21,566	69,882
Silver (recoverable content of ores, etc.)	troy ounces	644,574	3,526	860,562	6,033	854,413	5,588
Stone:							
Crushed	thousand short tons	e8,000	e30,700	8,045	33,465	e10,600	e42,400
Dimension	short tons	e3,600	e255	3,000	133	e3,450	e143
Combined value of cement, copper (1986–87), gypsum, lead, lime, molybdenum, peat, perlite, pyrites (1987), sand and gravel (industrial), tungsten (1986), vanadium, zinc, and values indicated by symbol W		XX	219,492	XX	167,104	XX	169,379
Total		**XX**	**370,008**	**XX**	**372,989**	**XX**	**364,005**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

American Corp. of South Africa Ltd. and DeBeers Consolidated Mines Ltd.). Consolidated Gold Fields officials claimed that a takeover by Minorco would imperil U.S. access to precious metals and strategic minerals vital to national security. Consolidated Gold Fields and Newmont Mining sued Minorco in New York Federal court in October 1988, claiming that Minorco's offer violated U.S. securities and antitrust laws. By the end of 1988, the takeover attempt had not been resolved.

Increasingly, in the development of construction material resources, an important hurdle to overcome is the reluctance of new and old residential communities to allow mining and quarrying in their vicinities. Legal proceedings in Boulder County in 1988 were typical of the problems encountered by mine and quarry operators. The crux of the legal battle in that county was whether or not local zoning laws applied to State-owned land. The debate continued into 1989.

Construction materials for the proposed new Denver airport, the E–470 beltway, and other projects in the northeastern quadrant of the State were estimated to require between 8 million and 12 million short tons of fine and coarse aggregates and portland cement during the construction period. The airport was to be completed within 3 to 5 years. The needs of the new airport alone, amounting to 11 million short tons of aggregates, would constitute an additional 3 to 4 million tons of demand each year of the construction period, cutting sharply into the already tight supply of aggregate production statewide.

On the Western Slope, seven uranium/vanadium mines were returned to production in 1987–88. The State's sole nuclear powerplant was to be shut down before June 30, 1990, however, because of continuing technological problems that have plagued the plant since its opening in 1976.

The Colorado Center for Advanced Ceramics was established at the Colorado School of Mines (CSM) in Golden. CSM had received a grant from its neighbor, the Coors Ceramics Co. of Golden, to endow seven laboratories to study the use of ceramics in superconductivity. Some of the newest superconductive mixtures were composed of bismuth, strontium, calcium, copper, and oxygen; others contained lanthanum. A few occurrences of minerals containing these elements are known in the State.

EMPLOYMENT

Nonfuel mining employment was estimated to be 5,100 in 1988, up from 4,900 in 1987, according to the Colorado Department of Labor and Employment. New gold projects accounted for most of the increase in mining employment. Among the State's 50 largest, publicly owned companies (ranked by total revenue), 8 were mining- or mineral-related and employed more than 2,700 people in Colorado, about 12% of the 50 companies' combined total employment of 23,350. The eight companies were AMAX Gold, CoCa Mines Inc., Cyprus Minerals Co., Ideal Basic Industries Inc., Manville Corp., Newmont Mining, Newmont Gold Co., and U.S. Gold.

REGULATORY ISSUES

Colorado received $4.55 million from Gulf + Western Industries Inc. to clean up the Eagle Mine site in Eagle County, one of seven mineral-related sites against which the State has gone to court to enforce cleanup. This payment brought to more than $13 million the State's total reimbursement from firms successfully sued under the Superfund laws (Comprehensive Environmental Response, Compensation, and Liability Act of 1980 [CERCLA]; Public Laws 96–510 and 99–499).

ASARCO Incorporated had been a defendant in litigation, under CERCLA and under State law, involving alleged hazardous substance releases at its Globe plant in Denver. Cadmium, lead, and other hazardous substances had been detected in soils around the plant. The litigation was suspended in 1987 when ASARCO agreed, among other points, to pay $625,000 in partial "response costs," to reimburse future response costs, and to negotiate settlement of other issues.

In the first step of another CERCLA cleanup effort near Leadville in Lake County, a $2 million pond and treatment system was being constructed to control hazardous waste spills into the Arkansas River from the Yak drainage tunnel and California Gulch. ASARCO had become a defendant in the Yak tunnel litigation in 1983, but additional entities had been enjoined since that date to participate in solving the cleanup problem.

The Governor signed into law House bill 1006, the State's, and also said to be the Nation's, first legal tool to hold polluters liable for the costs of cleaning up water they contaminate.

CRS Sirrine Inc. of Houston, TX, and Industrial Resources Inc. of Lakewood, CO, collaborated in the research and development of nahcolite as a means of reducing acid rain pollution. The proposed joint venture held Federal leases for nahcolite (naturally occurring sodium bicarbonate) and had developed extractive technology for bicarbonate preparation and fly ash disposal.[3]

EXPLORATION ACTIVITIES

Exploration continued around the historic mining camps of Breckenridge, Central City-Blackhawk, Cripple Creek, Idaho Springs, Lake City, Leadville, Ouray, and Silverton. Major projects that could come on-line as early as 1989–90 included Battle Mountain Gold Co.'s San Luis gold project in Costilla County and Nevada Goldfields' Empire gold, silver, and copper project in Clear

Creek County.[4] Litigation concerning the Empire project that developed between Nevada Goldfields and individual partners in the joint venture was settled; however, construction of the mine was put on hold until December 1989.

CoCa Mines of Denver and other co-owners of mineral rights in the Hardscrabble mining district, north of Silver Cliff in Custer County, completed core drilling and leased a proposed open pit silver project to Tenneco Minerals Co. of Lakewood, CO. Silver in the Hardscrabble district has been difficult to extract because of the presence of manganese.

Core drilling and analyses in the Independence Mountain area of Jackson County indicated the presence of "$150 million" worth of inferred mineral resources, including gold, silver, lead, zinc, copper, and yttrium, according to the companies involved, BHP-Utah International Inc. of San Francisco and Caprock Corp. of Denver.[5]

Old tailings piles were considered during 1988 as sources of gold and sometimes silver. Various firms showed an interest in extracting these metals from such piles near Colorado Springs. One firm proposed using a 10- to 15-mile-long pipeline to transport a slurry from the piles to a hydrometallurgical smelter east of town. By November 1988, however, the smelter had closed.

LEGISLATION AND GOVERNMENT PROGRAMS

The Governor revealed a nine-point program to boost Colorado's lagging mining industry. The proposed program required the State to review its regulatory process, streamline the permit process for small mines, recodify mining laws, promote the industry, establish a multi-State panel to review proposed Federal legislation, revise environmental cleanup requirements for old mines, and balance regulation reduction with environmental and public safety concerns. Some of these points became parts of Senate bills 128 and 162 and were enacted into law. The Governor also asked for the Department of Natural Resources to work with the Federal Government to establish less onerous royalty rates for mining operations on U.S. lands.

The State established a small-mine assistance program to simplify issuing permits to small mining operations. The program was coordinated by the Colorado Joint Review Process of the Department of Natural Resources.

The Colorado Mined Land Reclamation Board began its Mine Subsidence Protection Program on August 22. Under this program, about 7,500 houses that were built atop abandoned coal mines became eligible for insurance against subsidence damage.

Colorado legislators voted not to raise the severance tax on molybdenum to the scheduled 10 cents per ton, thus keeping the rate at 5 cents (House bill 1055). Colorado voters approved proposed laws exempting nonproducing, unpatented mining claims on Federal lands from county taxes and removing the 8-hour-per-day restriction on underground workers (Senate bill 72). The legislature was expected to vote favorably on these proposed laws in 1989.

The U.S. Congress approved a national charter for the National Mining Hall of Fame and Museum in Leadville, which is to become a repository of mining artifacts and serve the industry in educating the public about mining.

The U.S. Bureau of Mines and the U.S. Geological Survey reported on the mineral resources of wilderness study areas in Alamosa, Costilla, Delta, Gunnison, Huerfano, Moffat, and Montrose Counties.[6]

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Colorado metal mines were the source of copper, gold, lead, molybdenum, silver, vanadium, and zinc, a narrower variety of metals than in years past. As of early 1988, 40 State leases had been issued by the Colorado State Board of Land Commissioners and 112 permits for gold and other metal mining had been issued in 23 counties.

Copper.—Mines in El Paso, Lake, Mineral, Ouray, Park, and San Juan Counties reported copper production. Output was up nearly 8%, principally because the number of mines with byproduct copper in their ores doubled. The average price of copper increased more than 46% over 1987 levels, rising to $1.21 per pound. Colorado mines are not major contributors to the Nation's total copper output, ranking 8th of 12 producing States.

Gold.—More than 3.8 million short tons of ore was processed in 1988 to obtain 164,809 troy ounces of gold, but reported output was down nearly 14,000 troy ounces from the previous year. The average price of gold during 1988 was $438.31 per troy ounce, high enough to encourage a moderate amount of exploration and development in Colorado. Gold was produced from 13 gold-ore and gold-silver-ore lode mines and from 2 placer deposits. The largest producer was Galactic Resources Ltd.'s Summitville open pit heap-leaching operation in Rio Grande County. The State ranked 7th of 14 gold-producing States.

Galactic Resources foresaw only 2 more years of production at its seasonally operated Summitville surface mine. Summitville Consolidated Mining Co. Inc., a subsidiary of Galactic Resources, operated the facility. The company reported processing about 2.6 million tons of ore, which assayed 0.04 ounce of gold and 0.16 to 0.19 ounce of silver per ton. Output in 1988 amounted to about 66,000 troy ounces of gold, less than in 1987. The mine shut down on October 31 for the winter, having been open since mid-May. The carbon-in-pulp

plant and leach field operations continued through the cold season. The facility employed a 100-person work force, half of which was laid off during the winter season. A sizable portion of Rio Grande County's annual budget has been derived from the $2 million annual payroll at Summitville.

When operating costs at the Sunnyside Mine at Silverton in San Juan County exceeded the selling price of gold by about $12 per troy ounce, Echo Bay Mines entered into an agreement with Silver King Mines Inc. and Pacific Silver Corp., both of Salt Lake City, UT, in order to reduce costs and improve output. By late summer, costs were reportedly reduced by 50%, and the mine was being operated by Alta Gold Co. of Salt Lake City, a joint venture between Silver King and Pacific Silver. Echo Bay Mines retained a 40% interest in the operation. Alta Gold announced that, in an effort to reduce costs further at Sunnyside, an agreement had been reached effective November 1, 1988, with Washington Mining Co. (owner of the property and a subsidiary of Sharon Steel Corp.), in which Washington Mining would cease receiving lease and royalty payments and become a 33% partner in the Sunnyside. Further adjustments in administration made Washington Mining the operator of Sunnyside effective January 1, 1989. Sunnyside was the third largest gold producer in the State.

In Teller County, Cripple Creek and Victor Gold Mining Co. reportedly mined out the Portland Mine and the Proper Stopes. In anticipation of moving into another area in the Victor mining district, the company applied for and received approval to operate an open pit gold and silver mine along the Pharmacist Vein, north of Altman, in 1989. Cripple Creek and Victor is a joint venture between Texasgulf Minerals and Metals Inc. (a subsidiary of Elf Aquitaine Inc.) and Golden Cycle Gold Corp.; the venture was the second largest gold producer in Colorado in 1988.

ASARCO operated the Black Cloud Mine (Leadville Unit in Lake County) in which it and Resurrection Mining Co. each had a 50% interest in expenses and profits. In its 1988 annual report, ASARCO reported about 197,000 metric tons of ore milled at the Leadville Unit mill; average mill recovery was 85%. In decreasing order of metal value, production included more than 12,000 metric tons of zinc, more than 6,000 metric tons of lead, nearly 10,000 troy ounces of gold, more than 300,000 troy ounces of silver, and 51 metric tons of copper. Milled ore was transported by train from Lake County to the East Helena smelter in Montana.

The Camp Bird Mine joint venture of Chipeta Mining Corp. (a subsidiary of Western Mining Co. of Australia) and Royal Gold Inc. evaluated the feasibility of mining gold from the Monument claims (formerly the Chipeta vein). This project increased the number of exploration workers at the Ouray County mine and mill to 100, up from 6 in 1986. Mined gold output at the site, however, was not increased. The Camp Bird custom mill processed ore from other southwestern Colorado mines and extracted copper, gold, lead, silver, and zinc.

London Mine Venture, a joint venture between Cobb Resources Corp. and Boulder Gold Inc., began gold mining at its Park County London Mine after a decade of reconstruction, exploration, and development; the mine had been worked from 1874 to the 1940's. Mined ore, grading 0.3 to 0.5 ounce of gold per ton, was processed at the Silver State flotation mill near Alma.

Cambrian Gold Resources acquired American Rare Minerals' interest in the Rubie leach pad operation in the Cripple Creek-Victor mining district in Teller County.

Royal Gold and Montagu Mining Investments Ltd. of London, England, began evaluating the feasibility of reprocessing mill tailings at the 288-acre Gold Hill Mesa property in Colorado Springs, El Paso County. The tailings pile was thought to contain approximately 12 million tons, with an estimated grade of 0.04 ounce of gold per ton, according to Royal Gold's 1988 annual report.

Lead.—Lead was the principal metal in several mines that also coproduced gold and silver from Colorado lead-zinc ores. Output of lead decreased nearly 13% and its total value declined about 10% from 1987 levels. The average price of lead was 37 cents per pound, compared to 36 cents in 1987. Mines reporting lead production were the Black Cloud in Lake County, the 11th ranking lead-producing mine in the Nation, and the Sunnyside in San Juan County, the 12th ranking lead-producing mine.

About 95% of Black Cloud ore is extracted from veins and replacement bodies in the Mississippian Leadville Dolomite. The Sunnyside ores are in numerous narrow veins in the rim of the Silverton caldera.

Molybdenum.—Climax Metals Co. was formed as a subsidiary of AMAX in January 1988 and is, in turn, the parent of Climax Molybdenum Co. Output from Climax Molybdenum's Henderson underground mine in Clear Creek County amounted to 30 million pounds of molybdenum in concentrates, compared to 25 million pounds in 1987 and 35 million pounds in 1986, according to AMAX's 1988 annual report. Annual production capacity at the Henderson mine was 40 million pounds of molybdenum in concentrates. In mid-1988, the economic outlook was encouraging enough for the firm to return 5 employees to the Henderson mine and 10 to the mill. Henderson continued to reduce the cash cost of concentrate production and, for the third consecutive year, cost was below $2 per pound of contained molybdenum. According to the company's an-

nual report, the average price of molybdic oxide was $3.44 per pound in 1988. Molybdenum made its first positive contribution ($15 million) to AMAX's pretax earnings in 5 years, due to an improvement of about 10% in the western world's demand for the metal.

Climax Molybdenum took a write-down of its Climax underground mine in Lake County. The mine, which was also a source of tungsten and tin as well as molybdenum before closing in March 1987, was originally to have been allowed to fill with water, since the mine was expensive to maintain and labor intensive when in production. However, since the proposed flood level was also an old production and maintenance level, plans were revised and the mine was kept dry and ready for possible reopening. The open pit portion of the Climax Mine was estimated to contain 90 to 95 million tons of ore reserves. It had been in a care-and-maintenance status since August 1986. The recent strong recovery in the steel industry, which began in the latter half of 1987, led to an increase in demand for molybdenum during 1988 and a resultant reduction of excess molybdenum inventories. The Climax open pit mine was expected to reopen in mid-1989 if the price of molybdenum were to rise to at least $3.60 per pound. No production was recorded for 1988, compared with 2 million pounds from January through March 1987 and 11 million pounds from January through December 1986. Annual capacity at Climax was 25 million pounds of molybdenum in concentrates.

Ore from the Henderson Mine in Clear Creek County was transported by underground rail 15 miles to the firm's mill in Grand County. If the Climax surface mine reopens, its ore is to be processed at the Climax mill on Fremont Pass.

Silver.—Mine production of silver decreased in 1988 by 6,149 troy ounces; total value declined more than 7% from the previous year. Twelve of the 13 gold-producing mines also reported silver production. The leading silver mine was the Sunnyside in San Juan County.

Homestake Mining Co. shut down its Bulldog Mountain silver operation and ceased the exploration program in Mineral County that would have kept the mining claims valid, deeming exploration too expensive to pursue. Homestake reported that copper, gold, lead, and silver were extracted from inventory piles at the Equity Project in the county. Crown Resource Corp. of Denver planned to core drill 18,300 feet near the Bulldog site on the East Amethyst vein. The discovery of good ore at this site was expected to encourage future mining in the Creede area.

Vanadium.—Uranium-vanadium mines showed a marked increase in production, due to strong price increases for vanadium. Colorado Plateau ores were being milled at the White Mesa mill which is in Blanding, UT, and is co-owned by Umetco Minerals Corp. and Energy Fuels Nuclear Inc.

Zinc.—Mine output of zinc remained relatively unchanged in Colorado, but total value rose 44%. Severe production problems in Peru, which resulted in tight supplies, was partly responsible for the price per pound of zinc rising to reach a high of 72 cents by November 1988. The average price of zinc in 1988 was 60 cents, up 18 cents from 1987 levels. All of Colorado's zinc was extracted from underground mines operating on a year-round basis. Mines or mills reporting zinc output were the Black Cloud, Camp Bird, and Sunnyside.

Other Metals.—ASARCO's Globe plant, in its chemicals, manufacturing, and environmental services segment, produced cadmium metal; cadmium oxide, sulfide, and powder; "C.P. litharge" (chemically pure lead oxide); zinc; and arsenic. Materials were transported to Globe from ASARCO's El Paso, TX, smelter. Production capacity at the Globe plant was more than 60,000 pounds of cadmium per month. Full-time employees numbered 65, compared to a peak of 180 in the 1950's and 1960's. The plant has been cause for much concern in the north Denver community since detection of pollutants in nearby waters and soils and other environmental problems. The Colorado attorney general sued ASARCO in 1983, demanding a cleanup. As a result of the State action, the company built a $750,000 wastewater treatment plant and a fence shielding nearby homeowners from an industrial drainage ditch. ASARCO also agreed to pay $600,000 as compensation for Colorado's past, and expected future, health actions at the smelter.

Industrial Minerals

Mined industrial mineral products were clays, gem stones, crude gypsum, lime, peat, perlite ore, construction and industrial sand and gravel, and crushed and dimension stone. The combined values of industrial minerals equaled 45% of the total Colorado nonfuel mineral value in 1988.

Cement.—Portland and masonry cement production and value from the State's three cement plants decreased slightly in 1988; this downward trend has continued since 1985.

Both wet-process and dry-process kilns were operated in the State. Raw materials consumed included limestone and sandstone.

Finished portland cement was sold, in decreasing order, to ready-mixed companies (68% of sales), highway contractors, concrete product manufacturers, building materials dealers, other contractors and customers, and government agencies. Portland cement was transported by rail (82% of shipments) and truck from plant to terminal, largely by bulk, but some in containers.

Masonry cement was produced at Ideal Basic's portland plant at Canon City in Fremont County and at South-

COLORADO

LEGEND

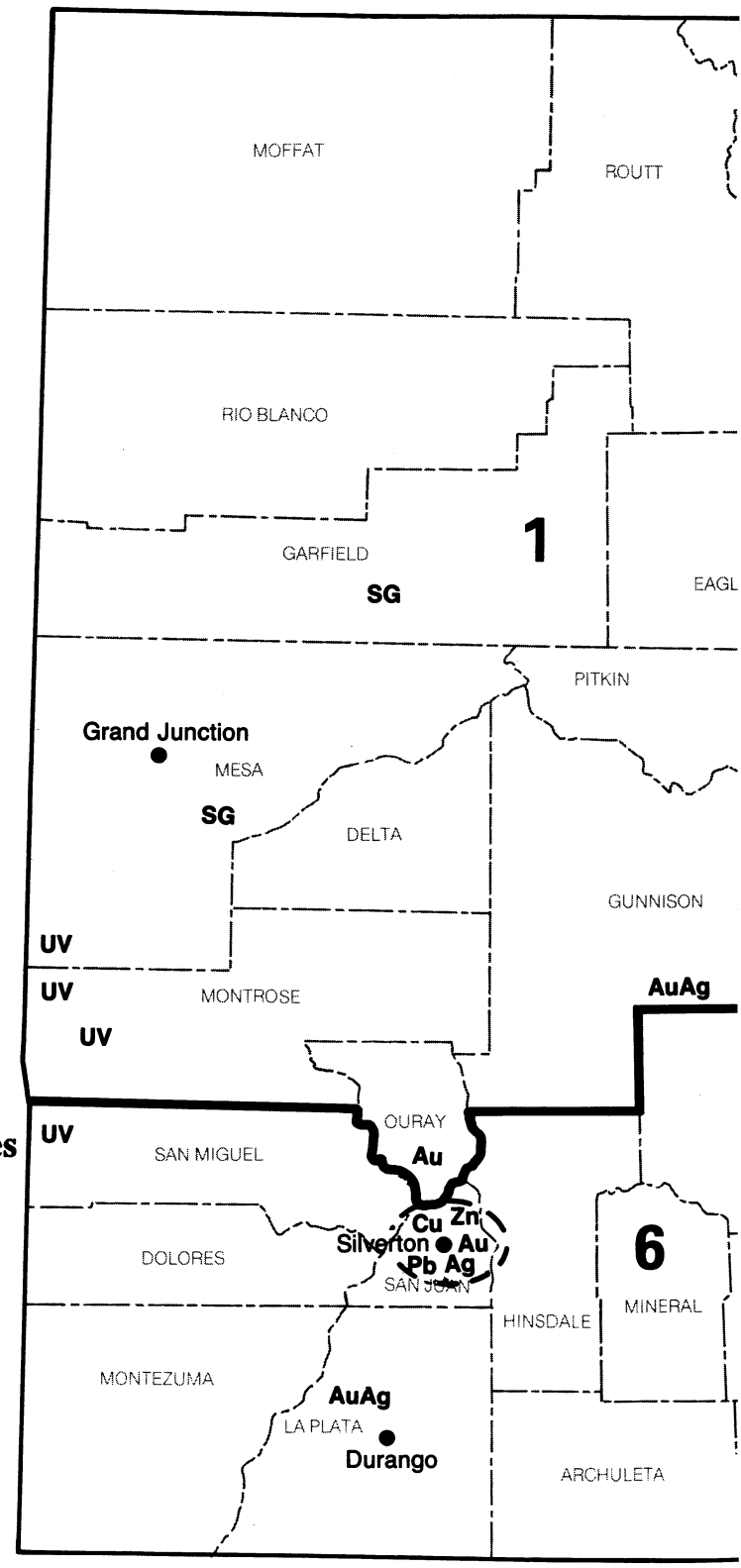
- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

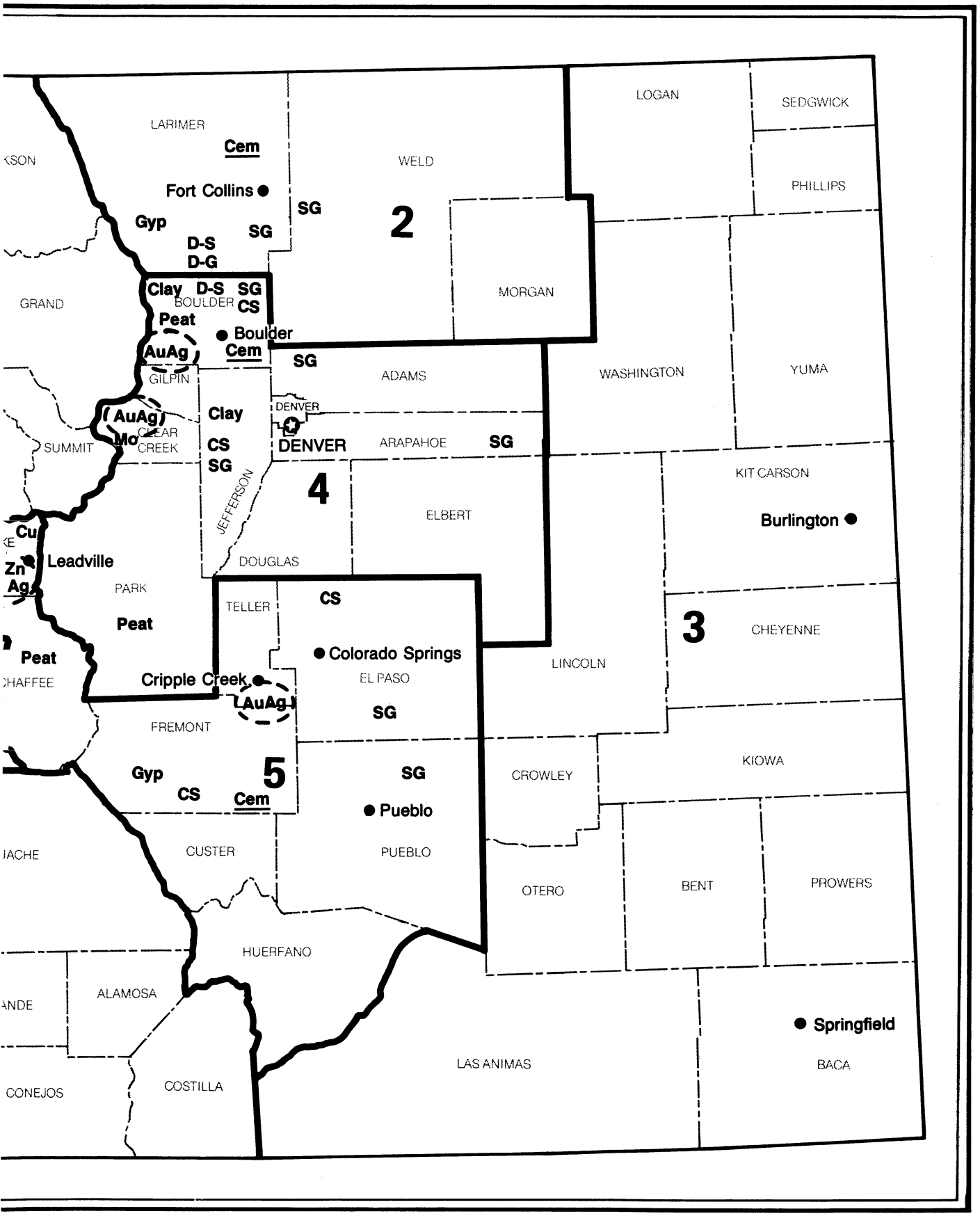
MINERAL SYMBOLS

AuAg	Gold-Silver
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper
D-G	Dimension Granite
D-S	Dimension Sandstone
Gyp	Gypsum
Mo	Molybdenum
Pb	Lead
Peat	Peat
SG	Sand and Gravel
UV	Uranium-Vanadium
Zn	Zinc

Concentration of mineral operations

Principal Mineral-Producing Localities

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BOULDER CS
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AuAg
Clay
DENVER
Mo
CLEAR CREEK
CS
SG
DENVER
ARAPAHOE
SG
SUMMIT
JEFFERSON
4
ELBERT
KIT CARSON
Burlington
Leadville
DOUGLAS
PARK
TELLER
CS
3
CHEYENNE
Peat
Peat
Colorado Springs
EL PASO
LINCOLN
Cripple Creek
AuAg
SG
FREMONT
KIOWA
Gyp
CS
Cem
5
SG
Pueblo
CROWLEY
CUSTER
PUEBLO
OTERO
BENT
PROWERS
HUERFANO
ALAMOSA
Springfield
LAS ANIMAS
BACA
CONEJOS
COSTILLA

western Portland Cement Co.'s plant at Lyons in Boulder County. Output, total value, and average price were down from 1987.

Ideal Basic's Boettcher cement plant in Larimer County has been undergoing a fourth modification since 1928. When modifications to the plant are completed in 1989, the plant is to use a limestone from E bands 1, 2, and 3 in the Niobrara Formation, in a quarry close to the cement plant. Combined E-band reserves should last for 75 to 100 years. Boettcher capacity was 600,000 tons of cement per year, compared with its plant at Canon City, which has a 1-million-ton-per-year production capacity.

Clay.—Clay output was down as compared with 1987, but total value increased from $1.8 million to $1.9 million in 1988. Colorado clay pits produced bentonite (nonswelling and swelling), common clay, fire clay, and kaolin. Bentonite output and total value increased very significantly over figures for 1987, but the State's bentonite production represents less than 1% of the Nation's total output. Fremont County and Elbert County pits were the sources of swelling and nonswelling bentonite, respectively. Common clay was produced in Boulder, Douglas, El Paso, Elbert, Fremont, Jefferson, and Pueblo Counties. Fire clay production, last reported in 1986, was extracted from pits in Fremont and Pueblo Counties. The average unit value of all types of clays produced in the State was $6.93 per short ton.

Gypsum.—Crude gypsum production was estimated to have fallen 10% from 1987 levels. The agricultural community and the U.S. Soil Conservation Service have used small gypsum blocks buried in the soil to measure moisture content and to reduce ground water pollution, soil erosion, and salt buildup. A study published in 1988 by the Rocky Mountain Institute in Snowmass, CO, concluded that such an inexpensive method of water conservation could raise water availability to a level higher than that expected from Denver's proposed Two Forks Dam-Reservoir.[7]

Quad-Honstein Joint Venture's Woodham gypsum mine in Larimer County remained idle during the year.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

Colorado construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data for the State's six districts.

Sand and gravel quarrying was a $69.9 million industry in Colorado in 1988, equal to more than 97% of the value of all the gold produced in the State in 1988, and 12 times the value of all the silver. Construction sand and gravel was used principally for road base and cover, concrete aggregates, fill, and asphaltic concrete.

Cooley Gravel Co. dedicated its new Sedalia plant on East Plum Creek in Douglas County in April. The dredge and new processing plant, which required an investment of $2.6 million, produced mainly concrete sand and some gravel. The deposit contained an estimated 6 million short tons of reserves and was expected to produce for 10 to 12 years. In January 1988, J. L. Shiely Co. of St. Paul, MN, parent of Cooley Gravel, was purchased by English China Clays PLC of England.

Industrial.—Industrial sand was extracted from pits in Arapahoe and El Paso Counties. Production in 1988 declined about 25% from the previous year, and total value was down nearly 20%. Industrial sand was used for blasting, filtration, and other uses.

TABLE 2

COLORADO: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	3,506	$14,806	$4.22
Plaster and gunite sands	54	303	5.61
Concrete products (blocks, bricks, pipe, decorative, etc.)	1,035	3,958	3.82
Asphaltic concrete aggregates and other bituminous mixtures	2,794	9,894	3.54
Road base and coverings[1]	4,804	14,484	3.01
Fill	925	1,641	1.77
Snow and ice control	215	973	4.53
Railroad ballast	19	169	8.89
Other[2]	291	1,724	5.92
Unspecified:[3]			
Actual	5,472	15,340	2.80
Estimated	2,450	6,589	2.69
Total[4] or average	**21,566**	**69,882**	**3.24**

[1] Includes road and other stabilization (cement).
[2] Includes roofing granules.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data may not add to totals shown because of independent rounding.

TABLE 3

COLORADO: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT[1]

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggretates (including concrete sand)	316	$1,525	448	$2,014	80	$303
Plaster and gunite sands	W	W	W	W	—	—
Concrete products (blocks, bricks, etc.)	W	W	—	—	—	—
Asphaltic concrete aggregates and other bituminous mixtures	319	2,041	641	1,981	W	W
Road base and coverings[2]	1,700	4,963	505	1,512	489	2,168
Fill	445	651	41	87	29	50
Snow and ice control	34	135	27	41	W	W
Railroad ballast	—	—	5	44	—	—
Other miscellaneous[3]	108	443	74	465	168	319
Other unspecified[4]	2,265	4,965	1,998	5,854	170	362
Total[5]	**5,188**	**14,723**	**3,739**	**11,996**	**937**	**3,203**

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	1,827	$7,681	660	$1,967	175	$1,316
Plaster and gunite sands	8	72	39	192	(6)	2
Concrete products (blocks, bricks, etc.)	W	W	W	W	(6)	(6)
Asphaltic concrete aggregates and other bituminous mixtures	1,119	3,823	521	1,571	W	W
Road base and coverings[2]	1,212	3,357	424	1,060	437	1,330
Fill	317	706	83	127	10	20
Snow and ice control	124	650	W	W	W	W
Railroad ballast	W	W	—	—	W	W
Other miscellaneous[3]	1,119	4,440	66	558	36	246
Other unspecified[4]	1,192	4,671	1,927	4,864	269	706
Totals[5]	**6,918**	**25,400**	**3,720**	**10,340**	**927**	**3,620**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Excludes 138,745 short tons valued at $600,745 not reported by county.
[2] Includes sand and gravel for road and other stabilization (cement).
[3] Includes sand and gravel for roofing granules.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.
[6] Less than one-half unit.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—Crushed stone output and total value were estimated to have increased 32% and 27%, respectively, from figures reported for 1987. Redland PLC of Reigate, Surrey, United Kingdom, acquired Koppers Co.'s 50% interest in Western Mobile Inc. Western Mobile quarried construction aggregates and supplied ready-mixed concrete in Colorado, Kansas, New Mexico, and Wyoming.

Dimension.—Dimension stone output and value rose an estimated 15% and 8%, respectively, over 1987 figures. Marble quarries in Chaffee and Gunnison Counties were coming into production to supply the rising demand by sculptors and architects. Colorado Yule

Marble Co. began rejuvenating its white marble quarries and planning a new mill in Gunnison County. Colorado Yule planned to quarry and ship as much as 1,000 blocks per year by 1992. Each block provides about 2,500 square feet of 2- to 3-centimeter-thick commercial marble facing valued at $8 to $12 per square foot. The quarry is on U.S. Forest Service land that had not been worked since 1941. Marble from this area was used for the Lincoln Memorial in Washington, DC.

The new Denver Convention Center will require about 4,200 tons of white marble to be used as column facings. An initial contract called for Wyoming marble to be used, but after a Colorado State representative threatened to cut a $6 million State subsidy to the center, the contractor agreed to test Colorado marble from Chaffee County. If Chaffee County marble is approved, Colorado Quarries Inc.'s Table Mountain quarry would employ 50 to 70 persons in a high (20%) unemployment area to cut and process the stone.

Also, a black marble deposit on Conundrum Creek in the Snowmass Wilderness Area was the subject of an application for a mining permit from the Colorado Mined Land Reclamation Division. The deposit was being evaluated by the Colorado Geological Survey.

The usage of marble, about 85% of which was imported, increased 850% in the Nation between 1980 and the end of 1987.

Other Industrial Minerals.—Three firms continued their diamond exploration projection in the State Line District on the Colorado-Wyoming border. Production of lime decreased nearly 20%, but value per short ton rose from nearly $32 to more than $55, about $7 higher than the national average. Quicklime was produced by Western Sugar Co. at plants in Morgan and Weld Counties; Calco Inc. produced quicklime in Chaffee County. Output from peat operations in Boulder, Chaffee, El Paso, and Park Counties reportedly more than doubled the State's output from levels in 1987, which was a notably poor year. The price for peat materials increased from $15 to $20 per short ton, a record high. Two companies expanded perlite at plants at Antonito in Conejos County and at Florence in Fremont County. Expanded perlite was used in cavity fill insulation, concrete aggregates, fillers, filter aids, and in horticultural and plaster aggregates. Sulfur was recovered during the processing of petroleum by Conoco Inc. at Commerce City in Adams County. W. R. Grace & Co. exfoliated vermiculite from out-of-State sources at its Denver plant. Vermiculite was used in concrete and plaster aggregates, in block and loose-fill insulation, in soil conditioning mixtures, and in fireproofing.

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[1] State Mineral Officer, U.S. Bureau of Mines, Denver, CO.

[2] Chief, Minerals and Mineral Fuels Resources, Colorado Geological Survey, Denver, CO.

[3] Industrial Minerals. Nahcolite Control of Acid Rain? No. 248, May 1988, p. 77.

[4] Ohl, J. P. Colorado. Mining Engineering. May 1989, pp. 306–307.

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[5] Rocky Mountain News. Caprock, BHP Joint Effort to Mine Near Ft. Collins. Aug. 4, 1988.

[6] Brown, S. D. Mineral Resources of the Gunnison Gorge Wilderness Study Area (CO–030–388), Delta and Montrose Counties, Colorado. BuMines Mineral Land Assessment OFR 26–88, 1988, 26 pp.

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TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Ideal Basic Industries Inc.[1]	Box 8789 750 17th St. Denver, CO 80201	Plants	Fremont and Larimer.
Southwestern Portland Cement Co.[1]	1111 South Colorado Blvd. Denver, CO 80222	Plant	Boulder.
Clays:			
General Refractories Co.	600 Grant St., Room 3000 Pittsburgh, PA 15219	Pits	Pueblo.
Lakewood Brick and Tile Co.	1325 Jay St. Lakewood, CO 80214	Pits and plant	Fremont and Jefferson.
G. W. Parfet Estate Inc.	1213-½ Washington Ave. Golden, CO 80401	Pits	Jefferson.
Robinson Brick Co.	Box 5243 Denver, CO 80217	Pits and plant	Douglas, Elbert, El Paso, Jefferson.
Gold:			
ASARCO Incorporated[2]	Box 936 Leadville, CO 80461	Mine and mill	Lake.
Cripple Creek and Victor Gold Mining Co.[3]	Box 191 Victor, CO 80860	Mine dump heap leaching	Teller.
Summitville Consolidated Mining Co. Inc., a subsidiary of Galactic Resources Inc.[3]	Box 2G Del Norte, CO 81132	Open pit, vat leaching, carbon-pulp plant	Rio Grande.
Sunnyside Gold Corp., a subsidiary of Echo Bay Mines Ltd.[2]	Box 177 Silverton, CO 81433	Mine and mill	San Juan.
Gypsum:			
Domtar Gypsum	1173 State Hwy. 120 Florence, CO 81226	Mine and plant	Fremont.
Lime:			
Calco Inc.	Box 1044 Salida, CO 81201	do.	Chaffee.
The Western Sugar Co., a subsidiary of Tate and Lyle PLC.	555 17th St. Denver, CO 80202	Plants	Morgan and Weld.
Molybdenum:			
AMAX Inc.	1707 Cole Blvd. Golden, CO 80401	Mines and mills	Clear Creek, Grant, Lake.
Peat:			
Universal Peat Sand & Gravel Inc.	1557 South Ingalls St. Lakewood, CO 80226	Bog	Park.
Perlite:			
Grefco Inc., Building Products Div.	Box 308 Antonito, CO 81120	Plant	Conejos.
Persolite Products Inc.	Box 105 Florence, CO 81226	Mine and plant	Custer and Fremont.
Sand and Gravel:			
Albert Frei & Sons Associates	11521 Brigton Road Henderson, CO 80217	Pits and plants	Adams, Clear Creek, Garfield, Weld.
Castle Concrete Co.	Box 2379 Colorado Springs, CO 80901	do.	El Paso and Pueblo.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Flatiron Sand & Gravel Co.	Box 229 Boulder, CO 80305	Pits	Boulder, Larimer, Weld.
Mobile Premix Co.	Box 5183 TA Denver, CO 80217	do.	Adams, Douglas, Eagle, Garfield, Jefferson, Larimer, Moffat, Routt, Weld.
Western Mobile Inc.	1400 West 64th Ave. Denver, CO 80221	Pits and plants	Boulder, El Paso, Larimer, Pueblo, Weld.
Stone:			
Asphalt Paving Co.	14802 West 44th Ave. Golden, CO 80401	Quarries	Jefferson.
Rocky Mountain Rose Red Inc.	North Star Route Lyons, CO 80540	Quarry	Larimer.

[1] Also stone.
[2] Also copper, lead, silver, and zinc.
[3] Also silver.

THE MINERAL INDUSTRY OF CONNECTICUT

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the State Geological and Natural History Survey of Connecticut, Department of Environmental Protection, for collecting information on all nonfuel minerals.

By Donald K. Harrison[1] and Robert J. Altamura[2]

Connecticut's 1988 nonfuel mineral production value was $118 million, a $4 million decrease from that of 1987. Crushed stone and construction sand and gravel were the two leading mineral commodities produced. In 1988, the combined value of these two commodities accounted for 92% of the State's total mineral production value. Other commodities produced included clay, dimension stone, feldspar, industrial sand, and mica.

TRENDS AND DEVELOPMENTS

Construction activity in the State experienced its seventh consecutive year of growth, making the 1981–88 construction boom one of the strongest ever in the State. All areas of construction grew with high-rise buildings and residential and commercial structures leading the way. Also in 1988, Connecticut was in the fifth year of a 10-year, $10 billion State program of infrastructure improvement. This continuing surge in construction activity has benefited crushed stone and sand and gravel producers because both these commodities are used heavily in construction.

LEGISLATION AND GOVERNMENT PROGRAMS

Public Act 88-231, effective October 1, placed requirements on the State to promote and accommodate recycling. Under the law, the Department of Transportation must assess the possibility of using materials recovered from the demolition of old buildings in new construction projects, and the Department of Economic Development must prepare a plan to support and promote Connecticut industries that use recycled materials. Also, the law requires the State's Department of Environmental Protection to study the environmental impacts of incinerating plastics and other materials.

Acid rain, radon gas exposure, and solid waste disposal were primary environmental concerns in the State. Recent data from a national acid rain monitoring network indicated that Connecticut led the Nation in the acid level of its rainfall. In December, Connecticut and eight other States filed a lawsuit against the U.S. Environmental Protection Agency (EPA) to force the Agency to order new pollution controls in the Midwest. Coal-burning plants and factories in the Midwest were blamed for emitting gaseous substances that cause acid rain. The other plaintiff States are Maine, Massachusetts, Minnesota, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. The Canadian province of Ontario and two private environmental organizations filed a similar lawsuit on November 1.

According to the Assistant Surgeon General, radon accounts for one-half of the total radiation dose to the U.S. population and causes about 20,000 cases of lung cancer each year. Radon, a naturally occurring radioactive gas, is produced from the breakdown of uranium in bedrock or soils. A survey by the Connecticut Department of Health Services found potentially dangerous levels of radon in about one of every five homes tested. At the time, the Department recommended that people living in one- or two-story buildings test their homes for radon. If high radon levels were found, the State advised residents about the techniques to reduce the gas.

Connecticut faced a severe landfill

TABLE 1

NONFUEL MINERAL PRODUCTION IN CONNECTICUT[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	156,680	$975	W	W	W	W
Gem stones		NA	2	NA	$2	NA	$2
Sand and gravel (construction)	thousand short tons	7,254	25,984	e8,400	e37,000	8,275	32,102
Stone:							
Crushed	do.	e7,700	e45,800	11,412	76,668	e11,400	e76,900
Dimension	short tons	e24,425	e1,653	18,140	1,646	e19,718	e1,914
Combined value of feldspar, mica (scrap), sand and gravel (industrial), and values indicated by symbol W		XX	6,040	XX	6,959	XX	7,198
Total		**XX**	**80,454**	**XX**	**122,275**	**XX**	**118,116**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

shortage with most usable capacity expected to expire over the next couple of years. To help resolve the problem, the Connecticut Resources Recovery Authority (CRRA) searched for land in the State for disposal sites for bulky waste. The Authority, working with over 100 towns on waste disposal issues, wanted to purchase industrially zoned land, in parcels of 10 acres or more, that was environmentally suitable to receive demolition materials and land clearing debris. Because Connecticut has few bulky waste disposal areas left, the objective was to find sites around the State that could be developed to serve CRRA towns regionally. Bulky materials deplete landfill capacity rapidly and are not acceptable at resource recovery plants.

The Connecticut Geological and Natural History Survey (CGNHS) continued the collection, interpretation, and distribution of information about the State's natural resources. CGNHS staff concentrated on several efforts: mapping topography, bedrock geology, surface geology, and soil; entering map data into a geographic information system; and collecting water and biological resource data.

The CGNHS began a geological investigation on a class of silicified faults that included the large mass of quartz known as Lantern Hill where U.S. Silica Co. of Connecticut quarries quartz for use as industrial sand.[3] The CGNHS participated in a project that involved the drilling of a 4,800-foot-deep research hole to investigate seismicity.[4] In a cooperative program with the U.S. Geological Survey (USGS) and Minerals Management Services, the CGNHS helped to conduct marine geologic investigations in Long Island Sound.[5] Also CGNHS continued to study the nature and distribution of radon within the State.[6]

Through cooperative programs between CGNHS and the USGS Water Resources Division, data were collected on the quantity and quality of surface and ground water, and current water use information was maintained. Precipitation was monitored in cooperation with the National Oceanic and Atmospheric Administration. The Natural Resources Center, the umbrella agency of the CGNHS, made a significant contribution to "Environment/2000," Connecticut's environmental plan for the year 2000. The Center's contribution focused on the fields of water resources and natural heritage. The Center also provided basic resource data for a Statewide aquifer protection program.

The American Association of State Geologists included a history of the CGNHS in a 500-page volume on all the State Surveys in the country. A brief discussion of the history of economic geology in the State, including State Survey and U.S. Bureau of Mines (USBM) cooperation, was included in this history.[7]

During fiscal year 1988, the USBM awarded a $47,132 contract to Perkin-Elmer Corp. in Norwalk for mineral-related studies.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Clays.—Two companies mined common clay and shale for use in manufacturing common and face brick. K-F Brick Co. mined Pleistocene glacial clay near South Windsor and also quarried Jurassic age shale near Suffield, both in Hartford County. The Michael Kane Brick Co., the State's other producer, operated an open pit mine in Middlesex County.

Feldspar.—Connecticut ranked second nationally of the six States that produced feldspar in 1988. The Feldspar Corp. operated three open pit quarries and a froth flotation plant in the old Middletown Pegmatite District in Portland and Middletown, Middlesex County. The processed feldspar was shipped by truck to markets in New England, New Jersey, and New York and was used principally as a flux by the glass and ceramics industry. Production in 1988 was down slightly from that of 1987. This decline resulted from fewer housing starts in the New England and Middle Atlantic States where production fell 19% and 12%, respectively.

Gem Stones.—Individual collectors and mineral clubs recovered an abundance of gem stones in quarries and abandoned mine sites, primarily from pegmatites. The Middletown Pegmatite District in the central part of the State was one of the most popular gem collecting sites.

Mica.—The Feldspar Corp. recovered mica as a byproduct of the company's feldspar mining operations in Middletown, Middlesex County. The mica was marketed as a filler and as an additive to well-drilling mud.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1985. Data for odd-numbered years are based on annual company estimates.

Construction sand and gravel was the State's second leading mineral commodity in terms of value and accounted for 27% of the State's value of mineral production. In 1988, 56 companies mined construction sand and gravel from 59 operations. Major uses were for construction and road building.

Sand and gravel operations were the subject of numerous hearings in many of the State's towns. Most of these hearings were the result of citizen concern about excessive noise, increased truck traffic, dust, and potential disruption of water supplies. Often town zoning and planning boards adopted new or stricter zoning laws and approved fewer mining permits to accommodate the citizens' concerns.

Because sand and gravel is a high-

volume, low-value commodity, the operations usually serve local or regional markets. When these operations are forced to move further away from their markets, transportation costs become a major factor in the delivered price of the material. The added transportation costs and higher production costs resulting from restrictive zoning, competition, and urban sprawl invariably are passed on to the consumer in the form of higher raw material costs.

Industrial.—Two companies produced industrial sand in the State in 1988. The Feldspar Corp. processed industrial sand as a byproduct of feldspar refining in Middletown, Middlesex County, and U.S. Silica Co. of Connecticut operated a quarry near North Stonington, New London County. Principal uses were for roofing granules, glass products, and filtration.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

Crushed.—Crushed stone was the State's leading mineral commodity and accounted for 65% of the State's total commodity value. Estimated crushed stone production (predominantly Jurassic aged basalt, which is commonly called traprock) remained essentially the same as that of 1987. Major uses were for roadbuilding and concrete aggregate.

In an agreement reached in early December, the Balf Co. informed the Newington town council that construction of a 480-ton-per-hour crushed stone processing plant at its Hartford Avenue quarry would not resume, pending a final zoning decision. Balf started construction of the controversial plant in October after receiving a preliminary permit from the State Department of Environmental Protection. Residents in the neighborhood around the quarry complained about dust from the quarry and contended that the new processing plant would add to the problem. In late December, Balf announced plans to spend $500,000 to reduce the levels of dust emanating from the quarry.

Dimension.—Dimension granite was quarried in New Haven County and dimension granite and quartzite were quarried in Tolland and Windham Counties. The stones were sold as irregular-shaped stones, rough blocks, and cut stones.

TABLE 2

CONNECTICUT: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	1,141	$6,926	$6.07
Plaster and gunite sands	9	88	9.78
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	4.37
Asphaltic concrete aggregates and other bituminous mixtures	221	1,164	5.27
Road base and coverings[1]	435	2,256	5.19
Fill	872	1,920	2.20
Snow and ice control	224	1,004	4.48
Other	67	325	4.85
Unspecified:[2]			
Actual	3,409	12,466	3.66
Estimated	1,897	5,954	3.14
Total or average	**8,275**	**[3]32,102**	**3.88**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data do not add to total shown because of independent rounding.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA.

[2] Geologist, Connecticut. Geological and Natural History Survey, Department of Environmental Protection, Hartford, CT.

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CONN

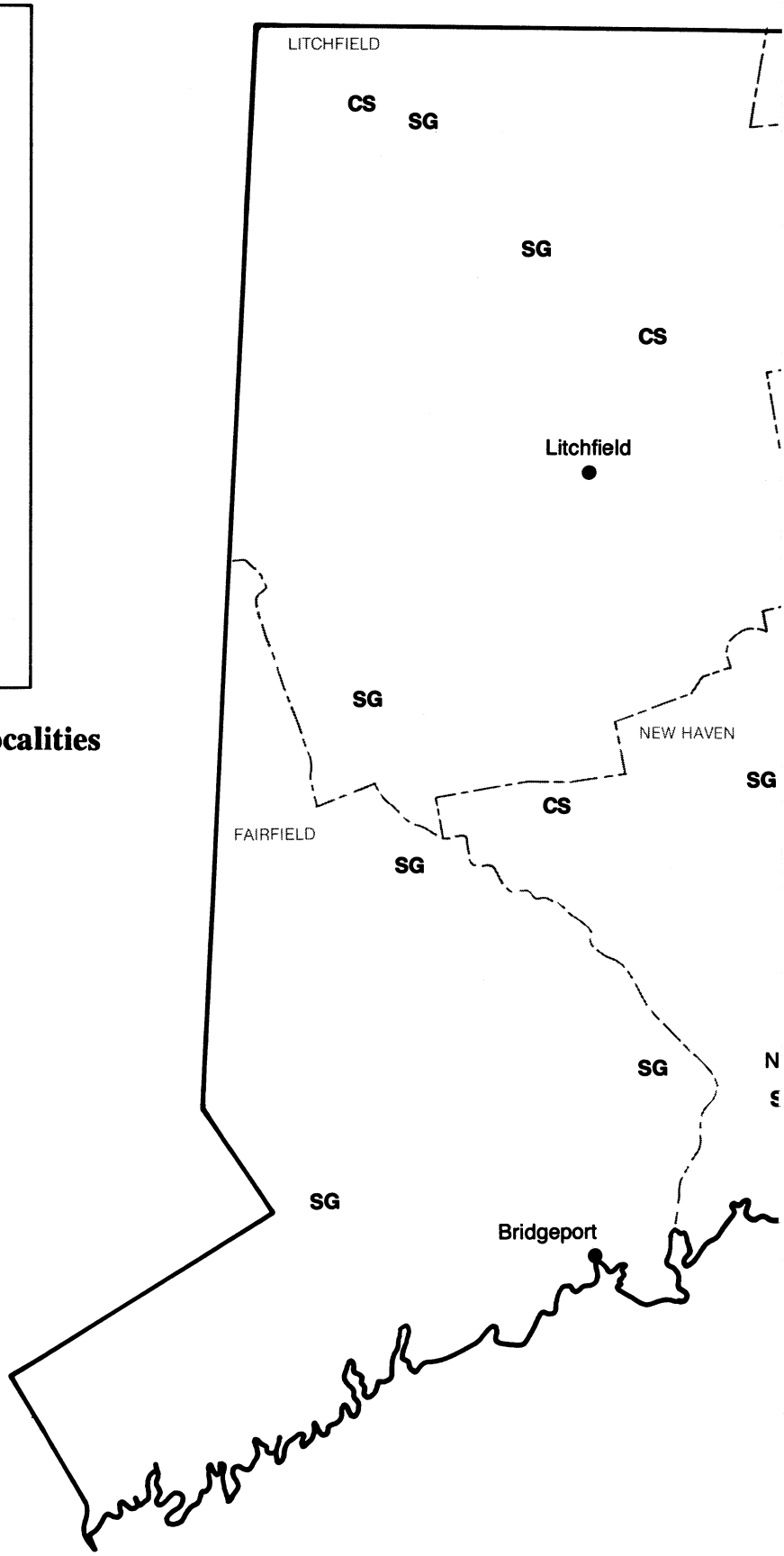
LEGEND

State boundary
County boundary
Capital
City

MINERAL SYMBOLS

CC-Sh	Common Clay & Shale
CS	Crushed Stone
D-G	Dimension Granite
D-Q	Dimension Quartzite
Fel	Feldspar
Mica	Mica
SG	Sand and Gravel

Principal Mineral-Producing Localities



TICUT

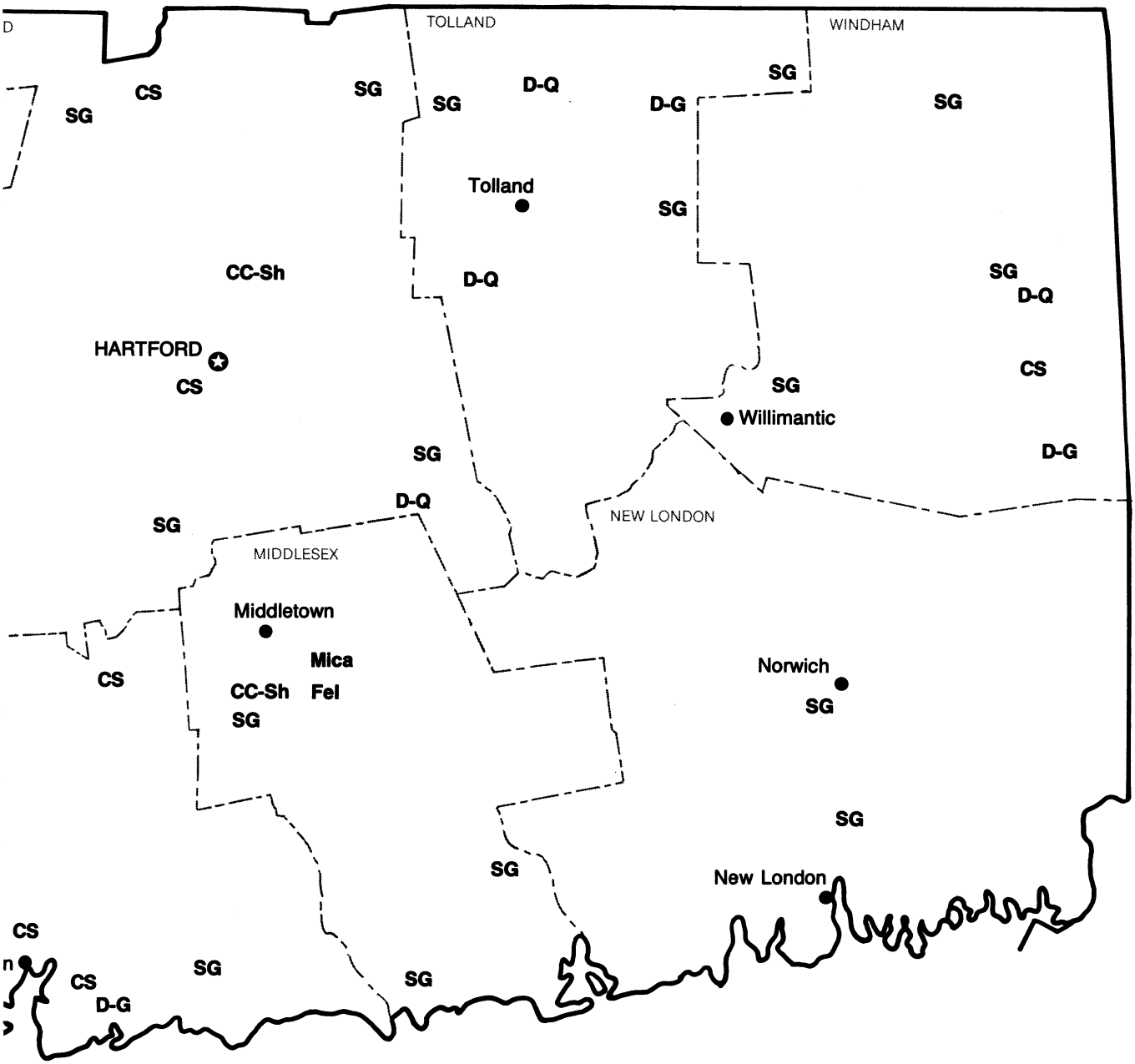

TOLLAND
WINDHAM
Tolland
HARTFORD
Willimantic
MIDDLESEX
NEW LONDON
Middletown
Norwich
New London
CS
SG
D-Q
D-G
CC-Sh
Mica
Fel

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Clays:			
The Michael Kane Brick Co.	654 Newfield St. Middletown, CT 06457	Pit and plant	Middlesex.
K–F Brick Co.	Box 375 East Windsor Hill, CT 06028	do.	Hartford.
Feldspar:			
The Feldspar Corp.[1]	Box 99 Spruce Pine, NC 28777	Mines and plant	Middlesex.
Sand and gravel:			
Construction:			
Bakerville Lumber and Construction Inc.	321 Maple Hollow Rd New Hartford, CT 06057	Pit	Litchfield.
Connecticut Sand and Stone Corp.	7 West Main Street Plainville, CT 06062	Pits	Hartford and Litchfield.
The Elm Construction Co.	400 North Frontage Road New Haven, CT 06473	Plant	New Haven.
O & G Industries Inc.	23 Carson Ave Torrington, CT 06790	Pit	New Haven.
R. A. Rawson Sand and Gravel Inc.	R.F.D. 1 Putnam, CT 06260	Pits and plant	Windham.
Industrial:			
U.S. Silica Co. of Connecticut	Box 187 Berkeley Springs, WV 25411	Pit and plant	New London.
Stone:			
Crushed:			
Edward Balf Co.	Box 11190 Newington, CT 06111	Quarry	Hartford.
O & G Industries Inc.	23 Casson Ave. Box 907 Torrington, CT 06790	Quarries	Litchfield and New Haven.
Roncari Industries Inc.	1776 South Main St. East Granby, CT 06026	Quarry	Hartford.
Tilcon Tomasso Inc.	Box 67 909 Foxen Rd. North Branford, CT 06471	do.	Hartford, New Haven, Windham.
York Hill Trap Rock Quarry Co.	Westfield Rd. Meriden, CT 06450	do.	New Haven.
Dimension:			
Castellucci and Sons Inc.	West River St. Providence, RI 02904	do.	Do.
R. B. Marriott & Sons Co.	Box 67 Oneco, CT 06373	do.	Windham.
Wayne C. Williams General Construction Inc.	R.F.D. 1, Conklin Rd. Stafford Springs, CT 06076	do.	Tolland.

[1] Also crude mica and industrial sand.

THE MINERAL INDUSTRY OF DELAWARE

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Delaware Geological Survey for collecting information on all nonfuel minerals.

By L. J. Prosser, Jr.[1]

The value of construction sand and gravel production in Delaware in 1988 was almost $6 million. Delaware was one of seven States producing magnesium compounds and one of only two States reporting output of greensand marl. Production and value data for both of these mineral commodities were excluded from the State total to avoid disclosure of company proprietary information.

TRENDS AND DEVELOPMENTS

Although Delaware's mining industry produced only three commodities, the mineral-related manufacturing sector contributed significantly to the State's economy. Manufacturing accounted for approximately $3 billion or about 25% of Delaware's gross product. Mineral commodities used in manufacturing included dolomite, gypsum, ilmenite, magnesium, magnesium oxide, salt, sulfur, and titanium oxide. Many of these commodities were shipped through the Port of Wilmington.

The construction sector accounted for about $565 million, or 5% of the State's gross product. Sand and gravel mined in Delaware was used by the construction industry for road and home-building projects. Other materials used extensively in construction were crushed stone, which was typically trucked from surrounding States, and cement, which was received from both domestic and foreign sources. Highway construction spending was expected to continue to increase in 1989, resulting in increased demand for stone and sand and gravel. The Delaware Department of Transportation's operating budget for fiscal year 1990 (July 1, 1989, to June 30, 1990) was $335 million, an increase of $87 million over the previous year's budget.

LEGISLATION AND GOVERNMENT PROGRAMS

In January, the State released a report, titled "Delaware's Environmental Legacy," that identified plans and programs for protection of the State's environment. Air, water, and waste issues were addressed along with economic development factors expected to impact the environment, such as migration of Delaware's shoreline. Shoreline erosion along Delaware's Atlantic Coast, a continuing and long-term problem, has an adverse effect on tourism, the State's third largest industry.

A follow-up report titled "Beaches 2000," which was published in June, provided a plan to mitigate the problems related to shoreline erosion. Recommendations in the plan included replenishment of sand; the Delaware Geological Survey (DGS) began an investigation of sand resources available in the State. Initially, existing sand pits were evaluated as sources for short-term beach nourishment projects. Through geologic mapping scheduled for 1989, areas that contain acceptable material of sufficient quantity to provide a supply of sand for future needs will be identified.

Also the DGS began a program with the U.S. Geological Survey (USGS) to update 7.5-minute topographic maps after receiving funding from the Delaware General Assembly. Under Delaware's Sunset Law, the General Assembly reviewed the DGS functions and recommended (Senate bill 259) continuation of the Survey. The Governor signed the bill into law and designated the DGS as the "point of contact" for the U.S. Bureau of Mines, USGS, and Mineral Management Service, all three of which are Department of the Interior agencies.

REVIEW BY NONFUEL MINERAL COMMODITIES

In addition to the minerals mined in the State (table 1), imports and shipments of raw materials were received from other sources, primarily at the Port of Wilmington. Georgia-Pacific

TABLE 1

NONFUEL MINERAL PRODUCTION IN DELAWARE[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	$1	NA	$1	NA	$1
Marl (greensand)	short tons	1,068	12	W	W	750	10
Sand and gravel (construction)	thousand short tons	1,547	4,156	e2,300	e6,400	1,933	5,988
Total[2]		**XX**	**4,169**	**XX**	**[3]6,401**	**XX**	**[3]5,999**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Partial total; excludes values that must be concealed to avoid disclosing company proprietary data.

[3] Value data excluded from partial total is included on "Undistributed States" table.

Corp. imported crude gypsum from Nova Scotia for use in manufacturing wallboard at a plant near the port facility. In the fiscal year ending June 30, 1988, almost 333,000 short tons of crude gypsum were received at the Port of Wilmington, a 2% decrease compared with the previous fiscal year total.[2] American Minerals Inc. also used the port facility as a site for its grinding-plant operations. Imported manganese ores were processed for use as a coloring agent and sold to the brick industry. E. I. du Pont de Nemours & Co. Inc. processed ilmenite shipped by barge from Florida for manufacturing titanium dioxide pigments at its plant in Edgemoor. Du Pont also began commercial production of a high-modulus, pitch-based carbon fiber at facilities in Wilmington. Pitch fibers, made from petroleum pitch, were used in high-performance military components. Rock salt was imported for use in highway deicing, and evaporated solar salt was imported by the chemical industry. In fiscal year 1988, the Port of Wilmington received almost 180,000 short tons of salt. Sulfur was recovered as a byproduct from petroleum refining in Delaware City. The sulfur-bearing crude oil was imported from Venezuela and Mexico.

Industrial Minerals

Greensand.—Contractors Sand & Gravel Co. Inc. mined greensand as a coproduct at its sand and gravel pit near Middletown. Zook & Ranck Inc. purchased the raw material and processed it at a plant in Gap, PA, about 50 miles north of the mine site. Greensand was sold for use as a soil conditioner. New Jersey was the only other State that produced greensand.

Magnesium Compounds.—Barcroft Co. extracted magnesium hydroxide from seawater near Lewes and processed it for use in antacids, laxatives, and other pharmaceutical products. Delaware was one of seven States that produced magnesium compounds.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter thus contains actual data for 1986 and 1988 and estimates for 1987.

In 1988, eight companies operating eight pits reported production of 1.9 million short tons of sand and gravel, whereas in 1986, sand and gravel production was about 1.5 million tons.

In addition to the production reported to the Bureau of Mines, the State dredged about 580,000 short tons of sand for beach nourishment at Fenwick Island. The State's Natural Resources and Environmental Control Department, Soil and Water Conservation Division, in a contract with the American Dredging Co. was responsible for the work as a part of its "Beaches 2000" project. Nourishment of Bethany Beach was scheduled for 1989.

Metals

In March, CitiSteel USA Inc. purchased the Phoenix Steel Corp., a firm that had been closed since 1986, for almost $13.5 million. The firm planned to produce steel at the 400,000-ton-per-year-capacity plate mill in Claymont by the first quarter of 1989.

Reclaimed Metals and Materials.—The Delaware Solid Waste Authority continued operation of a resource recovery plant at Pigeon Point, New Castle County. In 1988, the facility processed 237,000 short tons of municipal solid waste from which about 7,200 tons of ferrous metals, 1,050 tons of nonferrous metals (primarily aluminum), and 900 tons of glass were recovered.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA.

[2] Port of Wilmington, DE, Monthly Tonnage Report, June 1988, p. 3.

TABLE 2

DELAWARE: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	520	$1,902	$3.66
Plaster and gunite sands	W	W	4.28
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	3.76
Asphaltic concrete aggregates and other bituminous mixtures	W	W	3.76
Fill	482	1,081	2.24
Snow and ice control	W	W	4.17
Other	931	3,005	3.22
Unspecified: [1]			
Actual	W	W	7.69
Estimated	W	W	2.40
Total or average	**1,933**	**5,988**	**3.10**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."

[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.

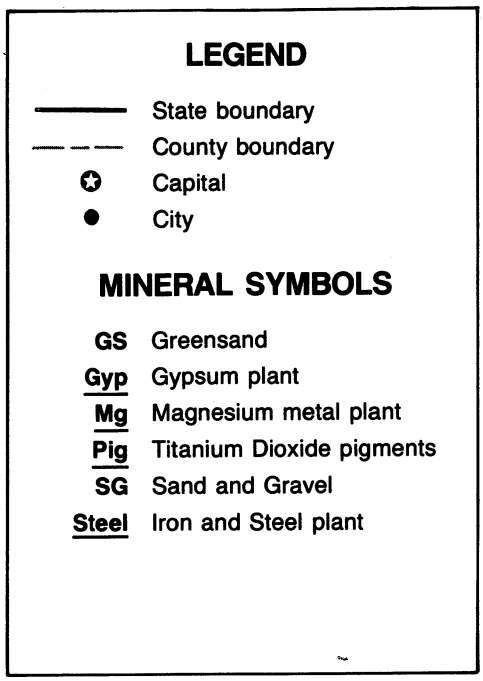
TABLE 3

PRINCIPAL PRODUCERS

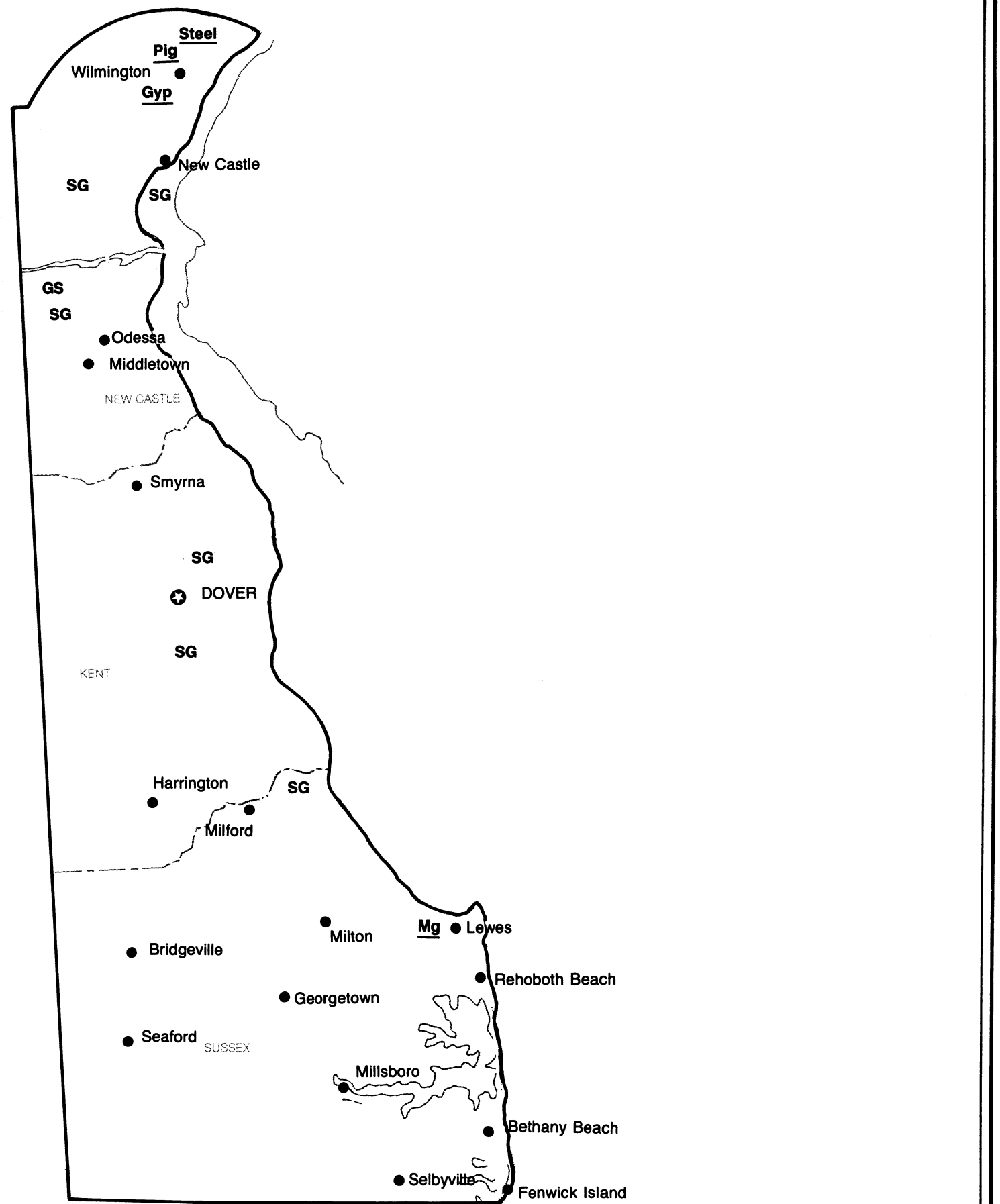
Commodity and company	Address	Type of activity	County
Greensand			
Contractors Sand & Gravel Co. Inc.[1]	Box 2630 Wilmington, DE 19805	Pit	New Castle.
Gypsum (calcined):			
Georgia-Pacific Corp., Gypsum Div.	Wilmington Marine Terminal Box 310 Wilmington, DE 19899	Plant	Do.
Magnesium compounds:			
Barcroft Co.	40 Cape Henlopen Dr. Lewes, DE 19958	do.	Sussex.
Sand and gravel (construction):			
Contractors Sand & Gravel Co.	Box 2630 Wilmington, DE 19805	Pit	New Castle.
George & Lynch Inc.	113 West 6th St. New Castle, DE 19720	Dredge	Kent.
Parkway Gravel Inc.	4048 New Castle Ave. New Castle, DE 19720	Pit	New Castle.
Steel:			
CitiSteel USA Inc.	4001 Philadelphia Pike Claymont, DE 19703	Mill (plate)	Do.
Sulfur (recovered):			
Texaco Inc.	Wrangle Hill Rd. Delaware City, DE 19706	Refinery (petroleum)	Do.
Titanium dioxide:			
E. I. du Pont de Nemours & Co. Inc.	1007 Market St. Wilmington, DE 19898	Corporate headquarters	Do.
Do.	Edgemoor, DE 19809	Plant (chemical)	Do.

[1] Also sand and gravel.

DELAWARE



Principal Mineral-Producing Localities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Pig
Wilmington
Gyp
New Castle
SG
SG
GS
SG
Odessa
Middletown
NEW CASTLE
Smyrna
SG
DOVER
SG
KENT
Harrington
SG
Milford
Milton
Mg
Lewes
Bridgeville
Rehoboth Beach
Georgetown
Seaford
SUSSEX
Millsboro
Bethany Beach
Selbyville
Fenwick Island

THE MINERAL INDUSTRY OF FLORIDA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Florida Bureau of Geology for collecting information on all nonfuel minerals.

By Doss H. White, Jr.,[1] and Walter Schmidt[2]

Florida's mineral industry produced $1.4 billion of nonfuel mineral commodities in 1988. This was the third consecutive year that mineral value increased, although it fell $300 million short of the record $1.7 billion set in 1981.

Nationally, Florida ranked sixth in total mineral production. The State was 1 of 11 States whose mineral value exceeded $1 billion, and its mineral producers accounted for 4.64% of the value of U.S. mineral production.

Florida ranked first nationally in the production of peat, phosphate rock, and staurolite; second in masonry cement and crushed stone; third in fuller's earth; and seventh in portland cement.

TRENDS AND DEVELOPMENTS

The 1980's has been a decade of "boom or bust" for Florida's mineral economy. The record for mineral sales was established in 1981, when $1.7 billion of mineral commodities was produced. Value fell by $500 million the following year, when mineral demand plummeted due to the nationwide recession. The downturn in Florida construction activity reduced sales of construction mineral commodities, including cement, clays, sand and gravel, and stone, by more than $111 million. Phosphate production fell drastically due to lower demand for fertilizers as a result of the recession.

During 1983 through 1985 mineral production rebounded, to a high of $1,559 million in 1985. However, production and value fell again in 1986 as phosphate output plummeted more than 25%, with a decline in value of almost 33%. There were two main reasons behind the decrease in demand and sales: a Federal agricultural acreage reduction program that affected fertilizer demand, plus foreign competition and a worldwide reduction in demand that restricted exports.

Phosphate sales have increased since 1986. Many of the world's phosphate conversion plants are old, and it is cheaper to purchase fertilizer from U.S. producers than to manufacture fertilizer or fertilizer components at some foreign facilities.

The State led the Southeast in 1988 in the number of building permits issued. The 171,000 permits authorized were almost 300% above the 63,000 permits authorized by second-place Georgia. At mid-1988, construction employment in Florida was 2,200 above the December 1987 total. The State also led the Southeast in new and reconstruction highway expenditures. A significant amount of cement, sand and gravel, and stone was used in the highway work.

EMPLOYMENT

Florida's job growth rate was 4.7%. In July, the State's unemployment rate was 1.1% lower than the national average. For the year ending in July, the

TABLE 1

NONFUEL MINERAL PRODUCTION IN FLORIDA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	352	$21,269	390	$24,069	411	$25,892
Portland	do.	3,189	147,643	3,565	165,944	3,682	168,719
Clays	short tons	725,903	43,261	597,187	39,496	591,855	44,423
Peat	thousand short tons	365	5,743	363	6,068	266	5,091
Sand and gravel:							
Construction	do.	28,233	67,898	e30,000	e74,900	18,654	53,083
Industrial	do.	1,467	14,930	1,884	19,713	636	6,928
Stone (crushed)	do.	e69,000	e288,200	[2]78,992	[2]350,537	e[2]83,200	e[2]374,400
Combined value of gem stones, lime (1986), magnesium compounds (1988), phosphate rock, rare-earth metal concentrates, staurolite, stone (crushed marl, 1987–88), titanium concentrates (ilmenite and rutile), and zircon concentrates		XX	700,919	XX	665,510	XX	713,345
Total		**XX**	**1,289,863**	**XX**	**1,346,237**	**XX**	**1,391,881**

e Estimated. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain stones; kind and value included with "Combined value" data.

State's nonmetal mine employment was 8,700, an increase of 1.3% over the previous 12-month period. Employment in the phosphate mining sector was 3,500, an increase of 5.7%.

LEGISLATION AND GOVERNMENT PROGRAMS

Legislation on solid waste management and pollution control was passed during 1988. Both measures were primarily administrative and had little direct impact on minerals.

The Florida Bureau of Geology, a division of the Department of Natural Resources, is comprised of the Geological Investigations, Mineral Resources and Environmental Geology, and Oil and Gas Sections. The Bureau maintained oil and gas field offices in Ft. Myers and in Jay.

During the year, work was underway on a revision of the State geologic map. The mineral resource potential for several Florida counties was investigated; studies were also conducted on the State's fuller's earth deposits. Investigations were also made into the pollution potential of aquifers in the Suwannee River. The Oil and Gas Section monitored onshore and offshore exploration activity for both oil and gas.

The Florida Institute of Phosphate Research was tranferred from the administrative-financial control of the Department of Education to the Board of Regents. A second year of reduced State funding necessitated setting new priorities. Despite the funding reduction, work continued on phosphogypsum use, new beneficiation methods for coarse phosphate feed, and reclamation research.

The U.S. Bureau of Mines reviewed several environmental impact statements on proposed construction activity in Florida. The reviews were conducted to ensure that mineral reserves were not unfavorably impacted by the proposed projects.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Florida's mineral producers marketed 13 industrial minerals during 1988. Sales of these mineral commodities added about $1.4 billion to the State's economy.

Cement.—The combined value of portland and masonry cement accounted for 14% of the State's mineral value in 1988. Florida ranked first of 39 States in the manufacture of masonry cement and sixth in portland cement production. In 1988, masonry cement output rose 21,000 short tons over 1987 levels, while portland cement production increased 117,000 short tons.

Six companies produced portland cement; four of the six were also masonry cement producers. The six companies operated eight rotary kilns, six wet process and two dry process.

National Portland Cement Co. sold 41% of its Port Manatee grinding plant to a group of Spanish cement manufacturers. Florida Crushed Stone Co. completed the first full year of operation at its Brooksville plant. The company began operations in 1988 at the powder and lime plants adjacent to the Brooksville cement plant. Lone Star Industries Inc. leased its Pennsuco cement plant and two cement import terminals at Edgewater and Jacksonville to Tarmac PLC. The term of the lease was 21 years at $2.5 million per year.

Clays.—The value of Florida's clay production ranked fourth among the 15 mineral commodities produced in 1988 and third among the clay-producing States. Output decreased by more than 5,000 short tons from 1987 production levels; however, value increased almost $5 million.

The State's clay industry comprised six companies operating six mines in six counties. In decreasing order of tonnage, these firms produced common clay, fuller's earth, and kaolin. Florida ranked 32d among the 44 common clay producing States, 2d among the 10 fuller's earth producers, and 10th among the 13 States with kaolin output.

Common clay was produced by two companies from surface mines in Clay and Lake Counties. Common clay production increased slightly over 1987 levels and accounted for approximately 22% of the State's 1988 clay output. The clay was used in the manufacture of cement and lightweight aggregate.

Fuller's earth, an absorbent clay, was produced by three companies from a three-county area in north-central Florida. Fuller's earth accounted for approximately 71% of the State's clay production. The three companies, Engelhard Corp., Floridin Co., and Mid-Florida Mining Co., produced approximately 10,000 short tons less than the quantity produced in 1987.

After mining, the clay was dried, ground, and screened prior to shipment. Principal sales were for pet waste and oil and grease absorbents, for fertilizer and pesticide carriers, and as a saltwater drilling mud component.

Feldspar Corp. mined kaolin from a pit in Putnam County. Both output and value increased over levels reported in 1987. Principal customers were the electrical porcelain, whiteware, and wall tile industries.

Peat.—Florida ranked first among 23 peat-producing States. Sales volume and value decreased 97,000 short tons and $977,000, respectively, below levels reported by the State's producers in 1987. Twelve companies harvested both reed-sedge and humus peat in an eight-county area. Principal shipments were made to horticultural establishments.

Phosphate Rock.—In 1988, phosphate rock production in Florida increased 9% over the tonnage reported in 1987. The U.S. Bureau of Mines combines phosphate rock data for Florida and North Carolina to protect pro-

duction and value information supplied by the single North Carolina producer. In Florida, phosphate rock production peaked in 1980, when the industry produced 43 million metric tons and employed 14,500 people. Foreign products, a rising dollar value, and a decrease in domestic fertilizer use eroded demand for the State's leading mineral commodity. The years 1982–85 were a recovery period, but in 1986 production fell to 29.7 million metric tons and phosphate-related employment dropped to 9,700.[3]

In 1988, the phosphate rock industry partially recovered; however, mines were operating at only 60% to 70% of capacity. Port of Tampa figures for the fiscal year ending September 30, 1988, indicate phosphate rock exports were down 4%, but exports of all phosphate-related products increased 4% over the previous fiscal year. Chemical-grade phosphate exports increased 12% to 7 million metric tons, while phosphoric acid exports decreased 7% to 497,796 short tons.

Foreign competition remained a major headache for the State's phosphate rock industry. Close to 500,000 metric tons of foreign phosphate rock was shipped on the Mississippi River system in 1988; most of the commodity was from Morocco. Florida producers lost Canada as a customer when Canada began purchasing phosphate rock from Togo.

Ten companies operated 15 mines during 1988. International Minerals & Chemicals (IMC) was the largest company; 5 mines were in operation utilizing 14 draglines and employing 3,000 workers. IMC announced plans to reopen its Four Corners Mine early in 1989. During 1988, IMC was negotiating with W. R. Grace to purchase one-half interest in Grace's phosphate operations. Grace sold the other one-half of its phosphate operations to Seminole Fertilizer Corp., Memphis, TN. The sale included Grace's Bartow phosphate mining and processing complex, Hookers Prairie phosphate rock mine, a 50% interest in Fort Meade Chemical Products, an ammonia storage terminal in Tampa, machinery, and other assets.[3]

Other companies active in the State's phosphate rock fields included Agrico Chemical Co., CF Industries Inc., Estech Inc., Gardinier Inc., W. R. Grace & Co., Hopewell Land Partners Ltd., IMC Fertilizer Inc., Mobil Mining and Minerals Co., U.S. Agri-Chemicals Corp., Occidental Chemical Agricultural Products Inc., Manko Co., Howard Phosphate Co., and Loncala Phosphate Co.

Estech announced in November that the Watson Mine south of Fort Meade was mined out and would be closed in 1989. The 8,500-acre mine, which opened in 1938, has been the oldest operating mine in central Florida.

Sand and Gravel.—Florida ranked 16th of the 50 sand and gravel producing States; sand and gravel accounted for approximately 4% of the State's mineral value. Output was reported by 29 companies operating 48 mines in a 20-county area.

Construction.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

Florida construction sand and gravel statistics are compiled by geographical districts, as depicted in the centerfold map. Table 3 presents end-use data for this commodity in the four Florida districts.

Despite the State's leading position in southeastern construction activity, construction sand and gravel output plummeted almost 10 million short tons below levels reported in 1986.

In 1988, 29 companies reported production from 48 mines in 20 counties. The five leading counties in terms of tonnage were Broward, Henry, Lake, Marion, and Polk.

Industrial.—Florida ranked 13th among the 37 States reporting industrial sand and gravel production in 1988. Output decreased 66%, from 1.9 million short tons in 1987 to 636,000 in 1988, and value fell $12.8 million. Six companies in six counties produced in-

TABLE 2

FLORIDA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	4,854	$17,052	$3.51
Plaster and gunite sands	441	1,427	3.24
Concrete products (blocks, bricks, pipe, decorative, etc.)[1]	128	239	1.87
Asphaltic concrete aggregates and other bituminous mixtures	381	1,761	4.62
Fill	1,764	3,449	1.96
Unspecified:[2]			
Actual	5,680	16,531	2.91
Estimated	5,407	12,625	2.33
Total[3] or average	**18,654**	**53,083**	**2.85**

[1] Includes road and other stabilization (lime).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

TABLE 3

FLORIDA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	630	1,808	3,787	14,057	437	1,187	—	—
Plaster and gunite sands	W	W	W	W	—	—	215	W
Concrete products (blocks, bricks, etc.)	W	W	—	—	—	—	—	—
Asphaltic concrete aggregates and other bituminous mixtures	W	W	W	W	—	—	—	—
Road base and coverings[1]	—	—	—	—	—	—	100	175
Fill	82	169	526	997	241	601	915	1,682
Other miscellaneous	303	1,667	331	911	—	—	—	674
Other unspecified[2]	894	2,179	5,081	14,353	5,036	12,416	75	208
Total[3]	**1,908**	**5,822**	**9,726**	**30,319**	**5,714**	**14,204**	**1,305**	**2,739**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (lime).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

dustrial sand; one operation was a byproduct of kaolin production. Major out-of-State markets were in Alabama, Georgia, and Tennessee.

Staurolite.—Florida remained the only U.S. producer of staurolite, an iron-aluminum silicate used in foundry applications, sandblasting, and cement manufacture. E. I. du Pont de Nemours & Co. Inc. recovered a staurolite concentrate as a coproduct of heavy-mineral processing at its Clay County operation. The company reported an increase in production.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Florida ranked second behind Pennsylvania among the 49 States reporting crushed stone production, and stone value was second among the mineral commodities mined within the State. Estimated 1988 production exceeded production reported in 1987 by more than 4 million short tons, reflecting the health of the State's construction and cement industries.

In 1987, the last year that a full year's production data were reported by the State's crushed stone industry, 86 companies operated 125 mines in a 25-county area. In terms of tonnage produced, the five leading counties were Dade, Hernando, Broward, Lee, and Sumter, which accounted for approximately 73% of the stone produced.

Florida's stone industry produced limestone and dolomite, oyster shell, and marl. Limestone and dolomite production was reported from 22 counties; output totaled approximately 75.5 million short tons. Dolomite production was reported from Citrus and Jackson Counties. Oyster shell was recovered by seven companies in five counties; the three leading counties were Hillsborough, Sarasota, and Manatee. Production totaled approximately 3.5 million tons. Marl output was reported by one company in Lee County. Principal end uses reported to the U.S. Bureau of Mines were graded road base (22%), concrete aggregate (19%), and construction sand (8%).

Other Industrial Minerals.—Fluosilic acid, a byproduct of wet-process phosphoric acid manufacture, was produced by six companies. The acid was used in several industrial applications, including water purification.

Imported and byproduct gypsum was used-recovered by several companies. Imported gypsum was calcined at three plants in Duval and Hillsborough Counties for wallboard manufacture. USG Corp., one of the three calciners, operated the largest plant in the two counties. Occidental Chemical Co. recovered byproduct gypsum at its White Springs facility.

Nitrogen was recovered by Air Products & Chemicals Inc. to produce anhydrous ammonia at a 100,000-short-ton-per-year facility at Pace Junction. Jones Chemical Inc. of Fort Lauderdale also produced anhydrous ammonia. Nitram Inc. produced nitric acid at a Tampa plant.

Perlite was expanded by four companies at plants in Broward, Duval, Es-

cambia, and Indian River Counties. Ore was shipped in from western States. Primary end uses were for construction aggregate, filler, horticultural purposes, and insulation. Sulfur was recovered at Exxon Corp.'s desulfurization plant in Santa Rosa County. Two firms operated four plants to exfoliate vermiculite. The tonnage of ore, shipped from out-of-State mines, ranked Florida fifth among the 29 States with exfoliation plants. Sales were to the concrete aggregate, horticulture, and insulation markets.

Metals

Florida was an important steel-producing State in 1988; the Nation's third largest minimill steel company conducted operations in the State, and numerous metal foundries were active during the year. In addition, Florida was the only State with a mineral sands industry.

Iron and Steel.—Florida Steel Corp. operated minimills at Jacksonville and Tampa. The Jacksonville facility was equipped with a 36,000 kilovolt ampere, 400,000-net-ton-per-year capacity furnace and a 4-strand continuous caster. The Tampa mill housed two 18,000 kilovolt ampere furnaces with a 90,000- and a 113,000-net-ton-per-year capacity, respectively. The Tampa facility was equipped with two 2-strand continuous casters.

Mineral Sands.—Associated Minerals (USA) Inc. at Green Cove Springs and E. I. du Pont de Nemours & Co. Inc. at Trail Ridge recovered mineral sands by dredging. Wet concentration, using spirals and cones, was used to produce a heavy mineral concentrate after mining. Dry separation, using magnetic and electrostatic techniques, was used to separate the heavy minerals into their individual concentrates.

Rare Earths.—Monazite was recovered as a concentrate by Associated Minerals at its Clay County operation. Titanium and zirconium concentrates were also recovered there. The monazite concentrate was shipped to Rhône-Poulence in France for processing. Rare earths were extracted and a fraction sent to a plant in Texas.

Titanium Concentrates.—Rutile, a titanium oxide; ilmenite, an iron titanium oxide; and leucoxene, an oxidized, high-titanium ilmenite, were recovered as concentrates by both Associated Minerals and Du Pont. Associated Minerals recovered three separate concentrates: ilmenite, which was sold to Du Pont's titanium dioxide pigments plants in Tennessee and Delaware; rutile, sold to Kemira Oy's titanium dioxide pigment plant in Savannah, GA; and leucoxene, sold to Kerr McGee's synthetic rutile plant in Mobile, AL. Du Pont produced a concentrate that contained all three titanium minerals and was used in Du Pont's titanium dioxide plants in Tennessee and Delaware.

Zirconia Concentrate.—Zircon, or zirconium dioxide, was recovered as a concentrate by both Associated Minerals and Du Pont. The Associated Minerals operation produced a concentrate containing approximately 66% zirconium dioxide that was sold to grinding plants in South Carolina and New York. After grinding, most of the zircon was used by the ceramics, refractory, and foundry industries.

Du Pont produced three grades of concentrate at its 77,000-short-ton-annual-capacity plant at Trail Ridge. The concentrates were sold to the ceramics and foundry industries.

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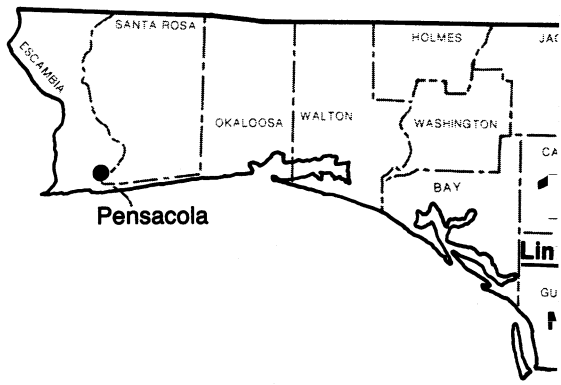
[1] State Mineral Officer, U.S. Bureau of Mines, Tuscaloosa, AL.

[2] Chief, Florida Bureau of Geology, Tallahassee, FL.

[3] Orlando Business Journal and Tampa Bay Business Journal, Special Supplement. Phosphate Industry Coming off the Ground. Dec. 4-10, 1988, p. 1.

FLO



LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Ful	Fuller's earth
Gyp	Gypsum plant
Kao	Kaolin
Lime	Lime plant
Mg	Magnesium
P	Phosphate rock
Peat	Peat
RE	Rare-earths
SG	Sand and Gravel
Shell	Shell
Zr	Zircon
	Concentration of mineral operations

Principal Mineral-Producing Localities

DA

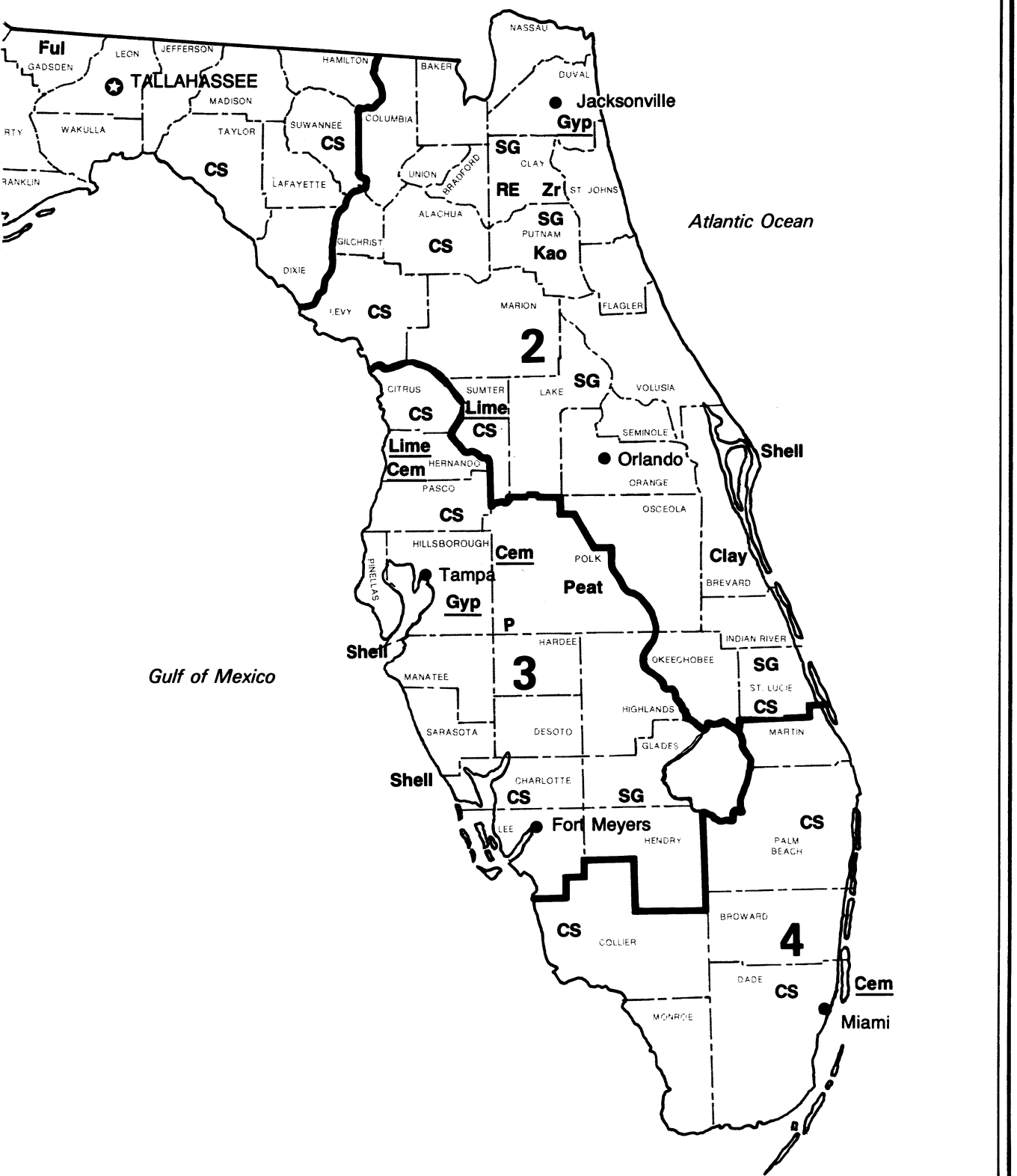

Ful
GADSDEN
LEON
JEFFERSON
TALLAHASSEE
HAMILTON
BAKER
NASSAU
DUVAL
Jacksonville
Gyp
MADISON
WAKULLA
TAYLOR
SUWANNEE
COLUMBIA
CS
SG
CLAY
UNION
BRADFORD
RE
Zr
ST. JOHNS
LAFAYETTE
ALACHUA
SG
PUTNAM
Atlantic Ocean
GILCHRIST
CS
Kao
DIXIE
LEVY
CS
MARION
FLAGLER
2
SG
CITRUS
SUMTER
LAKE
VOLUSIA
CS
Lime
CS
SEMINOLE
Shell
Lime
Cem
HERNANDO
Orlando
ORANGE
PASCO
OSCEOLA
CS
HILLSBOROUGH
Cem
POLK
Clay
PINELLAS
Tampa
Peat
BREVARD
Gyp
P
INDIAN RIVER
Shell
HARDEE
OKEECHOBEE
SG
Gulf of Mexico
MANATEE
3
ST. LUCIE
HIGHLANDS
CS
SARASOTA
DESOTO
MARTIN
GLADES
Shell
CHARLOTTE
CS
SG
LEE
Fort Meyers
HENDRY
CS
PALM BEACH
CS
COLLIER
BROWARD
4
DADE
CS
Cem
MONROE
Miami

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Lafarge Corp.	Box 223481 Tampa, FL 33622	Plants	Hillsborough.
Lonestar Florida Pennsuco Inc.	Box 122035 Hialeah, FL 33012	Plant	Dade.
Moore McCormack Resources Inc.	Box 23965 Tampa, FL 33630	do.	Hernando.
National Portland Cement Co.	Route 1 Port Manatee Palmetto, FL 34221	do.	Manatee.
Rinker Portland Cement Corp.	Drawer K Palm Beach, FL 33416	do.	Dade.
Clays:			
Engelhard Corp., Specialty Chemicals Div.	Menlo Park Edison, NJ 08817	Open pit mines and plant.	Brevard.
The Feldspar Corp., EPK Div.[1]	Box 8 Edgar, FL 32049	do.	Putnam.
Florida Solite Corp.	Box 297 Green Cove Springs, FL 32043	do.	Clay.
Floridin Co.	Box 187 Berkeley Springs, WV 25411	do.	Gadsden.
Mid-Florida Mining Co.	Box 68-F Lowell, FL 32663	do.	Marion.
Gypsum (calcined):			
Jim Walter Corp.	Box 135 Jacksonville, FL 32226	Plant	Duval.
National Gypsum Co.	4100 First International Bldg. Dallas, TX 57270	do.	Hillsborough.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do.	Duval.
Peat:			
Atlas Peat & Soil Inc.	Box 3867 Boynton Beach, FL 33435	Bog	Palm Beach.
Hyponex Corp.	2013 South Anthony Blvd. Fort Wayne, IN 46803	Bog	Lake.
TU-CO Peat	9601 Bear Road Sebring, FL 33870	Bog	Highlands.
Perlite (expanded):			
Airlite Processing Corp. of Florida	Route 2, Box 740 Vero Beach, FL 32960	Plant	Indian River.
Armstrong Cork Co.	Box 1991 Pensacola, FL 35289	do.	Escambia.
Chemrock Corp.	End of Osage St. Nashville, TN 37208	Plant	Duval.
W. R. Grace & Co.[2]	62 Whittemore Ave. Cambridge, MA 02140	do.	Broward.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Phosphate rock:			
Agrico Chemical Co.	Box 1110 Mulberry, FL 33860	Open pit mines and plants	Polk.
AMAX Chemical Inc.	402 South Kentucky Ave. Lakeland, FL 33801	Open pit mine and plant	Hillsborough.
Beker Phosphate Corp.	Box 9034 Bradenton, FL 33506	do.	Manatee.
Brewster Phosphates	Bradley, FL 33835	Open pit mines and plant	Hillsborough and Polk.
CF Industries Inc.	Box 790 Plant City, FL 33566	Open pit mine and plant	Hardee.
Estech Inc.	Box 208 Bartow, FL 33830	Open pit mines	Polk.
Gardinier Inc.	Box 3269 Tampa, FL33601	Open pit mine and plant	Do.
W. R. Grace & Co.	Box 471 Bartow, FL 33830	Open pit mines and plant	Do.
International Minerals & Chemical Corp.	Box 867 Bartow, FL 33830	do.	Do.
Mobil Mining and Minerals Co.	Box 311 Nichols, FL 33863	do.	Do.
Occidental Chemical Co.	White Springs, FL 32096	do.	Hamilton.
USS Agri-Chemicals Inc.	Box 867 Fort Meade, FL 33841	Open pit mine and plant	Polk.
Sand and gravel:			
Florida Crushed Stone Co.	Box 300 Leesburg, FL 32749	Pits and mines	Lake.
Florida Rock Industries Inc., Shands & Baker	Box 4667 Jacksonville, FL 32201	Pits	Clay, Glades, Lake, Marion, Polk, Putnam.
E. R. Jahna Industries, Inc.	First & East Tillman Lake Wales, FL 33853	do.	Henry, Lake, Polk.
Standard Sand & Silica Co.	Box 35 Davenport, FL 33837	do.	Polk.
Staurolite:			
Associated Minerals (USA) Ltd. Inc.[3]	Green Cove Springs, FL 32043	Mine and plant	Clay.
E. I. du Pont de Nemours & Co. Inc.[3]	Du Pont Bldg., D-10084 Wilmington, DE 19898	Mines and plants	Do.
Stone:			
Dixie Lime & Stone Co.	Drawer 217 Sumterville, FL 33585	Quarry	Sumter.
Florida Crushed Stone Co.	Box 317 Leesburg, FL 32748	Quarries	Hernando and Sumter.
Florida Rock Industries Inc.	Box 4667 Jacksonville, FL 32201	do.	Alachua, Collier, Hernando, Lee, Levy, St. Lucie, Taylor.
Rinker Southeastern Materials Inc.	Box 5230 Hialeah, FL 33014	do.	Dade.
Tarmac Florida Inc.	Box 8648 Deerfield Beach, FL 33441	Quarry	Do.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	Quarries	Broward and Dade.

[1] Also construction and industrial sand and gravel.
[2] Also exfoliated vermiculite.
[3] Also titanium concentrates.

THE MINERAL INDUSTRY OF GEORGIA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Georgia Geologic Survey, Environmental Protection Division, Georgia Department of Natural Resources, for collecting information on all nonfuel minerals.

By Doss H. White, Jr.,[1] and Bruce J. O'Connor[2]

In 1988, Georgia's mineral industry produced a State record of $1.4 billion of nonfuel mineral commodities, an increase of $161 million over that reported by the State's mineral producers in 1987. The 1988 total was the third consecutive year in which the value of mineral production exceeded $1 billion.

Clay sales, primarily kaolin, accounted for the greatest increase in value, 20% over that of 1987. The value of the principal construction mineral commodities—construction sand and gravel and crushed stone—increased only slightly over that reported for 1987. The increase reflected a slowing in construction activity in the third and fourth quarters.

Nationally, Georgia ranked seventh in total nonfuel mineral production. The State ranked first in the output of several industrial minerals, including crushed and dimension granite, crushed and dimension marble, and kaolin. Georgia also ranked in the top 10 States in the output of barite, common clay, fuller's earth, and iron oxide pigments.

TRENDS AND DEVELOPMENTS

Although the Georgia mineral industry extracted or manufactured 15 mineral commodities, approximately 89% of the 1988 mineral value was derived from the production of two commodities, clays and crushed stone. About 95% of the clay value was derived from kaolin sales. The State's leading position, nationally, in kaolin production helped to insulate the mineral industry from major recessions when construction declined significantly. In most of the other southeastern States, the sales of construction mineral commodities comprised over half of the annual mineral value, and a downturn in construction had a major effect on mineral output and value.

Clay's strong showing in 1988, $153 million over that reported in 1987, resulted from a continuing demand for paper coatings and fillers and from demands for filler and extender from other industries.

Georgia ranked second nationally in the number of building permits issued during the year, surpassed only by Florida. The State also spent $636 million in road construction, which accounted for a significant usage of crushed stone. However, stone demand slackened in the second half of 1988, and paralleled a downturn in construction. Most of the activity in Georgia's mineral industry in 1988 was in the industrial minerals sector and much of this activity involved plant expansions; the kaolin sector led the rest of the industry. Expansions of kaolin production facilities were announced or under way by ECC American Inc. at Sandersville, Engelhard Corp. at McIntyre, J.M. Huber Corp. at Huber and Wrens, Thiele Kaolin Co. at Sandersville, and Wilkinson Kaolin Associates Ltd. at Gordon.

During the year, Norfolk Southern Railroad, in response to the continuing growth of the kaolin market, initiated two trains to haul kaolin from Tennille to Atlanta and Birmingham, AL. The kaolin-filled cars were routed from At-

TABLE 1

NONFUEL MINERAL PRODUCTION IN GEORGIA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	9,826,662	$669,200	10,454,740	$756,093	11,325,528	$908,771
Gem stones		NA	20	NA	20	NA	20
Sand and gravel (construction)	thousand short tons	8,126	23,222	e9,000	e26,900	9,526	30,185
Stone:							
Crushed	do.	e56,700	e293,100	60,834	318,903	e57,400	e317,200
Dimension	short tons	e198,905	e20,678	179,207	21,683	e190,472	e27,768
Talc and pyrophyllite	do.	8,800	61	20,100	286	26,000	260
Combined value of barite, bauxite (1987–88), cement, feldspar, iron oxide pigments (crude), kyanite (1986), mica (scrap), peat, and sand and gravel (industrial)		XX	85,174	XX	88,485	XX	89,621
Total		**XX**	**1,091,455**	**XX**	**1,212,370**	**XX**	**1,373,825**

e Estimated. NA Not available. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

lanta to midwestern markets and from Birmingham to western and southwestern markets. At yearend, Hecla Mining Co. signed a letter of intent to purchase Cyprus Minerals Co.'s clay division. Included were mines and plants at Sandersville and Deepstep.

In other mineral activity, three new crushed stone quarries received the necessary zoning and/or State permits to begin operations, and the calcium carbonate division of Cyprus Minerals Inc. was sold to ECC American Inc. Riverside Products Corp. sold its sodium bicarbonate plant to FMC Corp., and Kemira Inc. began expansion work on its titanium dioxide plant in Savannah. In the Cartersville area, New Riverside Ochre Co. began work on a barite crusher and ore pipeline for the new Emerson Mine, Atlantic Steel announced expansion plans, and Bliss and Laughlin Steel Co. began work on a "greenfields" carbon steel bar mill.

LEGISLATION AND GOVERNMENT PROGRAMS

No legislation was enacted that directly affected the mineral industry. However, Washington County, the center of kaolin activity, hosted a 3-day legislative workshop for members of the Georgia Senate Economic Development and Tourism Committee and the House Industry Committee. Workshop participants visited kaolin mines and plants during the three-day session.[3]

The Georgia Geologic Survey continued investigations on the geology, mineral resources, and hydrology of the State. The geology program emphasized economic geology and the Accelerated Economic Minerals Program. Investigations were conducted in north Georgia for (1) massive sulfide deposits, (2) gold resources, and (3) platinum potential. Additional investigations included studies concerning pegmatites in the State and the construction sand and gravel potential of the Coastal Plain. Other activities of the Geology Program included (1) a major revision of the Cenozoic stratigraphy of the Coastal Plain (2) geological studies of the Fall Line area and east-central Georgia (3) an evaluation of the high-magnesium carbonates in Georgia and (4) a study of the geology of the Gulf Trough of Georgia. With a grant from the Minerals Management Service, the Survey continued to study phosphate and heavy mineral resources of coastal Georgia, including the Continental Shelf.

U.S Bureau of Mines geologists and engineers, located at its Intermountain Field Operations Center in Denver, CO, reviewed several environmental impact statements on planned construction in Georgia for possible conflict with existing mineral operations and/or mineral reserves. The Bureau's Research Center in Bruceton, PA, worked with personnel of the Southern Talc Co. to mitigate roof control problems.

The U.S. Geological Survey continued two ongoing programs: monitoring the State's stream flow and basic geologic mapping of several quadrangles.

The Georgia Mining Association, representing many of the State's mineral producers, held a reclamation workshop in February and a safety workshop in May. The association presented certificates of achievement for reclamation work to ECC American and Thiele Kaolin Co. at the annual meeting in October.

The Georgia Crushed Stone Association represented the majority of the State's crushed stone producers. During the year, the association worked with the National Stone Association (NSA) and Georgia Institute of Technology to establish a stone research center at the Institute. As a result of the Association's work on environmental concerns and community image, Georgia stone producers won 8 of 18 top showplace awards presented by the NSA in 1988.

In May, the China Clay Producers Association, composed of six major kaolin producers, unveiled an exhibit titled "The Kaolin Industry" at the State's capital. The exhibit, which displayed products containing kaolin, was placed on permanent display.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Thirteen industrial minerals were mined and two (portland and masonry cement) were manufactured. The leading industrial minerals in sales value were clay (66%), crushed stone (23%), and portland cement (value withheld).

Barite.—Georgia ranked second among the five States reporting barite production. The production of barite, a barium sulfate mineral used in chemical manufacturing and in oil-well-drilling mud, decreased 11% below the tonnage reported in 1987. Barite was first produced in the Cartersville area of northwest Georgia in the 1800's. Since then many companies have mined the Bartow County area. In 1988, New Riverside Ochre Co. and Cyprus Industrial Minerals Co. were the only producers. The ore was mined from the residuum of Cambrian age limestones and/or dolostones.

During the year, New Riverside continued reclamation work on its mine within the city limits of Cartersville; the mine was depleted after 100 years of production. A shopping center was built on the west end of the reclaimed mine, and local businesses have plans for using the remainder of the mine when reclamation is completed. New Riverside began development work on a new mine at Emerson, a few miles south of Cartersville. Ore was to be mined by dragline and trucked approximately 2 miles to a crusher. After washing and crushing, the ore would be transported by slurry pipeline to the company's plant on the Etowah River near Cartersville. Froth flotation would then be used to recover a barite concen-

trate. The Emerson mine and crusher were scheduled for full operation in 1989.

Cyprus operated a mine north of the Emerson operation on the south bank of the Etowah River. Ore was mined by dragline and trucked a short distance to a crusher-flotation plant. Concentrates were then trucked to a bagging plant located on the railroad south of Cartersville.

New Riverside concentrates were used by an associate company, Chemical Products Corp. in Cartersville, for barium chemical production. Barium chemicals with high density and brightness, inertness, and radiation absorption characteristics were used by a variety of industries. Cyprus produced three grades of barite used in automotive applications, primers, sound deadening, brake linings, and sporting accessories such as golf balls.

Bauxite.—American Cyanamid Corp. operated a mine and plant at Andersonville, southwest of Macon. The company mined a bauxitic kaolin to produce a chemical-grade material used in the manufacturing of liquid alum. The material's principal market was the paper industry where it was used in sizing operations. During 1988, the company operated one calciner and produced approximately 100,000 short tons.[4]

Cement.—The State ranked 17th among the 40 portland cement-producing States and 10th among the 37 States with masonry cement output. Georgia's cement production decreased 2% below the tonnage reported in 1987. The decrease was due to a drop in the demand for concrete and masonry products during the latter part of the year.

Two companies, Blue Circle Inc. and Medusa Cement Co., constituted Georgia's cement manufacturing industry; both produced portland and masonry cement. Blue Circle operated a plant in Atlanta, and Medusa's cement facility was at Clinchfield in Houston County. Blue Circle's plant contained four kilns, two wet-process units, and two dry-process kilns rated at 546,000 short tons per year.

Clay was mined from company-owned property in Douglas County, and limestone was shipped from the Rome area in northwestern Georgia. Sand and iron scale were purchased from Atlanta-area suppliers.

Medusa's Clinchfield plant operated two dry-process kilns with a 300,000-short-ton annual capacity. Clay, sand, and stone were obtained from mines in Houston County, and iron scale was purchased from an in-State supplier.

Clays.—Georgia continued as the Nation's leader in the production of clay, accounting for more than 65% of the U.S. total. Three types of clay were produced: kaolin, fuller's earth, and common clay and shale. Compared with 1987 figures, clay output and value increased by 871,000 short tons and, $153 million, respectively.

Kaolin.—Kaolin, light-colored clay derived from the weathering of feldspathic-bearing granite rocks, was the leading clay type produced in-State, both in tonnage and value. In Georgia, kaolin occurs in a belt extending along the fall line from South Carolina to the vicinity of Macon in east-central Georgia.

In 1988, kaolin production was reported by 18 companies operating 27 mines in a 10-county area. Output reached a record 8.2 million short tons, exceeding the 1987 level by 764,000 short tons; value exceeded that of the previous year by $148 million. Kaolin was mined by surface methods and transported to processing plants by pipeline and/or truck.

Two principal processes, dry and wet, were used to prepare kaolin for market. In the dry process, the kaolin was crushed, dried, pulverized, and air floated to remove grit; this process yielded a lower cost kaolin clay. Dry-processed kaolin was used as a paper filler, in some ceramic applications, in fiberglass, as an insecticide carrier, and as a rubber and adhesive filler. Wet processing involved several steps including fractionating, bleaching, dewatering, and drying. The end product, a high-quality clay, was shipped in both bag and slurry form. Several plants delaminated a portion of the plant feed to produce a product particularly suited for lightweight paper coating, paint, and special rubber applications. Calcining also was used to produce a whiter, brighter, and tougher product.

The continuing demand for the various grades of kaolin fueled a number

TABLE 2

GEORGIA: KAOLIN SOLD OR USED BY PRODUCERS, BY COUNTY

County	1987			1988		
	No. of mines	Quantity (thousand short tons)	Value (thousands)	No. of mines	Quantity (thousands short tons)	Value (thousands)
Jefferson	1	W	W	1	W	W
Richmond[1]	2	234	$6,719	3	440	$2,102
Twiggs	6	1,551	155,177	6	1,615	173,279
Washington	5	2,549	235,432	5	2,796	265,091
Wilkinson	4	1,093	130,962	5	1,133	145,081
Other[2]	8	1,996	185,235	8	2,204	275,785
Total[3]	**26**	**7,424**	**713,524**	**28**	**8,088**	**861,335**

W Withheld to avoid disclosing company proprietary data; included in "Other."
[1] Includes Jefferson County.
[2] Includes Columbia, Houston, Macon, Sumter, and Warren Counties and data indicated by symbol W.
[3] Data may not add to totals shown because of independent rounding.

TABLE 3

GEORGIA: KAOLIN SOLD OR USED BY PRODUCERS, BY USE

(Short tons)

Use	1987	1988
Domestic:		
Adhesives	46,779	43,980
Chemicals	150,947	155,000
Fiberglass and mineral wool	273,697	312,645
Firebrick, blocks and shapes	67,645	35,334
Floor and wall tile, ceramic	15,558	W
Paint	253,340	283,311
Paper coating	2,485,279	2,737,396
Paper filling	1,326,615	1,605,832
Plastics	48,167	52,363
Rubber	59,382	53,359
Sanitary ware	56,511	24,634
Whiteware	22,732	46,786
Other	1,011,868	1,121,933
Exports	1,605,300	1,714,996
Total	**7,423,820**	**8,187,569**

W Withheld to avoid disclosing company proprietary data; included in "Other."

TABLE 4

GEORGIA: FULLER'S EARTH SOLD OR USED BY PRODUCERS, BY KIND

(Thousand short tons and thousand dollars)

Kind	1985		1986		1987		1988	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Attapulgite	387	25,333	318	15,657	372	22,770	433	26,931
Montmorillonite	206	9,295	214	10,665	219	12,433	210	12,472
Total	**593**	**34,628**	**532**	**26,322**	**591**	**35,213**	**643**	**39,403**

of plant expansions in Georgia's kaolin industry; the expansions have a total value of almost $300 million.

During the year, ECC American Inc. completed a $50 million expansion which increased production by 40%. Increased capacity was achieved for high-brightness, high-glossing, delaminated, and calcined clays; part of the expansion included the installation of a new calciner, the company's fifth. Most of the increased output will go to the paper industry.

ECC purchased Cyprus Mineral Co.'s clay operations in Georgia, South Carolina, and Tennessee.

J.M. Huber Co. announced a 4-year, $100 million expansion for its Huber and Wrens facilities. The expansion will "computerize and automate" the two operations to "boost research, quality, and customer services."[5]

In June, Wilkinson Kaolin Associates Ltd. (WKA) announced a $3 million expansion plan for its Gordon facility. The expansion was to include modern airfloat grinding equipment, a new warehouse, additional supporting materials handling, and new mining equipment. The expansion was scheduled for completion in early 1989.[6]

Engelhard Corp. completed an $80 million expansion of its McIntyre facility. The expansion included a "new calciner, expanded processes for noncalcined kaolin-based products, and new facilities to centralize and enhance engineering and technological capabilities." The expansion added approximately 300,000 short tons to the annual capacity of the McIntyre plant.[7]

Thiele Kaolin Co. began work on a $45 to $50 million expansion, which included new spray dryers, calciners, conveying and storage equipment, "state-of-the-art mining equipment," and office space.[8]

To transport the increased tonnages of kaolin produced, Norfolk Southern Railroad began two new train operations, "The Kaolin Express" and "The Kaolin Expeditor." The "Express" was a 6-day-per-week train that operated from Tennille, east of Macon, to Atlanta where cars connected with trains to Chicago and other midwestern cities. The "Expeditor" operated daily between Tennille and Birmingham, AL, for connections to western and southwestern markets.[9]

Fuller's Earth.—Georgia's second leading clay, by value, was fuller's earth, a nonplastic clay with decolorizing and purifying properties. The State ranked first out of 9 States in fuller's earth production, which totaled 643,000 short tons valued at $39 million, an increase of 52,000 short tons and $4 million over that reported in 1987.

The industry consisted of six companies operating six mines in four counties. The clay was mined by surface methods using draglines and front-end loaders and was trucked to processing facilities where it was dried, crushed, milled, screened, and bagged for shipment. The principal market for Georgia

fuller's earth was as an absorbent, in both industrial and pet waste applications. Fuller's earth was also used in the manufacture of joint compound, as a filler in certain applications, and in the production of cracking catalysts for the petroleum industry.

Common Clays.—Georgia ranked fourth among 43 States in the production of common clay, a material which can be easily molded and vitrified below 1,100° C. Output of common clay and/or shale-phyllite decreased 55,000 short tons from that reported by the clay industry in 1987. Three years of increased demand for construction materials, brick, and other clay building products leveled off during the latter part of 1988.

The State's common clay industry was located in Bartow, Douglas, Floyd, and Fulton Counties in northwest Georgia, where five companies operated seven mines. Other locations were in Bibb, Columbia, and Richmond Counties in central and eastern Georgia. In the latter area, four companies operated six mines.

Georgia's clay output was used principally for use in the manufacture of brick and cement.

Feldspar.—Georgia ranked third behind North Carolina and Connecticut in the mining of feldspar, an aluminum silicate used in glassmaking and ceramics. Production increased 8% over that reported in 1987 because of the strong demand for glass products in new construction.

The Feldspar Corp., a subsidiary of Femex Corp., the Nation's major feldspar producer, operated surface mines in Greene and Jasper Counties. The Greene County quarry, developed in the weathered residuum of the Silom Granite, produces a high-potassium feldspar. A monitor was used to mine the weathered granite material. The Jasper County mine, using standard drilling and blasting techniques, produced a high-sodium feldspar. Ore from both mines was trucked to the company plant in Monticello where froth flotation, a process developed by the U.S. Bureau of Mines, was used to recover the feldspar concentrate. The concentrate was dried, bagged, and shipped to customers in more than 20 States, Canada, and Mexico.

Feldspar use within the State increased from 64,700 short tons in 1980 to 93,100 tons in 1988. Atlanta-area glass producers provided the principal market.

Iron Oxide Pigments.—New Riverside Ochre Co. continued as the largest natural ochre pigment producer in the country. The company mined zones in the lower Cambrian strata near Cartersville to produce ochre and umber. The crude pigments were processed to produce coloring agents for cement and construction materials.

Mica.—Georgia ranked third among six mica-producing States. Franklin Mineral Products Co., a subsidiary of the Mearl Corp., operated an open pit mine and beneficiation facility in Hart County in northeastern Georgia. Ore was mined by dragline and trucked to the plant where it was wet ground. Much of the plant's output was used by the parent company to manufacture pearlescent pigments. Crude mica also was shipped to a company grinding plant in Franklin, NC.

Mullite (Synthetic).—Synthetic mullite, formed when mixtures of aluminous and siliceous materials are sintered in kilns or fused in electric-arc furnaces, was used primarily in high-temperature refractory applications. C-E Minerals Inc. mined a bauxitic kaolin near Andersonville in west-central Georgia. The clay was blended, extruded into pellets, dried, and calcined at a seven-kiln plant to produce synthetic mullite. Three grades of material containing 47%, 60%, and 70% alumina content were marketed. The company also imported bauxite from China. Approximately one-half of the plant's output was sold for domestic use, while overseas markets absorbed the remainder.

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

Georgia's sand and gravel industry ranked 33rd nationally in sand and gravel production. In 1988, 40 companies reported production from 54 mines in 32 counties. Compared to 1987 estimates, production and value increased 526,000 short tons and $3.2 million, respectively. The three leading counties in production were Crawford, Talbot, and Taylor.

Georgia construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 6 presents end-use data for the State's three districts.

Industrial.—Sand for industrial use was produced by three companies with operations in Crawford, Marion, and Montgomery Counties in the central part of the State. The three major end uses reported to the U.S. Bureau of Mines were (1) glass container manufacture, (2) sandblasting, and (3) filtration. Output was up 11% and value increased 18% over that reported in 1987.

Silica (Fused).—Harbison-Walker Refractories in Calhoun and Leco Corp. in Lawrenceville produced silica grains and powder for the refractory, foundry, filler, and extender markets. Much of Harbison-Walker's grain production was used in an on-site company refractory products plant. The company exported to Europe and Japan. Much of Leco's fused silica was used in the company's refractory and investment casting products.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual

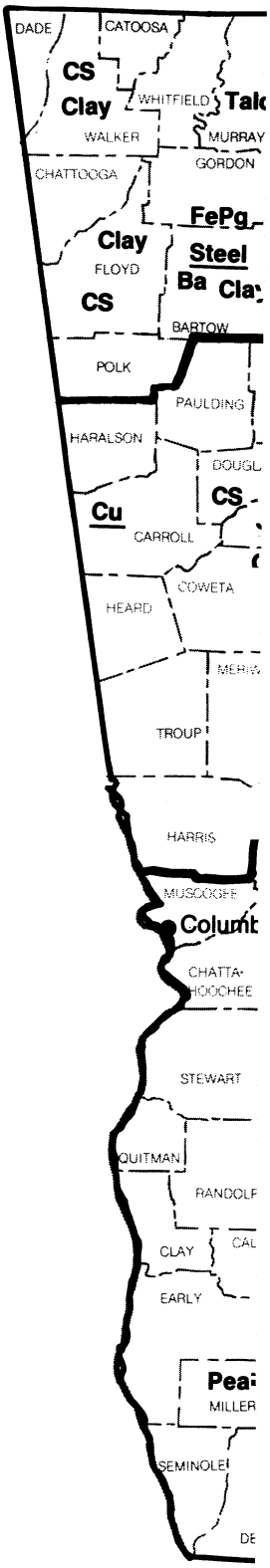
GEORGIA

LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Au	Gold
Ba	Barite
Bx	Bauxite
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper smelter
D-G	Dimension Granite
D-M	Dimension Marble
D-Q	Dimension Quartzite
Fel	Feldspar
FePg	Iron Oxide pigments
Ful	Fuller's earth
Gyp	Gypsum plant
Kao	Kaolin
Mica	Mica
Peat	Peat
Per	Perlite plant
SG	Sand and Gravel
Steel	Iron and Steel plant
Talc	Talc
Ti	Titanium plant
	Concentration of mineral operations



Principal Mineral-Producing Localities

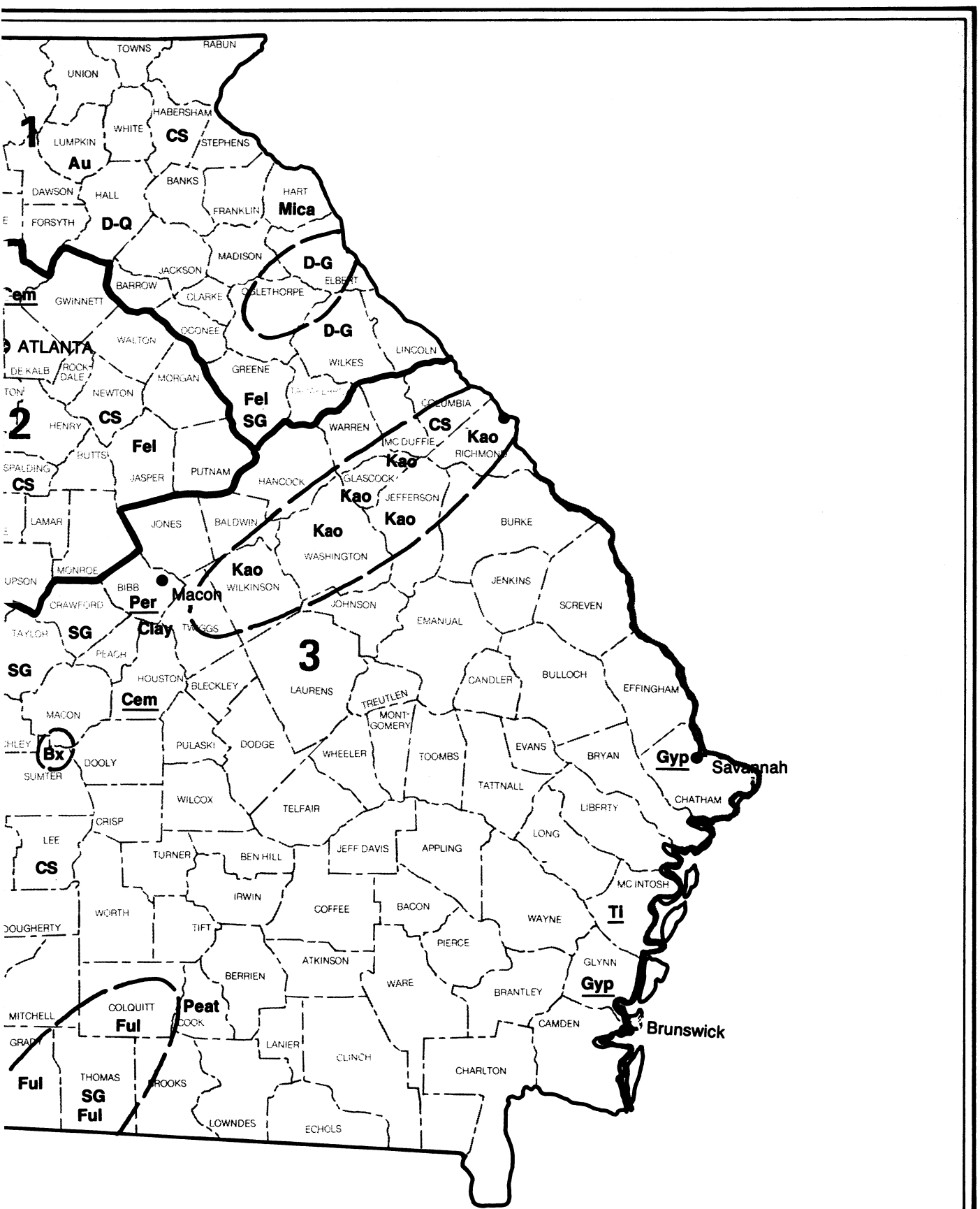

TOWNS
RABUN
UNION
HABERSHAM
WHITE
CS
STEPHENS
1
LUMPKIN
Au
BANKS
DAWSON
HALL
HART
FRANKLIN
Mica
FORSYTH
D-Q
MADISON
D-G
JACKSON
ELBERT
BARROW
CLARKE
OGLETHORPE
Cem
GWINNETT
D-G
DOONEE
WALTON
ATLANTA
LINCOLN
DE KALB
ROCK-DALE
GREENE
WILKES
MORGAN
NEWTON
Fel
SG
COLUMBIA
2
HENRY
CS
WARREN
CS
Kao
Fel
MC DUFFIE
RICHMOND
Kao
BUTTS
SPALDING
JASPER
PUTNAM
HANCOCK
GLASCOCK
CS
Kao
JEFFERSON
LAMAR
JONES
BALDWIN
Kao
Kao
BURKE
WASHINGTON
MONROE
Kao
JENKINS
UPSON
BIBB
Macon
WILKINSON
SCREVEN
CRAWFORD
Per
JOHNSON
EMANUAL
TAYLOR
SG
Clay
TWIGGS
3
PEACH
SG
HOUSTON
BLECKLEY
CANDLER
BULLOCH
EFFINGHAM
LAURENS
Cem
TREUTLEN
MONT-GOMERY
MACON
PULASKI
DODGE
EVANS
BRYAN
Gyp
Savannah
Bx
WHEELER
TOOMBS
DOOLY
SUMTER
TATTNALL
CHATHAM
WILCOX
TELFAIR
LIBERTY
CRISP
LONG
LEE
TURNER
BEN HILL
JEFF DAVIS
APPLING
CS
MC INTOSH
IRWIN
COFFEE
BACON
Ti
WORTH
WAYNE
DOUGHERTY
TIFT
PIERCE
ATKINSON
GLYNN
BERRIEN
WARE
Gyp
BRANTLEY
MITCHELL
COLQUITT
Peat
COOK
CAMDEN
Brunswick
Ful
LANIER
CLINCH
GRADY
THOMAS
BROOKS
CHARLTON
Ful
SG
Ful
LOWNDES
ECHOLS

TABLE 5

GEORGIA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	2,433	$8,011	$3.29
Plaster and gunite sands	260	872	3.35
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	2.86
Asphaltic concrete aggregates and other bituminous mixtures	37	80	2.16
Road base and coverings	W	W	3.58
Fill	48	119	2.48
Other	82	243	2.96
Unspecified: [1]			
Actual	4,739	14,106	2.98
Estimated	1,926	6,754	3.51
Total or average	**[2]9,526**	**30,185**	**3.17**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[2] Data do not add to total shown because of independent rounding.

TABLE 6

GEORGIA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products [1]	323	1,471	413	1,650	2,028	5,962
Asphaltic concrete aggregates and other bituminous mixtures	—	—	—	—	37	80
Road base and coverings	W	W	—	—	W	W
Fill	—	—	—	—	48	119
Other miscellaneous	4	27	—	—	8	16
Other unspecified [2]	216	648	53	249	6,396	19,962
Total	**543**	**2,146**	**466**	**1,899**	**8,517**	**[3]26,140**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for plaster and gunite sands.
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data do not add to total shown because of independent rounding.

company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—The State's stone industry in 1987, the last year that the industry was canvassed, consisted of 23 companies operating 69 mines in 43 counties. The industry produced granite, limestone, marble, slate, and quartzite.

The principal end uses reported included graded roadbase, 20%; concrete aggregate, 14%; bituminous aggregate, 10%; crusher run fill, 7%; and bituminous stone sand, 4%.

In 1987, 8 companies mined and crushed limestone at 10 quarries in 8 counties in the northwestern and coastal plain areas of the State. Output and value were withheld. Granite was mined and crushed by 16 companies operating 43 quarries in 31 counties in the northern half of Georgia (excluding the Valley and Ridge Province in northwestern Georgia). Output totaled 47 million short tons valued at $298 million.

The Georgia Marble Co. mined marble at underground mines in Pickens and Gilmer Counties in north-central Georgia. The stone was finely ground and sold for filler and extender applications and for agricultural uses. Reject marble blocks from the company's dimension stone operation either were crushed and sold for decorative stone and aggregate uses or were fabricated into floor tile. A second company in Hall County produced crushed marble from the Brevard Shear Zone for aggregate applications.

Galite Inc. in northwestern Georgia mined slate near Rockmart. The stone was expanded and the material marketed as a lightweight aggregate. Crushed quartzite was produced by one company in Richmond County and marketed as an aggregate.

Dimension.—Georgia ranked second among the 35 States with dimension stone production. Granite, marble, and metagraywacke were quarried for a variety of stone applications, both exterior and interior.

The Elberton granite district in northeastern Georgia continued as the leading granite-producing area in the world. Almost all of the Elberton district output was finished into monuments.

Georgia led the Nation in dimension marble production. Long Swamp Valley in Pickens County has been quarried for marble for more than 100 years. The Georgia Marble Company operated a quarry complex near Tate to

produce marble for both buildings and monuments. The company operated a structural marble fabricating plant at Ball Ground; blocks from the Tate quarries were transported by rail to Ball Ground to be fabricated into panels for building exteriors and interiors.

Several small companies in northern Georgia quarried a variety of stone types. The principal stone type, metagraywacke, a flagstone with a silver-gray sheen, was widely used in wall and walkway construction.

Talc.—Southern Talc Co., a subsidiary of United Catalysts Inc., operated a talc mine on Fort Mountain and a mill at Chatsworth. During the year, work continued on construction of a new Chatsworth mill, which would allow the company to expand its products. Current production was used by the insecticide, paper, roofing, and plastics industries.

The company continued its exploration program on Fort Mountain and investigated talc resources in South Carolina. The company planned to open a second mine on Fort Mountain.

Other Industrial Minerals.—Aragonite, a calcium carbonate, was imported from the Bahamas by Kemira Inc. in Savannah for acid neutralization at its titanium dioxide pigment plant. Celestite, a strontium sulfate mineral, was imported from Mexico by the Cartersville-based Chemical Products Corp. The ore was processed to produce strontium carbonate used in color television picture tube faceplates and other speciality applications.

Crude gypsum was imported from Nova Scotia and Newfoundland by Domtar Gypsum Inc., Gypsum Division of Georgia-Pacific Corp., and by Goldbond Building Materials Corp. to manufacture gypsum boards at plants in Chatham and Glynn Counties. Georgia-Pacific also operated a 36,000-short-ton-annual-capacity gypsum joint compound plant at Marietta. A fourth company, Kemira Inc. in Chatham County, produced gypsum as a byproduct of titanium dioxide pigment manufacturing. Gypsum output increased substantially over the 1987 level. During the year, Domtar converted its Savannah plant to use byproduct gypsum. During 1988, gypsum imports (calcined gypsum) totaled 782,000 short tons. Brunswick Pulp and Paper Co. operated the world's largest lime kiln at its plant in Brunswick. The kiln was installed in 1985. Atlanta-area glass plants imported limestone from Tennessee and glass-grade industrial sand for plant feed. Crude perlite was imported from Greece by Armstrong World Industries; the company operated an expansion plant near Macon in Bibb County. Perlite was expanded in a horizontal rotary furnace, classified in a cyclone classifier system, and stored before it was bagged and shipped.

Rutile from Florida and foreign sources and titanium-rich slag from smelting ilmenite-hematite ores in Canada were imported by Kemira Inc. to Savannah to manufacture titanium dioxide pigment. Rutile was feed for the plant's chloride process, and the slag was feed for the sulfide process. The company began expansion of the Savannah facility by approximately 50% to 160,000 short tons per year; the expansion was scheduled for completion in 1990. Principal pigment sales were to the paint, paper, and plastics industries. Steel slag from the Atlantic Steel Co. operations in Atlanta and Cartersville was marketed by a firm as an aggregate material. Trona, shipped from Wyoming, was used in the production of sodium bicarbonate in a plant near Cartersville. Riverside Products Corp. sold the plant to FMC Corp.

Metals

In the 1800's, Georgia was a metal-producing State with significant gold and iron industries. However, limited ore reserves and unfavorable economics, compared to other metal-producing areas, were factors in depressing Georgia's extractive metals industry; today only bauxite and iron oxide pigments (both used in industrial minerals applications) are mined. Several varieties of metal scrap and metal chemicals were shipped into the State and manufactured into metals or metallic acids. Nonextractive metal production statistics were not included in the table reporting Georgia's nonfuel production (table 1).

Copper, Aluminum, and Steel.—Southwire Corp. in Carrollton, west of Atlanta, operated a copper smelter and refinery, a continuous cast rod facility, and a wire plant; aluminum and copper wire and cable were produced. Southwire brought legal action against Venezuela wire manufacturers for "dumping" aluminum wire on the U.S. market, and the U.S. Department of Commerce imposed a 6.46% bond on imported Venezuelan rod to offset Venezuelan Government subsidies.[10]

Atlantic Steel Co. operated minimills at plants in Atlanta and Cartersville. The Atlanta mill was equipped with two 90-ton electric furnaces and bar, rod, and wire mills; the Cartersville mill contained a 100-ton electric furnace, a 4-strand continuous caster, and a bar mill. The two plants have an annual capacity of approximately 750,000 short tons of bar, rod, and wire.

In March, Atlantic Steel announced plans to spend $25 million to consolidate and upgrade its melting and casting operations in Cartersville. A 6-strand continuous caster "and other equipment" would be transferred from the Atlanta mill. The expansion of the Cartersville facility was scheduled for completion in 1990.[11]

Bliss and Laughlin Steel Co. announced construction plans for a cold-finished carbon steel bar mill at Cartersville. The 80,000-square-foot greenfield mill, scheduled for completion by mid-1989, would produce round, square, hexagonal, and flat bar.[12]

Other Metals.—Arsenic acid was produced by Hickson Corp., a subsidiary of Hickson International PLC, at

a plant in Conley and by Chemical Specialists Inc., owned by LaPorte Industries PLC, at a Valdosta facility. Arsenic acid is used in wood preservative applications. Acid was produced from arsenic trioxide obtained from reworking gold and copper tailings in Canada, Europe, and South America. Bauxite was mined by American Cyanamid for alum manufacture. The operation is described in the Industrial Minerals Section (Clays). The Mulcoa Division of C-E Minerals mined bauxite and bauxitic kaolin in west-central Georgia, near Andersonville. The operation is described in the Industrial Minerals Section (Mullite). Iron oxide pigments were mined and processed by one company in Cartersville. The operation is described in the Industrial Minerals Section (Iron Oxide Pigments).

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[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL.

[2] Principal Geologist, Georgia Geologic Survey, Environmental Protection Division, Georgia Department of Natural Resources.

[3] Sandersville Progress. County Hosts Legislative Workshop. Oct. 13, 1988.

[4] Industrial Minerals. Bauxite. Sept. 1988, p. 83.

[5] Macon Telegraph and News. Kaolin Plant Sinks Cash into Clay Technology. May 7, 1988.

[6] ———. Wilkinson Kaolin Will Expand Airfloat Mining Facility. June 10, 1988.

[7] Industrial Minerals. Engelhard in Major Expansion Program. Feb. 1988, p. 14.

[8] Sandersville Progress. Thiele Kaolin to Expand. Dec. 31, 1987.

[9] ———. Kaolin Keeping the Rails Hot and Profits High. June 9, 1988.

[10] Atlanta Constitution. U.S. Says Venezuela "Dumping" Aluminum Rod. Feb. 3, 1988.

[11] American Metals Market. Atlantic Steel Will Pay $25M to Consolidate Operations in GA. V. 96, No. 91, Mar. 29, 1988.

[12] B&L's First Expansion in Ten Years: Cold-finished Steel Bar Mill in Georgia. June 22, 1988, V. 96, No. 124.

TABLE 7

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Barite:			
Cyprus Industrial Minerals Co.	Box 130 Cartersville, GA 30120	Open pit mine and mill	Bartow.
New Riverside Ochre Co.[1]	Box 387 Cartersville, GA 30120	do.	Do.
Bauxite:			
Mullite Co. of America	Box 37 Andersonville, GA 31711	do.	Macon and Sumter.
Cement:			
Blue Circle Inc.	2520 Paul Ave., NW. Atlanta, GA 30318	Plant	Fulton.
Medusa Cement Co.	Box 5668 Cleveland, OH 44101	do.	Houston.
Clays:			
American Industrial Clay Co.	433 North Broad St. Elizabeth, NJ 07207	Open pit mines	Warren and Washington.
Engelhard Corp., Specialty Chemicals Div.	Menlo Park Edison, NJ 08817	do.	Decatur, Washington, Wilkinson.
J.M. Huber Corp.	Thornall St. Edison, NJ 08817	do.	Twiggs and Warren.
Thiele Kaolin Co.	Box 1056 Sandersville, GA 31082	do.	Warren and Washington.
Feldspar:			
The Feldspar Corp.	Box 99 Spruce Pine, NC 28777	Open pit mines and plant	Greene and Jasper.
Gypsum (calcined):			
Domtar Gypson Inc.	Box 1526 Savannah, GA 31498	Plant	Chatham.
Georgia-Pacific Corp.	133 Peachtree St., NE. Atlanta, GA 30303	do.	Glynn.
National Gypsum Co.	4500 Lincoln Plaza Dallas, TX 75201	do.	Chatham.
Mica:			
Franklin Mineral Products Co. Inc.	Box O Wilmington, MA 01887	do.	Hart.
Sand and Gravel:			
Construction:			
Bulter Sand Co.	Route 296 Butler, GA 31006	Open pit mine	Taylor.
Florida Crushed Stone Co.	Box 866 Nahunta, GA 31553	Pits	Brantley, Montgomery, Thomas.
Howard Sand Co.	Box 118 Butler, GA 31006	Open pit mines	Talbot and Taylor.
Industrial:			
Montgomery Sand Co., a subsidiary of Florida Crushed Stone Co.	Box 255 Mt Vernon, GA 30445	Open pit mine	Montgomery.
The Morie Co. Inc.	1201 North High St. Millville, NJ 08332	do.	Marion.

See footnote at end of table.

TABLE 7—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone:			
Crushed (1987):			
Florida Rock Industries Inc.	Box 4667 Jacksonville, FL 32201	Quarries	Clayton, Fayette, Floyd, Monroe, Spalding.
Georgia Marble Co.	Box 409 Lithonia, GA 30058	do.	De Kalb, Douglas, Forsyth, Gilmer, Hall, Newton, Pickens.
Martin Marietta Aggregates	Box 30013 Raleigh, NC 27612	do.	Jones, Lee, Richmond, Warren.
North Georgia Crushed Stone Co., a division of Koppers Co. Inc.	Box 458 Lithonia, GA 30058	do.	Clarke, De Kalb, Fayette, Fulton, Habersham, Hall, Stephens, Walker.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	do.	Carroll, Cobb, Coweta, Douglas, Fulton, Gwinnett, Henry, Troup.
Dimension:			
Bennie & Harvey Inc.	Box 958 Elberton, GA 30635	Quarry and finishing plant	Oglethorpe.
Coggings Granite Industries Inc.	Box 250 Elberton, GA 30635	do.	Madison.
Granite Panelwall Co., a division of Florida Crushed Stone Co.	Box 898 Elberton, GA 30635	do.	Elbert.

[1] Also produced crude iron oxide pigments.

THE MINERAL INDUSTRY OF HAWAII

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Department of Land and Natural Resources of the State of Hawaii for collecting information on all nonfuel minerals.

By Fred V. Carrillo[1]

Hawaii's nonfuel mineral production value in 1988 was $74.9 million. This slight increase over that reported in 1987 was attributed to rising prices and increased construction activity in Hawaii, Oahu, and Maui Counties; these increases, in turn, were prompted by a sixth consecutive year of economic expansion. Total construction in Hawaii maintained a 4-year growth trend, reaching a record dollar value of more than $2.5 billion, a 26.3% increase over that of 1987, according to the Bank of Hawaii.

Industrial minerals accounted for the total mineral value. Production of portland cement, lime, pumice, construction sand and gravel, and crushed stone accounted for approximately 98% of the total value. Hawaii ranked 45th in the Nation in value of minerals produced in 1988.

TRENDS AND DEVELOPMENTS

Near yearend, the State and the U.S. Department of the Interior entered into an agreement that called for joint planning and review of ocean mining within 200 miles of Hawaii. Under the new agreement, equal numbers of State and Federal representatives were to serve on a steering committee to resolve issues and develop policy positions related to seabed mining, particularly for future manganese crust exploration, leasing, and mining programs in ocean areas.

A final decision on the sale of marine leases for the exploration of cobalt-rich sea mounts in the Exclusive Economic Zone (EEZ) was postponed until 1990. Hawaii's State constitution added a new section that asserted the State's right to some control over mining in the EEZ, allowing the State to participate with the Federal Government in managing mining and other activities.

The University of Hawaii formally launched the School of Ocean and Earth Science and Technology. The school is expected to play a major role in ocean-mining research.

Quarry operations on Kauai were halted in response to the environmental concerns of area residents. The Kauai Planning Department obtained a temporary restraining order against the Naimalo quarry operations of Kauai Sand and Gravel Co. and ordered all excavating and grading halted after May 25. Kauai residents also presented petitions opposing the relocation of an asphalt plant from a rock quarry in Honamaulu to an agricultural-zoned site in nearby Kapaia Valley.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—In 1988, Hawaiian portland cement production and value increased to 354,000 short tons and $28.9 million, and masonry cement production decreased slightly to 10 million tons and $1.5 million.

The State of Hawaii licensed stockpiled coral materials at the Kawihae Harbor premises near Hilo for use in the manufacture of concrete products. The cumulative amount of coral material sold to all licensees was limited to 20,000 tons per year.

Lime.—Hydrated lime was produced by the Hawaiian Commercial and Sugar Co. Ltd. from the calcining operations near Paia, Maui County. The

TABLE 1

NONFUEL MINERAL PRODUCTION IN HAWAII[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	7	$1,078	10	$1,559	10	$1,531
Portland	do.	287	24,253	324	26,550	354	28,880
Gem stones		NA	25	NA	25	NA	W
Lime	thousand short tons	3	W	3	W	W	W
Sand and gravel (construction)	do.	605	2,666	e700	e3,500	652	3,173
Stone (crushed)	do.	e7,100	e42,100	5,732	41,548	e5,700	e41,000
Combined value of other industrial minerals and values indicated by symbol W		XX	290	XX	297	XX	348
Total		**XX**	**70,412**	**XX**	**73,479**	**XX**	**74,932**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

TABLE 2

HAWAII: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	W	W	$7.95
Plaster and gunite sands	W	W	13.67
Road base and coverings	261	$1,001	3.84
Fill	W	W	1.52
Other	391	2,173	5.55
Unspecified:[1]			
Actual	W	W	1.65
Estimated	W	W	5.88
Total or average	**652**	**[2]3,173**	**4.86**

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[2] Data do not add to total shown because of independent rounding.

State's reported 1988 lime production and value were slightly lower than that reported in 1987.

Pumice and Pumicite.—Pumice production was 66% below that of 1987, and value was 64% lower. Volcanite Ltd. in Hawaii County processed pumice for landscaping. Crude pumice for road construction was mined in Maui County by Maui Pineapple Co. Ltd. of Lahaina at its Honokohau cinder pit and in Hawaii County by Puna Sugar Co. Ltd. at its Iilewa pit.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter thus contains actual data for 1986 and 1988 and estimates for 1987.

Prineville Development Corp. mined sand from four areas near Anini Beach Road in Kauai County for the phase 2 golf course.

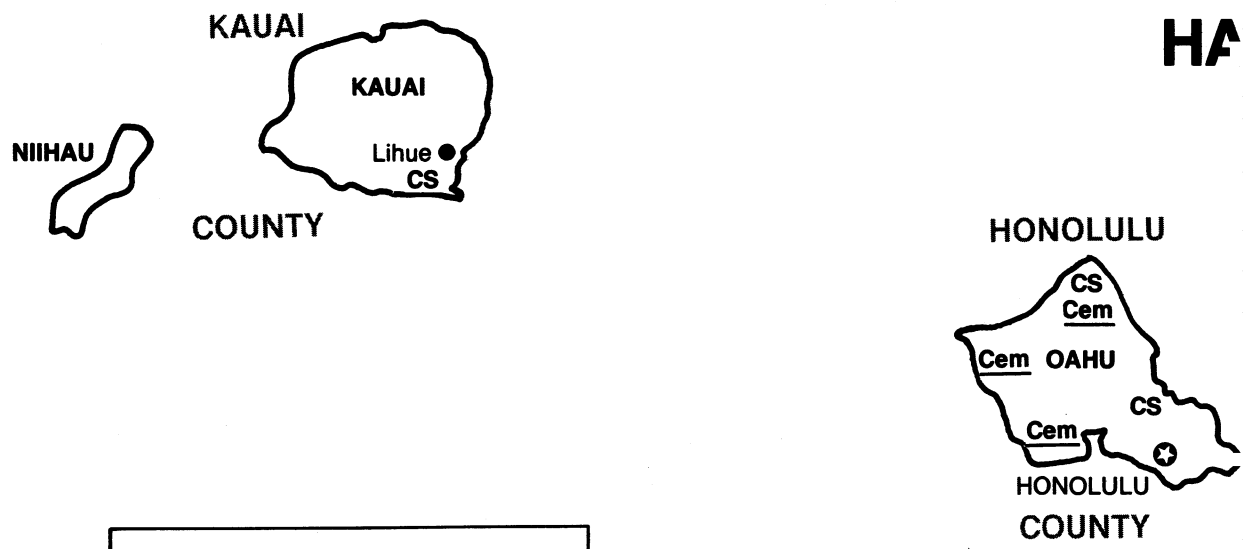
Stone (Crushed).—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data in 1987. The crushed stone production of 1.3 million short tons estimated in 1988 is slightly higher than the reported 1987 production of 1.264 million short tons.

[1] State Mineral Officer, Bureau of Mines, Reno, NV.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Hawaii Cement Corp.	Barbers Point Plant 91-055 Kaomi Loop Ewa Beach, HI 96706	Cement plant	Oahu.
Lime:			
Hawaiian Commercial and Sugar Co. Ltd.	Box 266 Puunenem, HI 96784	Rotary kiln and continuous hydrator.	Maui.
Pumice:			
Maui Pineapple Co. Ltd.	Box 445-C Lahaina, HI 96761	Surface mine	Do.
Puna Sugar Co. Ltd.	Box 120 Keaau, HI 96749	do.	Hawaii.
Volcanite Ltd.	Box 3000 Kailua Kona, HI 96740	do.	Do.
Sand and gravel (construction):			
Amelco Corp., Maui Concrete	Box 488 Kuhului, HI 96732	Plant and pit	Maui.
Kauai Sand and Gravel Inc.	4247 Kapaia Rd. Lihue, HI 96766	do.	Kauai.
Stone (crushed):			
Allied Aggregates Corp.	761 Keaa St. Hilo, HI 96720	Quarries	Hawaii.
Ameron Honolulu Construction and Drayage Ltd.	Box 29968 Honolulu, HI 96820	do.	Oahu and Maui.
Grace Pacific Corp., Concrete and Rock Div.	91-220 Farrington Hwy. Ewa Beach, HI 96707	do.	Do.
Grove Farm Rock Co. Inc.	Puhi Rural Station Lihue, HI 96776	do.	Kauai.
Herbert Tanaka Co.	87-1748 Farrington Hwy. Waianae, HI 96792	Quarry	Oahu.
Kuwaye Bros Inc.	160 Keaa St. Hilo, HI 96720	do.	Hawaii.
Lone Star Hawaii Rock Products	11555 Dublin Canyon Rd. Pleasanton, CA 94566	do.	Oahu.



LEGEND

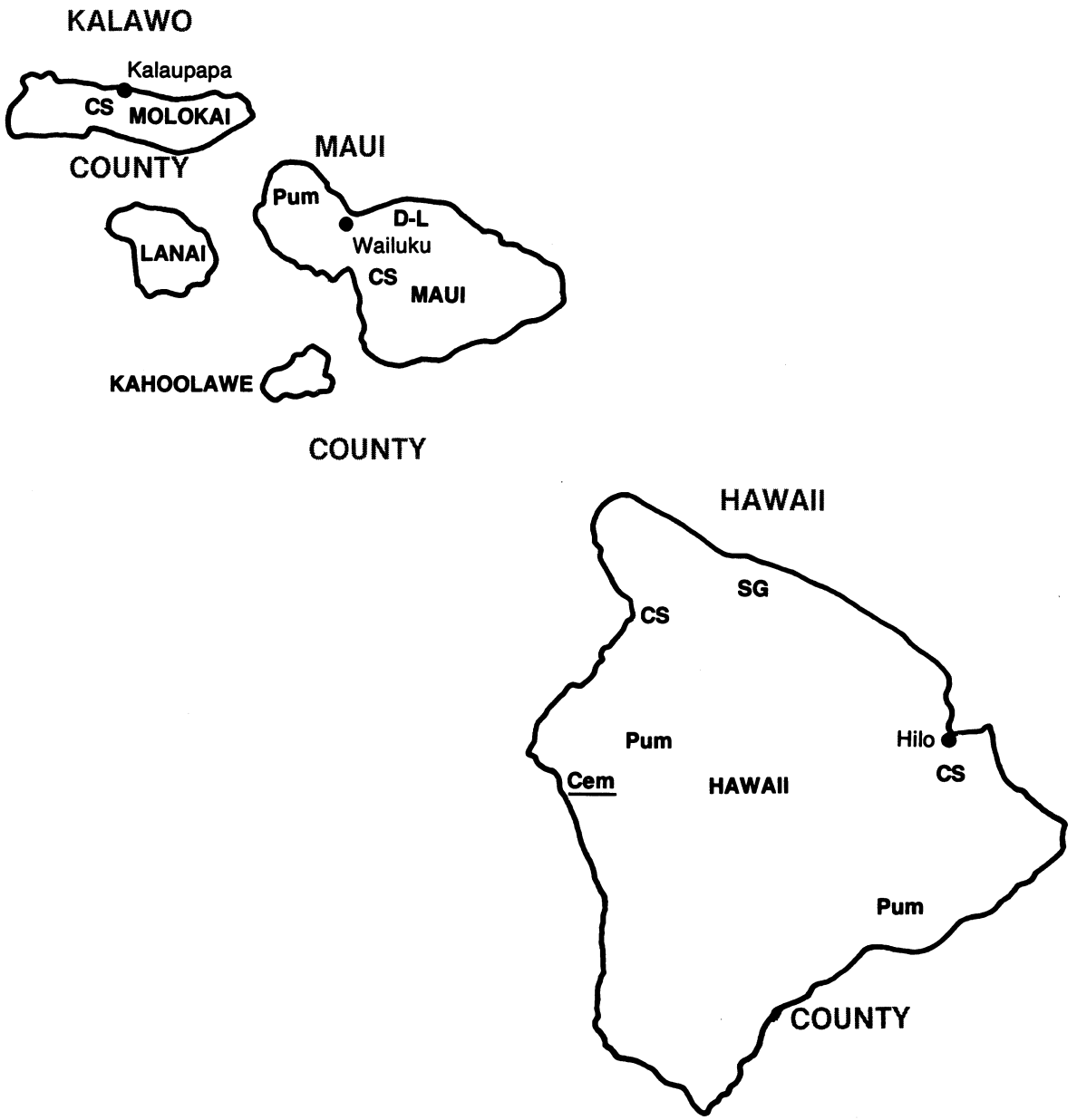
———	State boundary
COUNTY	County
✪	Capital
●	City

MINERAL SYMBOLS

Cem	Cement plant
CS	Crushed Stone
D-L	Dimension Limestone
Pum	Pumice
SG	Sand and Gravel

Principal Mineral-Producing Localities

All


KALAWO
Kalaupapa
CS
MOLOKAI
COUNTY
MAUI
Pum
D-L
Wailuku
LANAI
CS
MAUI
KAHOOLAWE
COUNTY
HAWAII
SG
CS
Pum
Hilo
Cem
HAWAII
CS
Pum
COUNTY

THE MINERAL INDUSTRY OF IDAHO

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Idaho Geological Survey for collecting information on all nonfuel minerals.

By W. L. Rice[1] and E. H. Bennett[2]

Nonfuel mineral production in Idaho was valued at $291 million in 1988, an 8% increase over that of 1987. Gains in the production value of gold, lead, phosphate, and silver contributed substantially to the increase.

Phosphate rock was the leading mineral commodity in terms of value, followed by silver, gold, and molybdenum. The metallic minerals—antimony, copper, gold, lead, molybdenum, silver, vanadium, and zinc—accounted for 68% of the State's total nonfuel mineral value for the year, compared with 58% in 1987, 52% in 1986, and 59% in both 1985 and 1984. Idaho ranked first in the Nation in antimony, garnet, and vanadium production; second in lead, phosphate rock, and silver output; third in the production of pumice and perlite; and fourth in molybdenum production. The State ranked 31st nationally in the value of nonfuel mineral production, the same ranking held in 1987.

TRENDS AND DEVELOPMENTS

The highest zinc prices in 15 years and substantial gains in the price of lead supported the midyear reopening of a major zinc-lead-silver mine. The mine had been closed for nearly 6 years.

Operational economies initiated by mine operators in the Coeur d'Alene silver belt kept all the major high-cost underground silver mines in production during the year, despite silver prices far lower than those in the early 1980's. Labor agreements that tied wages to metal prices became effective at two silver mines.

A strong regional demand for elemental phosphorus and phosphate fertilizers resulted in increased Idaho phosphate production. By midyear, all of the State's phosphate producers were working at or near capacity.

After a slow start, Idaho's molybdenum production responded to increased market demands and a reimposed tariff on certain foreign imports. By yearend, production had risen from 20% to 75% of capacity.

Exploration for gold reached a new high in 1988; discoveries included a 2-million-ounce deposit that reportedly was the largest single gold strike ever made in Idaho.

Following a prevalent trend in the western States toward abandonment of marginally profitable rail lines, the Union Pacific Railroad announced possible abandonment of its 72-mile-long branch line serving mines in the Coeur

TABLE 1

NONFUEL MINERAL PRODUCTION IN IDAHO[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	short tons	1,644	W	r8,944	rW	9,391	W
Copper (recoverable content of ores, etc.)	metric tons	W	W	W	W	2,269	$6,028
Gem stones		NA	$305	NA	$507	NA	500
Gold (recoverable content of ores, etc.)	troy ounces	70,440	25,938	97,773	43,797	103,463	45,349
Lead (recoverable content of ores, etc.)	metric tons	9,951	4,836	W	W	W	W
Lime	thousand short tons	89	4,729	97	5,149	W	W
Phosphate rock	metric tons	4,235,000	82,332	3,411,000	47,072	4,706,000	81,011
Sand and gravel:							
Construction	thousand short tons	5,708	14,830	e7,200	e28,000	6,914	19,897
Industrial	do.	W	W	W	W	483	5,089
Silver (recoverable content of ores, etc.)	troy ounces	11,206,851	61,301	W	W	10,934,631	71,512
Stone (crushed)	thousand short tons	e3,700	e12,700	3,852	15,346	e3,400	e13,100
Zinc	metric tons	351	294	W	W	W	W
Combined value of antimony (1986, 1988), cement, clays (bentonite, common, fire clay (1986), kaolin), garnet (abrasive), molybdenum (1986–87), perlite, pumice, stone (dimension), vanadium, and values indicated by symbol W		XX	66,783	XX	r129,502	XX	48,130
Total		**XX**	**274,048**	**XX**	**269,373**	**XX**	**290,616**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

d'Alene District. Mine operators believed that abandonment could damage an industry just recovering from 6 years of depressed metals prices.

EXPLORATION ACTIVITIES

Mineral exploration in Idaho, which was largely for gold deposits, increased in 1988. Some counties that experienced higher levels of activity were Boise, Elmore, Idaho, Lemhi, and Shoshone.

The largest gold discovery announced in 1988 was at the Beartrack deposit owned by the Meridian Gold Co.-Canyon Resources Corp. joint venture. The deposit, near Leesburg in Lemhi County, reportedly was the largest single gold discovery in the State's history. Resources were estimated at 40 million tons grading 0.055 ounce of gold per ton, for a total geologic resource in excess of 2 million ounces of gold. More than 100 holes had been drilled on the property since late 1987, with another 200 planned. A feasibility study was to determine whether the deposit should be developed as an open pit or underground operation. Production could start in 1991.

BP Minerals America and American Gold Resources drilled 14 holes near the Hardee Mine during the past 2 years and continued to acquire land adjacent to the Beartrack project. The companies planned a drilling and regional exploration program for 1989. Corona Gold drilled on claims immediately north of the Beartrack holdings and also planned to continue in 1989.

In the same region, Homestake Mining Co. drilled on Porphyry Ridge, Amax Exploration Inc. drilled eight holes near the Rabbitsfoot Mine, and GEXA Inc. explored claims south of Blackbird Creek.

FMC Gold Co. explored at its Ditch Creek property north of Salmon and drilled 15 holes on Sage Creek north of the Ulysses Mine. Noranda Exploration Inc. leased the Ulysses property from Echo Bay Exploration Inc., which drilled it during 1988; Noranda planned more work in 1989. West Fork Gold Mining Co. drilled on the West Fork of Indian Creek, and Sovereign Exploration drilled in Gold Star Gulch on Tower Creek. Idaho Energy Resources drifted on the Montana side of the Lemhi Pass thorium district and opened adits at the Wonder Lode and Caga Mines in Idaho.

Shama Minerals Chemical and Oil Co. increased its claim block to nearly 5,000 claims in the Challis area and drilled in the Baker Creek area of Custer County. In Boise County, Gold Post Resources USA Inc. evaluated results from a 14-hole, 5,000-foot drilling program at the Gold Hill Mine near Idaho City. Cactus West Exploration sampled on three vein systems at the Missouri gold mine near Idaho City and scheduled drilling for 1989. Frontino Corp. completed site preparation at the Mineral Hill and Ophir Mines and also planned to drill in 1989.

GEXA drilled about 25 new holes in Hardscrabble Gulch in the Rocky Bar District, Elmore County. About 225,000 tons of 0.037-ounce-per-ton gold ore had been outlined in Hardscrabble Gulch, and an additional 313,000 tons grading 0.046-ounce-per-ton gold had been delineated in Wide West Gulch, for a total reserve of about 500,000 ounces of gold.

Elsewhere in Elmore County, MVC Resources drilled three holes totaling 1,500 feet at the Hornet, Jingo, and President Mines in the Hunter Creek District. Yanke Machine Shop Inc. drilled six holes at the Golden Eagle Mine near the Neal District.

War Eagle Mining Co. drilled 39 holes on its claim block centered on War Eagle Mountain near Silver City, Owyhee County. Several holes in section 14 showed encouraging gold and silver values. Golconda Resources planned a 10-hole drilling program on the Morning Glory property about 2 miles from War Eagle's holdings.

Ican Minerals Ltd. did fill-in drilling at its Idaho Almaden gold deposit near Weiser, Washington County, and signed an option agreement with Granges Exploration Ltd. to develop the property. Chevron Resources Co. drilled four holes at its Haystack Peak project north of Weiser and four holes at a new project near Indian Head. Both Chevron properties were low-grade mercury-gold deposits similar to the Idaho Almaden.

Freeport McMoRan Gold Co. continued to drill on an epithermal gold target at Malad Summit, Bannock County. Western Gold Exploration picked up Meridian's claims near Scout Mountain and Mink Creek, where Meridian reportedly discovered low-grade gold values during 1986–87 drilling. Western Gold also acquired Meridian's Middle Mountain claim group south of Oakley in Cassia County, and drilled approximately 14 holes in 1988.

Freeport McMoRan, which began a 19-hole drilling program on Caribou Mountain near Grays Lake, Bonneville County, planned to continue the program in 1989. Oglebay Norton Co. drilled near its Wrights Creek perlite mine in Oneida County. The company explored for precious and base metal mineralization on extensive holdings in the area.

Cominco American Resources Inc. drilled three holes in Long Canyon near Fish Creek Reservoir, Blaine County. Rothschild Corp. continued to explore in the Vienna district; the company completed a raise and stockpiled ore at the Webfoot Mine. A few test batches of ore were run through its mill west of Ketcham.

Chevron Resources drilled nine rotary holes on a gold prospect northwest of the Craters of the Moon, Butte County; results were being evaluated in 1988.

In Shoshone County, Newmont Mining Corp. continued to explore and drill at the Golden Chest Mine near Murray. Newmont was searching for a low-grade, mass-minable gold deposit. Golden Chest Inc., owner of patented placer claims that covered part of the

ground Newmont explored, entered into an agreement with Brenda Queen Mines Inc. to develop and mine the Golden Chest placer deposits. Cominco continued to investigate the Prichard Formation by drilling near Blackdome Peak and No-Seeum Peak, and by trenching near St. Maries. The company also drilled near Lightning Peak southeast of Bonners Ferry, Boundary County.

Pegasus Gold Inc. drilled 5,000 feet in the Buffalo Hump area, Idaho County, in a second year of gold exploration at the Big Buffalo, Concorde, and Jumbo Mines. Bulk sampling also was done at the Big Buffalo property. Silver Crystal Mines Inc. explored for gold and platinum group metals at the Umatilla Mine near Orogrande. The company completed a pilot wet-chemical extraction plant for platinum group metals at the mine site.

EMPLOYMENT

A 2-year employment downtrend in the mineral sector of Idaho was reversed due to the following: reopening of the Bunker Hill zinc-lead-silver mine, resumption of production at the Sunshine silver mine, increased production at the Cyprus Minerals Co.'s Thompson Creek molybdenum mine, and a return to capacity production in Idaho's phosphate industry. The number of metal-mining employees increased by about 38% to 2,200. Overall mining employment rose by 32% from the 1987 level, to 3,300 employees.

Wages for mineral production workers in Idaho, however, were down from those of 1987. The lowered wages were due in part to an across-the-board general reduction, and in some instances, to wage rates that were tied to metal prices. Average weekly earnings were $571.13 for a workweek averaging 42.3 hours, down $35.71 from the previous year. Mineral industry wages, which have led the production workers' wage category for the past several years, slipped slightly behind those paid to electric, gas, and sanitary service workers.

According to the State of Idaho Department of Employment, the average annual wage increased substantially for mineral industry production workers in the Coeur d'Alene District of Shoshone County. The average wage was $40,807 in 1988, compared with $25,585 paid in 1987. Shoshone County mining employment increased from 978 workers in January to 1,358 employed at yearend.

REGULATORY ISSUES

The Federal Environmental Protection Agency (EPA) announced that the heavy-metal cleanup of populated areas in the 21-square-mile Bunker Hill Superfund site, Shoshone County, was scheduled to start in May 1989. Although contaminated soils in some heavy-traffic areas have been replaced, the major part of the 3-year project could involve replacing soil, grass, trees, and shrubs in up to 500 residential yards in Kellogg, Smelterville, and Wardner. In addition to lead, heavy metal contaminants included antimony, arsenic, cadmium, copper, mercury, and zinc. The contaminants were derived from the Bunker Hill smelter complex, mine tailings, windblown dust, and road dust. Total cost for cleanup at the site, including the smelter complex area, was estimated to exceed $50 million.

The State of Idaho fined two southeastern Idaho phosphate manufacturers for violating State air quality standards. Soda Springs Phosphate Inc. was fined $900 for three opacity violations, and the J.R. Simplot Co. in Pocatello was fined $3,850 for failing to bring its calciner into compliance with opacity standards under a 1987 consent law. The air pollution penalties were the first in 2 years to be collected by the State.

LEGISLATION AND GOVERNMENT PROGRAMS

On January 6, 1988, Idaho's new regulations for cyanidation processing of precious metal ores went into effect. The rules, which were the first national comprehensive set of regulations dealing with this subject, were designed to protect the environment against cyanide spills from pregnant solution ponds and tailings-disposal areas. The regulations, drafted with mining industry participation, were expected to set a pattern for similar legislation in other States where cyanidation is used to process precious metal ores.

An Idaho wilderness bill was introduced in Congress in March. It called for the establishment of 1.4 million acres of new wilderness and the setting aside of 616,000 acres for special management areas. The bill, sponsored by an Idaho Congressman, was a compromise effort involving input from the Governor of Idaho. A midyear revision, adding lands that brought the totals up to 1.6 million acres of wilderness and 650,000 acres of special management areas, proved futile in appeasing criticism from both sides of the wilderness issue. The bill died when Congress adjourned.

Federal funding was secured in 1988 to construct a state-of-the-art Center for Strategic Research and environmental laboratory at the University of Idaho College of Mines and Earth Resources campus at Moscow, Latah County. The proposed 40,000-square-foot facility would be devoted to teaching and research into a variety of strategic and critical minerals and materials. Federal, State, and private funding would be used: $3 million in Federal funds were appropriated for 1989, with an additional $4 million funded for 1990.

In October, the Idaho Land Board permanently prohibited mining in the bed of the Boise River, from the Lucky Peak dam downstream to Star in Canyon County. The State, which has con-

trol of all streambeds in Idaho, will now reject any mining claims or related activity in that stretch of the river. The withdrawal was triggered by a claim application for recreational placer mining; the Land Board based its decision on the popularity of the river for other recreational uses. Mineral withdrawal would not prohibit removal of sand and gravel for flood control purposes.

The Mining and Mineral Resources Institute of the University of Idaho received an allotment of $188,319 from the U.S. Bureau of Mines in 1988, bringing the total received since the program's inception in 1978 to nearly $3 million. The university assisted the Virginia Polytechnic Institute on work in the mine systems design and ground control generic areas during the year.

The U.S. Department of Labor awarded Idaho a $66,579 grant in 1988 to fund a mine safety program for the State's 3,300 miners. The annually funded program, which would be conducted by Idaho State University, Pocatello, was designed to help mine owners comply with the Federal Mine Safety and Health Act. The university program would help mining companies conduct required safety training and prepare reports to comply with the Federal law.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Antimony.—Idaho was the only State in the Nation reporting antimony production in 1988. Sunshine Mining Co. recovered antimony as a byproduct from the electrolytic treatment of tetrahedrite, the principal silver-bearing ore mineral at the Sunshine Mine near Kellogg, Shoshone County. Production at the mine was restarted during the second quarter; Sunshine's operations had been closed since mid-April 1986. Production in 1988 increased by nearly 75% in quantity and by almost 38% in value from that of 1986. Idaho had a small amount of antimony production reported from the Antimony Rainbow Mine, Valley County, in 1987.

Cobalt.—Blackbird Metals Co., a New York-based partnership, announced plans in midyear to buy and reopen the mothballed Blackbird cobalt mine near Salmon, Lemhi County. At the time, there had been no domestic cobalt mine production since 1971 and no refinery production since 1985. Blackbird Metals intended to purchase the property from Noranda Minerals Inc. and Hanna Mining Co., and to invest $85 million in the project. Some $47 million would be used to build an offsite refinery with a capacity of 5,000 short tons per year. Another $7 million would be given to the State to settle a stream-pollution lawsuit against current and former owners. The proposed operation was designed to produce 2,500 tons of cobalt per year, with employment approaching 450 workers. In November, Blackbird Metals asked to be released from the agreement to pay the $7 million to the State, citing a disagreement over terms as a reason. At yearend, the project was on hold, with Blackbird Metals still optimistic about the outcome.

Copper.—Idaho's copper production, predominantly a byproduct from silver recovery in the Coeur d'Alene District of Shoshone County, increased about 18% in quantity and 72% in value from that of 1987. Production was reported from six mines. The largest producers were the Galena, Coeur, Sunshine, and Lucky Friday Mines, which accounted for more than 85% of the State's total copper output. The additional small production was from Custer County.

Gallium.—In November, N. A. Degerstrom Inc. began construction at Soda Springs, Caribou County, on a $2.25 million processing plant to extract gallium and silver from "treater dust" generated by pollution-control equipment at an elemental phosphorus plant owned by Monsanto Co. Degerstrom planned to produce about 4,000 kilograms of gallium per year, which would be sold to the domestic electronics industry. The company also planned to extract 180,000 troy ounces of silver annually. The plant was expected to be operational by mid-1989, pending State approval of environmental permits.

Gold.—Gold production in Idaho increased by 6% in quantity and 4% in value from the production high of 1987. The State ranked 10th nationally in gold production for 1988. Production was recorded from 11 lode mines during the year, compared with 10 operations reporting production in 1987.

The DeLamar gold-silver mine in Owyhee County, owned by NERCO Minerals Co., was the State's first-ranked producer. According to the company's annual 10-K report, 1988 production from the open pit, vat and heap leach operation amounted to 32,000 troy ounces of gold and 1,738,000 troy ounces of silver from 1,909,000 tons of ore. NERCO stated that the mine's direct cost per ounce of silver had been reduced from $9.26 in 1984 to $3.99 in 1988 as a result of improved mining techniques, mill performance, heap leaching, and cost controls. Exploration at the company's nearby Florida Mountain gold-silver property identified reserves of 435,000 ounces of gold and 8.9 million ounces of silver. A feasibility study for mine development was ongoing at yearend.

Thunder Mountain Mine, Valley County, of Coeur d'Alene Mines Corp. ranked second in gold production. Production from the seasonal open pit, heap-leach operation totaled 24,250 ounces of gold and 29,066 ounces of silver from 542,733 tons of ore. The company made progress by developing the nearby Lightning Peak ore body, slated for mining in 1990. Ore reserves at the end of the 1988 mining season

were 1,507,000 tons grading 0.046-ounce-per-ton gold. More drilling was planned on the Upper Lightning Peak ore body to confirm and expand reserves.

The seasonal Yellow Pine Mine, of Hecla Mining Co. in Valley County was Idaho's third-ranked gold producer in 1988. Hecla operated the surface mine and the ore was processed by contract at the nearby Stibnite heap-leach facility owned by Pioneer Metals Corp. Hecla's 10-K report credited production of 20,701 ounces of gold and 6,802 ounces of silver from 278,193 tons of ore. Lower-than-expected production was due to a disagreement with Pioneer Metals, which caused a suspension of production in August and September.

Less than 75% of the planned tonnage was actually processed, but ore grade and recoveries were better than expected. A 1.1-million-ton oxide ore reserve, grading 0.07-ounce-per-ton gold, remained after the 1988 production season. Hecla also had a gold-bearing sulfide deposit at the Yellow Pine Mine estimated to contain between 15 and 20 million tons with 0.1 ounce of gold per ton. Hecla and Artech Recovery Systems agreed to pilot test its low-temperature Cashman chemical process to recover gold and other metals from Yellow Pine sulfide ores. Results from the tests, conducted in August and September, would determine whether Hecla would undertake full-scale use of the process.

Production at the Pioneer Metals-Min Ven Gold Corp. Stibnite seasonal open pit, heap-leach operation, near Hecla's Yellow Pine Mine, was down significantly from 1987 levels. The disagreement with Hecla over leach-pad usage resulted in 45 days lost from the limited operating season. According to company reports, Pioneer processed 241,576 tons of its own ore grading 0.031-ounce-per-ton gold; the ore yielded 5,516 ounces of gold and 4,884 ounces of silver. A 47-hole drilling program increased oxidized ore reserves from 800,000 tons grading 0.052-ounce-per-ton gold to 3,175,000 tons grading 0.04 ounce of gold per ton. The total geological resource at the Stibnite Mine was estimated to be 11,200,000 tons containing 0.037 ounce of gold per ton.

U.S. Antimony Corp. (USAC) operated a 350-ton-per-day mill at Preachers Cove on the Yankee Fork, Custer County. Primary mill feed came from USAC's Custer Pit on the Yankee Fork and from the company's Yellow Jacket property in Lemhi County. The company applied for a permit to construct an on-site mill at the Yellow Jacket Mine, which would eliminate a 110-mile truck haul to Preachers Cove.

American Diversified Minerals Inc. entered into a joint venture with Leesburg Land and Mining Co. to expand operations at the Leesburg placer mine. Production at the mine in mid-September averaged about 37.5 ounces of gold per day recovered from 1,500 tons of placer gravel. American also agreed to operate the underground Stormy Peak Mine and reportedly operated a small gold refinery in Salmon, Lemhi County.

Several Idaho gold deposits moved closer to production in 1988. Geodome Resources Ltd. completed construction of six sediment ponds for runoff control at its Sunbeam Mine project in the Yankee Fork District. The EPA issued a tentative National Pollutant Discharge Elimination System (NPDES) permit in late July, which was appealed by the National Wildlife Federation. Further construction at the Sunbeam site was halted pending issue of the NPDES permit. Exploration on the nearby Grouse Creek mineralized zone yielded encouraging results, with 14 out of 20 holes encountering ore-grade material.

Noranda Exploration Inc. received permits for its Black Pine gold project in the Sawtooth National Forest in Cassia and Oneida Counties. The company planned to develop three surface mines and two leach pads, and to build about 6 miles of haul road. From 7.5 to 10.5 million tons of ore would be mined at a rate of about 1 million tons per year; production was projected for 1989.

Joint venture partners Amir Mines Ltd., Glamis Gold Ltd., and Normine Resources Ltd. formed a new operating company, Idaho Gold Corp., to develop two gold properties. Construction at the Buffalo Gulch property near Elk City in Idaho County was slated to begin in 1989. The seasonal operation would process 900,000 tons of ore annually to produce 20,000 ounces of gold over a 6-year mine life. The company also obtained an option on the nearby Ericson Reef deposit where drill-indicated reserves total 2.5 million tons grading 0.06 ounce per ton gold at a 2:1 waste-to-ore stripping ratio.

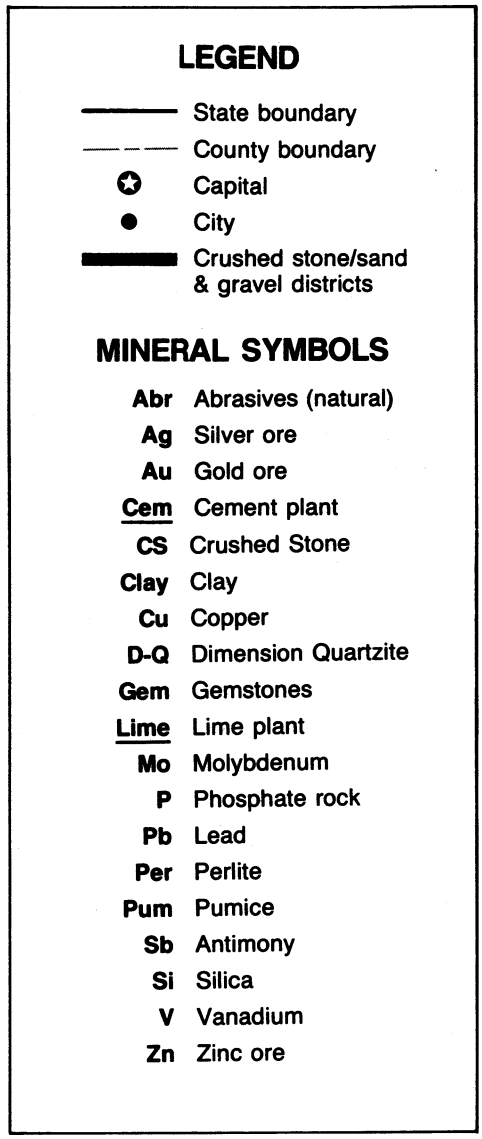
Idaho Gold also did development work and acquired permits to put its Champagne Mine into production near Arco, Butte County. Minable ore reserves were estimated at 2.5 million tons grading 0.03 ounce of gold and 0.85 ounce of silver per ton. The company had an additional 2 million tons of inferred reserves, with exploration ongoing on oxidized ore zones. The project was scheduled to produce 17,500 ounces of gold equivalent in 1989 and 19,000 ounces of gold equivalent annually thereafter over a 5-year mine life.

Atlanta Gold Corp. expanded reserves, conducted metallurgical studies, and examined production plans for the Atlanta property in Elmore County. Minable ore reserves were increased 46% to 861,000 ounces of gold and 2,256,000 ounces of silver. A feasibility study and granting of permits were expected to be completed in 1989.

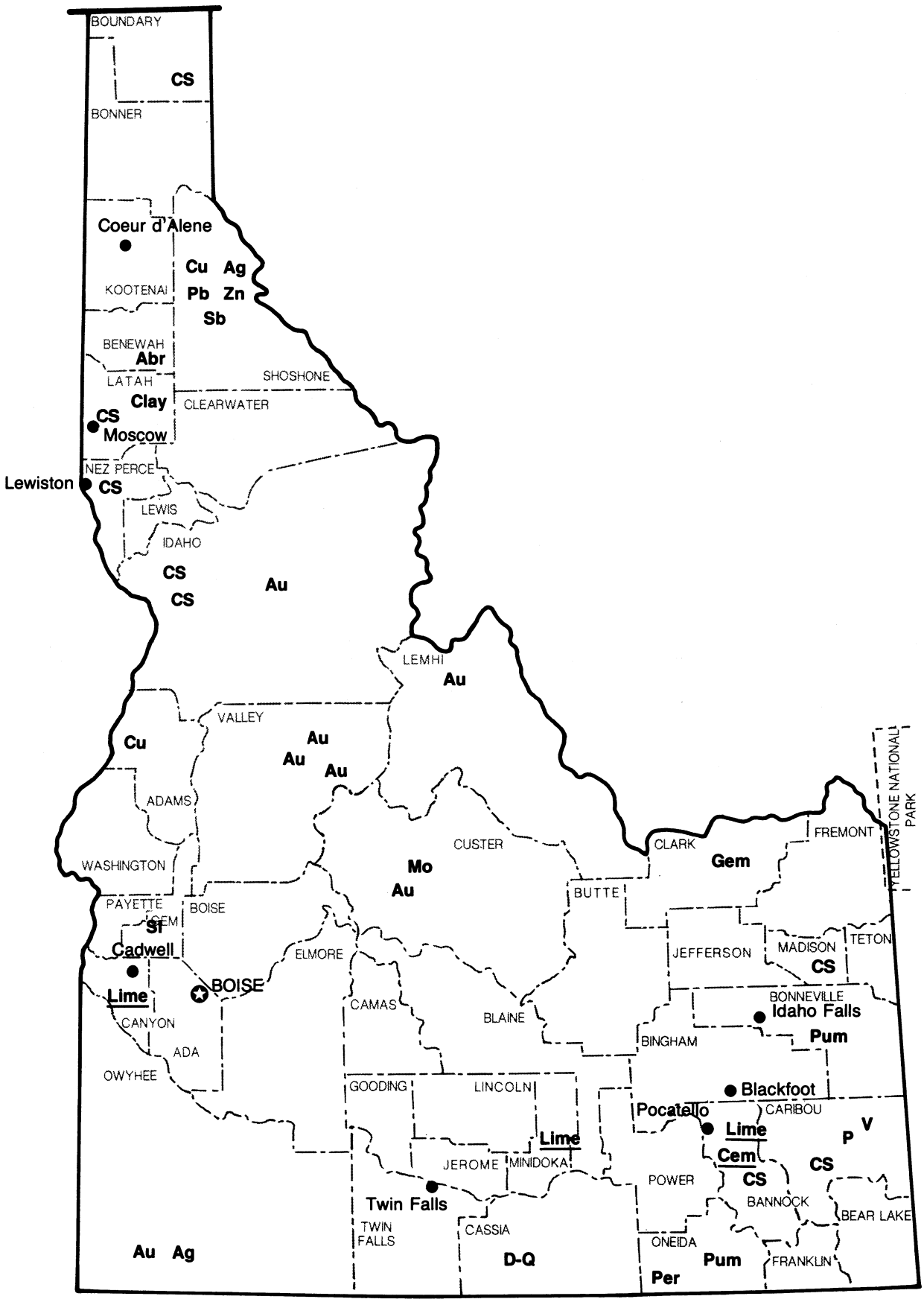
Canyon Resources Corp. and Golden Shamrock Mines Ltd. entered into a joint venture to develop Canyon's Robinson Dike gold deposit, Idaho County. Reserve expansion drilling was done in 1988; mine development was planned for 1989. Prior to the reserve expansion program, the Robinson Dike deposit contained 660,000 tons of reserves grading 0.042 ounce per ton gold.

In Custer County, Yanke Machine Shop Inc. did development work at the Greyhound Mine, rehabilitated the mill, and made several test runs on

IDAHO



Principal Mineral-Producing Localities


BOUNDARY
CS
BONNER
Coeur d'Alene
Cu Ag
Pb Zn
Sb
KOOTENAI
BENEWAH
Abr
LATAH
Clay
SHOSHONE
CLEARWATER
CS
Moscow
NEZ PERCE
Lewiston
CS
LEWIS
IDAHO
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ADAMS
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FREMONT
YELLOWSTONE NATIONAL PARK
BUTTE
PAYETTE
GEM
BOISE
Sf
Cadwell
ELMORE
JEFFERSON
MADISON
TETON
CS
BOISE
Lime
CANYON
ADA
OWYHEE
CAMAS
BLAINE
BONNEVILLE
Idaho Falls
Pum
BINGHAM
GOODING
LINCOLN
Blackfoot
Pocatello
CARIBOU
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Cem
CS
CS
JEROME
MINIDOKA
POWER
Twin Falls
BANNOCK
BEAR LAKE
TWIN FALLS
CASSIA
ONEIDA
Pum
FRANKLIN
Au Ag
D-Q
Per

about 800 tons of ore.

Lead.—Lead production in Idaho in 1988 ranked second nationally, although the quantity produced was small compared with that from Missouri, the Nation's leading producer. Production in Idaho nearly tripled in quantity and value from that of 1987. A midsummer resumption of production from the Bunker Hill zinc-silver-lead mine at Kellogg in Shoshone County and a full year of byproduct lead production at Hecla's Lucky Friday silver-lead mine at Mullen in Shoshone County largely accounted for the increase. Four mines reported lead production in 1988; the Lucky Friday remained the State's top producer.

Molybdenum.—Production at Cyprus Minerals Co.'s Thompson Creek molybdenum mine near Challis in Custer County decreased in quantity, but value increased substantially over that of 1987. Cyprus began the year with a production rate reduced to 20% of capacity and with a work force reduced to 136 employees. Improved market demand in early 1988 and the reimposition of a tariff on Chilean molybdenum led to a production expansion that continued throughout the year. A start-of-the-year production goal of 3.9 million pounds of molybdenum was increased to 10 million pounds by March; according to Cyprus' annual report, production from the Thompson Creek facility in 1988 totaled 14 million pounds. By yearend, production had been increased to 75% of capacity, and the work force had risen to 328 employees.

Rare Earths.—Rare earth-bearing black-sand placer deposits, derived from weathering of granite rocks at the Idaho Batholith, continued to attract attention in 1988. The black sands were being evaluated for rare earths used in superconducting materials and microelectronic components. Ashfield Mining Inc. leased and explored on the Ruby Meadows claims, which cover a large placer deposit containing gold, yttrium, and tantalum. Thunder Mountain Gold Inc. evaluated 2,500 acres of leased State lands and 380 acres of its own property for black-sand placer deposits.

Silver.—Although the quantity and value of Idaho's silver output rose substantially compared with that of 1987, the State again ranked second nationally to Nevada in silver production. The average price for silver in 1988 decreased about 7% to $6.54 per ounce; however, savings in labor and other production costs enabled the higher cost major producing mines to remain in production throughout the year. Bunker Hill's Crescent silver mine remained on standby status in 1988, awaiting higher silver prices.

ASARCO Inc.'s Galena Mine near Wallace in Shoshone County was the Nation's sixth-ranked silver producer in 1988. Asarco mined less silver in Idaho during the year, owing largely to lower ore grades and slightly decreased mill recoveries. The Galena Mine produced 3,050,000 ounces of silver, 1,000 tons of copper, and 500 ounces of gold from 207,000 tons of ore, according to the company's annual report. Mill recovery rate for silver averaged 96.7% for the year, compared with a 97% rate in 1987.

Production at Asarco's Coeur Mine near Wallace also decreased in 1988, to 2,115,000 ounces of silver, 900 tons of copper, and 300 ounces of gold recovered from 144,000 tons of ore. This compares with about 2.45 million ounces of silver, 1,100 tons of copper, and 400 ounces of gold from 155,000 tons of ore in 1987. Mill recovery rate for silver dropped slightly to an average of 98.7% in 1988.

Asarco reactivated its American Silver project near Osburn in late July. The company explored by crosscutting from the 3,400 level of the Coeur Mine; the target was American Silver's Wire Silver vein. When work was stopped in 1986, the vein was an estimated 345 feet distant. More than 1 mile of exploration crosscut had been driven since the project began in 1980.

Sunshine Mining Co.'s Sunshine Mine at Big Creek in Shoshone County returned to production in late January after a hiatus that began in mid-April 1986. In 1988, the Sunshine produced 2,291,249 ounces of silver and 658,671 pounds of copper from 146,659 tons of ore with an average silver grade of 16.05 ounces per ton, according to the company's annual 10-K report. Sunshine's electrolytic silver refinery produced 3.1 million ounces of silver and 46,808 ounces of gold, of which 1.5 million ounces were processed from doré produced by third parties.

The Sunshine reopened without a labor contract, and, on May 11, union workers struck. They objected to wage and benefit cuts proposed in the company's latest contract offer. The strike was settled on May 26, with ratification of a 3-year agreement with the United Steel Workers of America. The new contract contained a wage scale that fluctuated with silver prices. It also provided for profit sharing and a stock-purchasing option.

Production at Hecla's Lucky Friday Mine at Mullan more than doubled from 1987. The company's annual 10-K report credited the production of 1,786,716 ounces of silver, 12,675 tons of lead, 2,301 tons of zinc, 309 tons of copper, and 778 ounces of gold from 120,200 tons of ore milled. Mill recovery was about 98% for the silver-lead concentrate and approximately 83% for the zinc concentrate. Silver-lead concentrates were shipped in approximately equal proportions to the Asarco smelter at East Helena, MT and to the Cominco Ltd. smelter at Trail, British Columbia, Canada. Zinc concentrate was shipped to Trail and sold under an agreement with Cominco.

At yearend, proven and probable Lucky Friday ore reserves were 598,200 tons grading 15.4 ounces per ton silver, 13% lead, and 23% zinc. An underground diamond drilling program targeting small, high-grade silver ore

blocks was carried out from the west end of the 5,300 level, and a hole was drilled from the 5,300–101 crosscut through the projection of the Hook ore body. Hecla's mechanized underhand long-wall mining method proved effective in decreasing mining costs and controlling rock bursts. Production costs by conventional stoping amounted to $6.50 per ounce of silver in 1986; in April 1988, costs came close to meeting the company's goal of $5.00 per ounce of silver.

In late summer, Hecla began an exploration program for a stratabound low-grade copper-silver deposit at the Silver Mountain Lead Mines property east of Mullan. The company rehabilitated the 1,700-foot-long Snowstorm No. 3 tunnel and prepared a base station for a drilling program. Additional exploration at the Silver Mountain property may be undertaken at depth from the Lucky Friday workings.

Callahan Mining Corp. continued drifting and drilling on the $4 million second phase of the Caladay Project near Wallace. Exploration continued during 1988 on both the Hornsilver-Peerless property and the Boundary Vein. A wide zone of low-grade silver-lead mineralization was discovered on the Boundary Vein below the 4,900 level.

Asarco obtained a 25-year lease on the Silver Summit Mine, site of a $17 million exploration program by Consolidated Silver Corp. Asarco agreed to spend a minimum of $100,000 per year on exploration and to work toward bringing the property into production.

Vanadium.—Idaho again led the Nation in vanadium production. Its 1988 vanadium output rose by more than 10% in quantity and by nearly 16% in value from that of 1987. Kerr-McGee Chemical Corp. operated its vanadium recovery plant at Soda Springs, Caribou County; the operation recovered vanadium from ferrophosphorus slag generated by Monsanto's elemental phosphorus plant that was across the street. The company produced ammonium metavanadate, potassium vanadate, sodium vanadate, and vanadium pentoxide.

A strong demand for vanadium products and increased prices led Kerr-McGee to plan a 30% expansion in capacity, with the option to expand further if the market remained firm. The expansion, slated for completion in the third quarter 1989, would increase the company's annual vanadium pentoxide capacity by 1 million pounds, bringing the plant's total annual capacity up to 4.3 million pounds.

Zinc.—The 1988 quantity of zinc production in the State was more than five times that achieved in 1987, and the value was about seven times greater. Strong zinc demand and high prices led to the reopening of the Bunker Hill Mining Co. Bunker Hill zinc-silver-lead mine, closed since late 1981. Mining began at Bunker Hill in late August and, by late September, the first railroad car of lead concentrate had gone to Asarco's East Helena, MT, smelter. By October, shipments of zinc concentrate had been sent to the Dowa and Toho smelters in Japan. A production rate of about 700 tons per day had been achieved by yearend with a work force of slightly more than 100 employees; a 1,500-ton-per-day production rate was planned by mid-1989. Initial mining operations were in the Quill ore body, which had a reserve of 10 million tons grading 10% zinc, 5% lead, and 2 ounces of silver per ton. According to a published report, Bunker Hill milled 42,900 tons of ore in 1988 and produced 3,257 tons of zinc concentrate and 1,471 tons of lead concentrate.

Hecla's Lucky Friday Mine, restarted in June 1987, produced zinc as a byproduct of silver-lead production.

Industrial Minerals

Cement.—Cement production in Idaho increased significantly, by 32% in quantity and 36% in value over 1987. Ash Grove Cement West at Inkom, Bannock County, was the State's only cement producer. Most of the cement produced was general-use, moderate-heat Types I and II gray portland cement; lesser quantities of Type III high-early-strength portland cement and masonry cement also were produced. Finished portland cement was used by the following: ready-mixed concrete companies (54%); highway contractors (28%); other contractors, government agencies, and miscellaneous customers (12%); and building material dealers and concrete product manufacturers (6%).

The two-kiln, wet-process plant of Ash Grove used natural gas and bituminous coal for fuel, and electricity was purchased for energy. Raw materials used in the production of cement were limestone and quartzite mined locally, and gypsum and iron ore were shipped in from outside the State.

Clays.—Idaho clay production increased about 5% in quantity and 10% in value. Bentonite, common clay, and kaolinitic refractory clay were mined from six pits in Benewah, Clark, and Latah Counties. The State's largest volume producer was Interpace Corp. in Benewah Country.

Diatomite.—American Diatomite Co. continued to develop a deposit of fresh water diatomite north of Bliss in Gooding County. Preliminary mine construction was completed, and drilling continued to better delineate reserves. The company planned to mine 75,000 tons of diatomite during the first full year of operation; mining could extend into the 1990's and expand from 5 to 25 acres of land. The company planned to haul the raw diatomite 13 miles to the railhead at Bliss; no plans had been made for processing the material locally.

Garnet.—Idaho again ranked first in the Nation in garnet production. The Emerald Creek Garnet Milling Co. at Fernwood in Benewah County operated at capacity during 1988; production increased by nearly 18% in quantity and by about 22% in value over that of

1987. Garnet was mined from two sites on Carpenter Creek and three locations on Emerald Creek. Garnet-bearing gravel was mined by dragline dredge and rough-sorted by trommel. Washing plants on each creek employed jigs, classifiers, and shakers to recover the garnet, which was trucked to the Fernwood plant for drying, crushing, sizing, and packaging for shipment by rail and truck. Emerald Creek Garnet again was the largest domestic producer of garnet. Sandblasting garnet accounted for more than 50% of sales; other uses were as abrasives, as a filtration medium, and as the cutting medium for high-pressure water-garnet steel cutting. Between 25% and 30% of company sales were to foreign customers.

Construction was completed on a new processing plant near Fernwood, designed to increase production capacity from between 70 and 80 tons per day to 120 tons. The new mill employed more efficient propane-fired dryers and provided greater versatility in the production of various grades of garnet.

Gem Stones.—The value of 1988 gem stone production in Idaho decreased slightly; the State ranked eighth nationally. Active gem stone deposits were in Benewah, Boise, Clark, Clearwater, and Owyhee Counties. Aquamarine, gem quartz, jasper, precious opal, topaz, and star garnets were recovered during the year.

Lime.—Amalgamated Sugar Co. had three lime plants in Canyon, Minidoka, and Twin Falls Counties that accounted for all of the State's 1988 lime production. The limestone raw material was shipped by rail from Ash Grove Cement's quarry located in Durkee, OR. Quicklime production for sugar manufacture decreased in quantity and value from that of 1987.

Perlite.—National Perlite Products Co. mined perlite from the Wrights Creek deposit; the material was processed and expanded at the company's plant at Malad City, Oneida County. The expanded product was used for industrial fillers, in fireproofing, and as a filtering medium. Production in 1988 doubled in quantity, and value increased about 13% over that of 1987.

Phosphate Rock.—Idaho retained its third ranking nationally in marketable phosphate production. A substantial increase of nearly 38% in quantity and 72% in value was noted over that of 1987. An improvement in the domestic fertilizer market was largely responsible for the rise in production; by midyear, Idaho's phosphate industry was working at capacity. Intermittent electricity cutbacks, owing to drought conditions impacting hydroelectric power, affected the economics of the industry during the summer and fall by forcing the use of costlier fossil fuel-generated supplementary electric power. Four open pit phosphate mines in Bingham and Caribou Counties were operated in 1988. Idaho phosphate rock was used to produce wet-process phosphoric acid, elemental phosphorus, and normal superphosphate.

J.R. Simplot Co. operated the Gay Mine on the Fort Hall Indian Reservation in Bingham County and the Smoky Canyon Mine near the Wyoming border in Caribou County. Slurry concentrates from the Smoky Canyon Mine were pumped 27 miles through an 8-inch pipeline to the company's calcining plant at Conda; calcined material then was rail-shipped to the company's phosphoric acid and fertilizer plant at Pocatello. Simplot announced plans in 1988 to construct a $30 million, 60-mile-long slurry pipeline between the Conda and Pocatello plants; the pipeline was to be built in 1991. Ore from the Gay Mine was processed into phosphoric acid by Simplot, and into elemental phosphorus by FMC Corp. at its Pocatello plant. In May, FMC announced that the Gay Mine would be depleted in 7 years and that leases in Dry Valley, Caribou County, would be developed to replace Gay Mine production. Mine development was scheduled to begin in 1989, with production to follow in 1991.

The Conda Partnership joint venture of NuWest Industries Inc.-Western Cooperative Fertilizers Ltd. of Calgary, Alberta, Canada, mined phosphate rock at the Mountain Fuel and Champ Mines in Caribou County. The ore was beneficiated at Conda and the calcined product moved by conveyor to NuWest's fertilizer plant. NuWest initiated planning for a $30 to $35 million electric power cogeneration plant that would take from 18 months to 2 years to complete and could save from $7 million to $8 million in annual power costs.

Monsanto Co. operated its Henry Mine and Soda Springs elemental phosphorus plant at capacity during 1988. Stauffer Chemical Co. mined phosphate rock from the Wooley Valley Mine northeast of Soda Springs; the ore was rail-shipped to Stauffer's elemental phosphorus plant at Silver Bow, MT.

Evergreen Resources Inc., a small phosphate-based fertilizer manufacturing company, began production in January. Evergreen produced granular fertilizer products from raw material purchased from Kerr-McGee's vanadium operation at Soda Springs.

Pumice.—Idaho ranked third in the Nation for pumice production in 1988. Output increased about 43% in quantity and 53% in value over that of 1987. Two operations in Bonneville County and one in Oneida County accounted for the production in the State.

Hess Pumice Products, Idaho's largest pumice producer, operated its mine on Wrights Creek and a processing plant near Malad City, Oneida County. The bulk of its production was sold for specialty products; the company was one of the largest domestic producers of ground pumice products. Hess sold processed pumice for glass finishing, metal finishing, erasers, and soaps and cleansers. A small amount of the product was sold as aggregate for lightweight concrete building blocks.

Producers Pumice had the only other active mine, the Rock Hollow Mine near Ammon, Bonneville County. The product was used as lightweight concrete aggregate. Amcor Inc., near Idaho Falls, Bonneville County, shipped stockpiled material for use in lightweight concrete-block manufacture.

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

The 1988 output of construction sand and gravel in Idaho increased about 21% in quantity and by almost 34% in value over that of 1986. The three major producing counties were Ada, Canyon, and Kootenai. Major uses were for road base and/or stabilization (40%), concrete aggregate (14%), and asphaltic concrete (8%). More than 54% of Idaho's construction sand and gravel was transported by truck; the remainder was used on-site.

Industrial.—Industrial sand and gravel production nearly quintupled in quantity and almost tripled in value from that of 1987. Unimin Corp. produced these materials from an operation in Emmett, Gem County. Industrial sand was used in the following applications: in glass containers, for sandblasting sand, for filtration medium sand, in fiberglass manufacture, for roofing granules, and for other applications.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

Crushed.—The estimated crushed stone production for 1988 decreased by about 12% in quantity and by nearly 15% in value from that of 1987.

TABLE 2

IDAHO: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	933	$3,186	$3.41
Plaster and gunite sands	42	228	5.43
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	4.50
Asphaltic concrete aggregates and other bituminous mixtures	532	1,428	2.68
Road base and coverings[1]	2,736	6,242	2.28
Fill	93	147	1.58
Snow and ice control	W	W	1.33
Railroad ballast	10	W	W
Other	232	405	1.74
Unspecified:[2]			
Actual	1,703	6,033	3.54
Estimated	633	2,228	3.52
Total or average	**6,914**	**19,897**	**2.88**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.

Dimension.—Northern Stone Supply Inc. quarried quartzite from its property near Oakley, Cassia County, and sold it for flagstone and decorative stone. The Marble Shop Inc. mined travertine from its Medicine Lodge Creek quarry in Clark County.

Zeolites.—Teague Mineral Products Co. produced quantities of experimental high-purity zeolites from two deposits in Owyhee County. High potassium clinoptilolite was mined from the CH deposit; this material has demonstrated an ability to absorb radioactive cesium from nuclear-contaminated soils. High-sodium clinoptilolite from the X-Y deposit was tested as a potential high-value filter for the paper industry.

[1] State Mineral Officer, Bureau of Mines, Spokane, WA.

[2] State Geologist, Idaho Geological Survey, Moscow, ID.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Antimony:			
Sunshine Mining Co.	815 Park Blvd. Suite 100 Boise, ID 83702	Mine, mill, plant	Shoshone.
Cement:			
Ash Grove Cement West Inc.	5550 SW. Macadam Ave. Suite 300 Portland, OR 97201	Surface mine and plant.	Bannock.
Clays:			
Clayburn Industries Ltd.	3202 Beta Burnaby, BC, Canada	Surface mine	Latah.
A. P. Green Refractories Co.	Box 158 Troy, ID 83871	do.	Do.
Interpace Corp.	3502 Breakwater Ct. Hayward, CA 94545	do.	Benewah.
Copper:			
ASARCO Incorporated	Box 440 Wallace, ID 83873	Mines and mills	Shoshone.
Hecla Mining Co.	6500 Mineral Dr. Box C-8000 Coeur d'Alene, ID 83814	Mine and mill	Do.
Sunshine Mining Co.	815 Park Blvd. Suite 100 Boise, ID 83702	Mine, mill, refinery.	Do.
Garnet:			
Emerald Creek Garnet Milling Co. Inc.	Route 4, Box 190 Fernwood, ID 83830	Pits and plant	Benewah.
Gold:			
Coeur d'Alene Mines Corp.	505 Front Ave. Box 1 Coeur d'Alene, ID 83814	Surface mine and leach plant.	Valley.
Hecla Mining Co.	6500 Mineral Dr. Box C-8000 Coeur d'Alene, ID 83814	Mine and mill Surface mine	Shoshone. Valley.
NERCO Minerals Co.	111 SW. Columbia Suite 800 Portland, OR 97201	Surface mine, mill, leach plant.	Owyhee.
Pioneer Metals Corp.	7275 Franklin Rd. Boise, ID 83709	Surface mine and leach plant.	Valley.
Lead:			
Bunker Hill Mining Co. Inc.	Box 29 Kellogg, ID 83837	Mine and mill	Shoshone.
Hecla Mining Co.	6500 Mineral Dr. Box C-8000 Coeur d'Alene, ID 83814	do.	Do.
Lime:			
Amalgamated Sugar Co.	First Security Bank Bldg. Ogden, UT 84402	Plants	Various.
Molybdenum:			
Cyprus Minerals Co.	7200 South Alton Way Englewood, CO 80110	Surface mine and mill.	Custer.
Perlite:			
Oglebay Norton Co.	520 N. Michigan Ave. Chicago, IL 60611	Surface mine and plant.	Oneida.

TABLE 3—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Phosphate rock:			
Conda Partnership	Box 37 Conda, ID 83230	do.	Caribou.
Monsanto Co.	Box 816 Soda Springs, ID 83276	Surface mine	Do.
J. R. Simplot Co.	Box 912 Pocatello, ID 83201	Surface mine and plant	Bingham and Caribou.
Stauffer Chemical Co.	Box 160 Montpelier, ID 83254	Surface mine	Caribou.
Pumice:			
Hess Pumice Products	Box 209 Malad City, ID 83252	Quarry and plant	Oneida.
Producers Pumice	6001 Fairview Ave. Boise, ID 83704	Quarry	Bonneville.
Sand and gravel:			
Construction:			
Central Pre-Mix Concrete Co.	Box 3366 Spokane, WA 99220	Pits	Kootenai.
Nelson-Deppe Concrete Co.	Box 768 Nampa, ID 83651	do.	Canyon.
Rock Constractors	Box 815 Meridian, ID 83642	do.	Ada and Canyon.
Western Construction Co.	Box 5403 Boise, ID 83705	do.	Ada and Canyon.
Industrial:			
Unimin Corp.	258 Elm St. New Canaan, CT 06840	Pit	Gem.
Silver:			
ASARCO Incorporated	Box 440 Wallace, ID 83873	Mines and mills	Shoshone.
Bunker Hill Mining Co. Inc.	Box 29 Kellogg, ID 83837	Mine and mill	Do.
Hecla Mining Co.	6500 Mineral Dr. Box C-8000 Coeur d'Alene, ID 83814	do.	Do.
NERCO Minerals Co.	111 SW. Columbia Suite 800 Portland, OR 97201	Surface mine, mill, leach plant	Owyhee.
Sunshine Mining Co.	815 Park Blvd. Suite 100 Boise, ID 83702	Mine, mill, refinery	Shoshone.
Stone (dimension):			
Northern Stone Supply Inc.	Box 249 Oakley, ID 83346	Quarry	Cassia.
Vanadium:			
Kerr-McGee Chemical Corp.	Box 478 Soda Springs, ID 83276	Plant	Caribou.
Zinc:			
Bunker Hill Mining Co. Inc.	Box 29 Kellogg, ID 83837	Mine and mill	Shoshone.
Hecla Mining Co.	6500 Mineral Dr. Box C-8000 Coeur d'Alene, ID 83814	do.	Do.

THE MINERAL INDUSTRY OF ILLINOIS

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the State Geological Survey, Illinois Department of Energy and Natural Resources, for collecting information on all nonfuel minerals.

By James J. Hill[1]

Nonfuel mineral production in Illinois was valued at $587.6 million in 1988, a 14% increase over that of 1987. The State ranked 16th in the value of nonfuel mineral production and led the Nation in output of fluorspar, industrial sand, and tripoli. Crushed stone, portland cement, and construction sand and gravel (in order of value) were the leading mineral commodities produced in the State. All three had gains in production in 1988, and together they accounted for 76% of the State's total nonfuel mineral value.

The State's construction industry boomed during 1988, increasing demand for mineral commodities used in construction. State road contract awards were valued at $1.1 million, an increase of nearly 20% over 1987 figures. Nonresidential construction was valued at about $3.8 million, an increase of 41%. Residential housing dropped slightly, about 3%, mainly because of higher interest rates.

EMPLOYMENT

The Illinois Department of Economic Security reported the State's total civilian work force averaged nearly 5.8 million in 1988, an increase of about 14,000 workers over that of 1987. Unemployment averaged 6.8%, down from a 7.4% rate reported in 1987. Mining and quarrying employment, which includes coal miners and oil and gas extraction workers, totaling 21,100 persons, was somewhat below the 23,400 workers reported in 1987. Coal mining had the largest decline in workers, about 1,900 persons. Average hourly wages in mining and quarrying were $16.34, a 6% increase over 1987 figures.

Employment in the State's basic steel industry totaled 23,700 workers, about 400 persons lower than that of 1987. Average hourly wages were $14.14, an increase of about 3% over 1987 figures.

The Illinois Department of Labor reported one labor dispute in the State's nonfuel mineral industry in 1988. The U.S. Silica Co. operations were involved in a 19-day walkout by 102 members of the Aluminum, Brick & Glassworkers Union. The dispute was resolved on June 30.

EXPLORATION ACTIVITIES

Exploration activities in Illinois in 1988 were described in the May 1989 issue of Mining Engineering.[2] Ozark-Mahoning Co. operated three drilling rigs in Hardin County to support its fluorspar mining operations. In Alexander County, Illinois Minerals Co. continued its annual summer exploration program, using air drilling techniques to assess its tripoli holdings and direct mine development. A few companies drilled and evaluated kaolinitic clays associated with Cretaceous rocks in extreme southern Illinois. Mining companies also were interested in sources of high-calcium limestone for

TABLE 1

NONFUEL MINERAL PRODUCTION IN ILLINOIS[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	2,118	$83,783	2,119	$86,210	2,307	$101,760
Clays[2]	short tons	282,993	1,092	232,949	977	180,306	704
Gem stones		NA	15	NA	15	NA	30
Sand and gravel:							
Construction	thousand short tons	27,867	82,523	e28,300	e93,300	30,098	93,504
Industrial	do.	4,039	52,133	4,346	45,547	4,328	56,142
Stone:							
Crushed	do.	e44,200	e179,600	52,102	216,212	e57,900	e251,200
Dimension	short tons	e1,750	e107	W	W	e1,175	e129
Combined value of cement (masonry), clays (fuller's earth), copper, fluorspar, lead, lime, peat, silver, tripoli, zinc, and value indicated by symbol W		XX	70,272	XX	74,945	XX	84,157
Total		**XX**	**469,525**	**XX**	**517,206**	**XX**	**587,626**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

use in sulfur dioxide scrubbers for coal-fired boilers. Coal exploration activities slowed in 1988. Only 249 plugging affidavits for coal tests were filed with the Department of Mines and Minerals and Illinois State Geological Survey (ISGS) in 1988, compared with 689 affidavits filed in 1987.

LEGISLATION AND GOVERNMENT PROGRAMS

Two mineral-related pieces of legislation were enacted into law during 1988. Public Act 85-810 amended The Illinois Environmental Protection Act of 1978 and exempted coal-combustion fly ash from the rules and regulations governing waste disposal under the act. Public Act 85-1004 created an Underground Resources Conservation Enforcement Fund to be financed by a $100 charge for drilling permits, with the money appropriated to the Illinois Department of Mines and Minerals to enforce the rules and regulations of the Mining Board.

The ISGS, along with the U.S. Geological Survey (USGS), continued assessing the Paducah 1° by 2° quadrangle that covers parts of Illinois, Indiana, Kentucky, and Missouri. The project was initiated in late 1986 under the auspices of the Conterminous U.S. Mineral Assessment Program (CUSMAP) of USGS. Part of the study traced brine movements in deeper portions of the Illinois Basin, analyzing insoluble residues from major carbonate units by spectrographic methods to define the possibilities of Mississippi Valley-type (lead-zinc) mineralization. ISGS monitored two high-extraction coal mining panels during 1988 to obtain overburden, hydrology, and subsidence profile characteristics under the Illinois Mine Subsidence Research Program and a long-term cooperative research agreement with the U.S. Bureau of Mines. Survey scientists also were working on coal desulfurization methods to promote the use of Illinois high-sulfur coals.

The Illinois Department of Mines and Minerals regulates aggregate mining under the provisions of the State's Surface Mined Land Conservation and Reclamation Act. In 1988, 885 acres were permitted for aggregate mining. Of these, 406 acres were for limestone, 245 acres for sand and gravel, 154 acres for clay and shale, and 80 acres for silica sand.

Researchers at the Northwestern University's Steel Resources Center, which is funded by The American Iron and Steel Institute and other outside sources, had several projects underway during 1988. The researchers conducted studies on the following subjects: the material properties and behavior of strand-cast steel bars; sheet metal forming; vapor-deposited coatings on steel; deformation of electrogalvanized steel; and information systems dealing with production and planning, quality control, and manufacturing strategies.

Argonne National Laboratory was named one of three pilot centers to promote collaborative research between industry and Federal laboratories on high-temperature superconductivity under a Presidential initiative announced in July 1987. The other two centers were located at Oak Ridge, TN, and Los Alamos, NM. Each center received $2 million from the U.S. Department of Energy (DOE) in fiscal year 1988. The funding made Federal resources available to U.S. industry to develop commercial products from high-temperature superconductors. Emphasis on research was primarily applications-oriented.

Southern Illinois University at Carbondale received $309,758 from the U.S. Bureau of Mines in fiscal year 1988 as its Mining and Mineral Resources Research Institute allotment grant and for ongoing geotechnical studies concerning Illinois coal mining. The University also signed a $1.5 million cooperative agreement with DOE on January 1. The agreement expanded its research base to solve the problems of Illinois high-sulfur coal and to seek ways to make it competitive with low-sulfur coal mined in other States.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—In terms of value, cement was the second leading mineral commodity produced in the State, following crushed stone. Sales increased nearly 9% for portland cement and declined 23% for masonry cement, while their values increased 18% and declined 15%, respectively. Four companies operated plants in La Salle, Lee, and Massac Counties. The four plants, all dry-process, operated at approximately 79% of their finish grinding capacity during 1988, compared with 68% in 1987. Of the eight kilns at these plants, downtime for maintenance averaged 63 days.

All companies shipped gray portland cement Types I and II, general use and moderate heat. Type III, high-early-strength portland cement sales were reported by all companies except Lone Star Industries Inc. Illinois Cement Co. Inc. was the only company that did not report sales of masonry cement. Cement sales were to ready-mixed concrete companies (83%), highway contractors (8%), and concrete products manufacturers (7%). Lesser quantities went to other contractors, building material dealers, and miscellaneous customers.

Approximately 3.5 million short tons of raw materials was consumed in the manufacturing process. The raw materials included 3.2 million tons of limestone, 93,000 tons of clay and shale, 90,000 tons of gypsum, and lesser quantities of bauxite, clinker, fly ash, mill scale, sand, and other materials.

Cement shipments to and within Illinois included 3.5 million tons of portland cement and 99,000 tons of ma-

sonry cement, an increase of 37,000 tons and 3,000 tons, respectively, over 1987 figures. The Chicago metropolitan area received about two-thirds of the 1988 shipments.

Illinois Cement, La Salle, observed its 15th anniversary in 1988. The company invested approximately $1 million during the year for two 55-ton haulage trucks and a hydraulic shovel for its quarrying operations, to improve productivity.

Lone Star began a $14 million modernization project at its Oglesby plant. A state-of-the-art raw grinding mill was installed, as were new homogenizing silos with related equipment and a new high-efficiency air separator on its finishing mill. When completed in 1989, the project was expected to boost plant capacity by approximately 20% to 600,000 short tons per year. Lone Star also announced development of a new cement that it calls Pyrament. The new cement which hardens in 4 hours instead of the 7 to 14 days required for other cements, is expected to revolutionize construction of highways and airport runways.

Missouri Portland Cement Co. completed modifications of the evaporative cooling system at its Joppa plant. Key features of the new system are advanced nozzle technology; smaller, more effective sizing; and precise temperature and humidity controls that allow the company to run its offgas system at a lower, more efficient temperature of about 300° F.

Clays.—Common clay and shale was produced by six companies with operations in Bond, Kankakee, La Salle, and Livingston Counties. Output declined nearly 23%, and the value of production dropped about 28%. Most of the State's clay and shale was used in the manufacture of face brick, followed by cement and drain tile. Two companies produced fuller's earth in Pulaski County for use as absorbents for pet waste and oil and grease. Both production and value had moderate increases.

American Colloid Co. of Arlington Heights acquired Absorbent Clay Products Co. of Anna, one of the State's producers of fuller's earth, on November 15, American Colloid planned to diversify its base of industrial markets to include more consumer markets. American Colloid, with operations worldwide, is a major producer of bentonite.

USG Corp. of Chicago spun off its A.P. Green Refractories Co. unit to shareholders in early February, because the Green unit no longer fit its plans to concentrate on building materials. The A.P. Green unit operated a plant at Morris that produced refractory products for the cement and steel industries using clay mined in other States.

Fluorspar.—Illinois was the Nation's leading producer of fluorspar, accounting for more than 90% of all U.S. shipments. Both production and attendant value increased 6% during 1988. Ozark-Mahoning Co., a subsidiary of Pennwalt Corp. and the Nation's leading fluorspar producer, operated mines in Hardin and Pope Counties and a flotation plant near Rosiclare, Hardin County. The company also dried imported fluorspar to supplement its production. Pennwalt reported that, in 1988, approximately 193,000 short tons of crude ore was mined in 1988 and processed into acid-grade concentrate. About 25% of the concentrate was sold on the merchant market, mainly to the ceramic and steel industries. The remaining 75% was sold primarily for production of hydrofluoric acid, which is used to manufacture upgraded fluorochemical products.[3]

Hastie Trucking & Mining Co. intermittently mines metallurgical grade fluorspar, which is used by the steel industry, near Cave In Rock.

On May 9th, Ozark-Mahoning announced that it had purchased certain assets of Inverness Mining Co., a subsidiary of Seaforth Mineral & Ore Co. of Cleveland, OH. Included in the sale were the Minerva No. 1 Mine and mill and adjacent undeveloped acreage. Plans were to dewater and rehabilitate the Minerva No. 1 Mine, with limited production to begin in 1989.

Lime.—Illinois continued to rank seventh of 34 States in lime production. Output and attendant value increased 20% and 17%, respectively, in 1988. Two companies operated plants in Cook County. Marblehead Lime Co. produced both quicklime and hydrated lime at its South Chicago and Thornton plants, and Vulcan Materials Co. produced only quicklime at its McCook plant. Lime sales were primarily to the steel industry. The turnaround of the Great Lakes steel industry, which operated at 85% to 95% capacity in 1988, accounted for the increased sales of lime. Illinois lime consumption from all domestic sources totaled 538,000 short tons of quicklime and 110,000 tons of hydrated lime in 1988. This production amount was an increase of 31,000 tons and 11,000 tons, respectively, over the amount consumed in 1987.

Peat.—Illinois ranked fourth of 23 States in peat production. Both sales and value of sales decreased 20% in 1988. Four companies harvested peat in Lake and Whiteside Counties. Most of the production was of the reed-sedge variety with lesser amounts of hypnum and sphagnum. In descending order of use, sales were for general soil improvement, vegetable growing, earthworm culture, and nurseries. Most of the peat was sold in packaged form.

Hyponex Corp. of Fort Wayne, IN, which had operations in Whiteside County and was the State's largest producer, was sold to O. M. Scott & Sons Co. of Marysville, OH, in November.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1987. Data for odd-numbered years are based on annual company estimates.

Illinois construction sand and gravel production statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data for the State's four districts.

Illinois ranked ninth of 50 States in production of construction sand and gravel. Output climbed to nearly 30.1 million short tons, a 6% increase over production in 1987 and the highest level since 1979. Construction sand and gravel was the third-ranking mineral commodity produced in the State, following crushed stone and cement, in terms of value. Production was recorded for 107 companies operating 157 pits in 55 of the State's 102 counties. Twenty-six pits were dredging operations. McHenry County had the largest number of active pits and also led the State in total production. Kane County ranked second in production.

Industrial.—Nationally, Illinois continued to rank first in production of industrial sand. Value of sales increased 23% over that of 1987, nearing the $56.9 million record established in 1985. Output of sand declined about 18,000 short tons from 1987 production. Five companies produced sand at eight pits in La Salle, Mason, and Ogle Counties. La Salle County led the State in production. Most of the State's industrial sand was shipped to consumers by rail, with lesser quantities moving by truck and barge. About 42% of the sand was sold to manufacture glass containers and flat glass. The next largest consumers of sand were foundries (28%), where it was used for molding and core. The average value of all sales was $12.97 per short ton. Ground fillers commanded the highest price per ton; on the low end was sand used for metallurgical silicon carbide.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

Crushed.—Illinois ranked fifth of 49 States in production of crushed stone. Output was estimated at 57.9 million short tons in 1988, about 11% over that of 1987. Value of stone was estimated at $251.2 million, a record high for the State.

During 1988, Material Service Corp. completed a 1,800-foot access tunnel under the Des Plaines River at its Romeo Quarry near Chicago to reach aggregate reserves on the river's western side. The tunnel will extend the life of the quarrying operation about 35 years, as the reserves of aggregate on the eastern edge of the river are nearly depleted.

Dimension.—One company quarried dolomite in Kane County for irregular-shaped stone and cut and dressed stone for veneer and flagging.

Tripoli.—Illinois was the first of four States in tripoli production. All production was by Illinois Minerals Co. and Tammsco Inc. from mines and plants in Alexander County, located in the extreme southwestern part of the State. Crude production increased about 4%; value dropped about 11%. The amorphous (microcrystalline) silica was used as abrasives and as fillers and extenders.

Other Industrial Minerals.—National Gypsum Co. continued to calcine gypsum mined in Michigan at its wallboard plant in Waukegan, Lake County. Production and value remained about the same as in 1987. Finished iron oxide pigments were manufactured by three companies in Adams, St. Clair, and Sangamon Counties. Production and value increased 5% and 19%, respectively. Crude perlite mined in other States was expanded by three companies in Cook, La Salle, and Will Counties. Production and value increased 14% and 17%, respectively. Some of

TABLE 2

ILLINOIS: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	9,226	$27,310	$2.96
Plaster and gunite sands	306	1,084	3.54
Concrete products (blocks, bricks, pipe, decorative, etc.)	755	2,380	3.15
Asphaltic concrete aggregates and other bituminous mixtures	2,903	10,072	3.47
Road base and coverings[1]	4,642	19,134	4.12
Fill	4,120	9,896	2.40
Snow and ice control	44	114	2.59
Railroad ballast	55	184	3.35
Other[2]	508	1,832	3.61
Unspecified:[3]			
Actual	4,878	14,575	2.99
Estimated	2,661	6,923	2.60
Total or average	**30,098**	**93,504**	**3.11**

[1] Includes road and other stabilization (cement and lime).
[2] Includes roofing granules.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.

TABLE 3

ILLINOIS: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	6,217	17,971	624	2,236	1,507	4,713	878	2,390
Plaster and gunite sands	W	W	W	W	215	726	17	41
Concrete products (blocks, bricks, etc.)	619	1,940	W	W	W	W	W	W
Asphaltic concrete aggregates and other bituminous mixtures	2,133	7,554	195	593	498	1,824	77	100
Road base and coverings[1]	2,811	12,317	412	1,703	868	3,247	550	1,867
Fill	2,806	6,812	300	699	865	2,182	150	204
Snow and ice control	W	W	W	W	—	—	W	W
Railroad ballast	—	—	—	—	W	W	W	W
Other miscellaneous[2]	571	1,858	76	212	136	654	35	162
Other unspecified[3]	3,910	11,993	674	2,098	2,387	6,022	568	1,386
Total	**19,067**	**60,445**	**2,281**	**7,541**	**[4]6,475**	**19,368**	**2,275**	**6,150**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (cement and lime).
[2] Includes sand and gravel for roofing granules.
[3] Includes sand and gravel reported without a breakdown by end use and estimates for nonrespondents.
[4] Data do not add to total shown because of independent rounding.

the increase was attributed to Strong Lite Products Corp.'s starting up a new perlite line at its Seneca plant, La Salle County, which previously processed only vermiculite. Iron and steel slag was processed by three companies at steel mills in Alton, Chicago, and Granite City. Production and attendant value increased 4% and 3%, respectively. In descending order of quantities consumed, processed slag was used for roadbase material, asphaltic concrete, mineral wool, railroad ballast, fill, and other uses. Sulfur was recovered at four refineries in Crawford, Madison, and Will Counties. Production was about 257,700 metric tons, valued at nearly $22.4 million. Two companies exfoliated vermiculite brought in from other States at plants in Du Page and La Salle Counties. Sales and value were up about 8% and 9%, respectively. Major sales, in descending order, were for insulation, fireproofing, concrete aggregates, and horticulture.

Metals

Copper, Lead, Silver, and Zinc.—Metals produced from mines in Illinois are byproducts from Ozark-Mahoning's fluorspar operations in Hardin and Pope Counties. All metal recoveries declined during 1988; silver and zinc dropped the most. Zinc was the most valuable commodity recovered, followed by lead, copper, and silver.

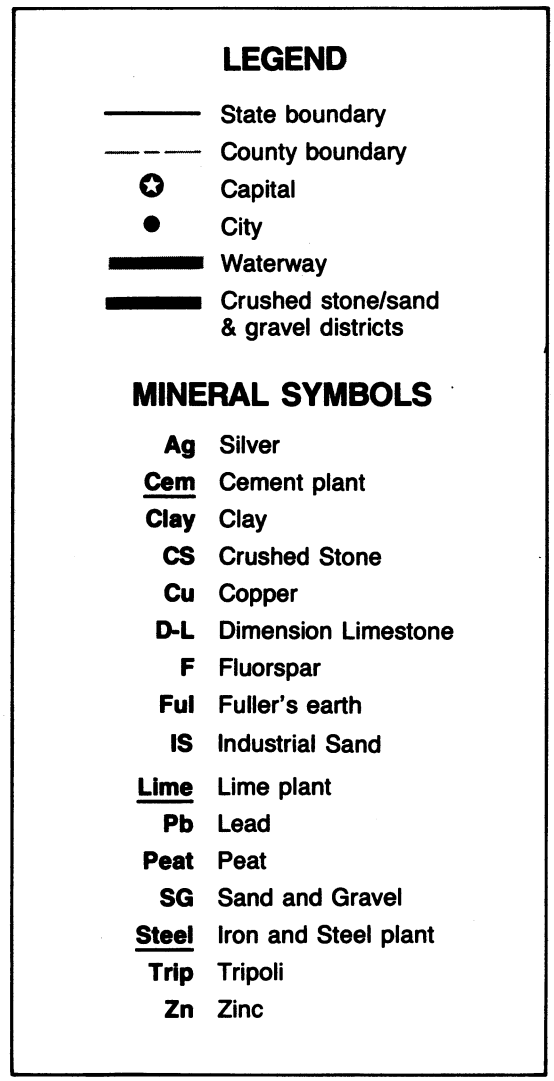
Iron and Steel.—According to the American Iron and Steel Institute, Illinois was the fifth-ranking State in raw steel production in 1988. Production climbed to 7.8 million short tons compared with 7.1 million tons in 1987, a 9% increase.

Several events took place in the State's steel sector. Keystone Steel & Wire Co. completed a $45 million modernization program at its Bartonville complex near Peoria in late March. Annual mill capacity was increased to 550,000 tons per year from its previous capacity of 350,000 tons by major improvements to the continuous caster. The rod mill and wire mill also were modernized.

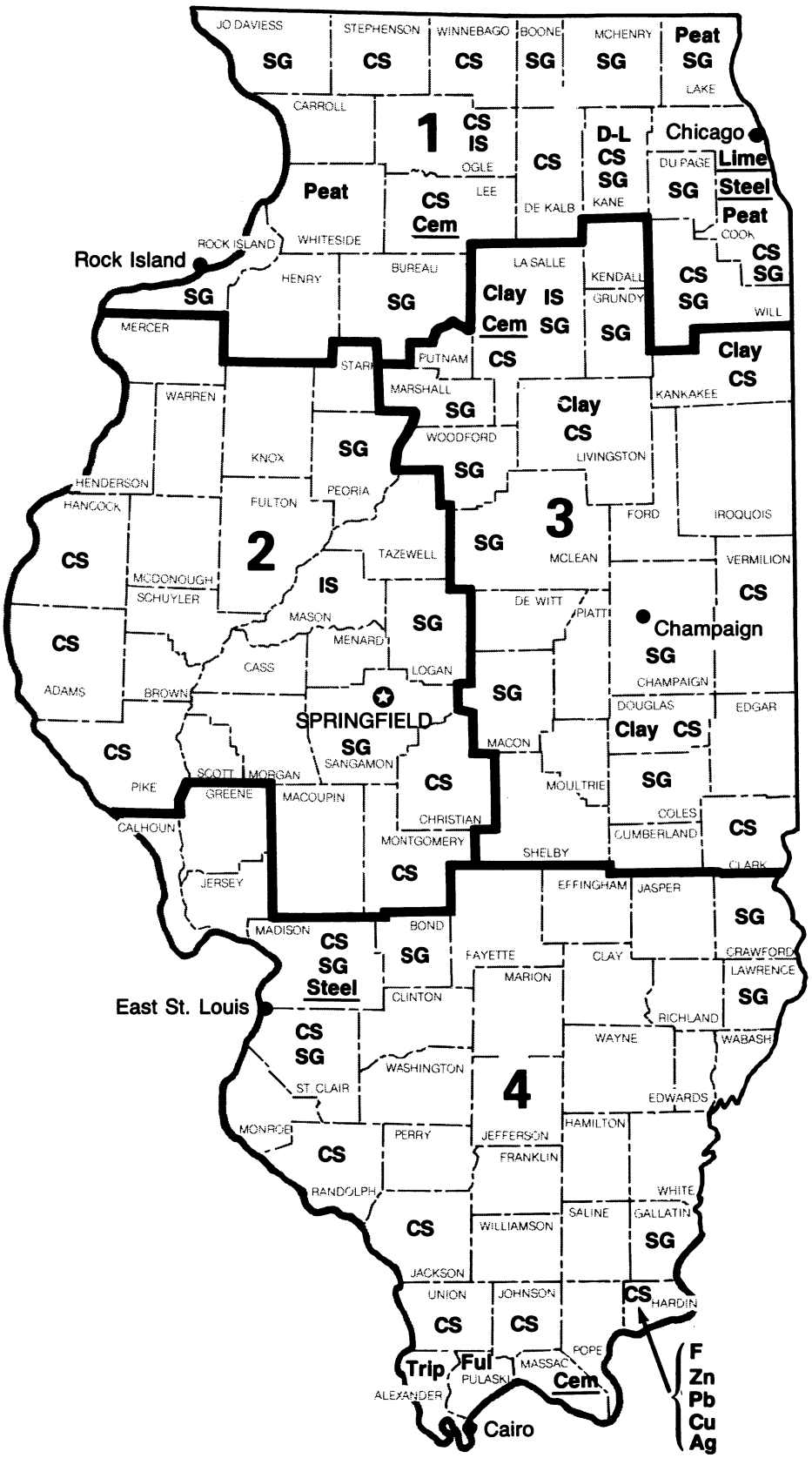
In November, National Steel Corp. announced that it would install a second continuous caster at its Granite City mill. The caster would make the company the only major U.S. steelmaker to produce 100% of its steel through continuous casting. Construction of the $140 million unit was expected to begin in April 1989, with completion slated for late 1990. Annual capacity of the new caster would be 1.6 million short tons.

In August, Northwestern Steel & Wire Co. of Sterling became the third employee-owned steel firm in the Nation, following McLouth Steel Products Corp. of Trenton, MI, and Weirton Steel Corp. of Weirton, WV. Northwestern Steel, with 2,750 employees, manufactures carbon steel prod

ILLINOIS



Principal Mineral-Producing Localities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ucts, which include structural shapes, bars, rods, wire, and wire products.

USX Corp. made several facility improvements at its South Chicago mill during 1988. The improvements led to greater efficiency in producing structurals and plates. The company installed a microcomputer-based combustion control system for the plate mill's continuous reheat furnace and new, longer lasting, water-cooled roofs for the electric furnaces. Both boosted productivity and quality.

Other Metals.—Olin Specialty Metals Corp., a division of Olin Brass of East Alton, announced in mid-December that it would begin production of beryllium copper strip at its East Alton facilities in the first half of 1989. The company would become the third U.S. producer in the beryllium copper market that supplies manufacturers of electronic components. On September 1, Amax Zinc Co. sold its Sauget zinc refinery to Big River Minerals Corp., a St. Louis-based investment firm. The refinery produced 85,000 short tons of zinc, its rated capacity in 1987. This amount equaled approximately 20% of the total primary zinc metal production in the United States, or about 8% of the total domestic consumption. Approximately 365 people were employed at the facility, now called Big River Zinc Corp.

ASARCO Incorporated announced plans in mid-October to install a third furnace at its French process zinc oxide plant in Hillsboro, raising the plant's production capacity from 14,000 short tons to 21,000 short tons. The number of employees at the plant was to increase from 30 to 36 when the furnace came on-line in the first quarter of 1989. Zinc oxide is used to strengthen rubber and to improve resistance to heat and abrasion. It is also used in glass, ceramics, and as a paint additive to retard mildew. Furnaces at the 85-year-old DePue zinc dust plant of Zinc Corporation of America, formerly owned by New Jersey Zinc Co., were shut down in mid-December because of high costs and decreased demand. Cleanup operations at the plant, which employed 18 persons, continued through yearend.

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[1] State Mineral Officer, Bureau of Mines, Minneapolis, MN.

[2] Mining Engineering. Exploration 1988. V. 41, No. 5, May 1989, p. 310.

[3] Pennwalt Corporation. 1988 Annual Report. 48 pp.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Dixon-Marquette Cement Inc., a subsidiary of Prairie Materials Sales Inc.	12152 South Plainfield Naperville Rd. Plainfield, IL 60544	Quarry and plant	Lee.
Illinois Cement Co. Inc., a subsidiary of Centex Corp.	Box 442 La Salle, IL 61301	Quarry, clay pit, plant	La Salle.
Lone Star Industries Inc., Cement and Construction Materials Group.	1 Greenwich Plaza Box 5050 Greenwich, CT 06836	do.	Do.
Missouri Portland Cement Co., a division of Cementia Holdings AG	Box 4288 Davenport, IA 52801	Plant Quarry	Massac. Hardin.
Clays:			
Absorbent Clay Products Co.	Box 120 Anna, IL 62906	Pit and plant	Pulaski.
Lowe's Southern Clay Inc.	348 South Columbia South Bend, IN 46624	do.	Do.
Richards Brick Co.	234 Springer Ave. Edwardsville, IL 62025	do.	Bond.
Streator Brick Systems Inc.	West 9th St. Streator, IL 61364	do.	Livingston.
Fluorspar:			
Hastie Trucking & Mining Co.	Cave In Rock, IL 62919	Open pit	Hardin.
Ozark-Mahoning Co., a subsidiary of Pennwalt Corp.[1]	Box 57 Rosiclare, IL 62982	Underground mines and plant	Hardin and Pope.
Gypsum (calcined):			
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	Plant	Lake.
Iron oxide pigments (finished):			
Pfizer Pigments Inc.	235 East 42d St. New York, NY 10017	do.	St. Clair.
Prince Manufacturing Co.	700 Lehigh St. Bowmanstown, PA 18030	do.	Adams.
Solomon Grind-Chem Service Inc.	Box 1766 Springfield, IL 62705	do.	Sangamon.
Iron and steel:			
Acme Steel Co.	13500 South Perry Ave. Riverdale, IL 60627	do.	Cook.
Granite City Div. of National Steel Corp	Box 365 Granite City, IL 62041	Iron and steel furnaces	Madison.
LTV Steel Co.	1641 GH Republic Bldg. Cleveland, OH 44101	do.	Cook.
Lime:			
Marblehead Lime Co., a subsidiary of General Dynamics Corp.	222 North La Salle St. Chicago, IL 60601	Plants	Do.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	Plant	Do.
Peat:			
Joseph W. Grenus Excavating & Trucking	39346 North Highway 83 Lake Villa, IL 60046	Bog and plant	Lake.

See footnote at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Hyponex Corp.	4501 Circle 75 Pkwy. Suite B2250 Atlanta, GA 30339	Bog and plant	Whiteside.
Markman Peat Co.	Route 3 Morrison, IL 61270	do.	Do.
Roots Peat Farm	Box 6005 Lake Villa, IL 60046	do.	Lake.
Perlite (expanded):			
Manville Corp.	Route 6, Box 3429 Joliet, IL 60434	Plant	Will.
Silbrico Corp.	6300 South River Rd. Hodgkins, IL 60525	do.	Cook.
Strong-Lite Products Corp.	Shipyard Rd. Seneca, IL 71611	do.	La Salle.
Sand and gravel:			
Construction:			
Felts Sand & Gravel Co. Inc.	RR 25, Box 159 North Aurora, IL 60542	Pits and plant	Kane and Kendall.
Material Service Corp., a division of General Dynamics Corp.	300 West Washington St. Chicago, IL 60606	do.	Grundy, Kane, McHenry.
McHenry Sand & Gravel Co. Inc.	Box 511 McHenry, IL 60050	do.	Boone, Kane, McHenry.
Midwest Sand & Gravel Inc.	Box 218, 101 South Main La Rose, IL 61541	do.	Marshall.
Road Material Corp.	Box 209 Algonquin, IL 60102	do.	Kane, McHenry, Peoria.
Thelen Sand & Gravel Inc.	28955 West Route 173 Antioch, IL 60002	Pit and plant	Lake.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	Pits and plants	Champaign, Livingston, McHenry, Macon.
Industrial:			
Manito Investment Co.	Box 166 Tremont, IL 61568	Pit and plant	Mason.
Manley Bros. of Indiana Inc.	Box 538 Chesterton, IN 46304	do.	La Salle.
Unimin Corp.	258 Elm St. New Canaan, CT 06840	Pits and plants	La Salle and Ogle.
U.S. Silica Co.	Box 577 Ottawa, IL 61350	Pit and plant	La Salle.
Wedron Silica Co.	Box 167 Wedron, IL 60557	Pits and plant	Do.
Slag (iron and steel):			
Heckett Co.	612 North Main St. Butler, PA 16001	Plants	Whiteside.
International Mill Service Co.	1818 Market St. Philadelphia, PA 19103	do.	Madison.
St. Louis Slag Products Co. Inc., a division of Standard Slag Co.	Box 430 Granite City, IL 62040	Plant	Do.

See footnote at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone (crushed limestone-dolomite, 1987):			
Columbia Quarry Co.	Box 128 Columbia, IL 62236	Underground mine, quarries, plants	Johnson, Monroe, Pulaski, St. Clair, Union.
Material Service Corp., a division of General Dynamics Corp.	300 West Washington St. Chicago, IL 60606	do.	Cook, Logan, Menard, Montgomery, St. Clair, Vermillion, Will.
Rein, Schultz & Dahl Inc.	5960 Falcon Rd. Rockford, IL 61109	Quarries and plants	Carroll, Douglas, Kane, Stephenson, Will.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	do.	Clark, Cook, Iroquois, Kankakee, Livingston, Will.
Sulfur (recovered):			
Marathon Oil Co.	Robinson, IL 62454	Plant	Crawford.
Mobil Oil Corp.	Box 874 Joliet, IL 60434	do.	Will.
Shell Oil Co.	Box 262 Wood River, IL 62095	do.	Madison.
UNOCAL Corp.	1650 East Golf Rd. Schaumburg, IL 60196	do.	Will.
Tripoli:			
Illinois Minerals Co., a subsidiary of Georgia-Kaolin Co.	2035 Washington Ave. Cairo, IL 62914	Underground and open pit mines and plant	Alexander.
Tammsco Inc.	Box J Tamms, IL 62988	Underground mine and plant	Do.
Vermiculite (exfoliated):			
W. R. Grace and Co., Construction Products Div.	6051 West 65th St. Bedford Park, IL 60638	Plant	Du Page.
Strong-Lite Products Corp.	Shipyard Rd. Seneca, IL 71611	do.	La Salle.

[1] Also copper, lead, silver, zinc.

THE MINERAL INDUSTRY OF INDIANA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Geological Survey, Indiana Department of Natural Resources, for collecting information on all nonfuel minerals.

By James J. Hill[1]

The value of nonfuel mineral production in Indiana increased for the sixth consecutive year, soaring to a record $406.4 million in 1988, 12% higher than the previous record of $363.9 million established in 1987. Record high total values were set for natural abrasives, portland cement, clays, construction sand and gravel, industrial sand, and crushed and dimension stone; production gains over 1987 levels were reported for all commodities except masonry and portland cement and gypsum. Nationally, the State ranked 24th in value of nonfuel mineral production and was the leading producer of dimension stone, iron and steel slag, and raw steel. Indiana ranked second in the output of masonry cement, third in peat, and fourth in aluminum. In terms of value, the leading mineral commodities produced in the State were crushed stone, portland cement, construction sand and gravel, and masonry cement; together these accounted for 85% of Indiana's total minerals production value.

Most of Indiana's mineral production was used in construction. The value of State road contract awards totaled $460 million, an increase of 27% over 1987 figures. Nonresidential construction increased 6% to $1.5 billion. Residential housing starts dropped 7% to 25,248 units; this decline was mainly due to higher interest rates.

EMPLOYMENT

Indiana's civilian labor force totaled about 2.8 million in 1988, approximately 67,000 persons more than in 1987. The State's average unemployment rate was 5.3%, slightly lower than the 6.4% rate reported in 1987. Mining and quarrying employment totaled about 8,400 persons, a decrease from the 8,600 persons reported in 1987. Average weekly earnings increased to $619.52 from $616.00 in 1987. Steel industry employment averaged about 37,800 persons in 1988, an increase over the 36,800 persons reported in 1987. Average weekly wages totaled $667.23, up from $648.24 reported in 1987.

LEGISLATION AND GOVERNMENT PROGRAMS

The 1988 legislative session resulted in the enactment into law of several mineral-related bills. Public Law 83 provided an $8 million economic incentive package for Nucor Corp.'s steel mill under construction near Whites-

TABLE 1

NONFUEL MINERAL PRODUCTION IN INDIANA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	395	$22,936	422	$32,299	405	$27,442
Portland	do.	2,136	92,327	2,320	103,177	2,315	107,179
Clays	short tons	743,859	3,044	[2]1,036,669	[2]4,056	1,141,813	4,630
Gem stones		NA	1	NA	10	NA	10
Peat	thousand short tons	79	W	44	W	54	W
Sand and gravel:							
Construction	do.	19,642	61,232	e18,900	e65,200	25,923	79,985
Industrial	do.	193	1,490	230	1,357	362	1,829
Stone:							
Crushed	do.	e[3]22,600	e[3]76,500	31,067	106,770	e36,600	e130,000
Dimension	short tons	e190,995	e20,252	183,609	23,115	e195,444	e24,956
Combined value of abrasives, clays (fire clay, 1987), gypsum, lime, stone (crushed marl, 1986), and values indicated by symbol W		XX	27,566	XX	27,881	XX	30,358
Total		**XX**	**305,348**	**XX**	**363,865**	**XX**	**406,389**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

[3] Excludes certain stones; kind and value included with "Combined value" data.

ville, Montgomery County. The funds were to be used for training workers and for on-site improvements such as railroad spurs and drainage.

Three laws revised parts of the existing Indiana surface coal mine reclamation law. Public Law 108 lessened the impact of archaeological and historical preservation efforts on surface coal mines. Public Law 109 required all members of the Natural Resources Commission to file an annual statement of financial interest. It also made changes concerning conflicts of interests, fees, and civil actions. Finally, Public Law 110 added self-bonding provisions and created a bond pool funded by mine operators. The pool was to be administered by the Department of Natural Resources and a committee appointed by the operators.

Public Law 144 amended the Indiana Code concerning deep coal mine safety. It also changed the qualifications and set a salary structure for the managers of the Indiana Bureau of Mines and Mine Safety. The law provided for leave of absence from coal company employment for persons accepting appointments as director or chief mining engineer of the Bureau.

Research conducted at the Indiana Geological Survey centered on energy resources (coal, oil, and natural gas), industrial minerals, the environment, and geologic framework studies. The Survey released a number of publications during 1988; these included a catalog of core samples stored at the Survey and a directory of sand and gravel producers. One report characterized the geology of Indiana with respect to indoor radon surveys. Two reports and a map dealt with State coal mining. In addition, the Geological Survey conducted studies on the effects of jointing on roof conditions in underground limestone mines and the use of limestone for the absorption of sulfur from stack gases.

The Division of Reclamation within the Department of Natural Resources issued permits and regulated coal, clay, shale, and/or oil shale mining operations. In fiscal year 1987–88 (ending June 30, 1988), the Division's Inspection and Enforcement Section had jurisdiction over 80 active coal mines, 287 coal mines undergoing reclamation, and 17 tipples-processing facilities. The Division received grants totaling nearly $2.3 million during the fiscal year from the Office of Surface Mining Reclamation and Enforcement for regulatory and administrative programs authorized under Public Law 95–87. The Division's Non-Coal Minerals Section received and approved requests from five companies to mine clay and shale on a total of 84.34 acres. At fiscal yearend, the section had eight mining units under its jurisdiction.

The Mining and Mineral Research Institute at Purdue University in West Lafayette received a grant of $138,000 channeled through the U.S. Bureau of Mines under Public Law 98–409. These funds were to be used by research institutions to assist in the training of engineers and scientists in mineral-related disciplines.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Nationally, Indiana ranked 2d and 10th in shipments of masonry and portland cement, respectively. These shipments lagged behind those for 1987, dropping by about 17,000 short tons for masonry cement and 5,000 short tons for portland cement. Three companies manufactured both portland and masonry cement at four plants in Cass, Clark, Lawrence, and Putnam Counties. One of these companies, Lehigh Portland Cement Co. also manufactured a calcium aluminate cement at its Buffington Station plant at Gary in Lake County. (This specialized cement, used in lining blast furnaces at steel mills, is not included in Bureau of Mines statistics.) Approximately 89% of portland cement sales were Types I and II, general-use and moderate-heat. The companies also produced Type III, high-early-strength, portland cement. Two companies sold small quantities of white portland cement.

Cement sales were to ready-mixed concrete companies (74%), concrete product manufacturers (13%), highway contractors (7%), building material dealers (5%), and other contractors and miscellaneous customers (1%). Approximately 92% of the finished portland cement was shipped to customers by truck in bulk form. Cement shipments from all sources to and within Indiana in 1988 totaled 1,773,000 tons of portland cement and 108,000 tons of masonry cement. This amount was 69,000 tons more of portland cement and 5,000 tons more of masonry cement compared with 1987 data.

Raw materials consumed in the manufacture of cement totaled 4.5 million short tons. This total included 3.6 million tons of limestone, 552,000 tons of clay and shale, and 154,000 tons of gypsum. Lesser quantities of fly ash, pyrite, sand, and slag also were used.

In October, union employees of Lehigh Portland Cement Co. ratified a new 3-year contract that reinstated some pension and supplemental unemployment benefits the company had unilaterally withdrawn in 1984. The agreement also called for cash settlement of a complaint, filed by the union with the National Labor Relations Board, alleging that Lehigh had failed to bargain in good faith when the workers' contract expired in 1984.

Clays.—Indiana ranked 10th of 43 States in the production of common clay and shale. In 1988, the quantity and value of sales increased 10% and 14%, respectively. Clay was mined by 10 companies with operations in 10 Indiana counties. Morgan County led the State's production, followed by Clay County and Clark County. Most of the clay mined in the State was used

for cement manufacture. The next largest quantities were used for brick manufacture and as lightweight aggregate in concrete blocks. Other uses included filler for animal feed, ceramic floor tile, drain tile, electrical porcelain, and pottery; it was also used in rubber manufacture.

Because of increased sales, KPT Inc., a Taiwan-owned ceramic tile producer that purchased Indiana clay, began a $3 million expansion of its plant near Bloomfield in Greene County. The plant came on-stream in 1986.

Gypsum.—Nationally, Indiana ranked seventh in the production of crude and calcined gypsum. Output of crude gypsum was down slightly during the year, whereas the quantity of calcined gypsum increased about 2%. All of the State's crude gypsum was mined near Shoals in Martin County by USG Corp. and National Gypsum Co.; the mines held by these companies ranked 5th and 10th, respectively, in national production in 1988. In addition, the USG mine was awarded the prestigious "Sentinels of Safety" trophy for the best safety record in the Nation in 1987 for nonmetal underground mining operations. The mine was awarded this honor four times previously. USG manufactured wallboard at a plant at East Chicago in Lake County, using crude gypsum mined in Michigan. Most of the State's gypsum was used in the manufacture of wallboard; lesser quantities were used in cement and plaster and for soil conditioning.

In November, the U.S. Forest Service began seeking public comment on a request by USG to lease approximately 500 acres in the Hoosier National Forest for gypsum mining on a noncompetitive basis. However, the Bureau of Land Management subsequently ruled that this leasing would have to be on a competitive basis. At yearend, the U.S. Forest Service undertook an environmental assessment of the proposed action.

Lime.—Indiana ranked 12th of 34 States in lime production. Output and value increased for the second consecutive year, surpassing 1987 figures by 3% and 13%, respectively. Moreover, output has increased nearly 33% since 1986, when lime production fell to a 10-year low. Because most of Indiana's lime is used by the steel industry, the lime production trends have closely paralled that for steel, which registered gains of nearly 26% since 1986. Two companies produced quicklime in 1988. These were Inland Steel Co., which operated a plant at Indiana Harbor, and Marblehead Lime Co., with a plant at Buffington Station near Gary. Marblehead Lime is the country's third largest producer.

Peat.—Of the 23 peat-producing States, Indiana ranked third, following Michigan and Florida. The quantity and value of sales increased 23% and 34%, respectively, compared with 1987 figures. Peat was harvested by five companies with operations in Allen, Hamilton, La Porte, and Madison Counties. The predominant peat extracted was reed sedge, with lesser quantities of humus and hypnum. Most of the peat was shipped to consumers in packaged form. Peat was sold for use in general soil improvement, golf courses, and earthworm culture, in mixed fertilizers; and as an ingredient in potting soil.

In November, Hyponex Corp. of Fort Wayne was acquired by O. M. Scott & Sons Co. of Marysville, OH. Hyponex, with operations in Hamilton County, was one of the two largest producers of peat in Indiana.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter thus contains actual data for 1986 and 1988 and estimates for 1987.

Indiana construction sand and gravel

TABLE 2

INDIANA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	7,441	$20,227	$2.72
Plaster and gunite sands	188	783	4.16
Concrete products (blocks, bricks, pipe, decorative, etc.)	542	1,315	2.43
Asphaltic concrete aggregates and other bituminous mixtures	2,355	6,355	2.70
Road base and coverings[1]	1,975	5,477	2.77
Fill	2,201	4,914	2.23
Snow and ice control	201	525	2.61
Railroad ballast	1	10	10.00
Other[2]	255	1,308	5.13
Unspecified:[3]			
Actual	8,653	33,322	3.85
Estimated	2,111	5,748	2.72
Total or average	**25,923**	**[4]79,985**	**3.09**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes road and other stabilization (cement and lime).
[2] Includes roofing granules.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data do not add to total shown because of independent rounding.

TABLE 3

INDIANA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	1,408	4,464	2,237	7,562	3,796	8,202
Plaster and gunite sands	135	598	W	W	W	W
Concrete products (blocks, bricks, etc.)	67	209	W	W	W	W
Asphaltic concrete aggregates and other bituminous mixtures	873	2,400	1,088	2,821	394	1,135
Road base and coverings[1]	605	2,193	1,218	2,723	152	561
Fill	513	1,067	1,276	2,932	412	916
Snow and ice control	110	258	63	204	29	63
Railroad ballast	1	10	—	—	—	—
Other miscellaneous[2]	106	610	574	1,604	103	386
Other unspecified[3]	1,801	5,565	7,348	28,428	1,615	5,077
Total[4]	**5,619**	**17,373**	**13,804**	**46,273**	**6,500**	**16,339**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (cement and lime).
[2] Includes sand and gravel for roofing granules.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data may not add to totals shown because of independent rounding.

statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents these statistics for the three Indiana districts.

Indiana ranked 10th in the Nation in the production of sand and gravel for construction use. Construction sand and gravel was the third most valued nonfuel mineral commodity produced in the State, following cement (masonry and portland) and crushed stone. Output and value of sales increased 37% and 23%, respectively, compared with 1987 figures. However, low estimates of production in 1987 may account for these high percentage increases.

Production was recorded for 85 companies operating 141 pits in 61 of the State's 92 counties. Over 1 million short tons of production was reported in Hamilton, Marion, Switzerland, Tippecanoe, and Wayne Counties, accounting for 35% of Indiana's total production. Most of the construction sand and gravel was transported to consumers by truck.

In June, Beazer PLC of the United Kingdom acquired Pittsburgh-based Koppers Co., a major producer of sand and gravel and stone. Koppers Co. subsequently was renamed Beazer Materials and Services Inc. The France Stone Co., a Beazer subsidiary, mined a sand and gravel deposit in Allen County.

Industrial.—Three companies mined industrial sand at five pits in Fountain, La Porte, and Porter Counties. Production and value were up 57% and 35%, respectively, over 1987 figures. Sand used for molding and core and refractories accounted for most of the increase in sales. The industrial sand was transported to consumers primarily by truck; lesser quantities were transported by rail.

Manley Bros. of Indiana Inc. announced that it had agreed to sell its sand mining property in Michigan City to an investor from Chicago, subject to the City's approval and completion of reclamation activities in 1989.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—Indiana's crushed stone production was estimated at 36.6 million short tons in 1988, an increase of nearly 18% over that of 1987. Value of production was estimated at $130 million. In June, as mentioned earlier, Beazer PLC purchased Koppers Co., thereby acquiring eleven stone quarries in Allen, Jennings, Putnam, Ripley, Scott, and Washington Counties. Martin-Marietta Corp. opened a new quarry at Noblesville to supply the Indianapolis area.

Dimension.—Indiana ranked first of 35 States in dimension stone production. Output and value were estimated to have increased 6% and 8%, respec-

tively, compared with 1987 figures. The renewed interest of architects in the use of stone, combined with lower interest rates, has helped the stone industry in the past few years. Indiana's dimension stone production in 1987 was from 15 limestone quarries and 1 sandstone quarry. To avoid winter shutdowns, the Elliott Stone Co. of Bedford began quarrying limestone underground with a French-made diamond saw. Bybee Stone Co. of Ellettsville reopened the long-dormant Romona Quarry northeast of Spencer in Owen County.

Other Industrial Minerals.—Hindostan Whetstone Co. continued to mine abrasive sandstone at a quarry near Orleans in Orange County, for use in its manufacture of cuticle removers, table coasters, and sharpening stones at its plant in Bedford. Sandstone production and value increased for the third consecutive year. Abrasives Inc. manufactured iron and steel shot and grit at a plant in Tippecanoe in Marshall County. Estimated value of gem stones and mineral specimens was $10,000. Sales of perlite, which was expanded by four companies with plants in Martin, Montgomery, and Tippecanoe Counties, declined slightly in 1988. Perlite was used in plaster aggregate, filter aids, and fillers, and for low-temperature insulation. Iron and steel slag was processed by three companies at five sites in Lake and Porter Counties. Sales totaled 4.3 million short tons, valued at $14.9 million. Most of the processed slag was used as road base material. Amoco Oil Co. continued to recover elemental sulfur at its Whiting refinery in Lake County.

Metals

Aluminum.—Indiana ranked fourth of 14 States in primary aluminum production; its production increased 10% over that of 1987. Aluminum Co. of America (Alcoa) was the State's sole producer, with facilities near Evansville in Warrick County. This plant is the second largest aluminum smelter in the United States and has a rated capacity of 298,000 short tons annually.

In early December, a 43-month contract covering aluminum industry workers, including those at the Warrick facility, was signed by Alcoa; Reynolds Metals Co.; the Aluminum, Brick, and Glass Workers Union; and the United Steelworkers of America Union. The pact, which was retroactive to January 1, 1988, entitled union workers to profit sharing in addition to bonuses and wage increases.

Alcan Rolled Products Co. of Terre Haute, a subsidiary of Alcan Aluminum of Toronto, announced plans to build a $60 million state-of-the-art foil rolling mill capable of producing foil 82 inches wide as fast as 6,000 feet per minute. Construction was expected to begin in January 1989 with completion scheduled for the second quarter of 1990.

Iron and Steel.—Indiana continued to lead the Nation in raw steel production. The American Iron and Steel Institute reported Indiana's production as nearly 21.2 million short tons, an increase of 10% over the 19.3 million tons reported in 1987. Pig iron shipments are not being reported by the Bureau of Mines for 1988 because some of the Nation's leading producers failed to respond to Bureau surveys.

The State's steel sector was very active in 1988. Bethlehem Steel Corp. broke ground for a $50 million state-of-the-art vacuum degassing facility at its Burns Harbor plant; the facility was expected to be completed in late 1989. Inland Steel Corp. and the United Steelworkers of America Union reached a new contract agreement that saved two bar mills from being shuttered at the Indiana Harbor Works. The mills were being grouped in a new shaped-products division; Inland was investing $100 million in new technology to keep them competitive. Inland also announced engineering studies for a joint venture with Nippon Steel Corp. of Japan for an electrogalvanizing and hot-dipped line to be built next to the I/N Tek mill that was under construction near New Carlisle. LTV Corp. completed a $14.4 million modernization program at the No. 2 sheet mill at its Indiana Harbor Works. In October, LTV announced that it would sell its bar division, which included a cold finishing mill in Gary. USX Corp. began a $41 million program, expected to be completed in early 1989, to upgrade its Gary tin-plate mill. Also at Gary, a hot-strip plate mill was under construction. This project was a joint venture between USX and Feralloy Corp. of Chicago; Feralloy was to manage the completed facility.

[1] State Mineral Officer, Bureau of Mines, Minneapolis, MN.

INDIANA

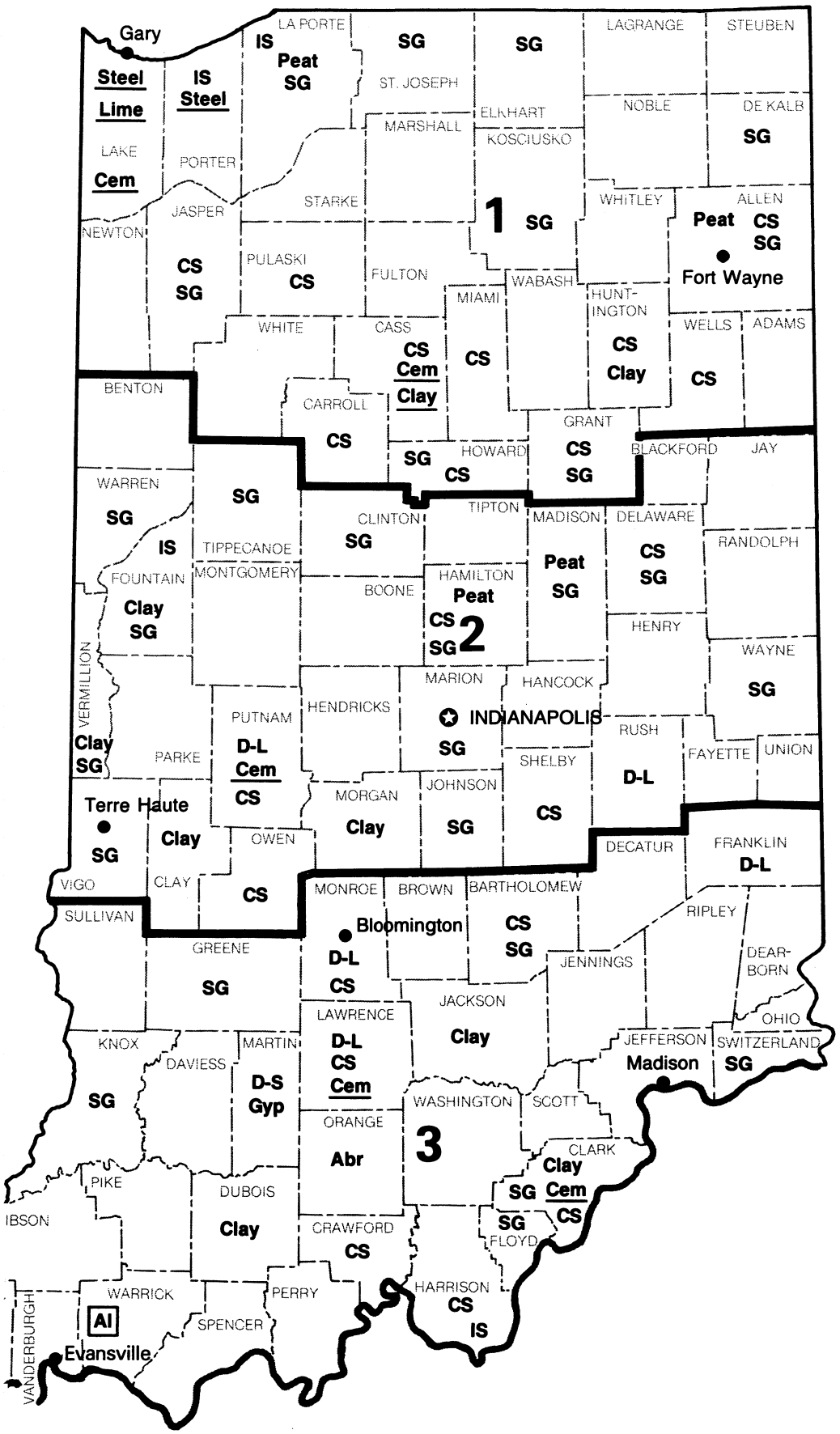
LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Abr	Abrasives
Al	Aluminum plant
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-L	Dimension Limestone
D-S	Dimension Sandstone
Gyp	Gypsum
IS	Industrial Sand
Lime	Lime plant
Peat	Peat
SG	Sand and Gravel
Steel	Iron and Steel plant

Principal Mineral-Producing Localities


Gary
LA PORTE
IS
Peat
SG
SG
SG
LAGRANGE
STEUBEN
Steel
Lime
IS
Steel
ST. JOSEPH
ELKHART
NOBLE
DE KALB
SG
MARSHALL
KOSCIUSKO
LAKE
Cem
PORTER
STARKE
1
SG
WHITLEY
ALLEN
Peat
CS
SG
JASPER
NEWTON
CS
SG
PULASKI
CS
FULTON
WABASH
Fort Wayne
MIAMI
HUNT-
INGTON
WELLS
ADAMS
WHITE
CASS
CS
Cem
Clay
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CS
Clay
CS
BENTON
CARROLL
CS
GRANT
SG
HOWARD
CS
CS
SG
BLACKFORD
JAY
WARREN
SG
SG
CLINTON
SG
TIPTON
MADISON
DELAWARE
CS
SG
RANDOLPH
IS
TIPPECANOE
FOUNTAIN
MONTGOMERY
BOONE
HAMILTON
Peat
CS
SG
2
Peat
SG
HENRY
Clay
SG
WAYNE
SG
VERMILLION
MARION
HANCOCK
PUTNAM
HENDRICKS
INDIANAPOLIS
SG
RUSH
Clay
SG
PARKE
D-L
Cem
CS
SHELBY
D-L
FAYETTE
UNION
Terre Haute
SG
Clay
MORGAN
Clay
JOHNSON
SG
CS
OWEN
DECATUR
FRANKLIN
D-L
VIGO
CLAY
CS
MONROE
BROWN
BARTHOLOMEW
RIPLEY
SULLIVAN
Bloomington
D-L
CS
CS
SG
JENNINGS
DEAR-
BORN
GREENE
SG
JACKSON
Clay
LAWRENCE
D-L
CS
Cem
OHIO
KNOX
MARTIN
JEFFERSON
Madison
SWITZERLAND
SG
DAVIESS
D-S
Gyp
SG
WASHINGTON
SCOTT
ORANGE
Abr
3
CLARK
Clay
SG
Cem
CS
PIKE
DUBOIS
Clay
IBSON
CRAWFORD
CS
SG
FLOYD
HARRISON
CS
IS
WARRICK
PERRY
AI
SPENCER
Evansville
VANDERBURGH

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Abrasives (natural);			
Hindostan Whetstone Co.	Box 862 Bedford, IN 47421	Quarry	Orange.
		Plant	Lawrence.
Aluminum:			
Aluminum Co. of America	Warrick Operations Box 10 Newburgh, IN 47630	Smelter and fabricating plant	Warrick.
Cement:			
Coplay Cement Co., a subsidiary of Societe des Ciments Francais:	Box 35750 Louisville, KY 40232		
Logansport plant [1 2]		Plant, quarry, clay pit	Cass.
Speed plant [1 2]		do.	Clark.
Lehigh Portland Cement Co., a subsidiary of Heidelberger Zement AG:	Box 1882 Allentown, PA 18105		
Buffington Station plant		Plant	Lake.
Mitchell plant		Plant and quarry	Lawrence.
Lone Star Industries Inc.: Greencastle plant [1 2]	Box 5050 Greenwich, CT 06836	Plant, quarry, clay pit	Putnam.
Clays:			
General Shale Products Corp.	Box 96 Mooresville, IN 46158	Pits and plant	Morgan.
Hydraulic-Press Brick Co., Haydite Div.	Brooklyn, IN 46111	Pit and plant	Do.
Log Cabin Coal Co.	304 South Depot St. Brazil, IN 47834	Pits and plant	Clay.
Gypsum:			
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	Underground mine and plant	Martin.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do. Plant	Do. Lake.
Iron and steel:			
Bethlehem Steel Corp.	Bethlehem, PA 18016	Mill (integrated)	Porter.
Inland Steel Co., a subsidiary of Inland Steel Industries Inc.	3210 Watling St. East Chicago, IN 46312	do.	Lake.
LTV Steel Co.	3001 Dickey Rd. East Chicago, IN 46312	do.	Do.
National Steel Corp., Midwest Steel Div.	U.S. 12 Portage, IN 46368	Mill (rolling)	Porter.
USX Corp., Gary Works Div.	1 North Broadway Gary, IN 46402	Mill (integrated)	Lake.
Lime:			
Inland Steel Co., a subsidiary of Inland Steel Industries Inc.	3210 Watling St. East Chicago, IN 46312	Plant	Do.
Marblehead Lime Co., a subsidiary of General Dynamics Corp.	222 North LaSalle St. Chicago, IL 60601	do.	Do.
Peat:			
Beusching Peat Moss and Black Dirt	9134 Cook Rd., Route 3 Ft. Wayne, IN 46818	Bog and plant	Allen.
Felger's Peat Moss and Black Dirt	9912 Valentine Rd. Ft. Wayne, IN 46818	do.	Do.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Filbrun Peat Moss	Route 2, Box 269 Pendleton, IN 46064	Bog and plant	Madison.
Hyponex Corp.	4501 Circle 75 Pkwy., Suite B2250 Atlanta, GA 30339	do.	Hamilton.
Millburn Peat Co. Inc.	Box 236 La Porte, IN 46350	do.	La Porte.
Perlite (expanded):			
Chemrock Corp.	Box 5465 Lafayette, IN 47903	Plant	Tippecanoe.
Grefco Inc.	Box 48 Crawfordsville, IN 47933	do.	Montgomery.
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	do.	Martin.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do.	Do.
Sand and gravel:			
Construction:			
ARC America Corp.	Drawer 160 Greenville, OH 45331	Pits and plants	Hamilton, Marion, Wayne.
Evansville Materials Inc.	Box 3596 Evansville, IN 47905	do.	Posey, Spencer, Vanderburgh.
Fairfield Builders Supply Co.	Box 4427 Lafayette, IN 47905	do.	Boone and DeKalb.
Hilltop Basic Resources Inc.	630 Vine St. Cincinnati, OH 45202	Pit and plant	Switzerland.
Irving Materials Inc.	Box 369, Route 5 Greenfield, IN 46140	Pits and plants	Clark, DeKalb, Delaware, Fayette, Hamilton, Henry, Madison, Wayne.
Martin Marietta Aggregates	Box 30013 Raleigh, NC 27622	do.	Clark, Grant, Howard, Marion, Vermillion, Vigo.
OK Sand & Gravel Co. Inc.	5320 South Belmont Indianapolis, IN 46217	Pit and plant	Marion.
Rogers Group Inc.	Box 849 Bloomington, IN 47402	Pits and plants	Fountain, Greene, Knox, Morgan, Owen, Warren.
Vulcan Materials Co.[1]	Box 7497 Birmingham, AL 35253	do.	Parke, St. Joseph, Tippecanoe.
Industrial:			
Crisman Sand Co. Inc.	6480 Melton Rd. Portage, IN 46368	Pits and plants	Porter.
Harrison Steel Castings Co.	Box 60 Attica, IN 47918	Pit and plant	Fountain.
Manley Bros. of Indiana Inc.	Box 538 Chesterton, IN 46304	Pits and plants	La Porte.
Slag:			
Iron and steel:			
The Levy Co. Inc.	Box 540 Portage, IN 46368	Plants	Lake and Porter.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Steel:			
Heckett Co.	Box 1071 Butler, PA 16001	Plant	Lake.
International Mill Service Co.	1818 Market St. Philadelphia, PA 19103	Plants	Do.
Stone (1987):			
Crushed:			
Limestone:			
ARC America Corp.	Drawer 160 Greenville, OH 45331	Quarries and plants	Greene, Hamilton, Marion, Owen.
The France Stone Co.	Box 1928 Toledo, OH 43603	do.	Allen and Putnam.
Irving Bros. Stone & Gravel Inc.	Box 300, Rural Route 13 Muncie, IN 47302	do.	Blackford, Delaware, Grant, Huntington, Wells.
Martin Marietta Aggregates	Box 30013 Raleigh, NC 27622	do.	Clark, Howard, Madison, Putnam.
Mulzer Crushed Stone Inc.	Box 248 Tell City, IN 47586	Quarries, mine, plants	Crawford.
Rogers Group Inc.	Box 849 Bloomington, IN 47402	Quarries and plants	Lawrence, Monroe, Newton, Putnam.
Marl:			
Vernon M. Kaufman	Route 1 Topeka, IN 46571	Pit	Lagrange.
M. W. Wolkins	Box 332 Union, MI 49130	Pit	Elkhart.
Dimension, limestone:			
Bybee Stone Co.	Box 968 Bloomington, IN 47402	Quarry and plant	Monroe.
Elliot Stone Co. Inc.	Box 743 Bedford, IN 47421	do.	Lawrence.
Evans Quarries Inc.	Box 711 Bedford, IN 47421	do.	Do.
B. G. Hoadley Quarries Inc.	Box 1224 Bloomington, IN 47402	Quarries and plants	Lawrence and Monroe.
Independent Limestone Co.	6001 South Rockport Rd. Bloomington, IN 47401	Quarry and plant	Monroe.
Indiana Limestone Co. Inc.	Box 72 Bedford, IN 47421	Quarries and plants	Lawrence and Monroe.
Reed Quarries Inc.	Box 64 Bloomington, IN 47402	Quarry and plant	Monroe.
Victor Oolitic Stone Co.	Box 668 Bloomington, IN 47402	do.	Do.
Sulfur (recovered):			
Amoco Oil Co.	Box 710 Whiting, IN 46394	Elemental sulfur recovered as a byproduct of oil refining.	Lake.

[1] Also crushed stone.
[2] Also clays.

THE MINERAL INDUSTRY OF IOWA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Geological Survey Bureau, Division of Energy and Geological Resources, Iowa Department of Natural Resources, for collecting information on all nonfuel minerals.

By Leon E. Esparza[1] and Robert M. McKay[2]

Iowa's nonfuel mineral production in 1988 was valued at about $290.3 million, a decrease of nearly 5% from that of 1987. Commodities contributing the greatest amount to the State's nonfuel mineral value were, in descending order, crushed stone, portland cement, and construction sand and gravel. Nationally, Iowa ranked 32d in the value of nonfuel mineral production. Most of the State's nonfuel mineral production was used in the construction industry.

The value of nonresidential construction permits in 1988 increased more than 13% to $472.1 million; the number of authorized private and public residential units increased over 17% to 6,785 units.[3] The value of State road contract awards was slightly over $1 billion, an increase of about 6% over the 1987 value.[4]

LEGISLATION AND GOVERNMENT PROGRAMS

Two bills related to the State's mining industry were signed into law in 1988. The first provided for the regulation of commercial coal mining from sites of one-half acre or less by the Department of Agriculture and Land Stewardship. Sites of this size were exempted previously from such regulation. The second new law provided for a county board of supervisors to sell county interest in gravel properties owned for more than 10 years. The board, after public notice and hearings, had to show that the property was not needed or not suitable for highway improvement purposes.

The Iowa State University Mining and Mineral Resources Research Institute (MMRRI) at Ames received a $138,000 allotment grant from the U.S. Bureau of Mines for fiscal year 1988 under Public Law 98-409. Research supported under this grant included mining and mining-related studies and education and training of scientists and engineers in these fields. Examples of programs initiated or continued included (1) a study of possible relationships between minor metal sulfide occurrences and deposits of the Upper Mississippi Valley zinc-lead mining district, (2) improvements in geostatistical approximation and prediction techniques related to mining and mineral resource problems, (3) development of a model for the ore-forming system in an Archean gold deposit through geochemical and field investigations, and (4) evaluation of micromechanisms of feldspar deformation for applicability to pillar and roof support studies in underground mines.

The MMRRI provided support to 11 students who entered the 1988 Land

TABLE 1

NONFUEL MINERAL PRODUCTION IN IOWA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	48	$3,199	W	W	W	W
Portland	do.	1,819	86,984	2,139	$104,457	2,029	$98,930
Clays	short tons	486,309	1,421	472,788	1,495	445,248	1,588
Gem stones		NA	20	NA	W	NA	W
Gypsum	thousand short tons	1,826	12,602	1,874	12,887	2,047	13,710
Peat	do.	14	381	24	W	14	433
Sand and gravel (construction)	do.	14,511	40,418	e19,000	e63,800	11,880	36,087
Stone:							
Crushed	do.	e23,400	e98,000	25,991	110,106	e29,200	e128,500
Dimension	short tons	W	W	W	W	W	e588
Combined value of other industrial minerals and values indicated by symbol W		XX	5,707	XX	12,332	XX	10,420
Total		**XX**	**248,732**	**XX**	**305,077**	**XX**	**290,256**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

scape Architecture Student Competition for Crushed Stone Operations cosponsored by the National Stone Association and the American Society of Landscape Architects. Participants proposed and designed a beautification and reclamation plan for an active or proposed commercial crushed stone or sand and gravel operation.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—In 1988, Iowa's cement industry posted slight declines in production and value after gains in the 2 previous years. Production and value figures for masonry cement dropped nearly 4% and 6%, respectively. Portland cement production and value both fell more than 5%. Markets for cement production were ready-mixed concrete companies (64%), concrete product manufacturers (20%), highway contractors (12%), and building material dealers and other uses (4%).

Gypsum.—Production and value of gypsum increased about 9% and 6%, respectively, compared with 1987 figures. Early in the year, the USG Corp. gypsum wallboard operations at Fort Dodge and Sperry were included in a potential leveraged buyout of the corporation by Desert Partners Limited Partnership of Midland, TX. USG successfully defended itself but, in the process, assumed a large debt load.

Lime.—Lime production and value increased 8% and 4%, respectively. The State's sole producer, Linwood Mining and Minerals Corp., limited its production mostly to quicklime, with lesser quantities of hydrated lime.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; this chapter thus contains actual data for 1986 and 1988 and estimates for 1987. Data for odd-numbered years are based on annual company estimates.

Iowa construction sand and gravel statistics are compiled by geographical districts. Table 3 presents end-use statistics for the six districts outlined in the centerfold map.

Construction sand and gravel value decreased about 43% in 1988, and accounted for about 12% of the State's total nonfuel mineral value. Commodity production decreased about 37%.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter thus contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

Crushed.—Limestone-dolomite, which accounted for 44% of Iowa's total nonfuel mineral value, was the only rock type used in crushed stone production. Its estimated 1988 production and value increased 12% and 17%, respectively, compared with those reported in 1987. These increases were, in part, attributed to new requirements by the Iowa Department of Transportation that a 4-inch to 6-inch crushed stone membrane be installed under all pavement to facilitate drainage. Sales of aglime also were expected to continue to grow because of its increased use as a soil conditioner.

At midyear, Vulcan Materials Co. acquired B. L. Anderson Inc. of Cedar Rapids. The Anderson family had operated 17 quarries in 7 counties in east-central Iowa in 1987.

Dimension.—Estimated production of dimension stone in 1988 increased about 25%. Limestone was cut for use in construction by Weber Stone Co. in

TABLE 2

IOWA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	3,485	$11,741	$3.37
Plaster and gunite sands	28	134	4.79
Concrete products (blocks, brick, pipe, decorative, etc.)	71	281	3.96
Asphaltic concrete aggregates and other bituminous mixtures	639	1,791	2.80
Road base and coverings[1]	2,042	4,811	2.00
Fill	1,572	3,259	2.07
Snow and ice control	104	325	3.13
Railroad ballast	W	W	1.00
Other[2]	156	813	5.21
Unspecified:[3]			
Actual	2,931	10,020	3.42
Estimated	852	2,912	3.42
Total or average	**11,880**	**36,087**	**3.04**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes road and other stabilization (cement and lime).
[2] Includes roofing granules and filtration.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.

Appanoose and Jones Counties and by William Becker & Sons Stone Co. in Dubuque County. Most of the production was used in building front veneers; lesser amounts were used for flagging and curbing.

Other Industrial Minerals.—Clay production decreased, and its value increased, 6%, compared with that of 1987. Most of the gem stone production was by amateur collectors and rockhounds who gathered small quantities of gem stones and mineral specimens from gravel pits or quarries. Gem stone value in 1988 was estimated to have been unchanged from that in 1987. Two companies produced peat from bogs in north-central and east-central Iowa during 1988. The Winnebago County peat operation of Fisons-Western (U.S.) Inc. was idle the entire year, resulting in a 42% decline in Iowa peat sales. Fisons-Western had purchased the operation from Eli Colby Co. on August 1, 1987. Perlite from out-of-State sources was expanded at two plants operated by National Gypsum Co. and USG Corp in Webster County.

Metals

Several mineral commodities produced in other States were processed or refined in Iowa. Aluminum Company of America (Alcoa), for example, had a large impact on the economy of east-central Iowa. In late October, Alcoa celebrated 40 years of business activity at its Davenport plant, which produced aluminum sheet and plate. In early December 1988, Alcoa and one of its competitors, Reynolds Metals Co.,

TABLE 3

IOWA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT[1]

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[2]	591	2,162	707	2,478	786	2,947
Asphaltic concrete aggregates and other bituminous mixtures	236	636	90	189	194	545
Road base and coverings[3]	826	1,807	517	1,136	369	926
Fill	348	589	178	422	652	1,506
Snow and ice control	23	50	32	125	16	48
Railroad ballast	W	W	—	—	—	—
Other miscellaneous[4]	24	94	81	414	9	70
Other unspecified[5]	1,098	3,023	316	1,132	972	3,509
Total[6]	**3,146**	**8,361**	**1,922**	**5,896**	**2,997**	**9,551**

Use	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[2]	567	1,575	164	561	769	2,432
Asphaltic concrete aggregates and other bituminous mixtures	30	129	W	W	W	W
Road base and coverings[3]	15	59	151	417	163	466
Fill	47	92	36	67	312	583
Snow and ice control	23	75	W	W	W	W
Railroad ballast	—	—	—	—	—	—
Other miscellaneous[4]	18	176	50	200	72	181
Other unspecified[5]	581	2,061	443	1,889	347	1,209
Total[6]	**1,282**	**4,165**	**845**	**3,134**	**1,663**	**4,872**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Excludes 25,080 short tons valued at $107,342 not reported by county.
[2] Includes sand and gravel for plaster and gunite sands.
[3] Includes sand and gravel for road and other stabilization (cement and lime).
[4] Includes sand and gravel for roofing granules and filtration.
[5] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[6] Data may not add to totals shown because of independent rounding.

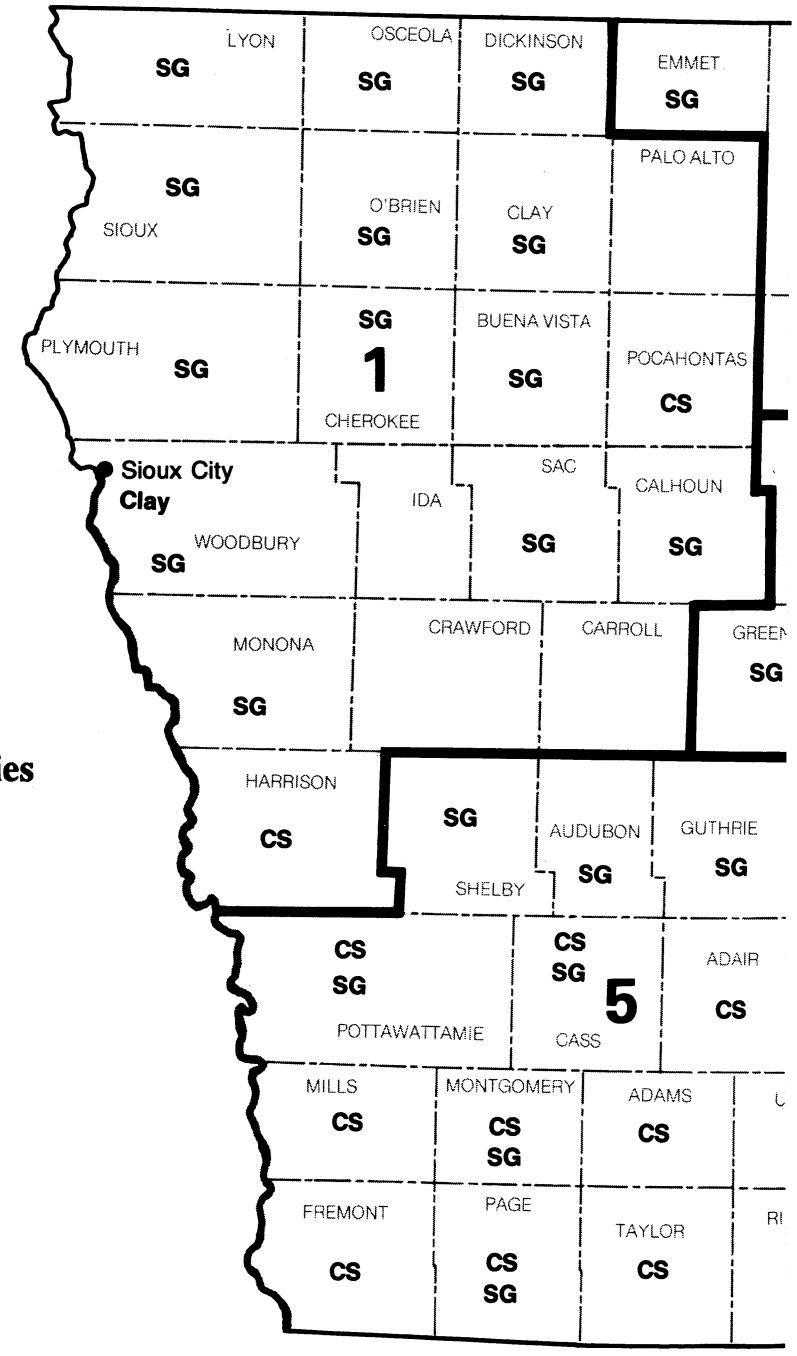
LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-L	Dimension Limestone
Gyp	Gypsum
Lime	Lime plant
Peat	Peat
SG	Sand and Gravel

Principal Mineral-Producing Localities



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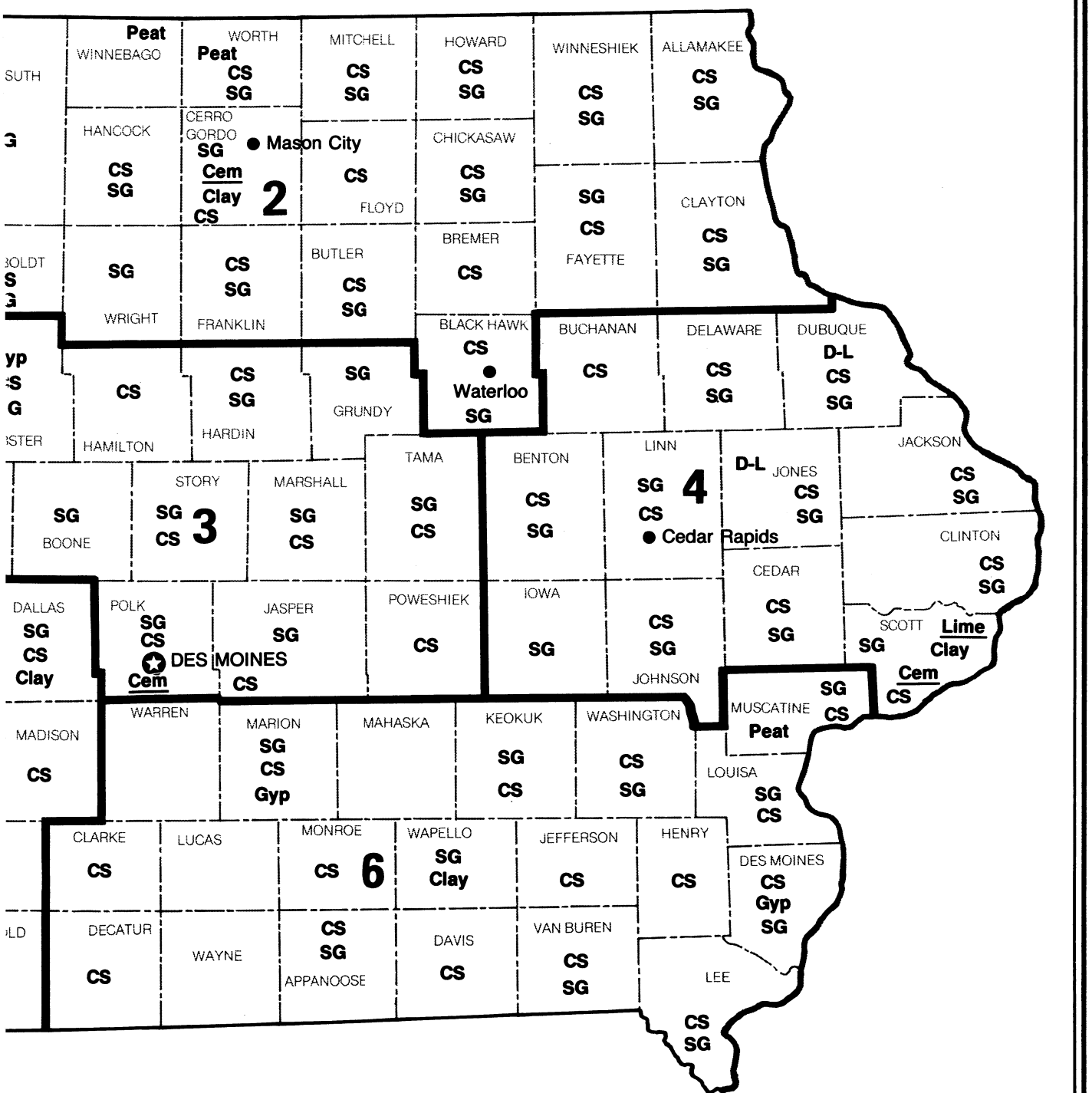
Peat
WINNEBAGO
WORTH
Peat
CS
SG
MITCHELL
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HOWARD
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WINNESHIEK
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HANCOCK
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CERRO GORDO
SG
Cem
Clay
CS
2
Mason City
FLOYD
CS
CHICKASAW
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LINN
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Cedar Rapids
D-L
JONES
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JACKSON
CS
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BOONE
STORY
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CS
3
MARSHALL
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CLINTON
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CEDAR
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DALLAS
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Clay
POLK
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DES MOINES
Cem
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JASPER
SG
POWESHIEK
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IOWA
SG
CS
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JOHNSON
SCOTT
SG
Lime
Clay
Cem
CS
MUSCATINE
Peat
SG
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MADISON
CS
WARREN
MARION
SG
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Gyp
MAHASKA
KEOKUK
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JEFFERSON
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HENRY
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reached a new nationwide contract agreement with the United Steelworkers Union and the Aluminum, Brick, and Glass Workers Union. The plan, which awaited approval by the rank and file union members at yearend, called for profit sharing, a cash signing bonus, a 50-cents-per-hour wage increase, continued cost-of-living adjustments, and increased pension fund payments. The timeliness of the new contract agreement was unprecedented, because the present contract was due to expire May 31, 1989; in the past, labor talks have begun a few weeks before a contract expired.

Production of silvery pig iron and 50% ferrosilicon continued by Keokuk Ferro-Sil Inc. at Keokuk after a management buyout from Foote Mineral Co. was completed on December 31, 1987. The plant is the Nation's only producer of silvery pig iron; its products are used to manufacture specialty steel alloys.

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[1] State Mineral Officer, Bureau of Mines, Minneapolis, MN.

[2] Geologist, Iowa Department of Natural Resources, Geological Survey Bureau, Iowa City, IA.

[3] U.S. Department of Commerce written communication.

[4] Highway and Heavy Construction. V. 130, No. 6, 1987, p. 36; and v. 131, No. 6, 1988, p. 34.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Davenport Cement Co., a subsidiary of Cementia Holdings AG.	Box 4288 Davenport, IA 52801	Quarry, clay pit, plant	Scott.
Lehigh Portland Cement Co., a subsidiary of Heidelberger Zement AG.	Box 1882 Allentown, PA 18105	do.	Cerro Gordo.
Monarch Cement Co.	Humboldt, KS 66748	Plant	Polk.
Northwestern States Portland Cement Co.	Box 1008 MasonCity, IA 50401	Quarry and plant	Cerro Gordo.
Clays:			
Midland Brick Co.	Box A Redfield, IA 50233	Pits and plants	Dallas and Wapello.
Sioux City Brick & Tile Co.	Box 87 Sioux City, IA 51102	do.	Dallas and Woodbury.
Gypsum:			
Celotex Div., a subsidiary of Jim Walter Corp.	1500 North Dale Mabry Tampa, FL 33607	Open pit mine and plant	Webster.
Georgia-Pacific Corp.	133 Peachtree St., NE. Atlanta, GA 30303	do.	Do.
Kaser Corp.	Box 3569 Des Moines, IA 50322	Underground mine and plant	Marion.
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	Open pit mine and plant	Webster.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	Underground mine and plant Open pit mine and plant	Des Moines. Webster.
Lime:			
Linwood Mining & Minerals Corp.	Route 2 Davenport, IA 52804	Plant	Scott.
Peat:			
Colby Pioneer Peat Co.	Box 8 Hanlontown, IA 50444	do.	Worth.
Pikes Peat Co.	Route 6, Box 21 Muscatine, IA 52761	do.	Muscatine.
Perlite (expanded):			
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	do.	Webster.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do.	Do.
Sand and gravel (construction):			
Acme Fuel & Material Co.	Route 5, Box 34 Muscatine, IA 52761	Pit and plant	Muscatine.
G. A. Finley Inc.	Box 406 Harlan, IA 51537	Pits and plants	Cass, Dallas, Montgomery, Page, Pottawattamie, Shelby.
Hallett Construction Co.	Box 13 Boone, IA 50036	do.	Audubon, Boone, Buena Vista, Cherokee, Dallas, Greene, Marshall, Osceola, Polk, Sac, Story.

See footnote at end of table.

TABLE 4—Continued.

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Martin Marietta Aggregates, Central Div.	Box 30013 Raleigh, NC 27622	do.	Various (20 counties).
Stevens Sand & Gravel Co. Inc.	Route 4, Box 35 Iowa City, IA 52240	do.	Johnson and Washington.
Stone (limestone, 1987):			
Crushed:			
B. L. Anderson Inc.	123 Third Ave., SW. Cedar Rapids, IA 52406	Quarries and plants	Benton, Clinton, Jackson, Johnson, Jones, Linn, Tama.
Kaser Corp.	7200 Hickman Rd. Des Moines, IA 50322	Underground mines, quarries, plants.	Des Moines, Jasper, Keokuk, Marion, Monroe, Polk, Poweshiek, Washington.
Martin Marietta Aggregates, Central Div.	Box 30013 Raleigh, NC 27622	do.	Clarke, Decatur, Linn, Madison, Marshall, Polk, Story.
P. Niemann Construction Co.	106 North Maple St. Sumner, IA 50674	Quarries and plants	Black Hawk, Bremer, Buchanan, Butler, Chickasaw, Fayette, Winneshiek.
River Products Co.	220 Savings and Loan Bldg. Iowa City, IA 52240	Underground mine, quarries, plants.	Johnson, Louisa, Washington.
Schildberg Construction Co. Inc.	Box 358 Greenfield, IA 50849	Quarries and plants	Adair, Adams, Cass, Madison, Pottawattamie, Union.
Dimension:			
Wm. Becker & Sons Stone Co.	1735 Kaufmann Ave. Dubuque, IA 52001	Quarry and plant	Dubuque.
Weber Stone Co.[1]	Route 1 Anamosa, IA 52205	Quarries and plant	Appanoose and Jones.

[1] Also crushed limestone.

THE MINERAL INDUSTRY OF KANSAS

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Kansas Geological Survey for collecting information on all nonfuel minerals.

By Jane P. Ohl[1] and David A. Grisafe[2]

Nonfuel mineral production value in Kansas was $292 million in 1988, down nearly 9% from that of 1987. The State ranked 30th in the Nation and accounted for 1% of the U.S. total nonfuel mineral value. Cement, crushed stone, and salt accounted for the greatest portion of the State's nonfuel mineral value.

The lowered total value of nonfuel minerals produced in Kansas in 1988 was attributable to decreased output of masonry and portland cements, crude helium, pumice, salt, industrial and construction sand and gravel, and dimension stone. Although a decrease in output was also estimated for crushed stone, its value was estimated to have increased. Both the output and value of clays, crude gypsum, and Grade-A helium increased.

TRENDS AND DEVELOPMENTS

For fiscal year 1989 (beginning July 1, 1988), the Kansas Department of Transportation reported in 1988 a total of 352 construction contracts let for $204 million, compared with 332 contracts for $164 million in fiscal year 1987. In 1988, the Kansas aggregate industry had a fairly stable year. Growth in the Wichita and Kansas City areas was expected to continue, but the employment base in Hutchinson was eroded by the sale of two salt companies to an investment group and the resulting transfer of administrative jobs.

EMPLOYMENT

Total nonfuel mining employment in Kansas was about 1,400 persons; this number was virtually unchanged from that of 1987 employment.

REGULATORY ISSUES

In July, subsidence over a leaking saltwater disposal well at Macksville, Stafford County, resulted in a sinkhole 200 feet across and 110 feet deep. Approximately the same diameter and depth of subsidence sometimes occurs over salt and gypsum mines. Coal mine subsidence also has occurred in Kansas, but such collapses were usually only a

TABLE 1

NONFUEL MINERAL PRODUCTION IN KANSAS[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	51	$3,264	52	$3,150	50	$2,988
Portland	do.	1,763	91,110	1,697	81,045	1,569	72,805
Clays	short tons	903,448	5,295	[2]603,680	[2]2,576	[2]612,597	[2]2,632
Gem stones		NA	3	NA	3	NA	3
Salt[3]	thousand short tons	1,656	68,887	1,689	70,148	1,284	55,753
Sand and gravel:							
Construction	do.	15,609	33,721	[e]15,600	[e]37,800	10,760	25,329
Industrial	do.	132	1,155	127	1,400	W	W
Stone:							
Crushed	do.	[e]16,600	[e]60,300	19,319	69,628	[e]17,300	[e]72,700
Dimension	short tons	W	W	11,423	445	[e]6,889	[e]219
Combined value of clays (bentonite, 1987-88), gypsum, helium (crude and Grade-A), pumice, salt (brine), and values indicated by symbol W		XX	53,910	XX	53,409	XX	59,284
Total		**XX**	**317,645**	**XX**	**319,604**	**XX**	**291,713**

[e] Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

[3] Excludes salts in brines; value included with "Combined value" data.

few feet deep because the mines were not deep when active. Geophysical detection of impending subsidence has been possible; however, prevention and stabilization have remained unsolved problems.

Exide Corp. proposed building a secondary lead smelter near Hays in Ellis County, but public outcry was so great about the perceived environmental impact of the smelter that the company did not apply to the Kansas Department of Health and Environment for a permit. Exide maintained a presence in the area, however; it operated a lead acid battery plant near Hays.

In the continuing Rice County salt pollution case, the U.S. Court of Appeals upheld a $13.06 million award granted to Lyons farmers in 1987 as compensation for salt damage to their soil. By yearend 1988, the award amounted to $18 million, including interest to be paid by General Host Corp., the parent of American Salt Co. at the time of the court's award.

LEGISLATION AND GOVERNMENT PROGRAMS

House bill 3009 abolished the Kansas Mined Land Conservation Board and transferred its duties to the Department of Health and Environment, which became responsible for zoning permits, reclamation bonds, and waste disposal.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Asphalt.—J. H. Shears & Sons Inc. of Hutchinson, Reno County, acquired the assets of Blacktop Construction Co. of Emporia, Lyon County. Shears operated asphalt plants in Hutchinson, Abilene, and Salina, and portable asphalt, crushed rock and sand plants at several locations.

Cement.—According to the LaFarge Corp. 1988 annual report, the company's cement plant at Fredonia, Wilson County, was being developed as a prototype coprocessing facility to be called the Fredonia Co-Processing Facility. This operation was to involve an integrated approach to waste recovery and cement production. For several years, the plant had used purchased waste fuels, notably organic solvents with high heat values; the plan was to use a larger variety of other waste products for the production of cement. Previously, supplemental fuels had been transported in bulk by rail or truck, but equipment added at Fredonia during 1988 allowed the handling of individual containers, drums, and bulk solids. Because cement kilns operate at high temperatures, all organic compounds are completely destroyed in the production process. The use of such waste fuels doubled between 1986 and 1988.

The five Kansas cement plants operating in 1988 used eight wet-process and seven dry-process kilns to produce more than 1.5 million short tons of portland cement and about 50,000 tons of masonry cement. Portland cement price per ton was down $1.36 from 1987 to $46.60. The average price of masonry cement declined about 83 cents to $59.74 per short ton.

Raw materials consumed in cement manufacture were 2.1 million tons of limestone, 420,000 tons of cement rock, 235,000 tons of shale, 220,000 tons of sandstone, and smaller amounts of clay, gypsum, iron ore, mill scale, pyrite, sand, and various resins and chemicals. Fuels used in the production of cement were predominantly natural gas, some soft and hard coals, and a very small amount of fuel oil.

Finished portland cement was sold to the following businesses, in decreasing order of quantity: ready-mixed concrete companies, highway contractors, concrete product manufacturers, building materials dealers, and miscellaneous customers. Cement sales to highway contractors were not significantly higher than in 1987, which was a very good year.

Bulk shipments of portland cement from plants to terminals were transported by truck (64%) and by rail.

Clays.—Kansas clay pits were the source of bentonite and common clay and shale. Reversing its former locally focused marketing coverage, Kansas Brick & Tile Co. Inc. of Barton County sold 90% of its product to buyers outside the State in 1988; total sales remained about the same. A new plant the company built in 1985 proved to be unexpectedly economical, and fuel consumption per brick was reduced by two-thirds.

Pittsburg Pottery Co., a subsidiary of Seville Industries, in Crawford County, reopened its Pittsburg facility after a lengthy closure during which improvements were made to the plant. A newly designed line of pottery was brought into production.

Gypsum.—The Sun City, Barber County, quarry and room and pillar mine of Gold Bond Building Products qualified as the Nation's sixth largest gypsum mine. The gypsum deposit extended westward from the existing work area; consequently, quarrying was moving farther away from the stationary crusher. Reserves in 1988 were equal to at least 3 more years of production, and Gold Bond planned to buy larger trucks and loaders to increase efficiency and reduce costs. The firm's facility at Medicine Lodge was one of the State's two calcining and gypsum board plants. Rock was transported 25 miles to the plant in 80-ton rail cars. LaFarge Corp. of France owned about 50% of National Gypsum Co., the parent of Gold Bond.

Helium.—Crude helium was produced at plants in Ellsworth and Grant Counties; both output and total value fell about 20% from those of 1987. Grade-A helium was produced at four plants in Ellsworth, Grant, Morton, and Rush Counties. The combined output and value of Grade-A helium from

these plants rose about 8%. Helium is used primarily for welding (25% of all uses), cryogenics, pressurization and purging, and controlled atmospheres.

Perlite (Expanded).—Lite-Weight Products Inc. expanded perlite at its Kansas City plant, producing cavity fill and horticultural aggregate. Cavity fill was valued at $460 per short ton and horticultural aggregate at $275. The total value of the company's sales rose about 30% over 1987 figures.

Pumice (Volcanic Ash).—A new plant at Mankato, Jewell County, was to process volcanic ash mined from the Burr Oak area. Kansas Minerals Inc. began constructing the plant in May. The firm planned to run two furnaces 24 hours a day when the plant becomes operational in 1989. The ore was to be dried into powder form to be used as a lightweight aggregate in concrete and asphalt or was to be heated to form glass beads and used (1) as filter aids, (2) in paint to enhance spreadability, or (3) as spackling compound. At another location, the Calvert Mine in Norton County processed volcanic ash for use as abrasive material.

Salt.—Reported salt sales from Kansas mines decreased about one-fifth from those of 1987. American Salt Co., a subsidiary of General Host Corp. of Stamford, CT, was sold on February 23, 1988, for $22 million plus a $9 million subordinated note to the investor group of D. George Harris and Associates. The investor group included some American Salt executives. American Salt had rock salt and evaporation facilities at Lyons in Rice County and other salt facilities at Grantsville, UT.

D. George Harris and Associates and another group of investors bought Carey Salt Co., a division of Processed Minerals Inc., a Delaware corporation owned by Canadian Pacific (U.S.). Carey Salt operated an evaporation plant for processing brine and a rock salt mine at Hutchinson, Reno County. The administrative functions of Carey Salt at Hutchinson were transferred to American Salt offices in Mission, Johnson County. Because of the consolidation, Carey Salt no longer provided administrative jobs. Through this transfer, Hutchinson lost jobs worth more than $1 million in annual payroll. Both General Host and Processed Minerals had originally purchased these salt companies to diversify their investments.

In the salt pollution lawsuit, which had been going on for more than a decade, General Host lost an appeal late in 1988 and was forced to pay the $13.06 million in actual and punitive damages awarded to Rice County farmers in 1984. These farmers fields had been spoiled by salt brines polluting the aquifer and surface. The salt produced in these counties was used for water conditioning, highway deicing, agricultural feed, and food preparation.

Vulcan Chemicals, a division of Vulcan Materials Co., extracted brine from 400-foot deep wells in Sedgwick County, 12 miles southwest of Wichita. The brine was transported by pipeline and fed into electrolytic cells to produce caustic soda, hydrogen, and chlorine. Vulcan also planned to construct an incinerator to process any waste products from its operations. Unlike American Salt and Carey Salt, none of the brine produced by Vulcan was used in the food industry.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter thus contains actual data for 1986 and 1988 and estimates for 1987.

For some States, construction sand and gravel statistics are compiled by districts. Table 2 presents end-use data for this commodity in Kansas as depicted in the centerfold map.

The reported quantity and value of construction sand and gravel fell more than 30% from figures estimated for 1987.

The U.S. Army Corps of Engineers studied dredging operations along the Kansas River, particularly the eastern reaches of the river between Topeka and Kansas City. The purpose of the study was to resolve the problem—resulting from reservoir and flood controls—of the significant, detrimental reduction of natural sand and gravel deposition. Because sand and gravel was no longer being deposited in the amounts needed in the lower reaches of the river, dredging operations were lowering the river bed and causing damage to manufactured structures. The Corps was expected to recommend restrictions on the amount of sand and gravel that could be dredged from the river annually. The question remained as to how the restriction quotas would be determined for individual companies. Any new restrictions would preclude new operations opening on the Kansas River. A restriction quota of no more than 1 million tons per year would force producers to extract higher priced sand from the floodplain to meet construction-related demands in the metropolitan Kansas City area. Alternative dredge sites along the Missouri River lacked the necessary coarser sand sizes and contained impurities such as lignite that must be removed at additional expense. Consumers who were paying some of the lowest prices in the Nation for dredged sand would have to begin paying several dollars more per ton.

Industrial.—Two firms operated industrial sand pits in Republic and Wyandotte Counties. Output continued to fall and was down by one-quarter from that of 1987, but the average price per short ton rose 76 cents to $11.79. Industrial sand was used to produce fiberglass, molding, and cores; in sand blasting; and for filtration and engine traction.

Construction of a glass plant at Spring Hill, Johnson County, neared completion. The plant, owned by AFG Industries Inc., was to be the first plate or float glass operation in the State and

was expected to employ 300 to 400 persons when in full production sometime in 1990.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter thus contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—Output of crushed stone in 1988 was estimated to have fallen more than 10% from that of the preceding year; however, the total value rose about 4%. These figures do not include dolomite production. Quartzite Stone Co. produced a high-compressive strength quartzite from its 2,600-acre quarry in Lincoln County. The quarry also contained very large embedded sandstone boulders, the most attractive of which were sold to landscape companies.

Dimension.—Bayer Stone Inc. recently added a laser beam to its circular sawblade sandstone-cutting operation to attain accuracy and slowed the saw speed from 15,000 to 10,000 revolutions per minute to improve blade life.

Other Industrial Minerals.—Thermo Dynamics Corp. of Merriam, Johnson County, was one of the Nation's two largest producers of cultured quartz crystal. Lascas, the raw feed material used to produce cultured quartz crystals, was quarried in Jessieville, AR. Cultured quartz crystals are used to make very accurate electronic timing devices, such as those found in watches and clocks, microprocessors, and electronic devices.

Petroleum-refining operations in Butler and Montgomery Counties continued to recover sulfur. Output rose about 12% over that of 1987, but the average unit price decreased $4.93 per metric ton to $71.21. PQ Corp. and Shell Polymers and Catalysts Enterprises Inc. entered a joint venture to manufacture and sell zeolite catalysts. The zeolites were to be synthesized at the PQ facility in Kansas City. The use of synthetic zeolites in detergents has doubled since 1986 in response to widening bans on phosphate use in detergents.

TABLE 2

KANSAS: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	2,536	$5,730	$2.26
Plaster and gunite sands	48	126	2.63
Concrete products (blocks, brick, pipe, decorative, etc.)	46	95	2.07
Asphaltic concrete aggregates and other bituminous mixtures	965	2,664	2.76
Road base and coverings[1]	2,135	4,952	2.31
Fill	1,175	2,409	2.05
Snow and ice control	65	251	3.86
Other[2]	120	460	3.83
Unspecified:[3]			
Actual	3,259	7,585	2.32
Estimated	410	1,057	2.57
Total or average	**[4]10,760**	**$25,329**	**2.35**

[1] Includes road and other stabilization (cement and lime).
[2] Includes roofing granules.
[3] Includes production reported without a breakdown by end use, and estimates for nonrespondents.
[4] Data do not add to total shown because of independent rounding.

[1] State Mineral Officer, Bureau of Mines, Denver, CO.
[2] Associate scientist, Mineral Information, Kansas Geological Survey, Lawrence, KS.

TABLE 3

KANSAS: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	456	1,150	253	768	5	14
Plaster and gunite sands	5	13	14	45	—	—
Concrete products (blocks, brick, etc.)	—	—	W	W	—	—
Asphaltic concrete aggregates and other bituminous mixtures	141	380	167	668	84	207
Road base and coverings[1]	159	407	172	644	341	750
Fill	183	317	163	606	—	—
Snow and ice control	8	18	23	108	(2)	(2)
Other miscellaneous[3]	59	258	—	—	3	3
Other unspecified[4]	1,951	4,751	114	215	223	395
Total[5]	**2,960**	**7,295**	**907**	**3,053**	**655**	**1,369**

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	265	657	1,556	3,142	—	—
Plaster and gunite sands	7	21	22	47	—	—
Concrete products (blocks, bricks, etc.)	—	—	W	W	—	—
Asphaltic concrete aggregates and other bituminous mixtures	88	290	485	1,119	—	—
Road base and coverings[1]	843	1,780	621	1,371	—	—
Fill	43	87	786	1,399	—	—
Snow and ice control	20	95	14	29	—	—
Other miscellaneous[3]	29	122	30	78	—	—
Other unspecified[4]	198	525	1,032	2,536	197	316
Total[5]	**1,493**	**3,576**	**4,547**	**9,721**	**197**	**316**

W Withheld to avoid disclosing company proprietary data, included with "Other unspecified."
[1] Includes sand and gravel for road and other stabilization (cement and lime).
[2] Less than 1/2 unit.
[3] Includes sand and gravel for roofing and granules.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

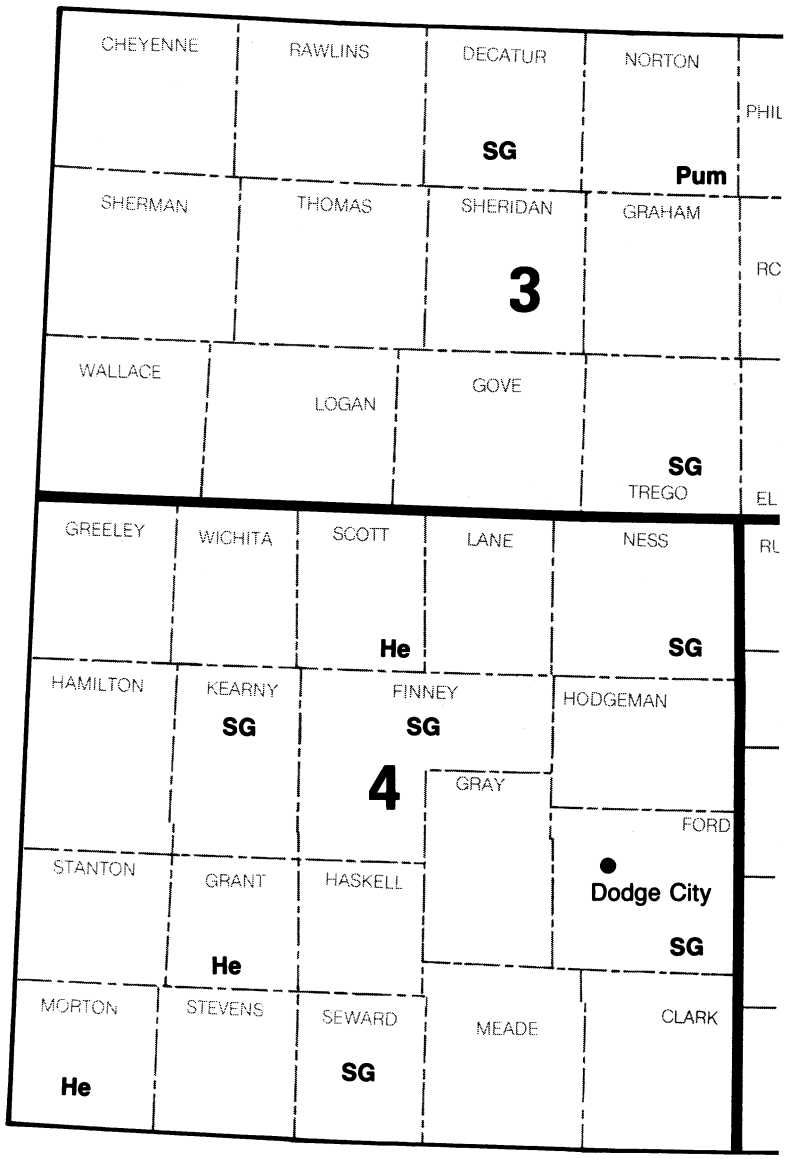
KA

LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

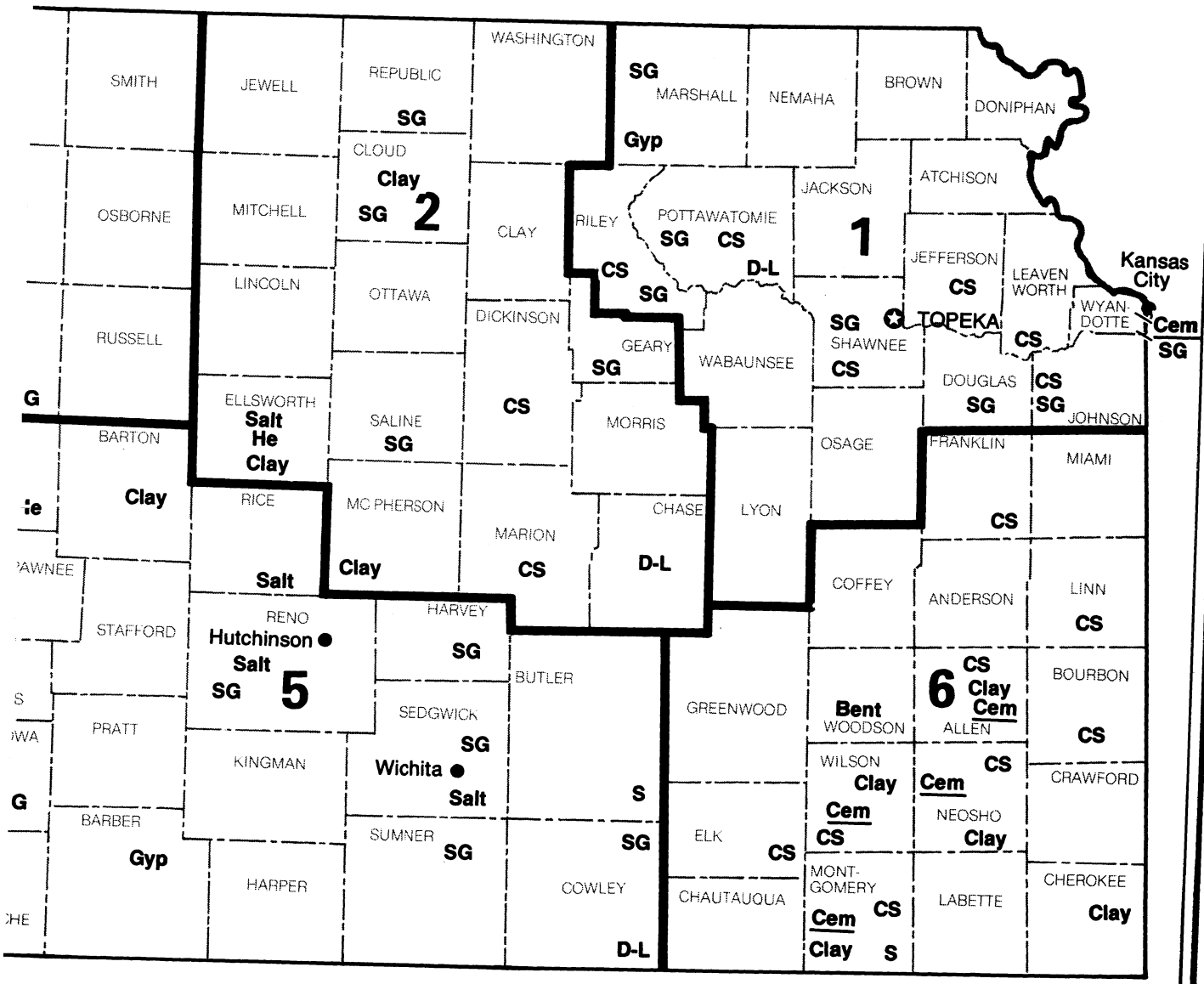
MINERAL SYMBOLS

Bent	Bentonite
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-L	Dimension Limestone
Gyp	Gypsum
He	Helium
Pum	Pumice
S	Sulfur
Salt	Salt
SG	Sand and Gravel



Principal Mineral-Producing Localities

AS


SMITH
JEWELL
REPUBLIC
SG
WASHINGTON
SG
MARSHALL
Gyp
NEMAHA
BROWN
DONIPHAN
CLOUD
Clay
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2
OSBORNE
MITCHELL
CLAY
RILEY
POTTAWATOMIE
SG
CS
D-L
JACKSON
1
ATCHISON
CS
SG
JEFFERSON
CS
LEAVEN WORTH
WYAN-DOTTE
Kansas City
Cem
SG
LINCOLN
OTTAWA
DICKINSON
RUSSELL
GEARY
SG
WABAUNSEE
SG
TOPEKA
SHAWNEE
CS
CS
DOUGLAS
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CS
SG
JOHNSON
ELLSWORTH
Salt
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Clay
SALINE
SG
CS
MORRIS
OSAGE
FRANKLIN
CS
MIAMI
BARTON
Clay
RICE
Salt
MC PHERSON
Clay
MARION
CS
CHASE
D-L
LYON
COFFEY
ANDERSON
LINN
CS
STAFFORD
RENO
Hutchinson
Salt
SG
5
HARVEY
SG
BUTLER
GREENWOOD
Bent
WOODSON
6
CS
Clay
Cem
ALLEN
BOURBON
CS
PRATT
SEDGWICK
SG
Wichita
Salt
S
WILSON
Clay
Cem
CS
Cem
CS
NEOSHO
Clay
CRAWFORD
KINGMAN
BARBER
Gyp
SUMNER
SG
ELK
CS
HARPER
COWLEY
SG
D-L
CHAUTAUQUA
MONT-GOMERY
Cem
Clay
CS
S
LABETTE
CHEROKEE
Clay

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Ash Grove Cement Co.[1] [2]	Box 25900 Overland Park, KS 66225	Plant and quarry	Neosho.
Heartland Cement Co., a subsidiary of Rugby Portland Cement and Unicem[3]	Box 42 Independence, KS 67301	do.	Montgomery.
LaFarge Corp.[4]	7701 East Kellogg St. Suite 240 Wichita, KS 67207	do.	Wilson.
Lone Star Industries Inc.[5]	Box 12449 Dallas, TX 75225	do.	Wyandotte.
The Monarch Cement Co.[6]	Box 187 Humboldt, KS 77648	do.	Allen.
Clays:			
Buildex Inc., a division of Clemons Coal Co.	Box 15 Ottawa, KS 66067	Pit and plant	McPherson.
Cloud Ceramics, a division of General Finance Inc.	Box 369 Concordia, KS 66901	Pit and plants	Cloud.
Justin Industries Inc., Acme Brick Co.	Box 98 Kanopolis, KS 67454	Pits and plants	Cherokee and Ellsworth.
Kansas Brick & Tile Co. Inc.	Box 450 Hoisington, KS 67544	Pit and plant	Barton.
Micro-Lite Inc.	Route 4, Box 50B Chanute, KS 66720	do.	Woodson.
Gypsum:			
Georgia-Pacific Corp.	133 Peachtree St., NE. Atlanta, GA 30303	Underground mine and plant	Marshall.
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	Open pit, underground mine, plant	Barber.
Helium:			
Kansas Refined Helium Co.	Otis, KS 67565	Plant	Rush.
Union Carbide Corp., Linde Div.	Box 444 Somerset, NJ 08873	Plants	Ellsworth, Grant, Morton, Rush.
Perlite (expanded):			
Lite-Weight Products Inc.	1706 Kansas Ave. Kansas City, KS 66105	Plant	Wyandotte.
Pumice and pumicite:			
Calvert Corp.	Box 97 Norton, KS 67654	Pit and plant	Norton.
Salt:			
American Salt Co.	3142 Broadway Kansas City, KS 64111	Wells and underground mine	Rice.
Associated Material & Supply Co. Inc.	Box 4064 Wichita, KS 67204	Pit and plant	Sedgwick and Sumner.
Builders Sand Co.	4150 Kansas Ave. Kansas City, KS 66106	Dredges and plants	Johnson, Shawnee, Wyandotte.
Cargill Inc., Salt Div.	Box 1403 Hutchinson, KS 67501	Wells	Do.

See footnotes at end of table.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Holliday Sand & Gravel Co., a division of List & Clark Construction Co.[7]	6811 West 63d St. Overland Park, KS 66202	Pits and plants	Johnson and Wyandotte.
Independent Salt Co.	Box 36 Kanopolis, KS 67454	Underground mine	Ellsworth.
Morton Salt Co., a division of Morton Thiokol Inc.	110 North Wacker Dr. Chicago, IL 60606	Wells	Reno.
Ritchie Sand Co., a division of Ritchie Corp.	6500 West 21st St. Wichita, KS 67204	Dredge and plant	Sedgwick.
Vulcan Materials Co., Chemical Div.	Box 7689 Birmingham, AL 35223	Wells	Sedgwick.
Stone (Crushed):			
N. R. Hamm Quarry Inc.	Box 17 Perry, KS 66073	Quarries and plants	Various (9 counties).
Inland Quarries, a subsidiary of Americold Inc.	Box 2249 Kansas City, KS 66110	Underground mine and plant.	Wyandotte.
McAdam Construction Co. Inc.	Main Street Moran, KS 66755	Quarries and plants	Allen, Anderson, Bourbon, Linn.
Martin Marietta Aggregates, Central Div.	Box 30013 Raleigh, NC 27622	do.	Various (7 counties).
Midwest Minerals Inc.	Box 412 Pittsburg, KS 66762	do.	Cherokee, Crawford, Labette, Montgomery, Neosho, Wilson.
Stone (Dimension):			
Bayer Stone Inc.	6th and Mission St. Marys, KS 66538	Quarries	Pottawatomie and Riley.
H. J. Born Stone Co. Inc.	Route 3, Box 312 Silverdale, KS 67005	do.	Chase and Cowley.
Sulfur (Recovered):			
Farmland Industries Inc.	North Linden St. Coffeyville, KS 67337	Secondary recovery plant	Montgomery.
Texaco Refining & Marketing	Box 1650 Tulsa, OK 74102	do.	Butler.

[1] Also clays in Neosho County.
[2] Also crushed stone in Johnson, Linn, and Neosho Counties.
[3] Also clays and crushed stone in Montgomery County.
[4] Also clays and crushed stone in Wilson County.
[5] Also crushed stone in Wyandotte County.
[6] Also clays and crushed stone in Allen County.
[7] Also industrial sand in Wyandotte County.

THE MINERAL INDUSTRY OF KENTUCKY

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Kentucky Geological Survey for collecting information on all nonfuel minerals.

By L. J. Prosser, Jr.,[1] and Garland R. Dever, Jr.[2]

The value of nonfuel mineral production in Kentucky surpassed $300 million for the first time in State history. Mineral value of about $345 million in 1988 was nearly 20% higher than the 1987 total. Increased demand from the construction industry for crushed stone boosted production of that commodity to a record high of almost 51 million short tons. Kentucky ranked ninth nationally in output of crushed stone in 1988.

LEGISLATION AND GOVERNMENT PROGRAMS

The 1988 Kentucky General Assembly enacted a number of bills affecting the minerals industry, particularly the coal industry. House bill 23 clarified existing statutory requirements governing public notice for zoning changes and required that written notices be sent to every landowner affected by a zoning change. House bill 655 placed a 2-cent-per-gallon fuel tax on vehicles weighing 60,000 or more gross pounds. It also imposed a weight-distance tax of 4 cents per mile until July 1990, when the rate will drop to 2.85 cents. The General Assembly also reduced the annual budget for the State energy research program over the next 2 years from $4.9 million to $3.0 million. Responsibility for operating the program was reassigned from the Kentucky Energy Cabinet to the University of Kentucky at Lexington.

The Kentucky Supreme Court ruled in March that the State must tax unmined coal property at the same rate as other real estate. That decision thereby increased the tax on unmined coal from one-tenth of one cent per $100 of assessed value to 21.4 cents per $100 of assessed value. In November, voters approved a constitutional amendment on broad-form deeds that essentially barred surface mining by the mineral owner unless permission was secured from the surface owner. Both of those actions were expected to increase the cost of mining coal in Kentucky, which was the Nation's second largest producer in 1988.

The Kentucky Geological Survey, by means of a $255,000 grant from the U.S. Geological Survey, began to assess Kentucky's minable coal resources. Previous estimates of the State's coal resources at 96 billion tons had not considered land-use restraints that restrict or prohibit mining. Furthermore, neither coal quality nor the relative thinness of 14-inch to 28-inch coalbeds included in the resource estimates had been assessed to determine if that coal could be mined economically in the future.

The Kentucky Geological Survey, together with the State Surveys of Illinois, Missouri, and Indiana, participated in the U.S. Geological Survey Conterminous United States Mineral Assessment Program to evaluate the mineral resource potential in the Paducah 2-Degree Quadrangle. The study area includes the Illinois-Kentucky Fluorspar District.

The University of Kentucky's Mineral Law Center completed a report entitled "Natural Resources and Development: An Annotated Bibliography," which focused on the legal literature in the field of natural resources. The report was funded through a matching grant agreement by the University of Kentucky's Institute for Mining and Minerals Research and the U.S. Bureau of Mines' Mineral Institute Program.

TABLE 1

NONFUEL MINERAL PRODUCTION IN KENTUCKY[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	short tons	721,111	$3,450	r883,267	r$3,393	840,317	$3,217
Gem stones		NA	3	NA	3	NA	3
Sand and gravel (construction)	thousand short tons	7,194	16,986	e7,100	e15,200	6,325	15,243
Stone (crushed)	do.	e[3]38,400	e[3]137,000	43,330	173,222	e50,700	e207,900
Zinc (recoverable content of ores, etc.)	metric tons	W	W	10	9	W	W
Combined value of cement, clays (ball clay, fire clay), lime, sand and gravel (industrial 1986–87), stone (crushed sandstone, 1987), zinc (1988), and values indicated by symbol W		XX	109,826	XX	r98,508	XX	118,616
Total		**XX**	**267,265**	**XX**	**290,335**	**XX**	**344,979**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

[3] Excludes certain stones; kind and value included with "Combined value" data.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Crushed stone accounted for about 60% of the State's total value of nonfuel mineral production, as shown in table 1. Lime, which is manufactured from limestone, was the second leading mineral commodity in terms of value.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Production exceeded 50 million short tons for the first time in Kentucky, a level indicative of the sustained period of growth in the State's construction industry. In addition, the use of limestone and lime in controlling sulfur dioxide emissions provided a new and expanding market for carbonate rocks. Both flue gas desulfurization and fluidized bed combustion systems were in use at coal- and gas-fired electric generating powerplants in the State.

A major acquisition in the crushed stone industry in 1988 was the purchase of Koppers Co. by Beazer PLC of the United Kingdom. Beazer acquired 80 stone quarries and 24 sand and gravel operations in a $1.8 billion transaction. The sale included Kopper's subsidiary, The Kentucky Stone Co., which operated 13 quarries and underground mines in Kentucky, the most of any producer in the State. Beazer named its new operations Beazer Materials & Services Inc. (BM&S).

Late in the year, BM&S received a 1-year contract from the Tennessee Valley Authority (TVA) to supply 125,000 tons of limestone from the firm's operation at Princeton. TVA paid $687,500 for the initial quantity of limestone and had the option to extend the agreement for 2 more years. The limestone was used by the TVA at its Shawnee operations west of Paducah, in a 160-megawatt, atmospheric fluidized-bed combustion demonstration plant.

Under a 10-year contract, Kosmos Cement Co., the State's only cement producer, began supplying the nearby Louisville Gas & Electric Co.'s Mill Creek Station with ground limestone through a slurry pipeline. Use of the limestone reduced sulfur dioxide emissions from the Mill Creek plant using a wet-scrubbing system.

One of Kentucky's largest capacity crushed stone operations, the 15th largest stone operation in the Nation, was sold in 1988. Dravo Basic Materials Co., a subsidiary of Dravo Corp., purchased the Three Rivers Rock Co. quarry near Smithland from Cyprus Minerals Co. The limestone quarry had reserves estimated at 200 million tons, and the plant had a 5-million-ton annual capacity.[3]

Other Industrial Minerals.—The mineral commodities discussed below collectively accounted for about 20% of the value of Kentucky's nonfuel mineral production, as shown in table 1.

Kentucky's only cement plant was involved in two transactions during the year. Moore McCormack Resources Inc. formed a partnership with Lone Star Industries Inc. that included the firm's Kosmos Cement Co. Plans were also announced to expand plant capacity to 1 million short tons by the end of 1989 at a cost of about $20 million.[4] Moore McCormack was then acquired by Southdown Inc., the Nation's fifth largest cement producer. Kosmos Cement produced portland and masonry cement at its plant in southwest Jefferson County.

Ball, common, and fire clays were mined in Kentucky. Most of the production was common clay used in brick manufacture and sold to the construction industry.

In December 1987, Kentucky-Illinois Fluorspar Corp. reopened a flotation plant near Salem in Crittenden County. Plans to reopen a fluorspar mine in

TABLE 2

KENTUCKY: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	417	$1,223	$2.93
Plaster and gunite sands	38	W	W
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	2.11
Asphaltic concrete aggregates and other bituminous mixtures	118	275	2.33
Road base and coverings	23	86	3.74
Fill	151	201	1.33
Snow and ice control	1	3	3.00
Other	140	770	5.50
Unspecified: [1]			
Actual	4,061	8,642	2.13
Estimated	1,376	4,042	2.94
Total or average	**6,325**	**[2] 15,243**	**2.41**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[2] Data do not add to total shown because of independent rounding.

TABLE 3

KENTUCKY: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	W	W	184	568	W	W	82	480
Asphaltic concrete aggregates and road base and coverings[2]	26	87	12	37	236	307	19	130
Snow and ice control	—	—	—	—	—	—	1	3
Other miscellaneous	78	206	—	—	224	554	28	185
Other unspecified[3]	622	2,313	575	1,828	4,228	8,505	12	39
Total	**726**	**2,606**	**771**	**2,433**	**4,688**	**9,366**	**[4]140**	**837**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for plaster and gunite sands.
[2] Includes sand and gravel for fill.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data do not add to total shown because of independent rounding.

1988 in the Crittenden-Livingston area were also announced by the company, but the opening did not take place. Kentucky-Illinois Fluorspar processed and shipped about 3,000 short tons of acid-grade fluorspar using previously mined material from the plant site.

Nationally, Kentucky ranked fifth in output of lime. Production and value data were proprietary because only one company produced lime in the State. Dravo Lime Co. operated underground limestone mines at Maysville and Carntown for use in lime manufacture. Most of the lime from the Maysville facility was used in flue gas desulfurization, a technology designed to remove sulfur dioxide at coal-fired utility powerplants.

Production of construction sand and gravel declined slightly in 1988 to about 6.3 million short tons. Since 1980, average annual output has been about 7 million tons. Sand and gravel production was reported from 16 of the State's 120 counties; Boone, Daviess, Jefferson, and Trimble were the top producing counties.

Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987. Kentucky construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data in the State's four districts.

Metals

Except for a small quantity of zinc recovered as a byproduct at an underground limestone quarry in Jessamine County, no other metals were mined in Kentucky in 1988. Aluminum, ferroalloys, and steel were the major metals manufacturing industries, and all reported increased output for the year.

Aluminum.—The Kentucky Public Service Commission approved a plan to prevent bankruptcy of Big Rivers Electric Corp. The State's two aluminum producers purchased about 70% of the electricity produced by Big Rivers Electric. Under the plan, Alcan Aluminum Corp. and National-Southwire Aluminum Co. will be required to pay a variable rate for electricity that is tied to the price of aluminum.

Also during 1988, Alcan announced plans to construct a $50 million, 120,000-metric-ton-per-year capacity aluminum-can recycling plant in Berea.[5] To meet the 120,000 metric-ton-per-year capacity, the plant will require about 6 billion used beverage containers annually. Construction was expected to be completed in late 1989, and employment at the facility was anticipated at about 100 workers.

Iron and Steel.—Armco Inc., the State's leading steel producer, signed an agreement in principle to sell 40% of its operations to Kawasaki Steel Corp. of Japan for about $350 million.[6] The agreement included Armco's plant in Ashland, as well as its plant in Middletown, OH, which make up the company's Eastern Steel Division. Armco manufactures flat-rolled and low- and high-carbon steel used by the appliance and automotive industries.

NS Group Inc. produced steel at minimills in northern Kentucky. At the Wilder plant, plans were announced to add a continuous caster, a $44.6 million investment, by 1990. The continous caster along with planned improvements at the Newport plant, was expected to boost NS Group's annual capacity to about 1 million tons.

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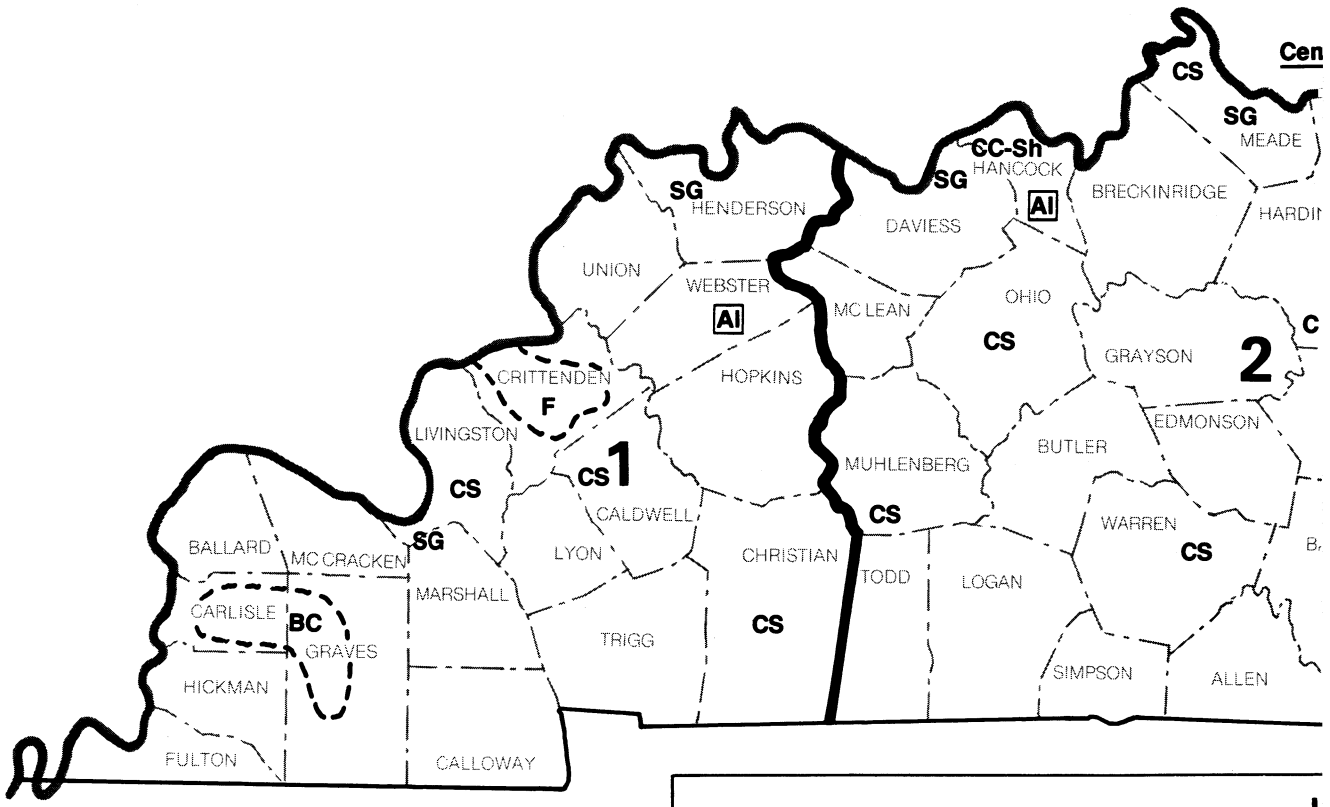


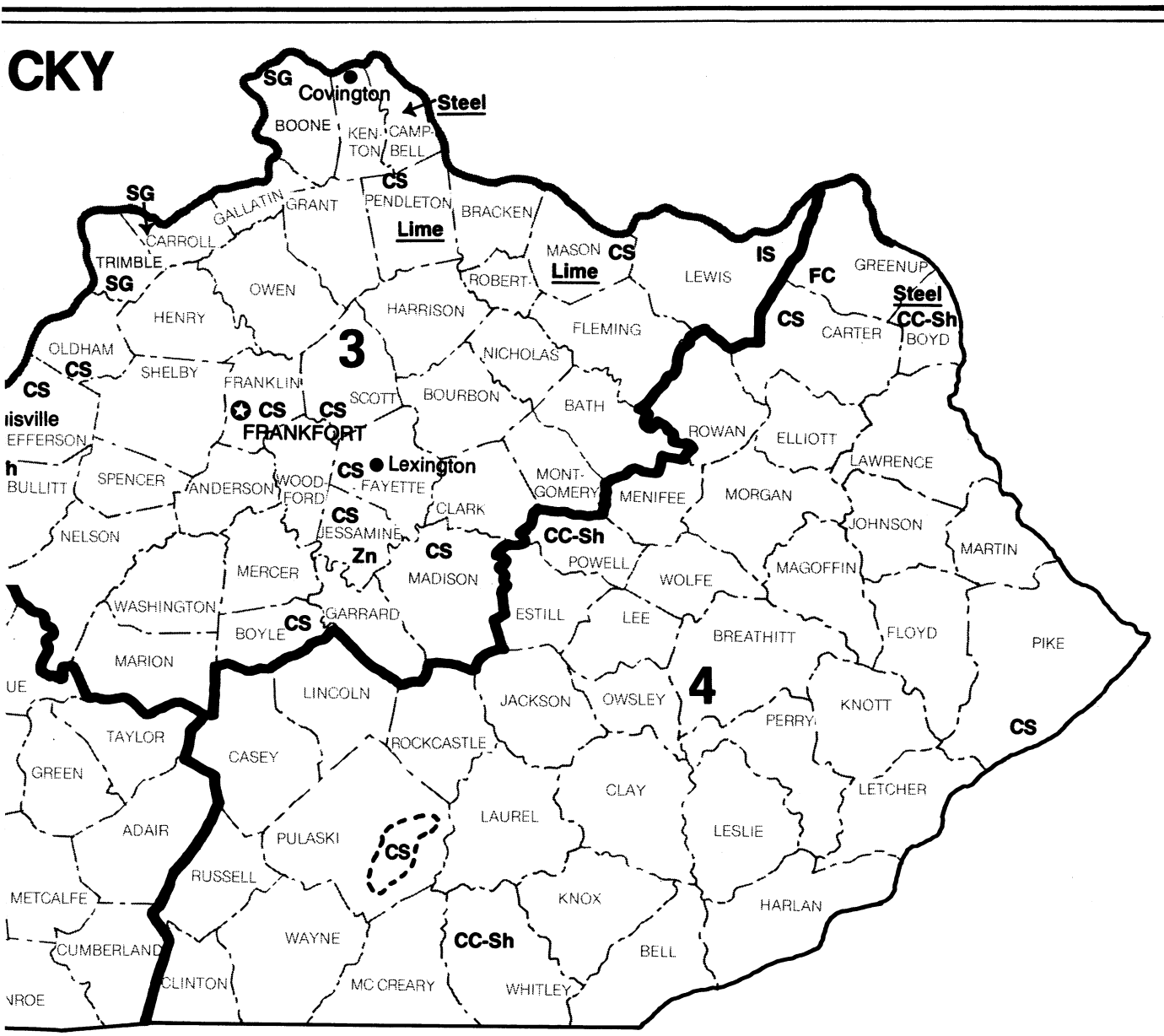
I

MINER

State boundary
County boundary
Capital
City
Waterway
Crushed stone/sand & gravel districts

AI Al
BC Ba
CC-Sh Cc
Cem Ce
CS Cr
F Flu
FC Fir

Principal Mineral-Producing Localities



D

MBOLS

plant	
Clay & Shale	
ant	
tone	

IS	Industrial Sand
Lime	Lime plant
SG	Sand and Gravel
Steel	Iron and Steel plant
Zn	Zinc
	Concentration of mineral operations

[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA.

[2]Geologist, Coal and Minerals Section, Kentucky Geol. Survey, Lexington, KY.

[3]The Crittenden Press (Marion, KY). Dravo Buys Quarry. March 24, 1988, pp. 1–2.

[4]The Courier-Journal (Louisville, KY). Joint Venture Plans to Invest $20 Million in Kosmos Cement. March 8, 1988, p. 1.

[5]American Metal Market. $50M Alcan Recycling Facility Will Be Located in Berea, KY. V. 96, No. 40, Feb. 26, 1988, p. 1.

[6]Lexington-Herald Leader. Armco Ventures Into The Unknown. Nov. 27, 1988, p. C1.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum (primary):			
Alcan Aluminum Corp.	Sebree, KY 42555	Smelter	Webster.
National-Southwire Aluminum Co.	Box M Hawesville, KY 42348	do.	Hancock.
Cement:			
Kosmos Cement Co.[1 2]	Dixie Highway Box 72319 Louisville, KY 40272	Plant	Jefferson.
Clays:			
Ball clay:			
Kentucky-Tennessee Clay Co.	Box 449 Mayfield, KY 42066	Mines and plant	Carlisle and Graves.
Old Hickory Clay Co.	Box 66 Hickory, KY 42051	do.	Graves.
Common clay:			
General Shale Products Corp.	Box 3547 CRS Johnson City, TN 37602	Mine and plant	Jefferson and Whitley.
Kentucky Solite Corp.	Box 27211 Richmond, VA 23261	do.	Bullitt.
U.S. Brick Inc., Sipple Div.	Box 567 Stanton, KY 40380	do.	Powell.
Fire clay:			
Ford Burchett Clay Co.	Route 1, Box 850 Olive Hill, KY 41164	Mine	Carter.
Ferroalloys:			
SKW Alloys Inc.	Box 217 Calvert City, KY 42029	Plant	Marshall.
Iron and steel (pig iron):			
Armco Inc.	Middletown, OH 45202	do.	Boyd.
NS Group Inc.	9th & Lowell Sts. Newport, KY 41072	Plants	Boyd and Campbell.
Lime:			
Dravo Corp.[2]	One Gateway Center Pittsburgh, PA 15222	Mines and plants	Mason and Pendleton.
Sand and gravel (Construction):			
Evansville Materials Inc.	Box 249 Tell City, IN 47586	Dredges	Daviess.
Northern Kentucky Aggregates	11641 Mosteller Rd. Cincinnati, OH 45241	do.	Boone.
Nugent Sand Co. Inc.	Box 6072 1833 River Rd. Louisville, KY 40206	Dredges	Trimble.
Stone (crushed):			
The Kentucky Stone Co.	Box 7529 Louisville, KY 40207	Underground mines, quarries, plants	Various.
Reed Crushed Stone Co.	Box 35 Gilbertsville, KY 42044	Quarry and plant	Livingston.
Rogers Group Inc.	Box 310 Shepherdsville, KY 40165	Quarries and plants	Bullitt, Christian, Grayson, Oldham.

[1] Also clays.
[2] Also stone.

THE MINERAL INDUSTRY OF LOUISIANA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Louisiana Geological Survey for collecting information on all nonfuel minerals.

By Doss H. White, Jr.[1]

Louisiana's nonfuel mineral production in 1988 totaled $434.5 million, $10.3 million over that of 1987. This reversed a 2-year decline in production and sales reported by the State's mineral producers.

Louisiana led the Nation in the production of salt and shell and ranked second in sulfur output. In comparison with the other 49 States, Louisiana ranked 23d in total mineral production. When compared on the basis of industrial mineral production, Louisiana ranked much higher.

TRENDS AND DEVELOPMENTS

The 1988 value of Louisiana's mineral production reversed a 2-year decline from the record year 1985, when $522 million worth of mineral commodities was produced. In the past decade, the State's exports have experienced a serious decline affecting, among others, industrial manufacturers who consumed mineral commodities as raw materials. The decline in oil prices that adversely affected the entire Louisiana economy had a drastic effect on the demand for new construction, which in turn affected the demand for construction mineral commodities. The demand for cement, sand and gravel, and stone had fallen over the past several years, and in 1988, the State's single cement producer used its plant as a shipping terminal rather than for the manufacture of cement.

In 1988, however, several plants using raw mineral commodities as basic process feed announced plans for facility expansion. The Louisiana Department of Commerce reported that a number of firms that processed mineral commodities had announced expansion plans to cost in excess of $37 million. Expansion plans were reported for alumina, chlorine, diammonium phosphate, fluorocarbons, and specialty silica.

In the fuels sector, North American Coal Co. and Phillips Coal Co. announced a tentative joint venture to mine lignite from Phillips' Oxbow reserve area in northwest Louisiana. The 300,000-short-ton-per-year surface mine would provide lignite to the Central Louisiana Electric Co. Development of the $10,500,000 mine started late in the year, with lignite deliveries scheduled for early 1990.[2]

EMPLOYMENT

From 1987 to 1988, mining employment in Louisiana increased 4% to 57,000 jobs. During the same period, national mining employment increased only 0.1%. Wages for mining employees in Louisiana averaged $33,426 in 1988, a 4% increase from 1987.[3]

REGULATORY ISSUES

For several years, shell dredging has been a controversial topic of activity between environmental and sportsperson groups and the mineral industry. Until 1987, leases for shell dredging were granted without competitive bids. In

TABLE 1

NONFUEL MINERAL PRODUCTION IN LOUISIANA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	331,982	$7,670	356,904	$9,192	[2]375,778	[2]$9,535
Gem stones		NA	1	NA	1	NA	3
Salt	thousand short tons	11,608	103,611	12,498	108,999	14,274	108,982
Sand and gravel:							
Construction	do.	14,292	46,134	[e]12,200	[e]43,600	14,233	52,820
Industrial	do.	256	4,225	289	3,997	318	4,786
Stone (crushed)[3]	do.	[e]5,400	[e]25,300	4,390	36,514	[e]3,700	[e]29,200
Sulfur (Frasch)	thousand metric tons	1,602	W	1,458	W	1,719	W
Combined value of cement (masonry (1987–88), portland), lime, gypsum (1987–88), lime, stone (crushed miscellaneous), and values indicated by symbol W		XX	259,857	XX	221,918	XX	229,210
Total		**XX**	**446,798**	**XX**	**424,221**	**XX**	**434,536**

[e] Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Excludes certain clays; kind and value included with "Combined value" data.
[3] Excludes certain stones; kind and value included with "Combined value" data.

1987, however, the State court ruled that the leases were invalid because of the lack of competitive bids. In 1988, the State Department of Wildlife and Fisheries set a minimum royalty and time limit for shell leases, and late in the year dredging leases were awarded to Dravo Basic Materials Co. Dravo won its leases over a joint venture by two Louisiana companies and continued to dredge in Lake Pontchartrain and offshore areas. During the bid proceedings, environmental groups filed suit to halt the dredging, charging that the State had failed to follow proper administrative procedures. No legal decision on the suit to halt dredging was reached by yearend.[4]

Louisiana's Department of Environmental Quality officials were seeking a $5 million grant from Congress to find ways to use 12 million tons of byproduct gypsum generated each year by Louisiana's four fertilizer producers. If funded, the research would be undertaken by the Louisiana Transportation Research Center at Louisiana State University. Three of the fertilizer manufacturers stockpiled gypsum, while the fourth had a permit for Mississippi River disposal.[5]

LEGISLATION AND GOVERNMENT PROGRAMS

A bill was passed by the legislature and signed into law allowing three companies to continue shell dredging until the State developed a procedure for competitive bidding.

The Louisiana Geological Survey, a nonregulatory unit of the Louisiana Department of Natural Resources, continued its geological research programs while also functioning as a research agency for Louisiana State University. During the year, the Survey conducted programs pertaining to energy and mineral resources, coastal geology, geologic mapping, water recharge mapping, and various environmental studies.

The U.S. Bureau of Mines' newly developed electromagnetic fire-warning system was scheduled to be tested in Morton Salt's Weeks Mine near New Iberia. The salt mine was selected to investigate electromagnetic wave transmission through water-saturated overburden. The system was designed to warn all underground workers of a fire or other hazard quickly, regardless of how remote or isolated the workers from central paging stations. Most mines used the slower, centrally located phone systems or injected stench gas into the air vents to warn miners of fire hazards.

The Mineral Resources Institute of Louisiana State University received a grant from the U.S. Bureau of Mines under Title III of Public Law 95-87. The law was designed to encourage the training of mining engineers and other scientists involved in mineral-related studies. The major portion of sponsored research centered on energy.

Severance tax receipts for 1988, as reported by the Louisiana Department of Revenue, totaled more than $3 million, a slight decrease from receipts in 1987. Minerals taxed included brine ($54,000), gravel ($411,000), salt ($290,000), sand ($508,000), shell ($224,000), stone ($8,000), and sulfur ($1.5 million). Only salt, stone, and sulfur showed increased values.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Louisiana's mineral industry produced eight industrial minerals, and the State's manufacturing industry used several different raw mineral commodities mined in other States or foreign countries in various industrial processes.

Cement.—For many years, Louisiana's cement industry consisted of one operation, Lone Star Cement Co., which operated a twin-kiln, wet-process plant at New Orleans. Cement production there was terminated in 1987, and the plant was used as a cement distribution terminal through 1988. At yearend, Ideal Basic Cement Co. was finalizing plans to lease the plant from Lone Star.

Clays.—Louisiana ranked 27th among the 44 States reporting production of common clay. Five companies operated five mines in five parishes; the bulk of the production reported was from Caddo and Coupee Parishes. Clay output increased from 356,904 short tons to 375,778 short tons, and value increased from $9.2 million to $9.5 million, reflecting the upturn in Louisiana's economy and demand for building materials. The principal markets were for (1) concrete block manufacture, (2) structural concrete, (3) common brick production, (4) highway surfacing, and (5) face brick manufacture.

Gypsum.—Anhydrite, a variety of gypsum, was mined by Winn Rock Inc. from a quarry near Winnfield. The material was marketed as a surfacing material for oil- and gas-drilling-site access roads.

Two companies, National Gypsum Co. of Jefferson Parish and U.S. Gypsum Corp. of Orleans Parish, calcined imported gypsum for wallboard manufacture at plants in Westwego and New Orleans. Four fertilizer plants produced approximately 12 million tons of byproduct gypsum during the year.

Lime.—Louisiana's sole lime producer, USG Corp. in Orleans Parish, produced both quicklime and hydrated lime. Production in 1988 was considerably lower than reported in 1987. Primary markets were in the chemical and industrial sectors.

Salt.—Louisiana, with 37% of the Nation's output, continued as the leading salt producing State. Salt sales accounted for 25% of the State's mineral value. Several near-surface salt domes occur in the southern part of the State,

and salt output came from these domes and from salt strata associated with the domes. Three types of salt production were ongoing during 1988: (1) rock salt production from underground mines, (2) evaporative salt obtained from the solution mining of domes and salt strata, and (3) brine production.

Salt production increased by 1.8 million tons in 1988, but total value was unchanged from 1987. Eleven companies reported salt output from 10 parishes.

Rock salt output including brines, 14.1 million tons valued at $88.6 million, was used primarily for chemical manufacture and road deicing. Evaporative salt production, 213,000 tons valued at $20.4 million, was used primarily for human consumption.

Sand and Gravel.—The value of sand and gravel production ranked second in the State's total mineral value during 1988. Ouput of 2.1 million tons, valued at $10 million, increased after a 3-year decline, reflecting the recovery in construction and mining employment.

Construction.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

Louisiana construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end use data for the State's three districts. In 1988, Louisiana's sand and gravel industry, comprised of 64 companies operating 101 mines in 24 parishes, produced 14 million tons valued at $53 million. Washington, St. Helena, and Rapides Parishes were the leading sand and gravel producers, accounting for 36% of the total production. Principal end uses, as reported by industry, were concrete aggregate, fill, and asphaltic concrete.

Gifford-Hill & Co. Inc. purchased Tri-States Sand and Gravel Co. in Sibley. Included in the purchase were land, gravel resources in-State and in Arkansas, two sand and gravel plants, and a rail terminal. The Louisiana plant is in Heflin.[6]

Industrial.—Louisiana ranked 24th among the 37 industrial sand-and-gravel-producing States, with output totaling 318,000 short tons valued at $4.8 million. Three companies operated four mines in four parishes. Principal sales were for (1) sandblasting applications, (2) container manufacture, (3) roofing granules, (4) chemical industry usage, and (5) foundry sand applications.

Stone (Crushed).—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

In 1987, the last year that complete data were available, crushed stone, including oyster shell, was produced by six companies with nine operations, both mine and dredge, in six parishes. More than 90% of the output was crushed shell; the remainder was reported as sandstone or "other" stone. The waters of Orleans Parish produced slightly less than 50% of the shell reported, followed by St. Mary and St. Tammany Parishes.

Of the end uses reported, approximately 85% was used for graded road base. Unpaved road surface, bituminous aggregate, and riprap and jetty stone made up the remainder.

As noted in the Regulatory Issues section, the shell dredging industry was under attack from environmental and sports fishing groups. However, to overcome potential rock (shell) shortages in the event of further dredging restrictions, several companies serving the Louisiana market acquired stone reserves and/or transportation facilities in other States.

Dravo Basic Materials Co. acquired the 4- to 5-million-short-ton-annual-capacity Three Rivers Rock Co. quarry

TABLE 2

LOUISIANA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	2,452	$8,349	$3.40
Plaster and gunite sands	W	W	3.80
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	3.71
Asphaltic concrete aggregates and other bituminous mixtures	700	4,090	5.84
Road base and coverings	520	2,004	3.85
Fill	1,000	1,850	1.85
Other	217	810	3.73
Unspecified:[1]			
Actual	6,559	26,721	4.07
Estimated	2,785	8,997	3.23
Total or average	**14,233**	**[2]52,820**	**3.71**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[2] Data do not add to total shown because of independent rounding.

TABLE 3

LOUISIANA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	741	2,866	569	2,612	1,142	2,870
Plaster and gunite sands	—	—	12	53	8	23
Concrete products (blocks, bricks, etc.)	W	W	—	—	W	W
Asphaltic concrete aggregates and other bituminous mixtures	295	1,931	270	1,761	135	397
Road base and coverings	78	441	W	W	W	W
Fill	W	W	W	W	718	1,354
Other miscellaneous	56	210	303	619	561	1,965
Other unspecified[1]	1,365	5,535	1,505	10,369	6,475	19,813
Total[2]	**2,536**	**10,984**	**2,659**	**15,414**	**9,038**	**26,422**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[2] Data may not add to totals shown because of independent rounding.

in Kentucky and stone distribution yards in Tennessee and Louisiana from Cyprus Minerals Co.[7]

Vulcan Materials Co. and Mexico's Grupo ICA continued development of a 6-million-short-ton-per-year crushed limestone operation in the Yucatan Peninsula.[8] Potential markets included the Gulf Coast area from Texas to Florida, and studies indicated that Vulcan would be the lowest cost supplier to gulf ports when shipments begin in 1989.[9]

Louisiana Synthetic Aggregates Inc. continued to make inroads into the natural aggregates market. The Geismar-based company developed a synthetic aggregate material using calcium fluoride as a raw material. The calcium fluoride was a waste product from Allied Chemical Co.'s Geismar complex. The synthetic stone, trade named Florolite, was available from powder size to a size large enough to be used as riprap.[10]

Sulfur.—Sulfur was the leading mineral commodity in terms of value produced in-State. Production of both Frasch and refinery-recovered sulfur was reported. The State ranked second nationally in Frasch production.

Freeport Minerals Co. operated three Frasch sulfur properties, and nine oil companies recovered elemental sulfur from nine refineries in seven parishes. Output of 1.7 million metric tons exceeded that reported in 1987 by 260,000 metric tons.

Freeport operated the Garden Island Bay and Grand Isle Frasch properties; output decreased approximately 10% from that reported in 1987. To offset the declining production, Freeport reopened its Caminada Pass Mine "to ensure adequate sulfur supply for both Freeport's fertilizer business and external customers." The property, inactive since 1969, has an estimated 6 million metric tons of sulfur reserves.[11]

Freeport, the operator for a consortium that included IMC Fertilizer Group Inc. and Felmont Oil Co., conducted exploration drilling on offshore Louisiana Federal lease Main Pass-Block 299. Lease reserves of sulfur were estimated to exceed 50 million metric tons.

Other Industrial Minerals.—Anhydrous ammonia was produced by 14 companies in-State. The annual capacity of the 14 plants totaled more than 7 million short tons, approximately 40% of national capacity.

Domestic and imported barite was crushed, ground, and bagged by Mil-Park Drilling Fluids at a grinding plant at Houma. Ground barite was used in oil-well-drilling fluids/mud. Much of the imported barite was from China and entered through the port at Lake Charles.

Louisiana was one of two States that reported production of synthetic calcium chloride. Allied Signal Corp. and Texas United Chemical Corp. produced synthetic calcium chloride, using salt as a raw material, at plants in Baton Rouge and Lake Charles. Output was used primarily to speed concrete setup, for dust control, in oil and gas drilling, and for road deicing.

A garnet reclaiming plant began production at Harvey in March. International Garnet Abrasives Inc. began operation of a 10,000-ton-per-year facility that may process foreign garnet concentrates.

Diammonium phosphate (DAP) production was scheduled to be transferred from Freeport-McMoRan's plant at

Monsanto to its facility at Taft. The Taft plant had a 816,000-short-ton annual DAP capacity and access to a deep-water dock.[12]

Crude perlite, obtained from New Mexico mines, was expanded by Filter Media Co. Inc. at Reserve. The expanded material was used as a filter material, for insulation, and to manufacture lightweight concrete.

Vermiculite from South Carolina was exfoliated by W. R. Grace & Co. at a plant in New Orleans. After exfoliation, the vermiculite was sold for use in concrete and plastic aggregate, horticulture, loose fill, and block insulation.

Metals

Louisiana's primary metals industry is relatively small with an average employment of about 3,000.

Alumina.—The Ormet Corp. alumina plant at Burnside restarted its first unit in November, with full capacity of 600,000 short tons per year expected to be reached early in 1989. Restart costs were estimated at more than $8 million. The plant had been closed since 1985 because of a slump in aluminum demand and had not operated at full capacity since 1981. Employees at the plant, owned by Ohio River Associates, ratified a 3-year contract with reduced benefits. The plant was to act as a service company, converting bauxite to alumina under a tolling agreement.[13]

Iron and Steel.—Bayou Steel Corp. operated a minimill at LaPlace, the only minimill in Louisiana. Capacity was 700,000 short tons, with a rolling capacity of 400,000 tons.

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[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL.

[2] NACCO Industries Inc. Interim Report. 1st Quarter, 1988.

[3] Morning Advocate (Baton Rouge). Primary Job Growth Boosts Louisiana. Sept. 27, 1989.

[4] Daily Iberian. Environmentalists Target Shell Dredging and Waste During Year. Dec. 29, 1988.

[5] Clarion-Ledger (Jackson, MS). Louisiana Officials Seek Fund for Gypsum Research. Mar. 25, 1988.

[6] Pit and Quarry. Gifford-Hill Purchases Tri-States S&G Assets. Aug. 1988, p. 10.

[7] Morning Advocate (Baton Rouge). Dravo Acquires Louisiana Limestone Quarry in Colo. Mar. 2, 1988.

[8] Pit and Quarry. IFC Invests $37 Million in Vulcan's Mexico Project. Jan. 1988, p. 12.

[9] Business Alabama Monthly. Vulcan Forges Into Mexico. Aug. 1988, p. 7.

[10] Louisiana Construction. Determination to Keep Money at Home as Solid as a Rock. Aug. 1988, pp. 46, 48–49, 52.

[11] Freeport-McMoRan Inc. Form 10–Q, 2nd Quarter Report, p. 15.

[12] Phosphorus and Potassium. Freeport Taft Restart. No. 155, May–June 1988, p. 10.

[13] Daily Echo (Moundsville, WV). Ormet Reopens Alumina Plant. Dec. 22, 1988.

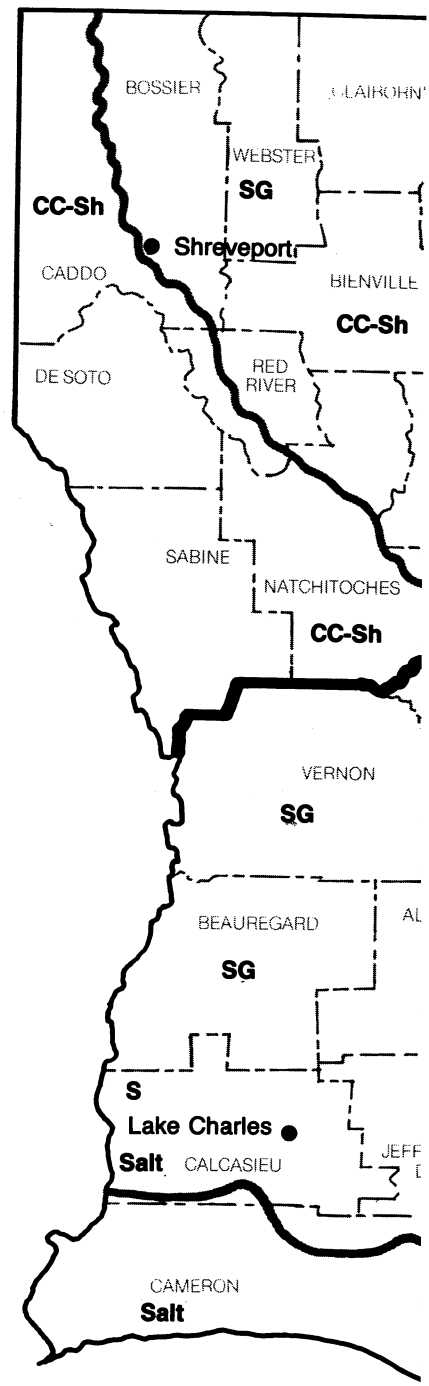
LOUISIANA

LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Al	Aluminum plant
CC-Sh	Common Clay & Shale
Cem	Cement plant
CS	Crushed Stone
Gyp	Gypsum plant
Lime	Lime plant
S	Sulfur
Salt	Salt
SG	Sand and Gravel
Shell	Shell



Principal Mineral-Producing Localities

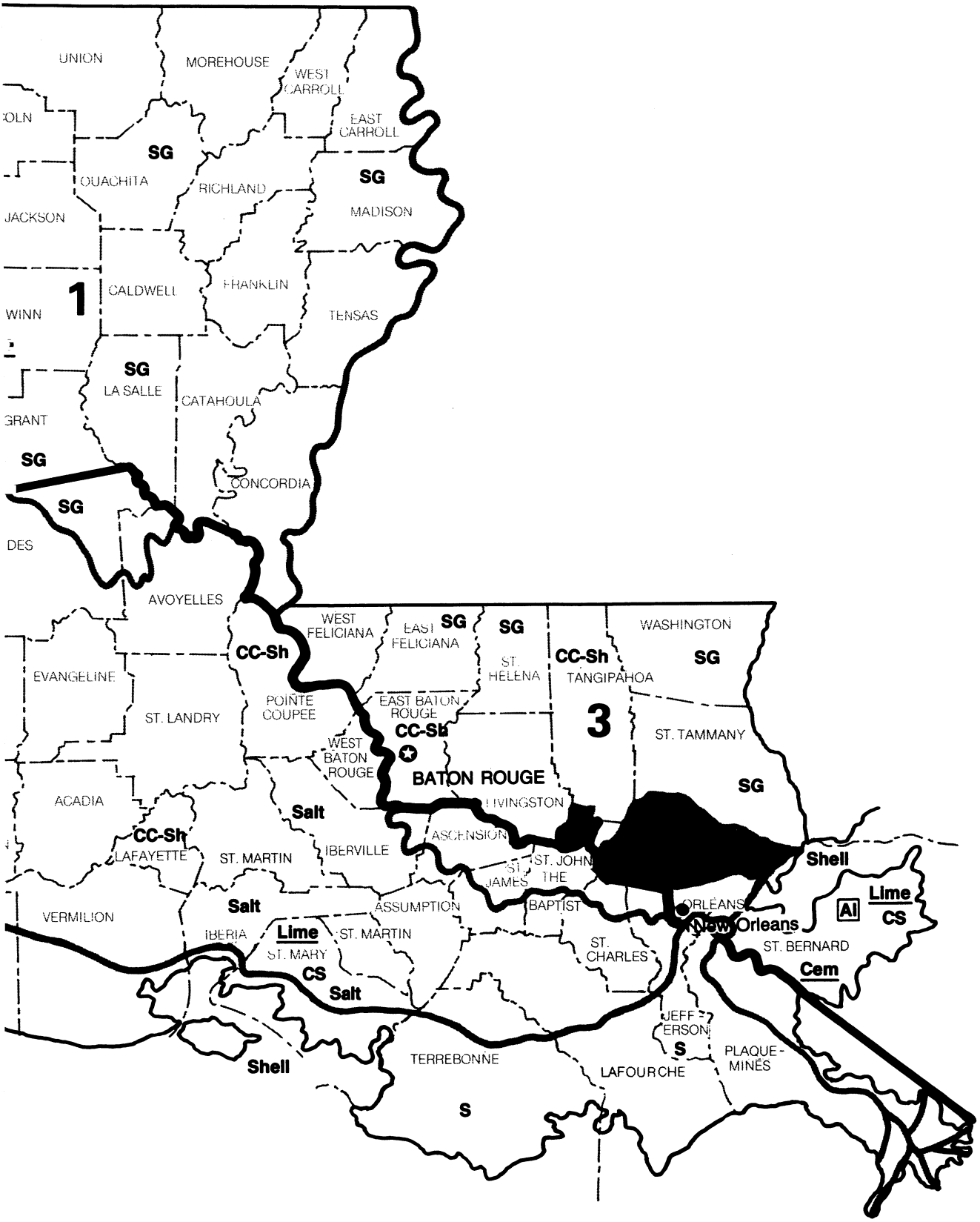

UNION
MOREHOUSE
WEST CARROLL
EAST CARROLL
SG
OUACHITA
RICHLAND
SG
MADISON
JACKSON
1
CALDWELL
FRANKLIN
WINN
TENSAS
SG
LA SALLE
CATAHOULA
GRANT
SG
SG
CONCORDIA
DES
AVOYELLES
WEST FELICIANA
EAST FELICIANA
SG
SG
WASHINGTON
CC-Sh
ST. HELENA
CC-Sh
SG
EVANGELINE
TANGIPAHOA
POINTE COUPEE
EAST BATON ROUGE
3
ST. LANDRY
CC-Sh
ST. TAMMANY
WEST BATON ROUGE
BATON ROUGE
SG
ACADIA
LIVINGSTON
Salt
CC-Sh
ASCENSION
Shell
LAFAYETTE
ST. MARTIN
IBERVILLE
ST. JAMES
ST. JOHN THE BAPTIST
Lime
Al
CS
VERMILION
Salt
ASSUMPTION
ORLEANS
New Orleans
IBERIA
Lime
ST. MARTIN
ST. CHARLES
ST. BERNARD
ST. MARY
CS
Cem
Salt
JEFFERSON
S
PLAQUEMINES
Shell
TERREBONNE
LAFOURCHE
S

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Kaiser Aluminum & Chemical Corp.	Box 1600 Chalmette, LA 70043	Plant	St. Bernard.
Cement:			
Lone Star Industries Inc.	515 W. Greens Rd. Houston, TX 77067	do.	Orleans.
Clays:			
Athens Brick Co. Inc.	Box 70 Athens, TX 75751	Mines and plant	Caddo.
Big River Industries Inc.	Box 66377 Baton Rouge, LA 70806	Mine and plant	Pointe Coupee.
Gypsum:			
National Gypsum Co.	Box 128 Westwego, LA 70094	Plant	Jefferson.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do.	Orleans.
Lime:			
Dravo Lime Co.	One Gateway Center 7th Floor Pittsburgh, PA 15222	do.	St. Mary.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do.	Orleans.
Salt:			
Domtar Chemicals Inc., Shifto Salt Div.	4825 North Scott Shiller Park, IL 60176	Underground mine	St. Mary.
The Dow Chemical Co.	Midland, MI 48640	Brine wells	Iberville.
International Salt Co.	Clarks Summit, PA 18411	Underground mine	Iberia.
Morton Salt Co.	110 North Wacker Dr. Chicago, IL 60606	do.	Do.
PPG Industries Inc.	Box 1000 Lake Charles, LA 70604	Brine wells	Calcasieu.
Sand and gravel:			
Beazer/Gifford-Hill	Box 6615 Shreveport, LA 71136	Dredges, pits, plants	Jefferson, Davis, Webster.
T. U. James & Co. Inc.	Box 31 Baton Rouge, LA 70821	Dredge and plant	St. Tammany.
Standard Gravel Co. Inc.	Rt. 7, Box 53 Franklinton, LA 70438	Dredges and plants	St. Tammany and Washington.
Texas Industries Inc.	Box 5472 Alexandria, LA 71301	Dredges, pits, plants	Ouchita, Rapides, St.Helena, St. Tammany, Veron, Washington.
Stone (crushed):			
Pontchartrain Dredging Corp.	Box 8005 New Orleans, LA 70182	Quarry and plant	Winn.
Southern Industries Corp.	Box 2068 Mobile, AL 36652	Dredges	Orleans and St. Mary.
Winn Rock Inc.	Box 790 Winnfield, LA 71483	Quarry and plant	Winn.

TABLE 4–Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sulfur:			
Native:			
Freeport Minerals Co.	200 Park Ave. New York, NY 10166	Frasch process	Jefferson and Plaquemines.
Recovered:			
Cities Service Oil Co.	Box 300 Tulsa, OK 74102	Refinery	Calcasieu.
Exxon Co. U.S.A.	Box 551 Baton Rouge, LA 70821	Plant	East Baton Rouge.
Vermiculite (exfoliated):			
W. R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	do.	Orleans.

THE MINERAL INDUSTRY OF MAINE

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Maine Geological Survey for collecting information on all nonfuel minerals.

By Donald K. Harrison,[1] Walter Anderson,[2] and Michael E. Foley[3]

The value of Maine's nonfuel mineral production in 1988 was $67.8 million, representing an increase of 4% over production in 1987. The improvement was due primarily to an increase in sand and gravel sales. Construction sand and gravel accounted for the greatest portion of the State's mineral commodity value, followed by cement, dimension stone, and crushed stone.

LEGISLATION AND GOVERNMENT PROGRAMS

Public Law Chapter 640, which concerned the siting of gravel pits, was signed into law in March. Prior to its enactment, borrow pits of less than 5 acres were not regulated by the Maine Department of Environmental Protection (DEP). This bill imposed notification and setback requirements to protect the property of adjacent landowners and gave DEP the authority to establish maximum slope rules to ensure safety at small borrow pits.

The Maine Human Services Department began testing homes randomly to determine which areas of the State had high levels of radon. Radon is formed from the decay of uranium and thorium, elements found in granite bedrock, which is abundant in Maine. The gas can accumulate in houses built over granite. Until the inception of this State program, radon monitoring had been performed informally, primarily by individual homeowners who had purchased commercially available monitoring kits. Final results of the survey, part of a 12-State study directed by the U.S. Environmental Protection Agency (EPA), were not to be known until mid-1990.

During the year, Maine joined eight other States in litigation to force the EPA to order new air pollution controls for the midwestern States. Besides Maine, plaintiff States were Connecticut, Massachusetts, Minnesota, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. The Canadian Province of Ontario and two private environmental organizations also filed a similar suit.

The Maine Geological Survey (MGS) continued bedrock mapping in the extreme northern part of the State under the U.S. Geological Survey's (USGS) COGEOMAP Program. This was the second year of the 3-year project aimed at providing basic stratigraphic and structural information for a virtually unmapped area.

The MGS also continued work on its Significant Sand and Gravel Aquifer Mapping Program. This project was initiated in 1981 in cooperation with the USGS and Maine DEP to define the thickness and extent of the State's gravel aquifers and to assess their water quality. Detailed information on the aquifers is needed to locate and protect Maine's water supplies and to comply with new environmental laws. The "significant" sand and gravel aquifers are those that can yield at least 10 gallons per minute and have a saturated thickness exceeding 10 feet.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Maine remained the only New England State that produced cement. The Dragon Cement Co. produced both portland and masonry cement at a plant in Thomaston, Knox County. Near the end of 1988, Coastal Cement, a subsidiary of Cementos del Norte of Boston, MA, purchased the Dragon cement plant for $81.3 million from the Passamaquoddy Indian Tribe.

TABLE 1

NONFUEL MINERAL PRODUCTION IN MAINE[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	46,000	$90	W	W	W	W
Gem stones		NA	200	NA	$1,172	NA	$150
Sand and gravel (construction)	thousand short tons	8,572	22,843	e8,600	e22,100	10,183	33,007
Stone:							
Crushed	do.	e1,600	e4,400	2,010	7,532	e1,400	e5,300
Dimension	short tons	W	W	7,512	5,924	e7,512	e5,924
Combined value of cement, garnet (abrasive), peat (1986), and values indicated by symbol W		XX	25,326	XX	28,729	XX	23,379
Total		**XX**	**52,859**	**XX**	**65,457**	**XX**	**67,760**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Coastal Cement indicated that it would retain Dragon's 280 workers and management staff. The Passamaquoddies had paid $22.5 million for the facility in 1983 with money received from the Indian Land Claims Settlement Act.

Clays.—Morin Brick Co., the State's only producer of clay, mined common clay, primarily for use in brick manufacture, at operations in Adroscoggin and Cumberland Counties.

Garnet.—Industrial Garnet Extractives Inc. (IGE), a garnet processor, ceased operations at its plant near West Paris in May. As its reasons for closing, the company cited problems in maintaining a reliable supply of high-quality raw materials, foreign competition, and inefficiencies in the engineering of its antiquated mill. Supply difficulties worsened in 1987 when IGE began to receive a poor grade of raw material from its principal supplier in New York State. IGE had also been involved in a legal dispute concerning its right to mine garnet ore from a site in Rangely, about 40 miles north of the processing plant. IGE had produced industrial-grade garnet used primarily in sandblasting and water filtration.

Gem Stones.—Semiprecious and gem-quality mineral specimens continued to attract rockhounds and mineral specimen collectors to the State. During the year, the MGS published a 131-page book entitled "A Collector's Guide to Maine Mineral Localities." The mineral guidebook describes 45 of the best collecting sites in Maine, with topographic maps and detailed driving and walking instructions. Site descriptions included lists of minerals found and comments on notable discoveries, such as large crystals of tourmaline and beryl.

Peat.—Construction of North America's first peat-fired electric powerplant was nearing completion at the end of 1988. Situated in Deblois, the $51 million Down East Powerplant was a joint venture of Peat Products of America, Bangor, ME; Ateliers de Constructions Electriques de Charleroi, Belgium; and Transco Energy Ventures Co., a unit of Transco Energy Co., Houston, TX. Fuel for the plant was to be harvested from the surrounding 1,200-acre Denbo Heath peat bog. When fully operational, the plant was to produce 22.8 megawatts of electricity, to be sold to Boston Edison in Massachusetts.

Perlite (Expanded).—Crude perlite shipped in from New Mexico was expanded by the Chemrock Corp. at a plant in Rockland, Knox County. The expanded perlite was sold locally, primarily as a filter aid.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

Construction sand and gravel was the State's leading mineral commodity in terms of value and accounted for nearly one-half of the State's mineral value. Output of 10.2 million short tons of construction sand and gravel in 1988 was the highest reported since 1979. In 1988, 89 companies mined construction sand and gravel from 120 operations in all of the State's counties. Leading counties in order of output were York, Cumberland, and Androscoggin. Major uses were construction and road building.

Cement-Roadstone Holdings (CRH), Dublin, Ireland, acquired the Pike Industries, Oxford County, sand and gravel operation in March. In addition to the Oxford County plant, CRH also acquired Pike Industries' quarries, sand and gravel plants, and asphalt plants in New Hampshire and Vermont.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter

TABLE 2

MAINE: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	1,211	$6,781	$5.60
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	2.00
Asphaltic concrete aggregates and other bituminous mixtures	344	2,121	6.17
Road base and coverings[1]	1,732	5,592	3.23
Fill	1,154	3,207	2.78
Snow and ice control	449	950	2.12
Other	323	653	2.02
Unspecified:[2]			
Actual	3,656	10,541	2.88
Estimated	1,314	3,163	2.41
Total or average	**10,183**	**[3]33,007**	**3.24**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes road and other stabilization (lime).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data do not add to total shown because of independent rounding.

contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—Estimated crushed stone production totaled 1.4 million short tons, valued at $5.3 million. Leading counties in order of output were Cumberland, Knox, and Penobscot. Limestone, sandstone, traprock, and marl were quarried for cement manufacture, concrete aggregate, and railroad ballast.

Dimension.—New England Stone Industries Inc. quarried dimension granite at Crotch Island, Hancock County. Both output and value remained about the same as 1987 levels. Most of the stone was used for veneer, flagging, curbing, and rough blocks.

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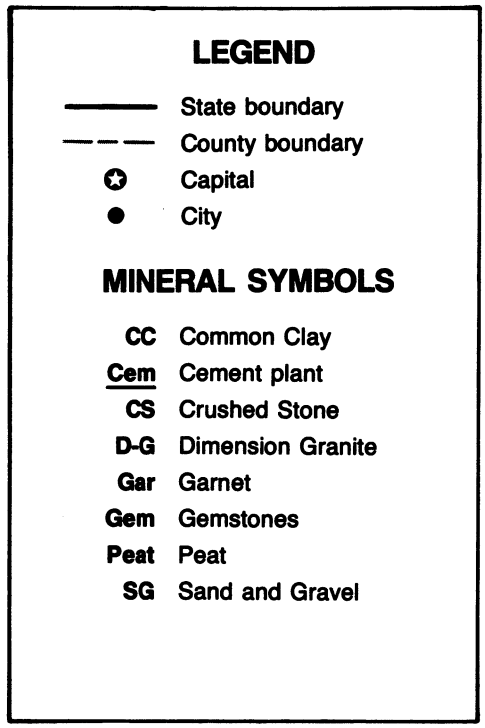
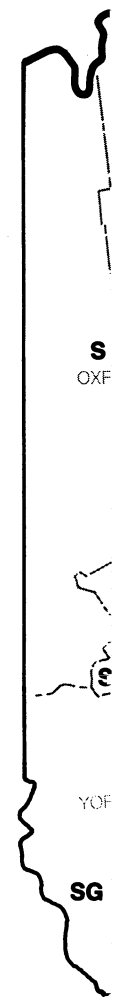
[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA.

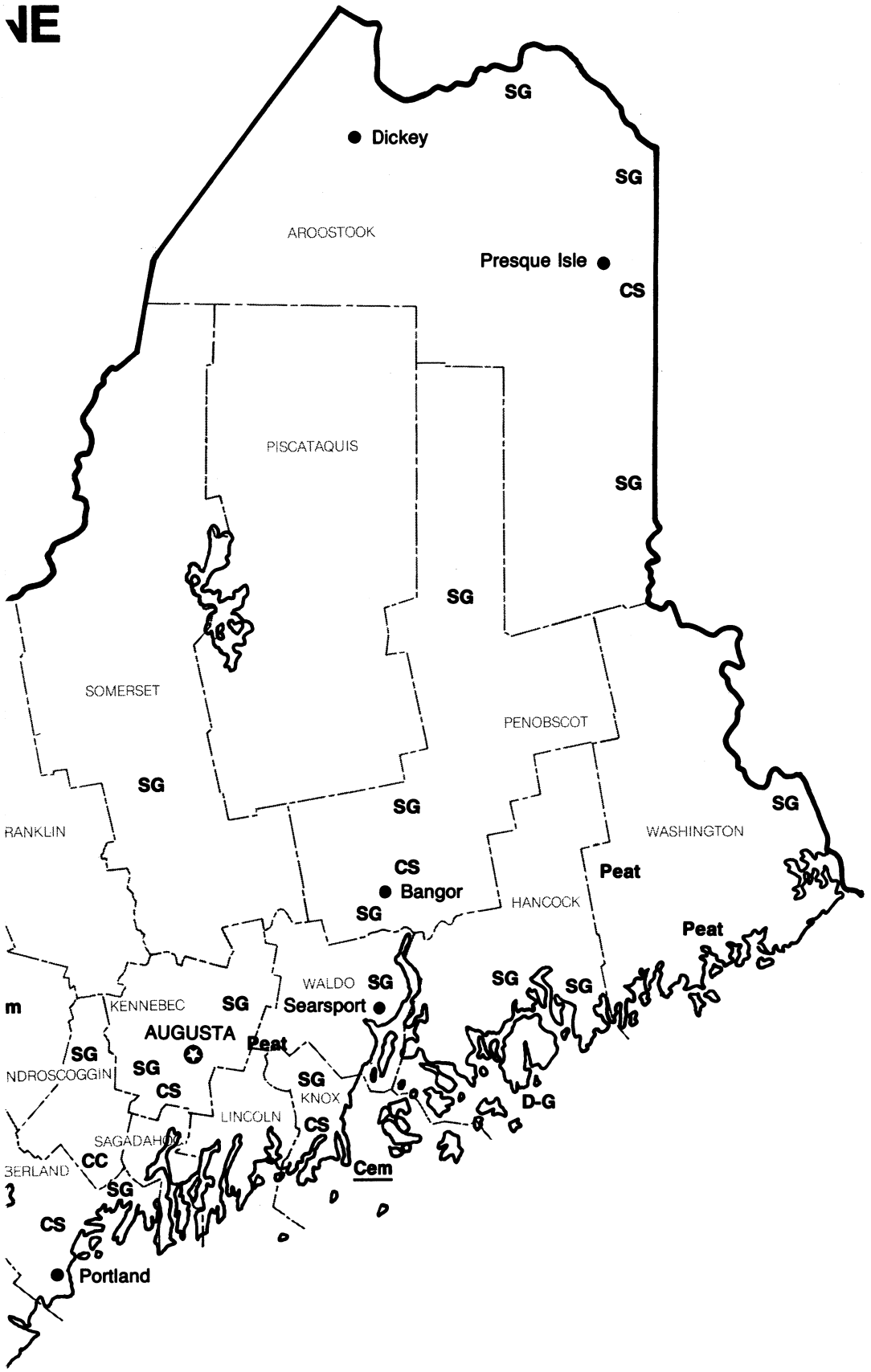
[2] Director and State geologist, Maine Geological Survey, Augusta, ME.

[3] Resource administrator, Maine Geological Survey, Augusta, ME.



Principal Mineral-Producing Localities

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SAGADAHOC
CC
BERLAND
SG
Cem
CS
Portland

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Dragon Cement Co.[1]	Box 191 Thomaston, ME 04861	Quarry and plant	Knox.
Clays:			
Morin Brick Co.	Mosher Rd. Gorham, ME 04038	Pits and mills	Androscoggin and Cumberland.
Garnet:			
Industrial Garnet Extractives Inc.	Box 56A West Paris, ME 04289	Mill Quarry	Oxford. Franklin.
Perlite (expanded):			
Chemrock Corp.	1101 Kermit Dr., Suite 503 Nashville, TN 37217	Plant	Knox.
Sand and gravel (construction):			
W. E. Cloutier Co. Inc.	Box 1849 Lewiston, ME 04240	Pit	Androscoggin.
Harry C. Crooker & Sons Inc.	Old Bath Rd. Brunswick, ME 04011	Pits	Androscoggin, Lincoln, Sagadahoc.
Dragon Products Co.	Box 101 Thomaston, ME 04861	Pits and plants	Androscoggin, Hancock, Oxford, Somerset.
R. J. Grondin and Sons	Rural Route 4 Gorham, ME 04038	Pits	Cumberland and York.
Maine Department of Transportation	Augusta, ME 04333	Pits and plants	Androscoggin, Kennebec, Knox, Oxford, Penobscot, Waldo.
Portland Sand & Gravel Co. Inc.	94 Walnut St. Portland, ME 04091	Pit	Cumberland.
Tilcon Inc.	Box 209 Fairfield, ME 04937	Pits	Penobscot and York.
Stone:			
Crushed:			
Blue Rock Industries	58 Main St. Westbrook, ME 04092	Quarries and mill	Cumberland and Kennebec.
The Cook Concrete Co.	960 Ocean Ave. Portland, ME 04103	Quarry and mill	Cumberland.
Dragon Products Co.	Box 191 Thomaston, ME 04861	Quarries	Knox.
Lane Construction Corp.	Box 103 Bangor, ME 04401	do.	Aroostook and Penobscot.
Dimension:			
New England Stone Industries Inc.	Providence Pike Smithfield, RI 02917	Quarry	Hancock.

[1] Also stone.

THE MINERAL INDUSTRY OF MARYLAND

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Maryland Geological Survey for collecting information on all nonfuel minerals.

By L. J. Prosser, Jr.[1]

The value of nonfuel mineral production in Maryland increased for the seventh consecutive year in 1988. The total nonfuel mineral value of $363 million was the highest ever reported for the State.

Crushed stone, the leading mineral commodity produced in Maryland, accounted for more than 45% of the value of mineral production. Significant gains in crushed stone output during the past 6 years have been directly responsible for the growth in the State's total value of nonfuel mineral production. Output of 32.7 million short tons of crushed stone in 1988 was more than double the 15.1 million tons produced in 1982. Similarly, the value of all minerals produced in the State increased from $171.5 million in 1982 to the record value of 1988.

TRENDS AND DEVELOPMENTS

Production records for Maryland show that, in 1967, crushed stone output surpassed sand and gravel output and it has continued to increase at a greater rate than sand and gravel since then. Urban development has removed or restricted land available for mining of both stone and sand and gravel resources, but has affected sand and gravel production more severely. Sand and gravel operations typically utilize more surface area per ton of material mined than do stone quarries. Encroachment of urban regions has also become an increasing concern for crushed stone producers. In most cases, the expansion of existing quarries or opening of new quarries in Maryland was opposed by area residents.

LEGISLATION AND GOVERNMENT PROGRAMS

Opposition by residents to the opening or expansion of quarries in Carrol County was the impetus for introduction of House bill 407. The bill would have assumed a quarry operator to be liable for damages to properties within a 3-mile radius of the quarry. The bill was defeated in committee. Two of the State's leading producers, one of crushed stone and the other of cement, have operations in Carrol County, both near Union Bridge. In March, Carrol County also adopted revised zoning ordinances requiring extensive environmental impact studies before land can be zoned for use as a quarry.

Land use conflicts also prompted action at the level of local government. In September, Charles County Commissioners formed a sand and gravel task force because of mining controversies during the year. The task force was expected to examine the economic, environmental, and neighborhood safety impact of sand and gravel pits and to establish guidelines for the county's Board of Zoning Appeals. In addition, the task force was charged with determining general policy for road maintenance, truck traffic, and taxation of sand and gravel producers. Results of the task force findings were expected by

TABLE 1

NONFUEL MINERAL PRODUCTION IN MARYLAND[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	1,785	$89,799	1,829	$90,020	1,808	$89,083
Clays	short tons	[2]361,729	[2]1,757	383,054	1,940	394,443	2,016
Gem stones		NA	5	NA	5	NA	5
Lime	thousand short tons	10	546	9	486	6	329
Peat	do.	W	W	W	W	7	W
Sand and gravel (construction)	do.	18,173	86,925	e19,600	e92,900	19,266	95,169
Stone:							
Crushed	do.	e26,400	e126,000	30,136	151,579	e32,700	e167,000
Dimension	short tons	e20,505	e1,286	22,843	1,516	e20,729	e1,515
Combined value of cement (masonry), clays (ball clay, 1986), sand and gravel (industrial), and values indicated by symbol W		XX	7,027	XX	6,688	XX	7,804
Total		**XX**	**313,345**	**XX**	**345,134**	**XX**	**362,921**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Excludes certain clays; kind and value included with "Combined value" data.

yearend 1989. Charles County produced the third highest quantity of sand and gravel among the counties in Maryland.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Portland cement, construction sand and gravel, and crushed stone accounted for $351 million, or nearly 97% of Maryland's nonfuel mineral production (table 1). Land use issues involving the question of mine development versus conservation continued to be a major concern of the industries producing these mineral commodities.

Other industrial minerals produced in Maryland included masonry cement, clays, lime, peat, dimension stone, and industrial sand. For the most part, these industries were small, long established, and stable operations; for these commodities, land use conflicts were not an issue.

Cement.—Portland cement was produced at three plants, and slag cement was produced at one plant. All four of the operations are less than 75 miles from markets in the Washington, DC, and Baltimore area. Because of strong demand, production remained at about 95% of capacity. In addition, about 411,000 short tons of imported cement was received at the Port of Baltimore in 1988, a 17% increase over the amount received during the previous year.

Lehigh Portland Cement Co. sought approval to open a new limestone quarry near New Windsor for use in cement manufacture at its Union Bridge plant. The State's Department of Natural Resources, Water Resources Administration, needed to approve the permit because groundwater is removed before mining the limestone. Public hearings on the matter were scheduled for 1989 and, pending permit approval, quarrying was expected to begin in 1990.

Sand and Gravel.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

Maryland construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data for the State's three districts.

Output of 19.3 million short tons in 1988 was slightly lower than 1987 levels. Despite the decline, production in 1988 was still the third highest total reported in the past 25 years. In 1988, sand and gravel was produced by 54 companies at 89 pits in 14 of Maryland's 23 counties. Prince Georges County led the State in output, followed by Anne Arundel and Charles Counties. Sand and gravel used for concrete aggregates accounted for more than one-half of the total sales. In the past 8 years, the price of sand and gravel has increased from $3.13 per ton to $4.94 per ton.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Record-setting production of crushed stone in Maryland continued for the fifth consecutive year with a 1988 total of 32.7 million tons. The construction industry remained the most significant consumer of crushed stone in Maryland. In 1988, highway and heavy construction, as measured by contract awards, increased by 30% over 1987 levels. In Prince Georges County, an estimated $10 billion in new construction work was underway or in the planning stages.[2]

During the year, Coplay Cement Co. requested permission from the Frederick County Planning Commission to expand operations at its limestone quarry near Buckeystown. The expansion was expected to enable the company to produce 850,000 tons of crushed limestone per year.[3] By yearend, Coplay had received

TABLE 2

MARYLAND: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	8,462	$46,006	$5.44
Plaster and gunite sands	335	872	2.60
Concrete products (blocks, bricks, pipe, decorative, etc.)	255	1,489	5.84
Asphaltic concrete aggregates and other bituminous mixtures	2,062	6,896	3.34
Road base and coverings[1]	950	2,295	2.42
Fill	661	1,397	2.11
Snow and ice control	24	78	3.25
Other[2]	133	714	5.37
Unspecified:[3]			
Actual	4,824	29,623	6.14
Estimated	1,561	5,801	3.72
Total[4] or average	**19,266**	**95,169**	**4.94**

[1] Includes road and other stabilization (lime).
[2] Includes filtration.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data may not add to totals shown because of independent rounding.

TABLE 3

MARYLAND: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	53	330	6,704	39,788	2,295	8,248
Asphaltic concrete aggregates and other bituminous mixtures	—	—	1,455	4,898	607	1,998
Road base and coverings[2]	—	—	783	1,974	167	321
Fill	—	—	332	674	329	722
Snow and ice control	—	—	22	72	2	6
Other miscellaneous[3]	11	97	122	616	([4])	1
Other unspecified[5]	—	—	6,011	34,134	375	1,290
Total[6]	**63**	**427**	**15,428**	**82,156**	**3,775**	**12,587**

[1] Includes sand and gravel for plaster and gunite sands.
[2] Includes sand and gravel for road and other stabilization (lime).
[3] Includes sand and gravel for filtration.
[4] Less than one-half of a unit.
[5] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[6] Data may not add to totals shown because of independent rounding.

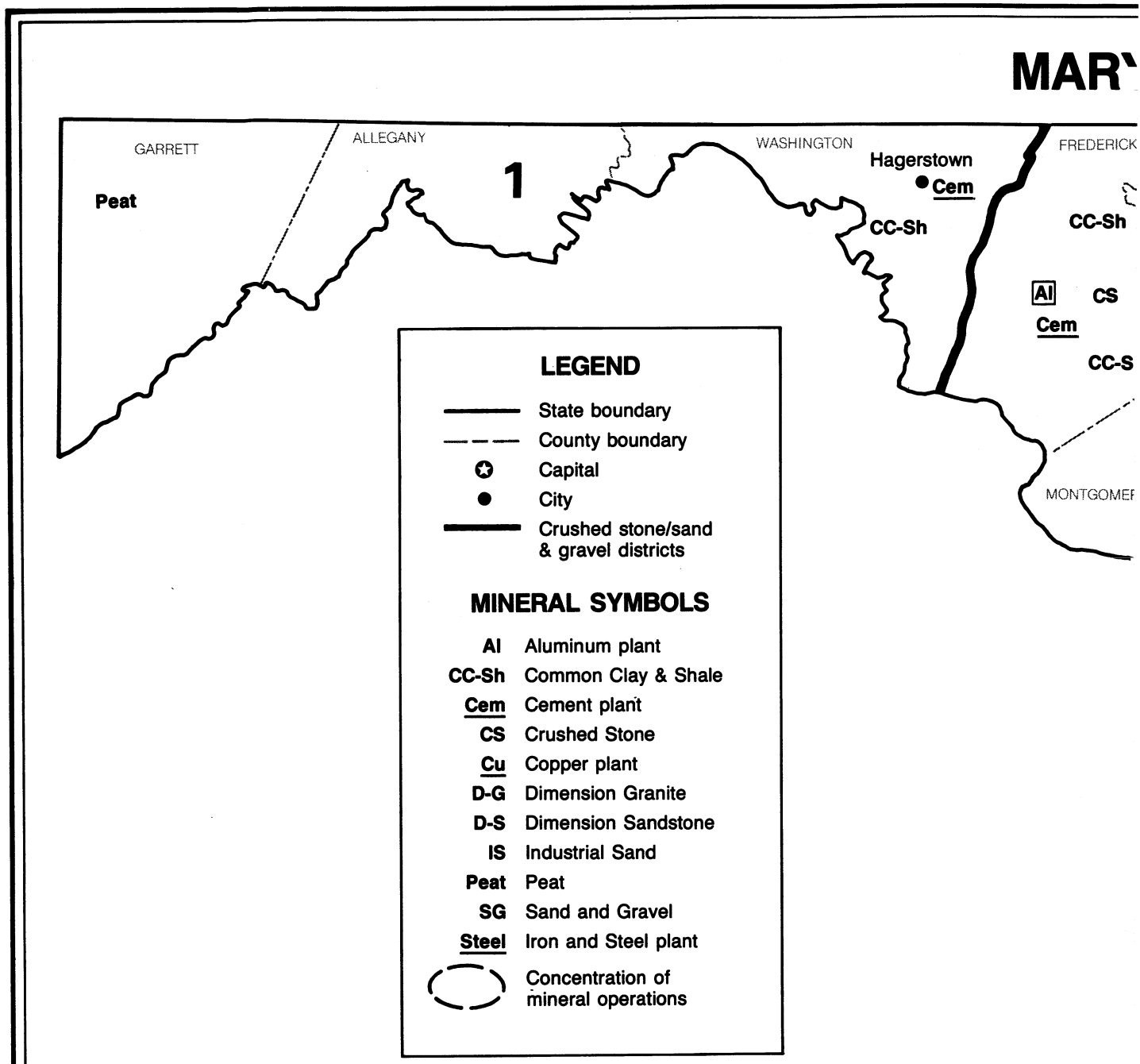
permission to construct a crushing facility; however, due to local opposition, the Planning Commission postponed a decision on the rezoning permit that was necessary before mining development could occur. Crushed stone producers attempting to open or expand operations in Carrol and Montgomery Counties were also involved in legal actions relating to zoning ordinances. Typically, these court cases take years to resolve and indirectly add to the cost of stone products.

Other Industrial Minerals.—The mineral commodities discussed below collectively accounted for about 3% of Maryland's value of nonfuel mineral production. Production of common clays increased for the third consecutive year as demand for brick used in construction remained strong. In 1988, clay was mined at six pits, the same number as in 1987. Baltimore Brick Co., one of the State's leading clay producers, completed a $3 million renovation project that increased production capacity for sand-cast bricks to 40 million brick per year at its Rocky Ridge plant.[4] The renovation project was undertaken because of architectural trends that showed that consumers prefer colonial-style construction, for which sand-cast bricks are used. Baltimore Brick is a division of Boral Bricks Inc., which is a subsidiary of Boral Ltd. of Sydney, Australia. S. W. Barrick & Sons Inc., at Woodsboro, the State's only lime producer, was purchased by Laurel Sand & Gravel Inc. in 1987 and ceased lime manufacturing in 1988. About 6,000 short tons of lime was sold from stockpile by Laurel in 1988. About 21,000 short tons of dimension granite, sandstone, and quartzite was produced at seven quarries. Most of the output was granite quarried in Montgomery County and sold as rough blocks. Two of the State's four portland cement producers also manufactured masonry cement at plants in Hagerstown and Union Bridge. One company produced industrial sand at a pit in Joppa, and one firm mined peat at a bog near Accident.

Mineral commodities processed in Maryland included those that were imported and those shipped from domestic sources. Crude gypsum imported from Canada was calcined for manufacturing wallboard by National Gypsum Co. and USG Corp. at plants in Baltimore. In 1988, about 652,000 short tons of gypsum was imported at the Port of Baltimore, according to data published by the Maryland Port Administration. SCM Chemicals Inc. operated one of eight domestic titanium dioxide plants in Baltimore. SCM also produced byproduct gypsum, which was sold locally for use in wallboard manufacture. W. R. Grace & Co., at Muirkirk in Prince Georges County, exfoliated crude vermiculite that was mined in South Carolina. Other mineral commodities imported into Maryland at the Port of Baltimore included iron ore (8.1 million short tons), bauxite (377,000 tons), salt (279,000 tons), ferroalloys (245,000 tons), clays (55,000 tons), and manganese ore (35,000 tons).[5]

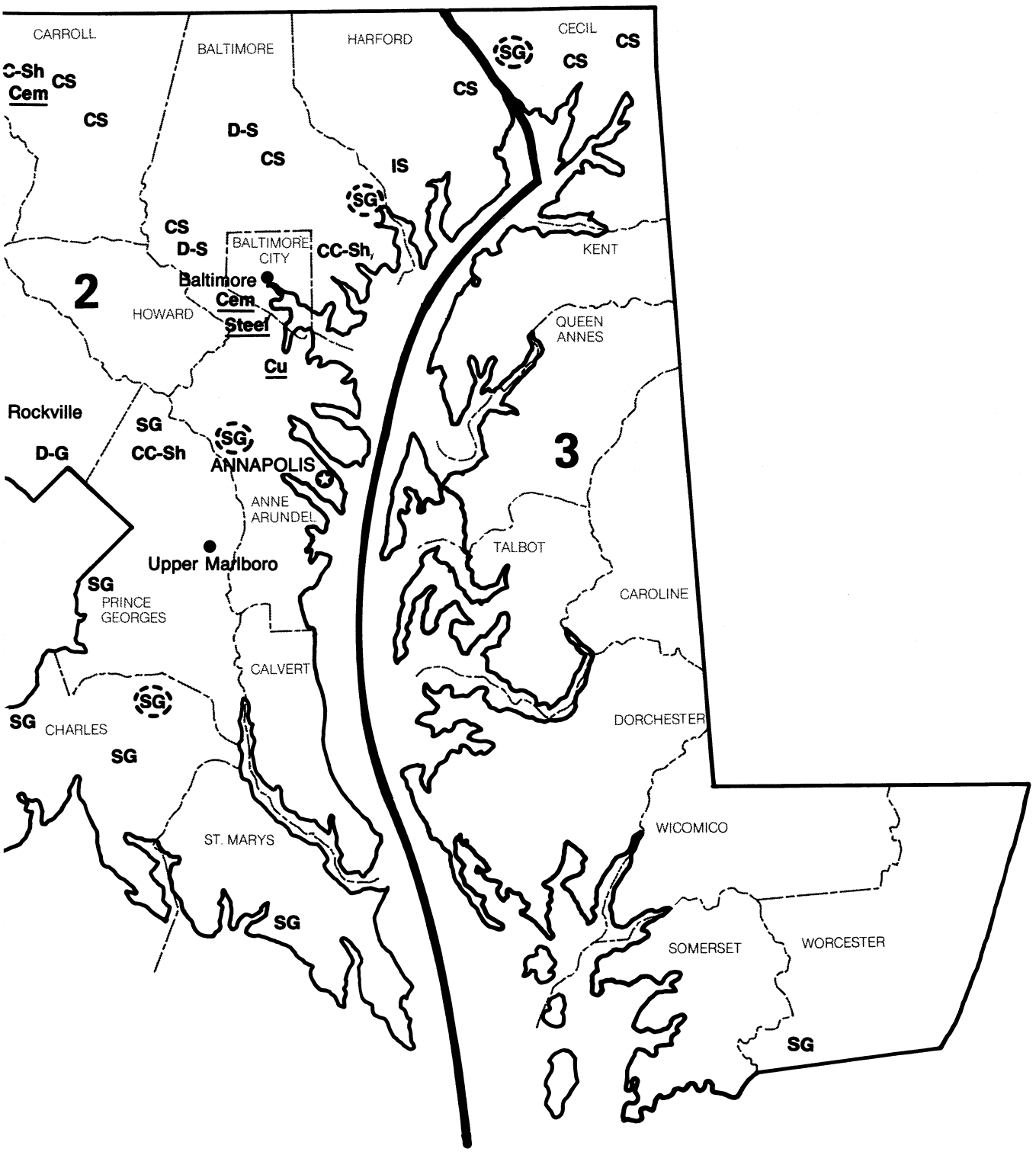
Metals

Metals discussed in this section were processed from materials received from both foreign and domestic sources. No



Principal Mineral-Producing Localities

AND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TALBOT
Upper Marlboro
PRINCE GEORGES
CAROLINE
CALVERT
DORCHESTER
CHARLES
ST. MARYS
WICOMICO
SOMERSET
WORCESTER

metalic ores were mined in Maryland. Production and value data for these processed metals, which are not included in table 1, are given if available.

Aluminum.—Eastalco Aluminum Co., a subsidiary of Alumax Inc., continued to produce aluminum at its smelter near Frederick. In 1988, the company operated at its full capacity of 160,000 metric tons per year.[6] The United States produced over 3.9 million tons of aluminum during the year, approximately 99% of domestic capacity, reflecting strong demand and higher prices for aluminum nationwide.

Copper.—Cox Creek Refining Co. at Baltimore began limited production at the 180,000-short-ton-per-year-capacity refinery that it purchased from Kennecott Refining Corp. in 1987. Cox Creek joined Mitsubishi Metal America, Halstead Industries Inc., and Southwire Co. (each of these 3 owning a 20% interest in the company) to reopen the refinery, which had been closed since 1983.

Iron and Steel.—Maryland's iron and steel industry was dominated by one producer, Bethlehem Steel Corp., at Sparrows Point. In 1988, demand for steel increased along with production. Bethlehem's facility at Sparrows Point set a production record with output of 3.2 million short tons of steel. In addition, the company exceeded the design capacity (2.9 million tons) of its two-strand continuous slab caster.[7]

Cyclops Industries Inc. purchased Eastern Stainless Steel Co. in Baltimore for a reported $58 million.[8] Cyclops continued production of stainless steel plate and expected to restart sheet operations in 1989. The company also planned to increase output of stainless hot rolled coils for processing at its Coshocton, OH, plant.

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[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA.

[2] American Metal Market. Increased Product Prices Offset Ferrous Costs: N. J. Steel. V. 96, No. 202, Oct. 14, 1988, p. 10.

[3] Frederick (MD.) Post. Coplay Expansion Decision Postponed. Aug. 25, 1988, p. 4.

[4] The Daily Record (Baltimore, MD). Old Bricks Make New Business. Sept. 20, 1988, Sec. C, p. 3.

[5] Maryland Port Administration. Foreign Commerce Statistical Report 1988. World Trade Center, Baltimore, MD 21202-3041, 267 pp.

[6] American Metal Market. Aluminum Ingot Capacity. V. 96, No. 249, Dec. 23, 1988, p. 8.

[7] ———. Northeast Steel Production Climbs Almost 3.2%. V. 97, No. 18, Jan. 20, 1988, p. 8.

[8] ———. Eastmet's Eastern Stainless Bought by Cyclops for $58M. V. 96, No. 150, Aug. 2, 1988, p. 16.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Eastalco Aluminum Co. (Alumax Inc.)	5601 Manor Woods Rd. Frederick, MD 21701	Reduction plant	Frederick.
Cement:			
Portland:			
Coplay Cement Co., (Société des Ciments Francais)	4120 Buckeystown Pike Lime Kiln, Box D Frederick, MD 21701	Quarry and plant	Do.
Portland and masonry:			
Independent Cement Corp. (St. Lawrence Cement Inc.)	Box 650 Hagerstown, MD 21740	do.	Washington.
Lehigh Portland Cement Co.[1] (Heidelberger Zement AG)	Box L Union Bridge, MD 21791	do.	Carroll.
Slag:			
Blue Circle—Atlantic (Blue Circle Industries PLC)	Box 6687 Sparrows Point, MD 21219	Plant (slag cement)	Harford.
Clays:			
Common clay and shale:			
Baltimore Brick Co.	110 West Rd. Baltimore, MD 21204	Pit and plants	Frederick.
Maryland Clay Products Inc. (Borden Brick & Tile Co.)	7100 Muirkirk Rd. Beltsville, MD 20705	do.	Frederick and Prince Georges.
Victor Cushwa & Sons Inc.	Clearspring Rd. & Rt. 68N Box 160 Williamsport, MD 21795	Pit and plant	Washington.
Copper:			
Cox Creek Refining Co.	Box 3407 Baltimore, MD 21226	Refinery	Anne Arundel.
Gypsum:			
Byproduct:			
SCM Chemicals Inc.[2]	3901 Glidden Rd. Baltimore, MD 21226	Plant	Baltimore.
Calcined:			
National Gypsum Co., Gold Bond Building Products Div.	2301 South Newkirk St. Baltimore, MD 21224	do.	Do.
USG Corp.	500 Quarantine Rd. Box 3472 Baltimore, MD 21226	do.	Do.
Iron and steel:			
Bethlehem Steel Corp.	Sparrows Point, MD 21219	Mill (integrated)	Do.
Peat:			
Garrett County Peat Products	R.F.D. 1, Box 91 Accident, MD 21520	Bog and plant	Garrett.
Sand and gravel:			
Construction:			
Charles County Sand & Gravel Inc.	Box 322 Waldorf, MD 20601	Pits and plants	Anne Arundel, Charles, St. Mary's.
Florida Rock Industries Inc.	Box 273 Leonardtown, MD 20670	Pits	Harford and St. Mary's.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Genstar Stone Products Co.	1000 Beaverdam Rd. Cockeysville, MD 21030	Pits and plants	Baltimore.
Laurel Sand & Gravel Inc.	Box 719 Laurel MD 20810	Pits	Anne Arundel and Prince Georges.
York Building Products Co. Inc.	Box 1708 York, PA 17405	Pit	Cecil.
Industrial:			
Harford Sands Inc.	Box 25 40 Fort Hoyle Rd. Joppa, MD 21085	Pits	Harford.
Stone:			
Crushed:			
The Arundel Corp.[3]	110 West Rd. Baltimore, MD 21204	Quarries and plants	Baltimore, Frederick, Harford.
Genstar Stone Products Inc.[3]	Executive Plaza 4 11350 McCormick Rd. Hunt Valley, MD 21031	do.	Baltimore, Carroll, Frederick, Harford.
Maryland Materials Inc.	Box W North East, MD 21901	Quarry and plant	Cecil.
Rockville Crushed Stone Inc.	Box 407 13900 Piney Meetinghouse Rd. Rockville, MD 20850	do.	Montgomery.
Dimension:			
Patapsco Natural Stone Quarry Inc.	Marriotsville Rd. Marriotsville, MD 21104	do.	Baltimore.
Stoneyhurst Quarries	Box 34463 8101 River Rd. Bethesda, MD 20817	do.	Montgomery.
Weaver Stone Co.	15027 Falls Rd. Butler, MD 21023	do.	Baltimore.
Vermiculite (exfoliated):			
W. R. Grace & Co., Construction Products Div.	12340 Conway Rd. Beltsville, MD 20705	Plant	Prince Georges.

[1] Also crushed stone.
[2] Also titanium dioxide (pigments).
[3] Also sand and gravel.

THE MINERAL INDUSTRY OF MASSACHUSETTS

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Commonwealth of Massachusetts, Executive Office of Environmental Affairs, for collecting information on all nonfuel minerals.

By Donald K. Harrison[1] and Joseph A. Sinnott[2]

The value of nonfuel mineral production in 1988 was approximately $192 million, an increase of almost $16 million compared to the 1987 value. The combined value of construction sand and gravel and crushed stone, the State's two leading mineral commodities, accounted for nearly 90% of the value. In 1988, the State ranked fifth among 35 States that produced dimension stone. Massachusetts ranked 11th of the 50 States that produced construction sand and gravel, even though the State ranked 45th in the Nation in total land area.

Although the 1988 output of construction sand and gravel (the State's leading mineral commodity) was essentially unchanged from that of 1987, unit value increased from $3.44 per short ton in 1987 to $4.19 per short ton in 1988. Shipping costs have also increased because of urban encroachment, competition from land developers, and stricter environmental regulations have forced many producers to mine aggregates further from the consuming areas.

TRENDS AND DEVELOPMENTS

Because demand for mineral aggregates is almost totally dependent on construction activity, there is usually a correlation between aggregate output and construction contracts awarded. In 1988, total residential building permits authorized fell nearly 20%. However, the dampening of the residential market did not impede continued growth in the State's construction industry. This industry added 14,300 new jobs on the strength of continued growth in commercial and industrial real estate. As a result, production of construction sand and gravel and crushed stone in 1988 remained essentially unchanged from 1987 levels.

In December, Patriot Energy announced plans to construct a $425 million, 240-megawatt, coal-burning energy, cogeneration plant near Ayer. A cogeneration plant produces two kinds of energy—electricity and steam. According to the company, the electricity would be sold to Boston Edison under a 20-year contract, and the steam would be sold to local businesses. In addition to the coal that would be consumed at the plant, limestone would also be utilized in the plant's fluidized bed combustion system. Before the plant could be built, Patriot Energy had to obtain both local and State site approval, as well as necessary environmental permits.

Several developments in the advanced materials sector occurred during the year. In August, the U.S. Department of Defense signed a $5.6 million, 3-year contract with Ceramics Process Systems Corp., Cambridge, to develop a superconducting motor designed to use high-temperature ceramic superconducting wire. Under the contract, Ceramics Process was to be the prime contractor on the project. Superconducting motors were expected to provide dramatic improvements in size, weight, and electrical performance. A working motor was expected to be produced by 1990.

TABLE 1

NONFUEL MINERAL PRODUCTION IN MASSACHUSETTS[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	139,995	$871	W	W	W	W
Gem stones		NA	W	NA	$1	NA	$1
Sand and gravel:							
Construction	thousand short tons	19,200	60,464	e21,800	e75,300	22,168	79,364
Industrial	do.	45	739	56	922	W	W
Stone:							
Crushed	do.	e10,000	e50,000	14,907	78,969	e17,500	e91,900
Dimension	short tons	e78,728	e14,928	76,579	12,747	W	W
Combined value of lime, peat, and values indicated by symbol W		XX	7,395	XX	8,583	XX	20,973
Total		**XX**	**134,397**	**XX**	**176,522**	**XX**	**192,238**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

The Advanced Ceramics unit of Norton Co. began production of prototype components to commercialize transformation-toughened zirconia (TTZ) ceramics at a pilot plant in Worcester. TTZ is formed through a fusion process using zirconium oxide. The crystalline phase of the fabrication process provides the toughening mechanism for the TTZ ceramic. Besides fabricating ceramic components, the Norton Co. facility also was vertically integrated to produce TTZ powder.

In February, Norton and the Torrington Co., a Connecticut-based subsidiary of Ingersoll Rand Co., formed the Cerbec Ceramic Bearing Co. as a joint venture to design, manufacture, and market ceramic bearings and components for the aerospace, defense, machine tool, biotechnology, and automotive industries. The partnership expected the ceramic bearings market to reach sales of $100 million by the end of the century.

At least two joint ventures in advanced materials were announced by Massachusetts firms during the year. American Superconductor Corp., Cambridge, and Inco Alloys International, Huntington, WV, indicated that they would use their respective areas of expertise to develop high-volume manufacturing techniques for high-temperature superconductors. Inco Alloys was to use its proprietary mechanical alloying technology to manufacture the precursors, primarily barium-copper and bismuth-strontium-calcium alloys. American Superconductor would then use its expertise to transform the precursors into superconductors. Norton Co., Worcester, an abrasives manufacturer, and the Torrington Co., CT, established a joint venture to design, manufacture, and market ceramic bearings and components for the aerospace, defense, machine tool, biotechnology, and automotive industries.

REGULATORY ISSUES

Acid rain, radon gas exposure, waste disposal, ground water contamination, and wetlands destruction were among the primary environmental concerns in the State. In the case of acid rain, Massachusetts joined eight other States in filing suit against the U.S. Environmental Protection Agency to force the agency to order new pollution controls for the Midwestern States. Besides Massachusetts, the plaintiff States were Connecticut, Maine, Minnesota, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. The Canadian Province of Ontario and two national environmental organizations also filed a similar suit during the year.

Near yearend, the Massachusetts Department of Environmental Quality announced that construction of new resource recovery plants had been banned for a year, while the State put more emphasis on recycling as an alternative to burning or landfilling solid waste. The moratorium affected only planned facilities that had not obtained a draft permit for operation and did not shut down any of the six existing plants in the State or the two that had already received draft permits. Massachusetts' Solid Waste Act calls for 50% incineration of solid waste, 25% recycling, and 25% landfilling. Although the State exceeded its 50% incineration goal, it recycled only 8% to 10% of its waste in 1988.[3]

LEGISLATION AND GOVERNMENT PROGRAMS

Under the ongoing State Mining and Mineral Resources Research Institute Program Act, the U.S. Bureau of Mines awarded an allotment grant of $138,000 to the Massachusetts Institute of Technology to support basic research in the mineral sciences. Under stipulations of the act, the State was to match the grant to the university on a 2-to-1 basis. The Bureau also awarded $354,193 in research grants and allotments for mineral-related studies to seven private firms in the State.

Massachusetts was one of five New England States that shared $178,463 in Federal grants to be used for mine safety and health programs. The grants, given by the U.S. Labor Department's Mine Safety and Health Administration, are determined by the number of mines in each State and the State's plan for conducting mine safety and health activities. Massachusetts received the largest grant at $72,681 (41%); other New England States receiving grants included Connecticut, Maine, New Hampshire, and Rhode Island.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Abrasives.—Norton Co., the world's leading manufacturer of abrasives, produced bonded and coated abrasives at its plant in Worcester. Washington Mills Abrasive Co., North Grafton, processed emery from a mine in New York for use as a nonslip additive for floors, pavements, and stair treads.

Clays.—Two companies, both in Plymouth County, mined common clay for the manufacture of face brick.

After months of hearings and public opposition, the Board of Selectmen of the town of Hubbardston granted a mining permit to Kataistos Inc., a clay mining firm. The company planned to sell the clay to landfill operators for use as cover.

Graphite (Manufactured).—Two companies, both in Lowell, Middlesex County, produced high-modulus graphite fibers used primarily by the aerospace industry.

Gypsum (Calcined).—Crude gypsum, shipped into the State from company-owned mines in other States and Canada, was calcined by USG Corp. at a plant in Suffolk County near Boston. The calcined gypsum was

made into wallboard and shipped throughout New England primarily for use in residential construction.

Lime.—Two companies continued to manufacture lime in Berkshire County from locally quarried limestone. The lime was shipped within Massachusetts and to New York, Connecticut, and other States for use by the agricultural, chemical, and construction industries.

Peat.—Reed-sedge peat was produced by Sterling Peat Co., Worcester County, in the north-central part of the State and was used primarily for agricultural purposes. All of the material was sold in packaged form.

Perlite (Expanded).—Whittemore Products Inc. expanded crude perlite shipped from New Mexico at its plant in Essex County. The expanded perlite was used in lightweight aggregate and as a horticultural medium.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1987. Data for odd-numbered years are based on annual company estimates.

Massachusetts construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data for the State's three districts.

The value of construction sand and gravel accounted for the second largest portion (41%) of the State's total mineral value. In 1988, 100 companies mined construction sand and gravel from 110 operations in 12 counties. Leading counties in order of output were Worcester, Middlesex, and Plymouth. The material was used mainly for concrete aggregates, fill, and road base and coverings.

At least two aggregate producers in Massachusetts were purchased by British aggregate firms in 1988, continuing a trend in the United States that has been apparent since the beginning of the decade. In May, the Bardon Group, United Kingdom, purchased the assets of Trimont Bituminous Products in Everett. The acquisition included two quarries and one sand and gravel plant in the State. Another British company planning to expand in the northeastern United States aggregate market was Egerton Trust PLC. In August, the company paid $4.8 million for Direnzo Brothers Sand & Gravel Inc., near Sutton and Worcester. Direnzo Brothers was a family-owned company that supplied both ready-mixed concrete and aggregates. In June 1987, Egerton Trust had announced its intention to purchase the Massachusetts-based aggregates business, Emaral Corp. The acquisition cost totaled $29.3 million, of which $15 million remained outstanding until the performance appraisal of the operations to be made at the end of 1990. Based in the Worcester and Springfield areas, Emaral operates a 2.5-million-short-ton-per-year sand and gravel pit and a ready-mixed concrete plant. Emaral owned about 850 acres of aggregate-bearing land in the State.

Industrial.—Two companies, one each in Middlesex and Plymouth Counties, produced industrial sand primarily for use in molding, coremaking and in sandblasting.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

Crushed.—Crushed stone was the State's leading mineral commodity, accounting for 48% of the State's total value. Production remained essentially

TABLE 2

MASSACHUSETTS: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	4,202	$21,306	$5.07
Plaster and gunite sands	68	567	8.34
Concrete products (blocks, brick, pipe, decorative, etc.)	60	458	7.63
Asphaltic concrete aggregates and other bituminous mixtures	611	2,401	3.93
Road base and coverings[1]	1,737	6,802	3.91
Fill	2,878	6,026	2.09
Snow and ice control	552	2,595	4.70
Railroad ballast	W	W	9.75
Other	886	3,268	3.68
Unspecified:[2]			
Actual	8,949	30,848	3.44
Estimated	2,224	5,094	2.29
Total[3] or average	**22,168**	**79,364**	**3.58**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes road and other stabilization (lime).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

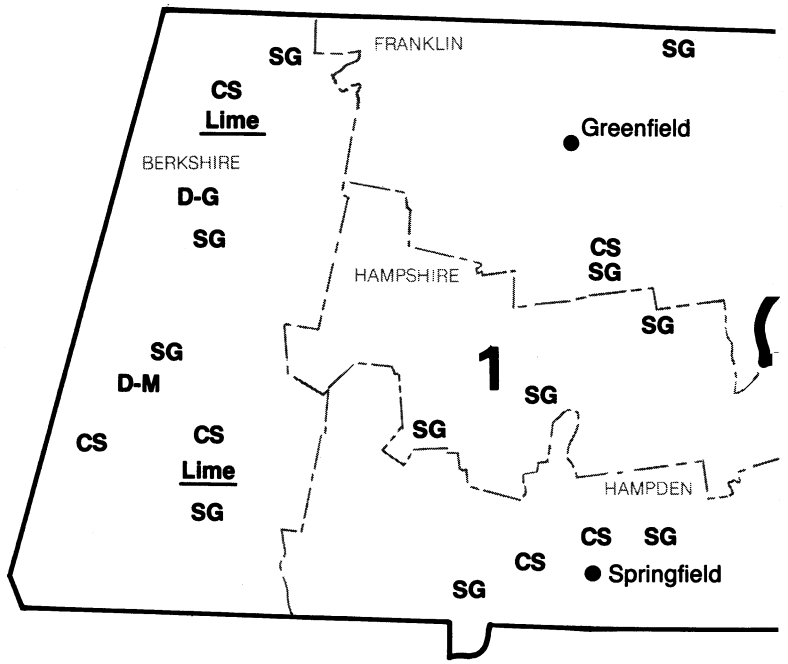
MASSA

LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

CC	Common Clay
CS	Crushed Stone
D-G	Dimension Granite
D-M	Dimension Marble
Gyp	Gypsum plant
Lime	Lime plant
Peat	Peat
SG	Sand and Gravel



Principal Mineral-Producing Localities

USETTS

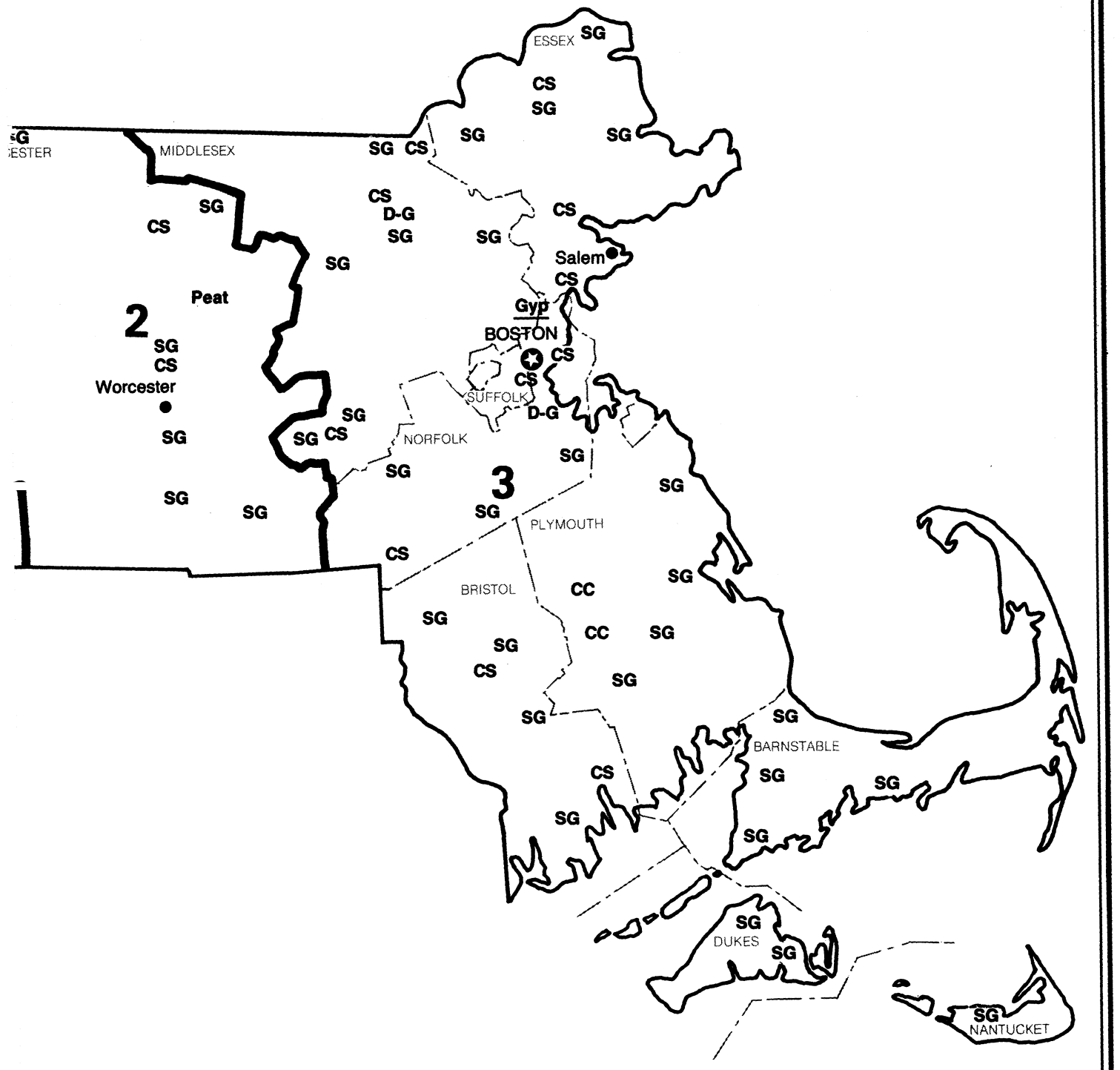

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TABLE 3

MASSACHUSETTS: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	1,097	4,981	987	3,584	2,246	13,766
Asphaltic concrete aggregates, and road base and coverings[2]	578	2,890	1,061	3,256	710	3,056
Fill	646	1,103	1,304	2,761	928	2,162
Snow and ice control	132	510	223	925	197	1,160
Railroad ballast	—	—	W	W	—	—
Other miscellaneous	451	869	12	47	423	2,351
Other unspecified[3]	1,431	2,152	1,601	4,300	8,141	29,490
Total[4]	**4,334**	**12,506**	**5,188**	**14,873**	**12,646**	**51,985**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for plaster and gunite sands.
[2] Includes sand and gravel for road and other stabilization (lime).
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data may not add to totals shown because of independent rounding.

the same in 1987. Traprock (basalt) accounted for the majority of the stone produced, followed by granite and limestone. Major uses included road and concrete aggregates.

Dimension.—Massachusetts ranked fifth nationally in dimension stone input. Dimension granite was quarried in Berkshire, Middlesex, and Plymouth Counties primarily for curbing. A small amount of dimension marble was also quarried and sold as rough blocks.

Near yearend, Australia's Pioneer International Ltd. acquired Fletcher Granite Co. Inc. in Chelmsford. The acquisition was made through Pioneer's U.S. subsidiary, Pioneer Concrete of America, and became effective on January 3, 1989. The acquisition price was not disclosed. Fletcher operated six granite quarries throughout New England, one in Massachusetts and the others in New Hampshire and Maine. The acquisition, Pioneer's first in New England, gives the company substantial granite reserves, which are ideally located to serve the Boston area.[4]

Vermiculite (Exfoliated).—W. R. Grace & Co. exfoliated imported vermiculite at its Easthampton plant in Hampshire County. Major uses included insulation and fireproofing.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA.

[2] State geologist, Executive Office of Environmental Affairs, Boston, MA.

[3] World Wastes. V. 32, No. 1, 1989, p. 16.

[4] Rock Products. V. 92, No. 2, 1989, p. 9.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Clays:			
K–F Brick Co. Inc.	River St. Middleboro, MA 02346	Pit	Plymouth.
Stiles & Hart Brick Co.	Box 367 Bridgewater, MA 02324	Pit	Do.
Graphite (synthetic):			
Avco Corp.	1275 King St., Box 9000 Greenwich, CT 06836	Plant	Middlesex.
The Stackpole Corp.	Foundry Industrial Park Lowell, MA 01852	do.	Do.
Lime:			
Lee Lime Corp.[1]	Marble St. Lee, MA 01238	Plant and quarry	Berkshire.
Pfizer Inc.[1]	260 Columbia St. Adam, MA 01220	do.	Do.
Peat:			
Sterling Peat Co.	Sterling Junction, MA 01565	Bog	Worcester.
Sand and gravel:			
Construction:			
Kimball Sand Co. Inc.	Box 29 Mendon, MA 01756	Pit	Worcester.
P. A. Landers Inc.	Box FF Hanover, MA 02339	Pit	Plymouth.
Lone Star Industries Inc.	Ayer Road Littleton, MA 01460	Plant	Middlesex.
S. M. Lorusso & Sons Inc.	230 West Street Walpole, MA 02081	Pit	Norfolk.
Nemasket Sand and Gravel Corp.	Box 131 No. Carver, MA 02355	Pit	Plymouth.
Industrial:			
Holliston Sand Co. Inc.	303 Lowland St., Box 97 Holliston, MA 01746	Pit	Do.
Whitehead Bros. Co.	259 River Rd. Leesburg, NJ 08327	Pit	Plymouth.
Stone:			
Crushed:			
John S. Lane & Son Inc.	730 East Mountain Rd. Westfield, MA 01085	Quarries	Berkshire, Hampden, Hampshire.
S. M. Lorusso & Sons Inc.	331 West St. Walpole, MA 02081	do.	Middlesex, Norfolk, Suffolk.
Simeone Corp.	1185 Turnpike St. Stoughton, MA 02072	do.	Bristol and Norfolk.
Tilcon Inc.	Box 114 Acushnet, MA 02743	Quarry	Bristol.
Trimount Bituminous Products Co.	1935 Revere Beach Parkway Everett, MA 02149	Quarries	Essex.
Dimension:			
Fletcher Granite Co. Inc.	Groton Rd. West Chesterford, MA 01863	Quarry	Middlesex.
Williams Stone Co. Inc.	Box 278 East Otis, MA 01029	do.	Berkshire.
Vermiculite (exfoliated):			
W. R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	Plant	Hampshire.

[1] Also stone.

THE MINERAL INDUSTRY OF MICHIGAN

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Geological Survey Division, Michigan Department of Natural Resources for collecting information on all nonfuel minerals.

By James J. Hill[1]

Michigan's nonfuel mineral production was valued at nearly $1.6 billion in 1988, a gain of 16% over the 1987 value. In terms of value, this was a record year, with all commodities registering gains in production except for calcium chloride, copper, gypsum, silver, and dimension stone. Output of copper and byproduct silver declined because of a major roof fall at the White Pine Mine that damaged equipment and hindered production. Gypsum sales were down slightly due to higher interest rates and fewer housing starts.

Nationally, Michigan ranked fourth in value of nonfuel mineral production and accounted for more than 5% of the U.S. total. The State was the leading producer of calcium chloride, crude iron oxide pigments, peat, and magnesium compounds. It ranked second in production of bromine, iron ore, and sand and gravel (both construction and industrial). In terms of value, iron ore was the State's leading mineral commodity, followed by portland cement and construction sand and gravel. Industrial minerals accounted for 57% of the State's total mineral value.

EMPLOYMENT

According to figures provided by the Michigan Employment Security Commission, the State's civilian work force totaled 4.6 million in 1988, a slight increase over the 1987 total. Of the total work force, 134,000 persons were employed in the Upper Peninsula, little changed from the 1987 figure. The State's unemployment rate averaged 7.6% in 1988, down from 8.2% in 1987. In the Upper Peninsula, unemployment averaged 8.8%, down from the 10.5% rate reported in 1987. Mining employment in the State averaged 10,500 persons, a 6% increase over the 1987 figure. Of these mine workers, 3,600 were employed in the Upper Peninsula, an increase of nearly 6%. No strikes were reported in the Michigan mining industry in 1988.

EXPLORATION ACTIVITIES

Michigan did not conduct a metallic mineral lease sale in 1988 because of a poor response from the mining industry to an offer for bids. Approximately 9,400 acres in the Upper Peninsula were

TABLE 1

NONFUEL MINERAL PRODUCTION IN MICHIGAN[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	257	$17,026	263	$23,004	265	$22,915
Portland	do.	4,713	216,120	4,755	207,332	5,253	231,141
Clays	short tons	1,402,446	5,684	1,333,498	5,338	1,375,816	4,432
Gem stones		NA	25	NA	25	NA	25
Gypsum	thousand short tons	1,979	11,052	1,977	12,190	1,958	11,630
Iron ore	thousand metric tons	11,133	W	12,509	W	14,623	W
Lime	thousand short tons	556	27,257	569	30,320	714	36,088
Peat	do.	324	6,599	281	5,290	342	6,256
Sand and gravel:							
Construction	do.	42,514	91,886	e42,800	e105,300	53,508	138,171
Industrial	do.	3,343	29,493	2,792	22,451	3,045	27,150
Stone:							
Crushed	do.	e27,800	e83,900	37,909	109,514	e38,800	e120,300
Dimension	short tons	e5,863	e148	W	W	W	W
Combined value of bromine, calcium chloride (natural), copper, gold, iron oxide pigments (crude), magnesium compounds, salt, silver, and values indicated by symbol W		XX	750,393	XX	844,846	XX	989,453
Total		**XX**	**1,239,583**	**XX**	**1,365,610**	**XX**	**1,587,561**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

under lease for metallic minerals exploration and development at yearend. Six companies drilled 56 test holes on private and State leases during 1988 in Dickinson, Gogebic, Iron, and Marquette Counties. Drilling totaled 38,795 feet. Mining company interest was focused on precious metals and diamonds.

Callahan Mining Corp. continued its exploration program in the Marquette Greenstone Belt, seeking to supplement limited reserves at its Ropes Gold Mine near Ishpeming. The company had more than 40,000 acres under lease from Cleveland-Cliffs Iron Co. and other companies.

During 1988, Dow Chemical Co. sold its diamond exploration project in the Upper Peninsula to Crystal Exploration Inc., a subsidiary of Restech International Ltd. of Sydney, Australia, for an undisclosed sum. Dow had been actively exploring for diamonds in the area since 1982, after a kimberlite deposit was described near Lake Ellen, northeast of Crystal Falls. Subsequently, Dow found six other kimberlite pipes, some of which have yielded microdiamonds. Crystal Exploration planned to continue sampling the pipes already discovered and search for other kimberlite bodies.

SHIPPING

The U.S. Army Corps of Engineers reported that the 1988 commercial navigation season through the U.S. locks at Sault Ste. Marie began on March 22 and ended on January 15, 1989, 300 days later. This was the second consecutive year of extended shipping through the locks, which normally open on April 1 and close on December 15. Increased demand for raw materials, plus lower lake levels that forced shippers to lighten cargos, prompted the Corps of Engineers to extend the shipping season. In 1988, a total of 5,319 cargo carriers passed through the locks, an increase of 215 over the 1987 season. Total tonnage passing through the locks was nearly 90.7 million short tons, an increase of nearly 4.9 million tons over the 1987 tonnage. Table 2 summarizes mineral commodity traffic passing through the locks in 1987 and 1988.

The Lake Carriers Association reported that shipments of iron ore from U.S. Great Lakes ports totaled 51.9 million long tons in 1988, a 10% increase over the 47.1 million tons shipped in 1987. Michigan shipments from the Ports of Escanaba and Marquette totaled 14.5 million tons in 1988, a 12% increase over the 13.0 million tons shipped in 1987.

LEGISLATION AND GOVERNMENT PROGRAMS

Two mineral-related pieces of legislation were enacted into law in 1988. In early January, Public Act 277 of 1987 was signed by the Governor. This act amended existing legislation to tax a power generating facility for a low-grade iron ore property under the specific tax for low-grade iron ore properties instead of under the general property tax. The legislation had been introduced to provide tax relief to Cleveland-Cliffs Iron Co. for the 1987 tax year only.

Public Act 188 of 1988 created a forest and mineral resources development fund that would be supported by annual appropriations from the State's general fund. The fund was to be administered by a governing board that would provide advice and recommendations to the Legislature, Governor, and executive departments on ways to stimulate the State's forest and mineral industries. Grants would be distributed to academic and industry researchers to promote new technologies, products, and marketing techniques for the two industries.

On the Federal level, Michigan legislators introduced bills in the House and Senate to establish a National Historic Park in the Calumet area to recognize the Michigan native copper district on the Keweenaw Peninsula and its contributions to the Nation. Congress adjourned before the bills could be acted upon, but similar legislation was expected to be introduced in the 1989 session.

The Michigan Geological Survey Division continued its regulatory func-

TABLE 2

MICHIGAN: MINERAL PRODUCTS SHIPPED THROUGH THE SAULT STE. MARIE LOCKS

(Short tons)

Commodity	1987	1988
Cement	296,237	293,735
Coal	15,880,174	16,022,092
Iron ore	43,267,148	47,975,937
Iron and steel (manufactured), pig iron	499,091	740,635
Potash	1,676,495	1,696,209
Salt	308,046	340,786
Scrap (ferrous)	19,472	50,308
Stone[1]	2,909,199	4,497,131
Total	**64,855,862**	**71,616,833**

[1] Includes broken stone, gravel, and sand.

Source: U.S. Army Corps of Engineers, Detroit District.

tions for oil and gas production, drilling and plugging of mineral test wells, and sand dune mining. Severe budget constraints have limited the Survey's programs in basic geology and geologic research in recent years. In 1988, some funding support was awarded to Michigan Technological University (Michigan Tech) students and faculty engaged in mapping precious metal occurrences and graphite resources in the Upper Peninsula. The Survey continued to collect information for the Statewide Groundwater Database Project that will aid in the State's management and protection of ground water resources. Publications released during 1988 included an open file report on an investigation of manganese occurrences in Keweenaw County conducted by Michigan Tech personnel.

Scientists in the Mineral Technology Research Group at Michigan Tech evaluated graphite resources in Baraga and Marquette Counties and the mineral's possible utilization. Significant deposits of amorphous graphite are found in shales in the area that contain 15% to 35% carbon. The material may be utilized as a reducing agent in metallurgical processes or as an ingredient in the manufacture of portland cement. Michigan Tech was awarded an $85,000 grant from the Eastern Upper Peninsula Regional Planning and Development Commission to conduct a 1-year study of Michigan's limestone-dolomite resources and alternate uses. Limestone-dolomite from the eastern Upper Peninsula is utilized largely by the steel and construction industries, which are cyclical in nature and suffer from high unemployment rates in periods of slack demand. One use to be investigated is the manufacture of calcium magnesium acetate, from the region's dolomite resources, that may be used as a substitute for road salt with less adverse environmental effects.

The Mining and Mineral Resources Research Institute at Michigan Tech received $303,005 passed through the U.S. Bureau of Mines under Public Law 98-409, which makes funds available to research institutions to assist in the training of engineers and scientists in mineral-related disciplines.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Bromine.—Michigan was the lesser of two States in bromine production, following Arkansas. All production was from Dow Chemical's plant at Ludington in Mason County. Output and attendant value were estimated to have increased 33% and 78%, respectively, in 1988, compared with 1987 figures. All of the Michigan product was shipped to Arkansas for processing before being used or sold to consumers.

Calcium Chloride.—Michigan was the leading U.S. producer of calcium chloride, far outranking production in California and Washington. Two companies produced calcium chloride from well brine: Dow had operations in Mason and Midland Counties, and Wilkinson Chemical Corp. conducted an operation in Lapeer County. Production and attendant value declined in 1988. Dow markets calcium chloride as pellets and flake. Wilkinson markets its product in solution only.

Cement.—Nationally, Michigan ranked fourth and fifth, respectively, in sales of portland and masonry cement, after ranking fifth and sixth in 1987. Sales of portland cement increased more than 10% in 1988, while masonry cement sales increased about 1,500 tons. Portland cement sales averaged $44.00 per short ton in Michigan, whereas total U.S. sales averaged $48.27 per ton. Sales of masonry cement in the State averaged $86.47 per short ton, considerably higher than average U.S. sales of $68.25 per ton.

Michigan's five cement plants operated at approximately 84% of their finish grinding capacity during 1988, compared with 77% in 1987. Dundee Cement Co. and St. Marys Peerless Cement Co. operated wet-process plants; Medusa Cement Co. and Lafarge Corp. operated dry-process plants; and Aetna Cement Corp. operated a grinding plant only. Downtime for maintenance at the nine kilns of the four producing plants averaged 61 days. All companies sold gray portland Types I and II, general use and moderate heat, and all but Medusa sold Type III, high-early-strength. Medusa reported sales of small amounts of white portland and waterproof portland cements, and Dundee sold some portland pozzolan cement. All except Dundee had sales of masonry cement. The State's cement sales were to ready-mixed concrete companies (75%), concrete product manufacturers (13%), highway contractors (7%), and building materials dealers (4%). Most shipments to consumers were by truck in bulk form.

Approximately 9.1 million short tons of raw materials was consumed in the manufacturing process, including 6.6 million tons of limestone, 1.5 million tons of clay and shale, 228,000 tons of gypsum, and lesser quantities of anhydrite, clinker, fly ash, iron ore, sand, and other materials.

Cement shipments to and within Michigan included 2.7 million tons of portland cement and 152,000 tons of masonry cement. Compared with 1987, this was a decrease of 20,000 tons of portland cement and an increase of 6,000 tons of masonry cement. Overall, the State ranked seventh nationally in consumption of cement.

Dundee Cement came under the scrutiny of Michigan's Air Pollution Control Commission during 1988 because of its plant's unsightly stack plumes. The company's limestone source contains kerogens that make the facility's emission-cleaning equipment inefficient. Bechtel Corp. was hired by the company to find a remedy to the problem, which may cost upwards of $18.5 million.

Medusa Cement built a new barge, The Medusa Conquest, to complement

its steamship, The Medusa Challenger. About 95% of the Charlevoix plant's output is shipped by water to distribution terminals in Illinois, Michigan, Ohio, and Wisconsin. A new terminal was brought on-stream at Toledo, OH, in 1988.

St. Marys Peerless Cement applied to the State Department of Natural Resources for a controversial permit to burn waste products such as paint sludges, thinners, and solvents in the kiln at its Detroit plant. No action had been taken on this request by the end of 1988.

Clays.—Michigan ranked seventh of 43 States in production of common clay and shale. Output increased about 3% during 1988, while value dropped about 17%. Five companies mined clay from pits in four counties, with Alpena County leading the State's production. Most of the State's clay was used in cement manufacture, while lesser quantities were used for making brick and flower pots. Potters were also reported to have used local clays in their art studios.

Gypsum.—Michigan ranked third of 21 States in crude gypsum production and 11th of 28 States in calcined gypsum production. In 1988, production of both crude and calcined gypsum varied less than 1% from the previous year. The value of crude production was down nearly 5%, and calcined production declined about 1%. Five companies operated two underground mines in Kent County and three open pit mines in Iosco County. All but one company operated calcining plants. USG Corp.'s Alabaster Mine and National Gypsum Co.'s Tawas Mine ranked third and fourth in production, respectively, of 64 active mines in the U.S.

Lime.—Michigan ranked ninth of 34 States in lime production. Output and attendant value increased 25% and 19%, respectively, in 1988. Lime was manufactured by five companies at eight plants in seven counties. Wayne County led the State's production. Marblehead Lime Co. produced both quicklime and hydrated lime. Detroit Lime Co. and Dow Chemical produced only quicklime. Michigan Sugar Co. and Monitor Sugar Co. produced only hydrated lime. Lime was used in steelmaking, sugar refining, and water treatment. Lime shipments to and within Michigan, from all domestic sources, totaled 1.1 million short tons of quicklime and 83,000 tons of hydrated lime, compared with 954,000 tons of quicklime and 29,000 tons of hydrated lime in 1987.

Magnesium Compounds.—Nationally, Michigan ranked first of six States in production of magnesium compounds. Production was reported from the well brine operations of Dow Chemical in Mason and Midland Counties and of Martin Marietta Chemicals and Morton Chemical Co. in Manistee County. Production and attendant value increased 40% and 26%, respectively, in 1988. Products of the three Michigan producers were magnesium carbonate, magnesium hydroxide, magnesium sulfate, caustic-calcined magnesia, and refractory magnesia. Improvements in the aluminum and steel industries prompted increases in magnesia production during 1988. Martin Marietta introduced several new products during the year, including a rapid-patch refractory for lining steel furnaces and an improved coating material for specialty steels used in electrical transformers.

Peat.—Michigan regained its number one position in peat sales in 1988 after yielding to Florida in 1986 and 1987. Sales climbed nearly 22% to their highest level ever, and value of sales increased about 18%. Michigan sales accounted for 37% of the Nation's total. Twelve companies harvested peat at 14 locations in 10 counties. Most of the State's sales were used for general soil improvement (92%). Sixty-eight percent of Michigan's peat was sold in packaged form; the rest was sold in bulk. Reed-sedge was the predominant type of peat harvested (64%), followed by lesser quantities of humus and sphagnum.

Hyponex Corp. of Fort Wayne, IN, which had operations in Lapeer and Shiawassee Counties and was the State's second largest producer, was sold to O.M. Scott & Sons Co. of Marysville, OH, in November.

Salt.—Sales of salt increased less than 1% in 1988 after climbing 21% in 1987. Value of sales increased 9% following a 49% increase in 1987. Two companies solution-mined salt: Diamond Crystal Salt Co. had operations in Manistee and St. Clair Counties, and Morton Thiokol Inc. had an operation in Manistee County. Major sales of salt were for food and chemical processing and table salt. Salt was sold in bulk, as pressed blocks, and in packaged form.

Early in the year, Diamond Crystal completed the sale of its 102-year-old Salt Division to International Salt Co. for $65 million in cash. Included in the sale were plants in St. Clair and Manistee, and plants in Akron, OH, Williston, ND, and Great Salt Lake, UT. The Michigan operations were renamed International Salt Co.—Diamond Crystal Salt Division.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

Michigan construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 4 presents end-use data for the State's three districts.

Michigan ranked second nationally in production of construction sand and gravel. Tonnage produced in 1988 ex-

ceeded 1987 output by 25% and was the highest since 1974. Value of production reached a record high, eclipsing the previous high reached in 1987, by 31%. The large percentage increases in production and value may have been due in part to low estimates for 1987 production. Mining was conducted in 69 of the State's 83 counties at 457 pits. Production was reported by 224 companies. Major producing counties were Oakland and Livingston.

Industrial.—Michigan continued to be the second largest industrial sand producer in the Nation, trailing Illinois by 1.3 million short tons in 1988. Production and attendant value increased 9% and 21%, respectively, when compared with 1987 figures. Nine companies produced sand from 19 pits in 12 counties, mostly from dunes along Lake Michigan shores. Ottawa County continued to lead the State's production, followed by Van Buren and Muskegon Counties. Eighty-five percent of the State's production was used

TABLE 3

MICHIGAN: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	6,712	$22,469	$3.35
Plaster and gunite sands	99	370	3.74
Concrete products (blocks, bricks, pipe, decorative, etc.)	457	1,326	2.90
Asphaltic concrete aggregates and other bituminous mixtures	3,085	7,151	2.32
Road base and coverings[1]	7,525	18,169	2.41
Fill	2,512	3,896	1.55
Snow and ice control	319	698	2.19
Railroad ballast	24	77	3.21
Other	188	622	3.31
Unspecified:[2]			
Actual	28,181	73,396	2.60
Estimated	4,406	9,999	2.27
Total or average	**53,508**	**[3]138,171**	**2.58**

[1] Includes road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data do not add to total shown because of independent rounding.

TABLE 4

MICHIGAN: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	244	1,063	681	1,924	5,787	19,481
Plaster and gunite sands	W	W	W	W	90	346
Concrete products (blocks, bricks, etc.)	8	33	216	604	233	689
Asphaltic concrete aggregates and other bituminous mixtures	287	970	229	581	2,569	5,600
Road base and coverings[1]	987	2,591	1,126	2,657	5,412	12,921
Fill	318	459	159	284	2,035	3,153
Snow and ice control	73	116	158	343	88	240
Railroad ballast	W	W	W	W	13	39
Other miscellaneous	45	103	120	355	44	225
Other unspecified[2]	489	1,022	3,524	6,874	28,574	75,499
Total[3]	**2,451**	**6,356**	**6,213**	**13,622**	**44,844**	**118,192**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

for foundry molding and core. The next largest use was for refractories. Average value of Michigan's industrial sand was $8.92 per short ton, an increase of nearly 11% over the previous year's value. Thirty-nine percent of the sand was moved to market by truck, while lesser quantities were transported by rail and waterway.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

Crushed.—Michigan ranked 14th of 49 States in crushed stone production. Production was estimated to have been 38.8 million short tons valued at $120.3 million in 1988. Bethlehem Steel Corp. completed the sale in May of its Drummond Island dolomite quarry to Osborne Materials Co. of Grand River, OH. In the past, the 6,500-acre quarry had production levels of more than 1 million tons per year.

Dimension.—Two companies produced dimension stone in 1988. Jude Stone Quarry Co. near Napoleon in Jackson County produced sandstone for curbing. Inwood Stone Products Co. quarried dolomite in Schoolcraft County for use as flagging and veneer and for other uses. Production of stone was estimated to have declined for the year.

Other Industrial Minerals.—Gem stones and mineral specimens collected in Michigan were valued at $25,000 in 1988. Crude perlite from out-of-State sources was expanded by Harborlite Corp. at a plant in Kalamazoo County. Sales and attendant value increased 6% and 20%, respectively. Most of the product was used as a filter aid. Sales of processed iron and steel slag, mainly for road base material and asphalt and concrete aggregate, increased about 11% in 1988. Sulfur was recovered at two of the State's petroleum refineries. Sales and value declined 6% and 11%, respectively. Vermiculite from out-of-State sources was exfoliated by W.R. Grace & Co. at a plant in Wayne County. Shipments and value increased 11% and 16%, respectively. In descending order of quantities sold, the product was used for fireproofing, block insulation, horticulture, loose-fill insulation, soil conditioning, and concrete aggregates.

Metals

Copper, Gold, and Silver.—Nationally, Michigan ranked 5th, 9th, and 12th, respectively, in production of copper, silver, and gold. All output was from two mines: Copper Range Co.'s White Pine Mine in Ontonagon County (copper and silver) and Callahan Mining Corp.'s Ropes Mine in Marquette County (gold and silver). Copper and silver production dropped 5% and 22%, respectively, in 1988, compared with 1987 figures. Gold production increased nearly 5%. Copper prices averaged $1.21 per pound in 1988, compared with 82 cents per pound in 1987, a 46% increase. Gold prices averaged $438.31 per troy ounce in 1988, down about 2% from $447.95 per troy ounce in 1987. Silver prices dropped nearly 7%, from $7.01 per ounce in 1987 to $6.54 per ounce in 1988.

In early February, a major roof fall curtailed operations at the White Pine Mine; a main conveyor belt line that serviced the mine's active southwest section was damaged. The event postponed a planned public stock offering, the proceeds from which were to have been used for capital investment. Concerted efforts by mine employees and management restored mining in the southwest section by mid-May after two half-mile-long tunnels were constructed and 10,000 feet of conveyor belt installed. During the construction period, mine production was switched to the northeast section of the mine, which had been under development. The period of reduced mining activity also allowed the rebuilding of the smelter's reverberatory furnace for more efficient operation.

White Pine officials announced in November that they were pursuing a commitment from a major national bank for a line of credit sufficient to allow the company to purchase the refinery at the White Pine Mine owned by Louisiana Land and Exploration Co., the former owners of the mine. Copper Range had been operating the refinery under a lease purchase agreement. Also, talks were underway with Metall Gesellschaft AG, a West German metals producer, on the possibility of its purchasing an interest in the mine.

Callahan Mining Co. suffered a setback on the first day of the year at the Ropes Mine when an unworked portion of the mine caved in and stopped all mine production. Nearly all of the mine's 70 workers were laid off in January and then gradually recalled in February and March as repairs were completed and production resumed. The mill, with 40 workers, continued running on stockpiled ore during the mining suspension. During 1988, development work continued on the mine's lower levels where higher grade reserves were indicated. The mine's declined rampway also was being advanced to the 1,944-foot level. Ventilation and escapeway raises were also completed. Improved ore grades in the latter part of the year helped bring the mine's production above the previous year's level.

High copper prices prompted Allouez Township on the Keweenaw Peninsula to apply for a small-cities planning grant to undertake a feasibility study on reopening the Kingston native copper mine, last operated by the Calumet & Hecla Co. in 1968. The mine, which was discovered in 1962, was Calumet & Hecla's newest operation in the native copper district and yielded more than 20 million pounds of copper be-

fore it was closed following a bitter labor strike. Approval of the $60,000 small-cities grant was received in December for a proposed 6-month feasibility study to be conducted by a private engineering group. A new joint-venture company, Kingston Mining Co., was formed to provide local matching funds for the study. At the end of 1988, a private group was studying the feasibility of reopening the Centennial No. 6 Mine in Calumet Township.

Iron Ore.—Michigan continued to rank second behind Minnesota in shipments of iron ore, the State's leading nonfuel mineral commodity in terms of value. In 1988, shipments totaled 14.6 million metric tons, a gain of nearly 17% over the 12.5 million tons shipped in 1987. Value of iron ore shipments also increased about 17%. Most of the State's production was in the form of pellets from the Empire and Tilden Mines, partially owned and managed by Cleveland-Cliffs Iron Co. (CCIC). The mines' pellet plants had both been converted to fluxed pellet production during 1987. In 1988, about 44% of the Empire plant and 61% of the Tilden plant output was fluxed pellets. Some siliceous ore was shipped from the Empire plant. CCIC also shipped crude iron oxide pigments from a stockpile at its Mather Mine in Marquette County. Sales and value of sales increased 4% and 16%, respectively, over those reported the previous year.

Early in the year, Cleveland-Cliffs Inc. (CCI) and co-owners of the Tilden facilities (Algoma Steel Corp. and Stelco) agreed to convert the operation to magnetite production. The $31 million project, expected to be completed by mid-1989, was financed internally. CCI also ended a wage deferral program and paid back employees who had agreed to the deferrals in December 1987 to help fund the magnetite project. A $2.7 million pebble-crushing system that was expected to lower unit costs and remove a production restraint was put on-stream in early August at the Empire Mine. CCI announced in September that it had tentatively settled two unsecured claims against Wheeling-Pittsburgh Steel Corp., which was attempting to emerge from Chapter 11 bankruptcy. Under the agreement, Wheeling-Pittsburgh was to reassume its 10% share in the Empire Iron Mining Partnership. CCI was to be allowed an unsecured claim of $100 million for damages resulting from Wheeling-Pittsburgh's rejection of certain iron ore purchase contracts and its partnership agreements in the Tilden Mine.

CCIC initiated tests in November on the feasibility of shipping stone from Inland Lime & Stone Co.'s quarry at Gulliver to Escanaba, where it would be trans-shipped via the Chicago Northwestern Transportation Co.'s railroad to the Empire and Tilden Mines for use in fluxed pellets. Previously, the limestone had been shipped by boat through the locks at Sault Ste. Marie to Marquette and then transported by truck to the mines. With most of the production at the mines to be fluxed pellets, CCIC was interested in determining the most cost-effective way of bringing the limestone to the mine.

Iron and Steel.—Michigan continued to rank fourth in raw steel production, following Indiana, Ohio, and

TABLE 5

MICHIGAN: USABLE IRON ORE[1] PRODUCED (DIRECT SHIPPING AND ALL FORMS OF CONCENTRATES), BY RANGE

(Thousand metric tons, gross weight, unless otherwise specified)

Year	Marquette Range	Menominee Range (Michigan part)	Gogebic Range (Michigan part)	Total		
				Gross weight		Iron content (percent)
				Ore[2]	Iron content	
1854–1983	547,982	[3]321,307	[4]253,631	1,122,919	NA	NA
1984	13,190	—	—	13,190	8,508	64.50
1985	12,679	—	—	12,679	8,181	64.52
1986	10,727	—	—	10,727	6,911	64.43
1987	12,491	—	—	12,491	7,956	63.69
1988	14,589	—	—	14,589	9,063	62.12
Total[2]	**611,659**	**[5]321,307**	**[5]253,631**	**1,186,596**	**NA**	**NA**

NA Not available.

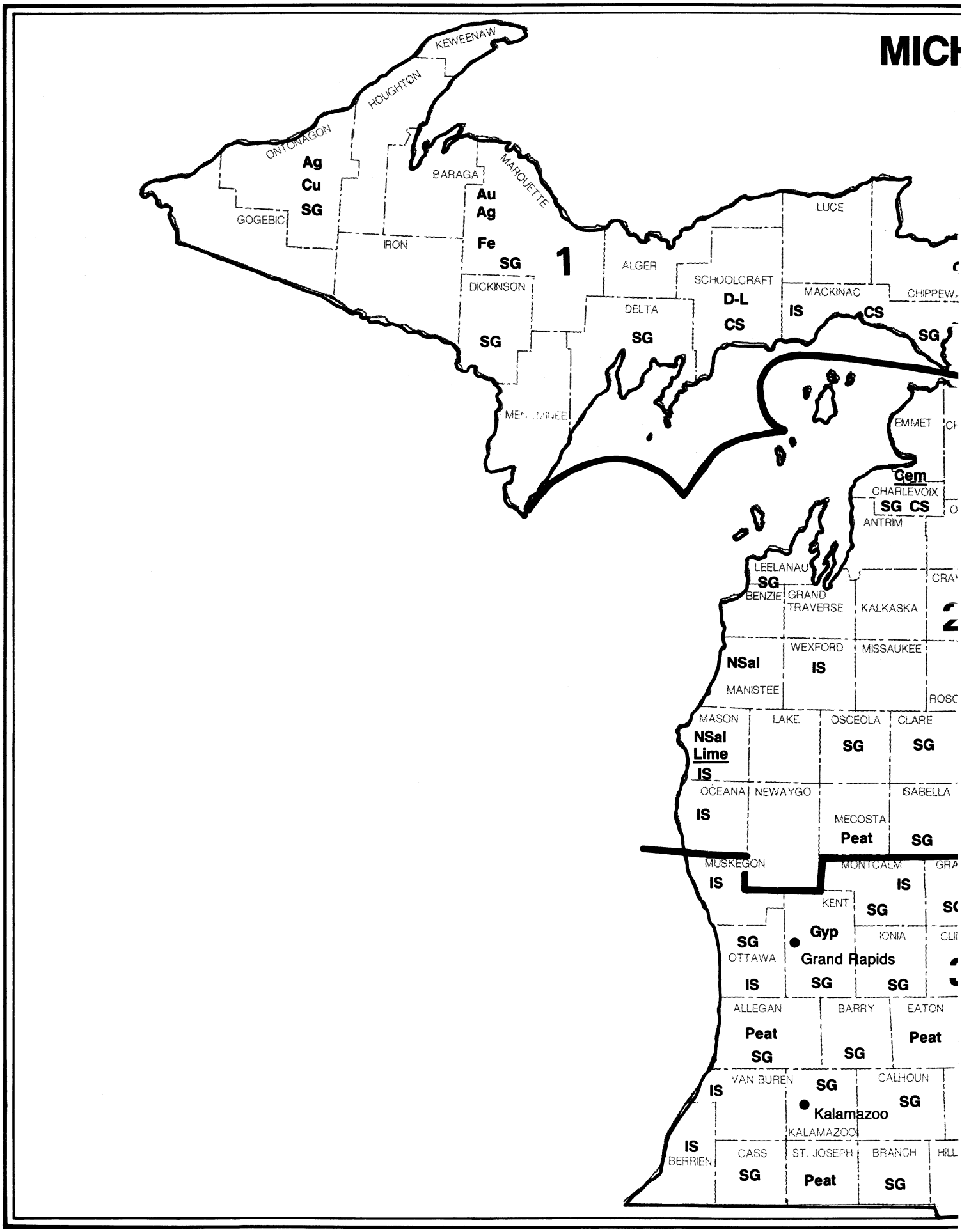
[1] Exclusive after 1905 of iron ore containing 5% or more manganese.

[2] Data may not add to totals shown because of independent rounding.

[3] No production after 1981.

[4] No production after 1979.

[5] Distribution by range partly estimated before 1906.


MICH
KEWEENAW
HOUGHTON
ONTONAGON
Ag
Cu
SG
GOGEBIC
IRON
BARAGA
Au
Ag
Fe
SG
MARQUETTE
1
DICKINSON
SG
MENOMINEE
ALGER
DELTA
SG
LUCE
SCHOOLCRAFT
D-L
CS
MACKINAC
IS
CS
SG
CHIPPEWA
EMMET
Cem
CHARLEVOIX
SG CS
ANTRIM
LEELANAU
SG
BENZIE
GRAND TRAVERSE
KALKASKA
WEXFORD
NSal
IS
MISSAUKEE
MANISTEE
MASON
NSal
Lime
IS
LAKE
OSCEOLA
SG
CLARE
SG
OCEANA
IS
NEWAYGO
MECOSTA
Peat
SG
ISABELLA
MUSKEGON
IS
MONTCALM
IS
KENT
SG
Gyp
Grand Rapids
IONIA
SG
OTTAWA
IS
SG
SG
ALLEGAN
Peat
SG
BARRY
SG
EATON
Peat
VAN BUREN
IS
SG
Kalamazoo
CALHOUN
SG
KALAMAZOO
IS
BERRIEN
CASS
SG
ST. JOSEPH
Peat
BRANCH
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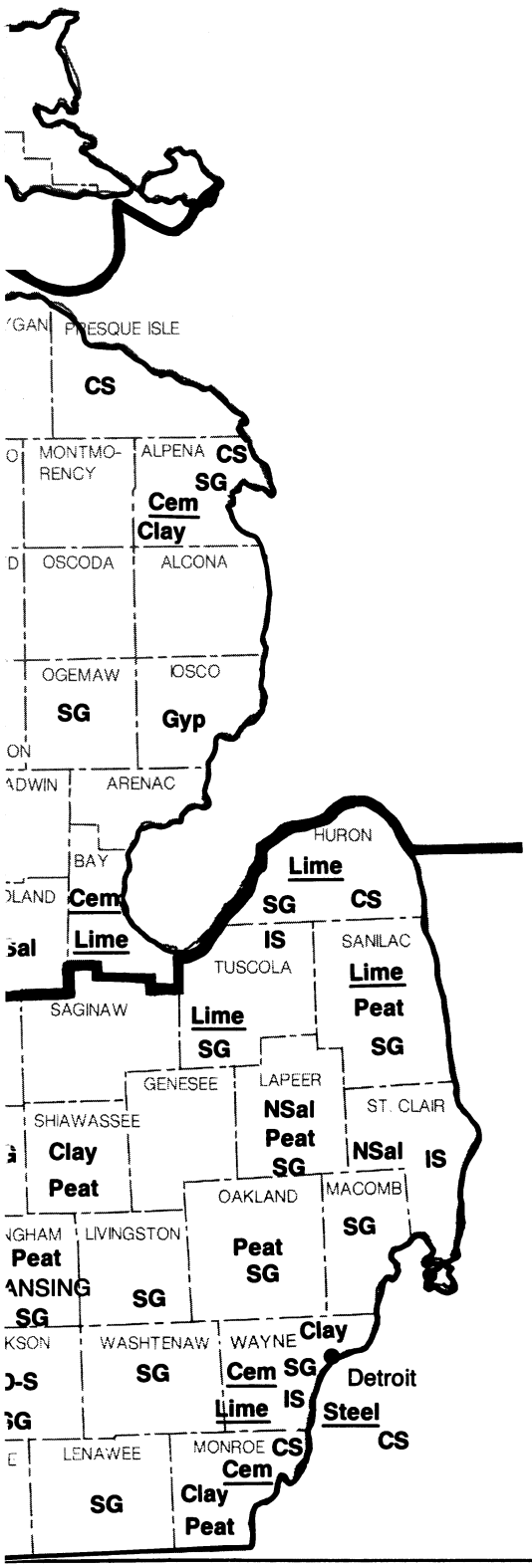

LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Ag	Silver
Au	Gold
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper
D-L	Dimension Limestone
D-S	Dimension Sandstone
Fe	Iron
Gyp	Gypsum
IS	Industrial Sand
Lime	Lime plant
NSal	Natural Salines
Peat	Peat
SG	Sand and Gravel
Steel	Iron and Steel plant

Principal Mineral-Producing Localities

Pennsylvania. The American Iron and Steel Institute reported Michigan's raw steel production climbed to nearly 8.2 million short tons in 1988, a 6.4% increase over the 7.7 million tons produced in 1987. Pig iron production figures were not available for 1988 because of a poor response by major producers to the U.S. Bureau of Mines canvass of production.

Several events took place in the State's steel industry. McLouth Steel Products Corp. of Trenton became the country's second employee-owned integrated steel company, following Weirton Steel Co. of Weirton, WV, when documents establishing an Employee Stock Ownership Plan (ESOP) and restructuring of some $130 million in debts were signed on May 20. The ESOP, which had been in the making since late 1986, was to distribute 85% of the company's 7 million shares of common stock to McLouth's 2,000 workers over a 10-year period, based on the employees' years of service and compensation levels. McLouth has in recent years produced about 1 million short tons of sheet steel annually, mainly for the automotive market.

National Steel Corp.'s Great Lakes Steel Div. formally dedicated a $245 million continuous-caster and ladle-metallurgy station at its Ecorse plant on January 13. The caster, which began operating in late 1987, was capable of producing 2.2 million short tons of high-quality steel slabs per year. It joined another 2.2-million-ton caster that went on-stream in 1977. National Steel opened its new Howard M. Love Technical Research Center at Trenton in May. Staffed by 70 persons, the facility is to provide technical support to National's steelmaking divisions by being able to simulate or model virtually every primary steelmaking process and finishing operation. National announced plans in late September to build a $70 million vacuum degasser at the Great Lakes plant. Expected to be completed in the first quarter of 1990, the facility was to have the capacity to produce 1.8 million tons per year of ultralow carbon steels.

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[1] State Mineral Officer, U.S. Bureau of Mines, Minneapolis, MN.

TABLE 6

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Aetna Cement Corp., a subsidiary of Societe des Ciments Francaise	Box 80 Essexville, MI 48732	Grinding plant	Bay.
Dundee Cement Co., a division of Holderbank Financiere Glaris SA[1 2]	6211 Ann Arbor Rd. Dundee, MI 48131	Quarry, clay pit, plant	Monroe.
Lafarge Corp., Great Lakes Region[2]	4000 Town Center Suite 200 Southfield, MI 48075	do.	Alpena.
Medusa Cement Co., Medusa Corp., a subsidiary of Crane Co.	Box 5668 Cleveland, OH 44101	do.	Charlevoix.
St. Marys Peerless Cement Co., a division of St. Marys Cement Ltd.	9333 Dearborn St. Detroit, MI 48209	Plant	Wayne.
Clays:			
F. W. Ritter Sons Co.	12670 North Dixie Hwy. South Rockwood, MI 48179	Clay pit and plant	Monroe.
U.S. Brick Inc., Michigan Div., a subsidiary of Canada Brick Co.	3820 Serr Rd. Corunna, MI 48817	do.	Shiawassee.
Copper:			
Copper Range Co.[3]	Box 100 White Pine, MI 49971	Underground mine, concentrator, smelter, refinery	Ontonagon.
Gold:			
Callahan Mining Corp.[3]	6245 North 24th St. Phoenix, AZ 85016	Underground mine and plant	Marquette.
Gypsum:			
Domtar Industries Inc.	Box 1670 Grand Rapids, MI 49501	do.	Kent.
Georgia-Pacific Corp.	133 Peachtree St., NE Atlanta, GA 30303	do.	Do.
Michigan Gypsum Co.	2840 Bay Rd. Saginaw, MI 48603	Open pit mine	Iosco.
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	Open pit mine and plant	Do.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	Open pit mine Plant	Do. Wayne.
Iron ore:			
Cleveland-Cliffs Iron Co.[4]	504 Spruce St. Ishpeming, MI 49849	Open pit mines and plants	Marquette.
Iron and steel:			
McLouth Steel Products Corp.	1650 West Jefferson Trenton, MI 48183	Plant	Wayne.
National Steel Corp., Great Lake Steel Div.	1 Quality Dr. Ecorse, MI 48229	do.	Do.
Rouge Steel Co., a subsidiary of Ford Motor Co.	3001 Miller Rd. Dearborn, MI 48121	do.	Do.
Lime:			
Detroit Lime Co., a subsidiary of Edward C. Levy Co.	8800 Dix Hwy. Dearborn, MI 48823	do.	Do.

See footnotes at end of table.

TABLE 6—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
The Dow Chemical Co., Ludington Div.	2020 Dow Center Midland, MI 48640	Plant	Mason.
Marblehead Lime Co., a division of General Dynamics Corp.	222 North LaSalle St. Chicago, IL 60601	do.	Wayne.
Michigan Sugar Co.	Box 1348 Saginaw, MI 48605	do.	Huron, Saginaw, Sanilac, Tuscola.
Monitor Sugar Co.	2600 South Euclid St. Bay City, MI 48706	do.	Bay.
Peat:			
Al-Par Peat Co.	9551 Krouse Ovid, MI 48866	Bog and plant	Shiawassee.
Douglas Farms	0-998 Chicago Dr. Jenison, MI 49428	do.	Allegan.
Fletcher & Rickard	25800 Haas Rd. New Hudson, MI 48165	do.	Oakland.
Hyponex Corp.	4501 Circle 75 Pkwy. Suite B2250 Atlanta, GA 30339	Bogs and plants	Lapeer and Shiawassee.
Michigan Peat Co.	Box 980129 Houston, TX 77006	do.	Sanilac.
Milburn Peat Co.	Box 236 La Porte, IN 46350	Bog and plant	St. Joseph.
Perlite (expanded):			
Harborlite Corp.	Box 458 Escondido, CA 92025	Plant	Kalamazoo.
Salines (natural):			
The Dow Chemical Co.	2020 Dow Center Midland, MI 48640		
Ludington plant[5 6 7]		Brine wells and plant	Mason.
Midland plant[6 7]		do.	Midland.
Martin Marietta Corp., Magnesia Specialties Div.[7]	Executive Plaza II Hunt Valley, MD 21030	do.	Manistee.
Morton Thiokol Inc.[7]	110 North Wacker Dr. Chicago, IL 60606	do.	Do.
Wilkinson Chemical Corp.[6]	8290 Lapeer Rd. Mayville, MI 48744	do.	Lapeer.
Salt:			
International Salt Co.	916 South Riverside St. Clair, MI 48079	Brine wells and plants	Manistee and St. Clair.
Morton Thiokol Inc.	110 North Wacker Dr. Chicago, IL 60606	Brine wells and plant	Manistee.
Sand and gravel:			
Construction:			
ARC America Aggregates Corp.	67500 Mound Rd. Romeo, MI 48065	Pits and plants	Kalamazoo, Livingston, Macomb, Oakland.
Holloway Sand & Gravel Co. Inc.	29250 Wixom Rd. Wixom, MI 48096	do.	Oakland, Washtenaw, Wayne.
Edward C. Levy Co., Lyon Sand & Gravel Co.	4780 South Hill New Hudson, MI 48165	do.	Oakland.

See footnotes at end of table.

TABLE 6—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Natural Aggregates Corp.	65545 Mound Rd. Romeo, MI 48065	Pit and plant	Livingston.
Portable Aggregates Producers	1401 Souter Blvd. Troy, MI 48084	Pits and plants	Livingston and Oakland.
Searles Construction Inc.	2265 W. Park Rd. St. Johns, MI 48879	Pit and plant	Clinton.
Bill Smith Sand & Gravel Inc.	Box 23 Otsego, MI 49078	Pits and plants	Allegan and Cass.
South Kent Gravel Inc.	8255 South Division Byron Center, MI 49315	do.	Kent and Ottawa.
Tri-City Aggregates Inc.	1401 Souter Blvd. Holly, MI 48442	Pit and plant	Oakland.
Industrial:			
Cheyenne Sand Corp., a subsidiary of Construction Aggregates Corp.	Box 68 Ferrysburg, MI 49409	Pits and plants	Ottawa.
Great Lakes Minerals Corp., a division of Evans Mining Corp.	1900 Richman Rd. Smiths Creek, MI 48074	do.	St. Clair and Tuscola.
Manley Bros. of Indiana Inc.	Box 538 Chesterton, IN 46304	do.	Berrien and Van Buren.
Nugent Sand Co. Inc.	Box 1209 Muskegon, MI 49443	Pit and plant	Muskegon.
Sand Products Corp.	1938 First National Bldg. Detroit, MI 48226	Pits and plants	Mackinac and Oceana.
Sargent Sand Co.	Box 6280 Saginaw, MI 48603	do.	Mason, Tuscola, Wexford.
U.S. Silica Co.	20837 North Huron River Dr. Rockwood, MI 48173	Pit and plant	Wayne.
Slag (iron and steel):			
International Mill Service Co.	1818 Market St. Philadelphia, PA 19103	Plant	Monroe.
Edward C. Levy Co.	8800 Dix Ave. Detroit, MI 48209	Plants	Wayne.
Stone (1987):			
Crushed:			
Limestone-dolomite:			
Drummond Dolomite Inc., a division of Bethlehem Steel Corp.	Martin Tower Bethlehem, PA 18016	Quarry and plant	Chippewa.
The France Stone Co.	Box 1928 Toledo, OH 43603	do.	Monroe.
Inland Lime & Stone Co., a division of Inland Steel Co.	Gulliver, MI 49840	Quarries and plants	Mackinac and Schoolcraft.
Michigan Foundation Quarry Co. Inc.	110 West Jefferson Ave. Trenton, MI 48483	Quarry and plant	Wayne.
Michigan Limestone Operations Ltd. Partnership.	Rogers City, MI 49779	Quarries and plants	Mackinac and Presque Isle.
Presque Isle Corp.	Box 426 Alpena, MI 49707	Quarry and plant	Presque Isle.
Rockwood Stone Co. Inc.	Box 113 Rockwood, MI 48173	Quarries and plants	Monroe and Wayne.
Stoneco Inc.	Box 29A Maumee, OH 43603	do.	Monroe.

See footnotes at end of table.

TABLE 6—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Marl:			
Poehlman & Son	Route 2 Cassopolis, MI 49031	Pit	Cass.
Quartzite:			
A. Lindberg & Sons Inc.	560 Mather Ave. Ishpeming, MI 49849	Quarry and plant	Marquette.
Traprock:			
Houghton County Road Commission	Box 269 Hancock, MI 49930	do.	Houghton.
Dimension:			
Limestone-dolomite:			
Inwood Stone Products Co.	Box 24 Cooks, MI 49817	do.	Schoolcraft.
Sandstone:			
Jude Stone Quarry Co.	338 Austin Rd. Napoleon, MI 49261	do.	Jackson.
Sulfur (recovered):			
Marathon Oil Co.	1300 South Fort St. Detroit, MI 48217	Elemental sulfur recovered as a byproduct of oil refining	Wayne.
Shell Western E&P Inc.	Box 1523 Houston, TX 77251	do.	Manistee.
Vermiculite (exfoliated):			
W. R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	Processing plant	Wayne.

[1] Also clays.
[2] Also crushed limestone.
[3] Also silver.
[4] Also iron oxide pigments.
[5] Bromine.
[6] Calcium chloride.
[7] Magnesium compounds.

THE MINERAL INDUSTRY OF MINNESOTA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Mineral Resources Research Center, University of Minnesota, for collecting information on all nonfuel minerals.

By James J. Hill[1]

Minnesota's nonfuel mineral production in 1988 was valued at nearly $1.3 billion, about $125 million more than in 1987. Iron ore shipments, which accounted for most of this increase, were at their highest level since 1981. Minnesota ranked eighth nationally in nonfuel mineral production value and accounted for 4% of the U.S. total. The State led the Nation in production of iron ore, contributing 71% of total U.S. iron ore. In 1988, production increased in Minnesota for all commodities except gem stones, peat, industrial sand, and crushed stone. In terms of value, iron ore was the leading mineral commodity produced, accounting for nearly 90% of the State's total. Construction sand and gravel was the second leading commodity, followed by crushed stone, dimension stone, industrial sand, lime, peat, clays, and gem stones.

EMPLOYMENT

Minnesota's total civilian labor force averaged 2.3 million persons in 1988, an increase of 66,000 over 1987. The State's unemployment rate averaged 4.0%; in 1987, it was 5.4%. Total mining employment averaged 6,900 persons in 1988, an increase of 900 people since 1987. All of the increase was related to metal mining, which averaged 5,200 workers in 1988 compared with 4,300 workers in 1987. Total mining wages averaged $13.04 per hour, an 8-cent-per-hour gain over the previous year's hourly wage. Metal mining average hourly wages fell from $14.10 in 1987 to $13.77 in 1988.[2]

EXPLORATION ACTIVITIES

Metallic mineral exploration was at an alltime high in 1988, as mining companies focused their interest on precious metals, specifically gold in the Archaean greenstone belts and platinum-group metals in the Proterozoic Duluth Gabbro Complex. Base metals and diamonds also commanded some attention. Of the 18 companies registered to explore in the State in 1988, 11 conducted drilling programs, completing 89 holes totaling 36,075 feet in 12 counties. St. Louis County had the greatest number of holes drilled (47), followed by Itasca County (14) and Koochiching County (13). The Minerals Division, Department of Natural Resources (MDNR), drilled seven holes totaling 2,791 feet in Beltrami and Koochiching Counties for geologic control in mapping. Also, 26 holes were drilled in an overburden testing program that began in 1985. This drilling totaled 4,629 feet. A summary of drilling activity is shown in table 2.

In September, Minnesota held its 11th metallic mineral lease sale in conjunction with the Fifth Annual Current Minerals Activities Forum in Chisholm, MN. Leases were offered on over 1.6 million acres of land comprising 3,726 mining units in 11 counties. Nearly 300,000 acres were offered for the first time. The remaining acreage had been offered at previous lease sales but was not currently under lease. At the sale, the State received 504 bids for mineral leases from 31 parties and subsequently awarded 246 leases totaling 99,826 acres to 19 companies. At yearend, Minnesota had 237,700 acres of State-owned metallic mineral lands in 10 counties under lease to 34 companies. St. Louis County had the largest number of acres under lease (115,865 acres), followed by Itasca

TABLE 1

NONFUEL MINERAL PRODUCTION IN MINNESOTA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	$5	NA	$40	NA	$40
Iron ore	thousand metric tons	29,241	1,017,261	r34,274	1,012,788	40,735	1,134,539
Peat	thousand short tons	W	W	30	W	29	1,027
Sand and gravel (construction)	do.	24,055	53,116	e25,200	e67,400	33,769	72,678
Stone:							
Crushed	do.	e8,300	e26,300	8,995	29,246	e8,300	e28,200
Dimension	short tons	e27,973	e10,507	41,354	12,967	e45,000	e13,000
Combined value of clays, lime, sand (industrial) and values indicated by symbol W		XX	20,438	XX	20,308	XX	18,015
Total		**XX**	**1,127,627**	**XX**	**1,142,749**	**XX**	**1,267,499**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

TABLE 2

MINNESOTA: EXPLORATION DRILLING IN 1988, BY COUNTY

County	Number of drill holes	Total footage drilled	Company or agency
Beltrami	3	1,486	Exmin Corp. and Newmont Exploration Ltd.
Benton	1	137	Exmin Corp.
Carlton	5	662	Great Lakes Exploration Inc.
Clay	1	240	Exmin Corp.
Clearwater	1	370	Do.
Itasca	14	6,501	Exmin Corp., FMC Minerals Corp., Lehmann Exploration Management Inc., Normin Mining Co.
Koochiching	13	8,595	BHP-Utah International Inc., Kerr-McGee Corp., Normin Mining Co.
Morrison	1	100	Exmin Corp.
Norman	1	982	Newmont Exploration Ltd.
St. Louis	47	15,693	Chevron U.S.A. Inc., Coca Mines, Lehmann Exploration Management Inc., Newmont Exploration Ltd., Resource Exploration Co.
Stearns	1	998	Exmin Corp.
Stevens	1	311	Do.
Total	**89**	**36,075**	

Source: Minnesota Department of Natural Resources, Division of Minerals, Hibbing, MN.

County (41,132 acres), Koochiching County (33,105 acres), and Beltrami County (23,895 acres).

LEGISLATION AND GOVERNMENT PROGRAMS

Several mineral-related pieces of legislation were enacted into law in 1988. Chapter 508 of the 1988 Session Laws amended an existing statute to allow the Commissioner of Natural Resources to lease for mineral exploration those unregistered severed mineral interests that, under law, had reverted to the State. The lessee cannot mine properties until State forfeiture proceedings are completed and ruled absolute by a court.

Chapter 530 exempts local and State governmental units, including the Iron Range Resources and Rehabilitation Board, from tort liability claims for losses resulting from idled or abandoned mine pits or shafts or water-filled mine pits to which access had been provided for recreational use. Also, the law changed the fencing requirements for abandoned mine sites and provided for the appointment of county mine inspectors.

Chapter 686, the Omnibus State Departments bill, established a new State park at the Hill Annex Mine, a depleted natural iron ore pit near Calumet in Itasca County. Also, the law appropriated money for pumping costs at the Hill Annex Mine and for nonferrous mineral strategic planning.

The MDNR completed amendments to the State's mineral lease rules; these became effective in May. The modifications simplify and reduce royalty rates, allow for the subtraction of base smelter treatment charges and smelter losses from the value of the ore before calculation of royalties due, change performance requirements, and allow for a partial deferral of royalties due during the first years of mining. These changes were expected to result in increased mineral exploration and development in the State.

Minnesota's Minerals Diversification Plan got under way during 1988 with direction and funding provided by the 1987 Legislature. Under this legislation, a Minerals Coordinating Committee (MCC) was formally established to direct, coordinate, and set priorities for mineral-related research that could expand Minnesota's mineral base and enhance its mineral economy. The MCC originally had been organized in 1975 by the Legislation Commission on Minnesota Resources (LCMR) to coordinate proposals and set priorities for LCMR funding requests. MCC members include the directors of MDNR, the Minnesota Geological Survey (MGS), the Minerals Resources Research Center (MRRC), and the Natural Resources Research Institute (NRRI).

In late September, the MCC sponsored its fifth Annual Current Minerals Activities Forum in Chisholm, MN. Here, industry representatives, legislators, and the general public had a chance to review current mineral-related research and progress under the Minerals Diversification Plan.

The MDNR, as lead agency in mining regulation, has management responsibilities for 12 million acres of State-owned mineral rights and 3 million acres of peatlands. In 1988, the Agency conducted the State's 11th metallic minerals lease sale. To encourage mineral exploration and development, Agency personnel were active participants in the State's minerals diversification program.

Ongoing studies in 1988 included the evaluation of Duluth Complex core stored in the State's core library for platinum-group metals, drilling in the State's little-known Archaean greenstone belts to aid in geologic mapping, overburden drilling for geochemical studies, glacial drift geochemistry, and geophysical studies. Also, the MDNR had an aggregate mapping program

underway for selected counties in which urban expansion may preclude aggregate extraction. Peatlands were being evaluated in Koochiching County, and an industrial mineral inventory was in progress.

MGS involvement in the minerals diversification program focused on (1) expanded scientific drilling to support the statewide aeromagnetic survey funded by the Legislation Commission on Minnesota Resources and (2) preparing regional framework maps to encourage exploration in previously unexplored areas. Evaluations also were made of industrial uses for carbonate rocks, pre-Cretaceous kaolin clay resources, and graphitic-carbonaceous rock as potential feed materials for direct reduction of taconite pellets. Mapping continued in the Finland-Silver Bay area of northeastern Minnesota as part of the USGS Cooperative Geologic Mapping (COGEOMAP) program. County geologic atlases were being prepared for Dakota, Hennepin, Olmsted, and Washington Counties to aid in land- and water-use planning. Finally, investigations were underway on the manganiferous ores and iron formation on the Cuyuna Range.

The NRRI was conducting several studies related to the minerals diversification program in 1988. For example, investigations were made of (1) the geology and structure of the Partridge River Intrusion in the Duluth Complex, (2) the precious metal content of the copper-nickel sulfides in the Duluth Complex, and (3) the geochemical studies of the Deer Lake Complex and associated greenstone volcanics in Itasca County. Also, characterization of the State's clay and carbonate resources was progressing. The NRRI Coleraine Research Laboratory continued its contract work with USX Corp. at the Minntac plant in Mountain Iron. Efforts were directed toward fluxed pellet production and assisting plant personnel with operations in the agglomerator and concentrator. Laboratory personnel also conducted pelletizing tests for Cyprus Minerals Co.; this company was interested in purchasing the Reserve Mining Co. properties at Babbitt and Silver Bay.

The MRRC has a legislative mandate for education and research related to the wise use of mineral resources. This research ranges from mineral characterization studies to process metallurgical engineering. The MRCC was designated the Minnesota Mining and Mineral Resources Research Institute in the Federal Mineral Institute Program in 1978. The LCMR designated the MRRC in 1988 as project manager in a multi-agency study of Minnesota clay resources. The study will develop and organize historical, geological, mineralogical, processing, economic, and environmental data related to Minnesota clay resources to increase the probability of commercial development. In 1988, the MRRC initiated processing tests on a bulk sample of kaolinic clay provided by Georgia Kaolin Co. from a lease south of Fairfax. Preliminary tests indicated the ability to recover approximately 20% of the feed as a filler-grade product and an additional 20% as a coarser product. Refining of this coarser product was being studied.

Under the minerals diversification program, the MRRC began a study to characterize Minnesota ilmenite resources and investigate the applicability of plasma reduction to produce a high-grade synthetic rutile and the technical feasibility of a new direct chlorination process. In fiscal year 1988, the MRRC received $445,289 in pass-through funding from the U.S. Bureau of Mines under the Federal Mineral Institute Program.

The U.S. Bureau of Mines Twin Cities Research Center expended about $900,000 for contracts, grants, equipment, and services by Minnesota firms in fiscal year 1988. Several research projects were in progress concerning the State's mineral industry, including two studies dealing with Cuyuna Range manganese resources. One investigation will try to develop an economic method of producing intermediate-grade (25%) manganese concentrates by physical beneficiation; the second study will investigate the feasibility of in situ leaching of manganese ores. As a member of the Iron Ore Cooperative Research Committee, the Center initiated two projects in 1988 scheduled for completion in 1990. One study was to investigate oxygen addition to pellet induration systems to determine the most effective method of addition. The second concerned development of a computer digital image interpretation sensing system for on-line particle characterization.

The Iron Ore Cooperative Research Committee was formed in November 1985 under MDNR sponsorship. The members consisted of the Minnesota taconite mining companies, the NRRI, the MRRC, the U.S. Bureau of Mines, and Minnesota Power. The Committee's focus was directed to short-term objectives to improve the quality and lower the production costs of Minnesota taconite pellets.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Iron Ore.—Minnesota was the leading iron ore producer in the Nation, accounting for 71% of total U.S. shipments. Iron ore was the State's leading mineral commodity in terms of value, representing nearly 90% of the State's total mineral value. All production was from the Mesabi Range in Itasca and St. Louis Counties. Shipments increased for the second consecutive year, surpassing 1987 shipments by nearly 6.5 million metric tons, or nearly 19%. Capacity utilization of the Nation's steel mills was an unprecedented 89.2%, thus creating high demand for Minnesota iron ores.

Six pelletizing plants were active in 1988. Another, the Reserve Mining Co.

TABLE 3

MINNESOTA: PRODUCTION AND SHIPMENTS OF USABLE IRON ORE[1]

(Thousand metric tons, gross weight, unless otherwise specified)

Year	Production				Shipments			
	Natural ore and concentrates	Pellets	Total	Iron content (percent)	Natural ore and concentrates	Pellets	Total	Proportion of pellets to total ore (percent)
1984	866.69	36,419.19	37,285.87	64.71	1,212.14	34,961.16	36,173.30	96.65
1985	1,485.46	33,984.74	35,470.20	64.20	1,481.40	34,056.88	35,538.27	95.83
1986	1,178.61	26,297.33	27,475.94	r64.07	1,366.58	27,875.25	29,241.83	95.33
1987	1,515.94	r32,748	r34,264	r64.22	1,663.27	r32,610	r34,273	95.15
1988	825.03	40,623.59	41,448.62	63.95	760.00	39,974.33	40,734.34	98.13

r Revised.
[1] Exclusive of ore containing 5% or more manganese.

plant at Silver Bay, remained inactive. Shipments of natural iron ore concentrates were reported from the active LTV Steel Mining Co. McKinley Extension Mine operation near Hoyt Lakes and from the Pittsburgh Pacific Co. stockpile at the Connie Mine; both of these are in St. Louis County. USX Corp. reportedly shipped 91,031 long tons of purchased natural iron ore fines.[3] Both USX and Inland Steel Mining Co. shipped acid and fluxed pellets during 1988. Eveleth Mines shipped a partially fluxed pellet. The State's other three producers shipped acid pellets.

In July, Eveleth Mines reactivated a second iron ore pellet line at its Forbes plant, which had been idle since 1982, and recalled approximately 80 laid-off employees. The production increase and employee callback were triggered by increased demand for iron ore by Rouge Steel Co. and Armco. These companies are Eveleth's two primary customers; they are also two of the four owners of the plant. With the second

TABLE 4

SALIENT STATISTICS FOR PORTS SHIPPING MINNESOTA IRON ORE

Year, port, and dock	Date of first shipment	Date of last shipment	No. of shipments	Total shipments (gross tons)	Average shipment (gross tons)	Largest shipment (gross tons)
1987:						
Duluth, MN: DM&IR	Mar. 28	Dec. 25	237	7,595,375	32,048	61,739
Silver Bay, MN: Reserve[1]	NA	NA	4	182,603	45,651	NA
Superior, WI: Burlington-Northern	Mar. 24	Jan. 7	268	11,313,051	42,213	62,061
Taconite Harbor, MN: LTV Steel	Mar. 31	Jan. 6	175	7,899,067	45,138	62,096
Two Harbors, MN: DM&IR	Apr. 2	Jan. 14	159	7,121,685	44,790	61,863
Total or average			**843**	**34,111,781**	**40,465**	**62,096**
1988:						
Duluth, MN: DM&IR	Apr. 2	Dec. 24	239	6,918,963	28,950	57,760
Superior, WI: Burlington-Northern	Mar. 28	Jan. 9	314	11,996,794	38,206	58,810
Taconite Harbor, MN: LTV Steel	Apr. 1	Jan. 4	167	7,718,500	46,219	59,006
Two Harbors, MN: DM&IR	Mar. 24	Jan. 14	258	10,808,214	41,892	59,871
Total or average			**978**	**37,442,471**	**38,285**	**59,871**

NA Not available.
[1] Operations ceased after LTV Steel Co., co-owner of Reserve Mining Co., filed for bankruptcy on July 17, 1986. All stockpiled pellets remaining at Silver Bay were shipped out in October and November 1987.

Source: Annual Reports of the Lake Carriers' Association, 1987 and 1988.

line on-stream, the plant's capacity was raised to 6.1 million long tons. Eveleth Mines renegotiated a contract with Minnesota Power that would provide rate reductions of $4.3 million through 1991. Development work was well under way on the company's Spruce Hill reserve, which was to be mined in 1989–91. Construction of a temporary road around the pit to provide access to Leonidas and West Eveleth was completed in July. It was to be replaced later with a permanent road.

National Steel Pellet Co. near Keewatin approved a 3-year contract with Minnesota Power in late March. This approval ended a 2-year battle over power costs that included threats to close the facility. National Steel also negotiated substantial rate cuts with Burlington Northern Railroad, cutting costs about 20%. It also announced that it would not renew its contract with M. A. Hanna Co. as managing agent for the pellet plant, but would assume control itself of the facility effective January 1, 1989. Hanna was to continue operating the National Steel research center near the former Butler Taconite plant to provide service to Hanna operations and outside clientele. In February and March, test runs were made of fluxed pellets for blast furnace trials at the National Steel Co. Great Lakes Steel Division in Detroit and at the Granite City Steel Division at Granite City, IL. On June 4, the pelletizing complex was shut down for vacations and annual maintenance and repairs. Pellet production resumed on June 30.

On February 26, LTV's union workers at Hoyt Lakes ratified a new 25-month contract that cut wages and benefits by about $2.19 per hour. Workers gained a profit-sharing and stock option plan as well as strong limits on outside contracting. In late August, LTV placed one of the world's largest two-axle haulage trucks into service in its stripping operations, the first on the iron range. The 240-ton payload haulage unit was expected to increase production by 30% over the largest trucks previously used.

The USX Corp. Minntac plant in Mountain Iron brought its flotation unit on-stream in mid-July to reduce silica content in concentrates for fluxed pellet production. During the year, fluxed pellet production was added to the step 2 and step 3 sections of the plant with output expected to be 100% fluxed pellets by yearend unless acid pellets were required by customers. At yearend, USX Corp. sold its huge railroad and shipping businesses to Blackstone Capital Partners Ltd. The sale included the DM&IR Railroad and the USS Great Lakes Fleet based in Duluth. However, USX did retain a 40% interest in the new transportation company.

On November 18, Denver-based Cyprus Minerals began pumping water from the Reserve Mining Co. taconite mine near Babbitt under a cost-sharing agreement with Reserve bondholders and the State of Minnesota. The winterizing effort was undertaken to keep the property in condition for possible sale. State officials had been active in trying to place the mine in production for the employment opportunities it offered; they expected Cyprus to make an offer for the facilities in the future.

Other Metals.—North Star Steel Co., a unit of Minnetonka-based Cargill Inc., reorganized its operations into two primary business segments consisting of a bar and wire-rod group and a specialty products group. The bar and wire-rod group, which makes such products as concrete reinforcement bars and wire for fencing and coat hangers, includes mills in St. Paul; Wilton, IA; Calvert City, KY; and Beaumont, TX; it also has a grinding ball plant in Duluth.

Industrial Minerals

Clays.—All Minnesota clay production was by two companies in 1988. Ochs Brick & Tile Co. mined common clay in Brown County and a low-grade kaolin clay in Redwood County for brick manufacture at its plant near Springfield, Brown County. Northwestern States Portland Cement Co. mined a low-grade kaolin clay in Redwood County for cement manufacture at its plant in Mason City, IA. Consumption of clay at the cement plant, the largest use of Minnesota clay, declined for the year.

Several State agencies had ongoing investigations of the kaolin potential in the Minnesota River Valley near Redwood Falls during 1988 as part of the State minerals diversification program. For instance, the MGS drilled several holes to determine the resource extent; processing and beneficiation studies were under way at the MRRC; and the NRRI in Duluth was studying characteristics of known deposits. Also, several mining companies were investigating the kaolin resources; among them were English China Clays International, Georgia Kaolin Co., Hecla Mining Co., and J. M. Huber Corp.

In August, eight south-central Minnesota cities banded together and signed a joint-powers agreement that would allow them to work as one organization in promoting kaolin resources in the Minnesota River Valley. The group, Minnesota River Valley Coalition of Kaolin, was to seek outside funding for kaolin research and promotion efforts.

Lime.—Minnesota lime production reached a record high, surpassing the previous high of 162,090 short tons set in 1980. Production in 1988 was 28% higher than that of 1987; however, the average value dropped nearly 40%. American Crystal Sugar Co. operated three plants, one in Clay County and two in Polk County. Southern Minnesota Sugar Co-op. operated a plant in Renville County. All the production was used for sugar beet processing. Limestone for the lime-making process was obtained from out of State. Lime consumption in Minnesota from all domestic sources totaled 324,000 tons,

nearly 28% more than in 1987.

Peat.—Minnesota ranked seventh of 23 States in peat sales. Nine companies reported production from bogs in Aitkin, Carlton, Hennepin, Isanti, Otter Tail, and St. Louis Counties. Both sales and the value of sales declined for the year. Average value was $35.81 per short ton. Sphagnum was the major type of peat produced, with lesser quantities of hypnum and reed-sedge. Over 58% of peat sales was for general soil improvement, and about 62% of the peat sold was in packaged form.

Minnesota Sphagnum Inc. began harvesting peat in June on a 640-acre tract of leased State land in the Arlberg Bog near Floodwood. All company production was to be marketed by Hyde Park Inc., a horticultural products distributor in New York.

Peatrex, owned by VAPO, a Finnish company, was purchased by Premier Ltd. of Riviere-du-Loup, Quebec, in October. Peatrex harvested sphagnum peat from land leased from the State and Carlton County near Cromwell. In November, Premier began construction on a $2 million peat processing facility scheduled to open in mid-1989. Previously, the Peatrex operation had contracted with nearby Michigan Peat Co. to process and bale its harvested peat.

In 1988, Minnesota had 2,469 acres of State-owned land under lease for peat production. Companies harvesting peat on State lands were Michigan Peat Co., Minnesota Sphagnum, and Peatrex Ltd.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter thus contains actual data for 1986 and 1988 and estimates for 1987.

Minnesota construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 6 presents end-use data for the State's six districts.

Minnesota ranked sixth of all States in the production of construction sand and gravel. In terms of value, construction sand and gravel was the second leading mineral commodity mined in the State, following iron ore. Output reached 33.8 million short tons, the highest level since the mid-1970's. Value of production was $72.7 million, a record high, and production was reported in 78 of the State's 87 counties by 205 companies at 429 pits. District 5, which includes the Twin Cities metropolitan area, accounted for over 37% of the State's total production.

On January 5, English China Clays PLC of the United Kingdom completed the acquisition of the J. L. Shiely Co. of St. Paul, the State's second largest sand and gravel producer and the largest crushed stone producer, for $73 million. The firm will be operated as part of ECC Quarries America Inc.

Industrial.—Minnesota ranked 13th of 37 States in industrial sand production. Although 1988 production declined slightly when compared with that of 1987, value increased about 5% because of a rise in per ton price. Two companies mined sand at three pits in Le Sueur, Scott, and Washington Counties. The largest quantities of sand sold were for use in hydraulic fracturing, followed by glass containers, sand blasting, and foundry molding and core.

In July, the Le Sueur County Board of Commissioners awarded Unimin Corp. a conditional use permit to expand its Ottawa mine by 3.5 acres. Numerous conditions were attached to the permit to minimize the effects of blasting and to establish a program for presurvey of structures and timely reporting in the event of alleged damage from blasting.

TABLE 5

MINNESOTA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	5,305	$14,351	$2.71
Plaster and gunite sands	128	543	4.24
Concrete products (blocks, bricks, pipe, decorative, etc.)	631	1,622	2.57
Asphaltic concrete aggregates and other bituminous mixtures	5,145	10,310	2.00
Road base and coverings[1]	6,294	11,975	1.90
Fill	1,990	3,549	1.78
Snow and ice control	271	528	1.95
Other[2]	916	2,289	2.50
Unspecified:[3]			
Actual	11,632	24,234	2.08
Estimated	1,456	3,277	2.25
Total or average	**[4]33,769**	**72,678**	**2.15**

[1] Includes road and other stabilization (cement and lime).
[2] Includes roofing granules and railroad ballast.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data do not add to total shown because of independent rounding.

TABLE 6

MINNESOTA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	559	1,692	378	1,551	534	1,362
Plaster and gunite sands	W	W	31	224	W	W
Concrete products (blocks, bricks, etc.)	33	139	W	W	W	W
Asphaltic concrete aggregates and other bituminous mixtures	827	1,718	343	594	1,709	3,117
Road base and coverings[1]	1,200	2,416	872	1,565	1,745	3,276
Fill	195	322	352	576	167	366
Snow and ice control	53	122	51	104	31	49
Other miscellaneous[2]	14	92	10	33	323	499
Other unspecified[3]	2,481	4,757	733	1,298	3,952	7,034
Total[4]	**5,362**	**11,257**	**2,769**	**5,945**	**8,460**	**15,705**

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	337	1,144	2,836	6,387	661	2,217
Plaster and gunite sands	2	7	W	W	18	98
Concrete products (blocks, bricks, etc.)	9	W	538	1,287	W	W
Asphaltic concrete aggregates and other bituminous mixtures	912	1,986	954	1,996	400	898
Road base and coverings[1]	1,081	2,180	1,001	1,755	396	784
Fill	120	176	860	1,642	297	466
Snow and ice control	17	29	72	139	47	85
Other miscellaneous[2]	71	161	605	1,824	20	91
Other unspecified[3]	1,111	2,004	4,700	12,091	113	326
Total[4]	**3,660**	**7,686**	**11,566**	**27,120**	**1,952**	**4,965**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (cement and lime).
[2] Includes sand and gravel for roofing granules and railroad ballast.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data may not add to total shown because of independent rounding.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter thus contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—Crushed stone production in 1988 was estimated at 8.3 million short tons, valued at $28.2 million. In late 1987, Meridian Aggregates Co. purchased the Green Company Granite Falls Quarry just west of Granite Falls. Crushed granite from this 240-acre quarry, which was renamed the Yellow Medicine Quarry, was marketed mainly to Burlington Northern Railroad for use as ballast. After obtaining the quarry, Meridian added new equipment and a wash plant to help develop new commercial uses for the rock ranging from aggregate for road construction to fines for landscaping.

On January 5, as mentioned, English China Clays PLC of the United Kingdom purchased J. L. Shiely Co. of St. Paul, the State's largest crushed stone producer.

Dimension.—In 1988, dimension stone production was estimated at 45,000 short tons and valued at $13

MINNESOTA

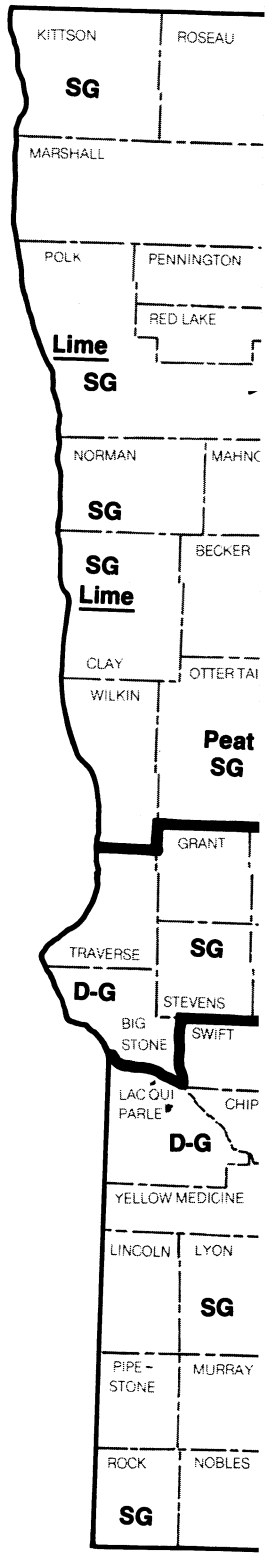
LEGEND

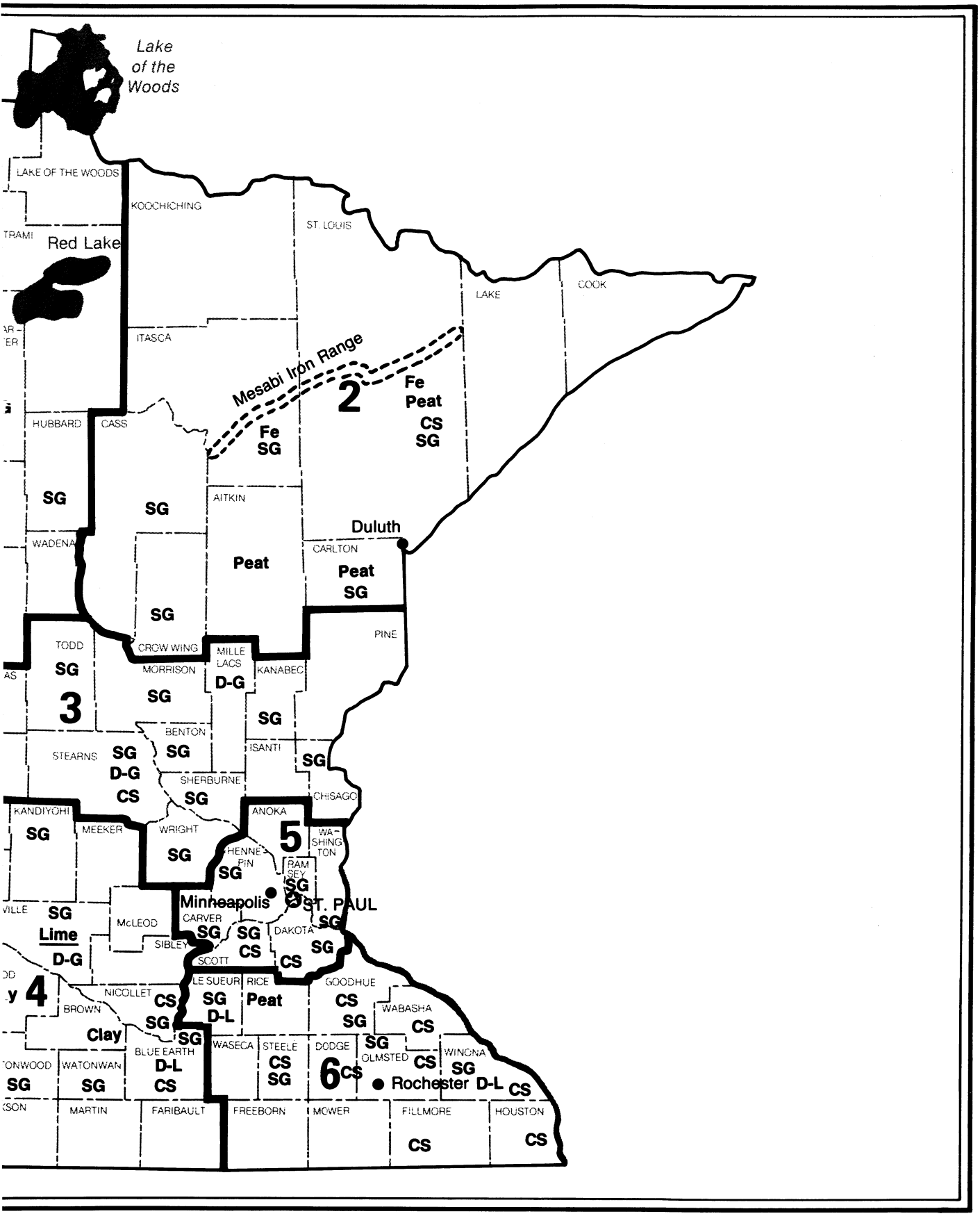
- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Clay	Clay
CS	Crushed Stone
D-G	Dimension Granite
D-L	Dimension Limestone
Fe	Iron
Lime	Lime plant
Peat	Peat
SG	Sand and Gravel
	Concentration of mineral operations

Principal Mineral-Producing Localities




Lake of the Woods
LAKE OF THE WOODS
KOOCHICHING
ST. LOUIS
TRAMI
Red Lake
LAKE
COOK
ITASCA
Mesabi Iron Range
2
Fe
Peat
CS
SG
Fe
SG
HUBBARD
CASS
SG
SG
AITKIN
Duluth
WADENA
Peat
CARLTON
Peat
SG
SG
PINE
TODD
SG
3
CROW WING
MILLE LACS
D-G
MORRISON
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STEARNS
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KANDIYOHI
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MEEKER
WRIGHT
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ANOKA
5
WA-SHING-TON
HENNE-PIN
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RAM-SEY
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Minneapolis
ST. PAUL
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CARVER
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McLEOD
Lime
D-G
SIBLEY
DAKOTA
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SCOTT
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4
LE SUEUR
RICE
Peat
GOODHUE
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SG
NICOLLET
CS
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D-L
WABASHA
CS
BROWN
Clay
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BLUE EARTH
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WASECA
STEELE
CS
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DODGE
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OLMSTED
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WINONA
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Rochester
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MARTIN
FARIBAULT
FREEBORN
MOWER
FILLMORE
CS
HOUSTON
CS

million. Production increased nearly 9% over 1987 figures. Because of the competitive pressures exerted by imports from Italy and Spain, however, value of sales increased only slightly. Cold Spring Granite Co., the State's largest producer, expanded its product line to include highly polished granite table tops and kitchen and bath counter tops for upper-bracket homes. In October, Cold Spring announced that it would move its corporate offices to Minneapolis, while sales and administrative functions would remain in St. Cloud.

Other Industrial Minerals.—Gem stones and mineral specimens were estimated to have contributed $40,000 to the total State mineral value; this value was the same as in 1987. Perlite from out-of-State sources was expanded at the USG Acoustical Products Co. plant near Cloquet. Sales increased nearly 16%; value of sales declined nearly 14%. International Mill Service Co. processed steel slag from the North Star Steel Co. St. Paul mill. Sales and attendant value declined 23% and 31%, respectively, compared with 1987 figures. The largest single use of steel slag was for road base material; other uses included asphaltic concrete, fill, railroad ballast, and snow and ice control. The sales and value of sulfur recovered at Minnesota's two petroleum refineries increased 13% and 9%, respectively. Average value per short ton dropped $2.99. Vermiculite from out-of-State sources was exfoliated at the W. R. Grace & Co. plant in Minneapolis; its sales and value dropped 13% and 2%, respectively. Nearly 71% of these sales were for loose-fill and block insulation, followed by soil conditioning and fireproofing.

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[1] State Mineral Officer, Bureau of Mines, Minneapolis, MN.

[2] Minnesota Department of Jobs and Training. Employment, Hours, & Earnings—Minnesota, 1980 to 1988. May 1989, 40 pp.

[3] Skillings' Mining Review. USX's Pellet Shipments from Minntac at 12.2 Million Tons. V. 78, No. 3, Jan. 21, 1989, p. 16.

TABLE 7

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Clays:			
Northwestern States Portland Cement Co.	Box 1008 Mason City, IA 50401	Pit	Redwood.
Ochs Brick & Tile Co.	Box 106 Springfield, MN 56087	Pit and plant Pit	Brown. Redwood.
Iron ore:			
The M. A. Hanna Co.:	1301 East 9th St. Suite 3600 Cleveland, OH 44114–1824		
Butler Taconite Project		Stockpile shipments	Itasca.
National Steel Pellet Project		Mine, concentrator, agglomerator	Itasca and St. Louis.
Inland Steel Mining Co., Minorca	30 West Monroe St. Chicago, IL 60603	do.	St. Louis.
LTV Steel Co., Northwest Ore Div., McKinley Extension	Box 196 Aurora, MN 55705	Mine and concentrator	Do.
Oglebay Norton Co., Eveleth Mines	1100 Superior Ave. Cleveland, OH 44114	Mine, concentrator, agglomerator	Do.
Pickands Mather (a subsidiary of Cleveland-Cliffs Inc.):	1100 Superior Ave. Cleveland, OH 44114		
Hibbing Taconite Co.		do.	Do.
LTV Steel Mining Co.		do.	Do.
Pittsburgh Pacific Co., Connie	2521 1st Ave. Hibbing, MN 55746	do.	Do.
Rhude & Fryberger Inc., Rana	Box 66 Hibbing, MN 55746	Stockpile and plant	Do.
USX Corp., Minnesota Ore Operations, Minntac	Box 417 Mountain Iron, MN 55768	Mine, concentrator, agglomerator	Do.
Lime:			
American Crystal Sugar Co.	101 North 3d St. Moorhead, MN 56560	Plants	Clay and Polk.
Southern Minnesota Sugar Co-op	Box 500 Renville, MN 56284	Plant	Renville.
Peat:			
Michigan Peat Co.	Box 980129 Houston, TX 77098	Bog and plant	Carlton.
Minnesota Sphagnum Inc.	Box 58 Goodhart, MI 49737	do.	St. Louis.
Peatrex Ltd.	Box 67 Cromwell, MN 55762	do.	Carlton.
Power-O-Peat Co.	Box 956 Gilbert, MN 55741	do.	St. Louis.
Quostar Products Inc.	Route 1, Box 669 Ogilivie, MN 56358	do.	Isanti.
Perlite (expanded):			
USG Acoustical Products Co., a subsidiary of USG Corp.	Arch St. Cloquet, MN 55720	Plant	Carlton.

TABLE 7—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Construction:			
Bauerly Brothers Inc.	Route 2 Sauk Rapids, MN 56379	Pits and plants	Benton.
Fairway Construction Co.	Box 426 Hector, MN 55342	do.	Meeker and Renville.
Fisher Construction Co., Inc.	6801 West 150th St. Apple Valley, MN 55124	do.	Dakota.
Northwestern Aggregates Model Stone	400 W. 61st St. Minneapolis, MN 55419	Pit and plant	Do.
J. L. Shiely Co.	1101 North Snelling Ave. St. Paul, MN 55108	Pits and plants	Dakota and Washington.
Thorson Inc.	Box 40 Bemidji, MN 56601	do.	Beltrami and Polk.
Tri-City Paving Co.	Box 326 Little Falls, MN 56345	do.	Morrison.
Industrial:			
Twin City Silica Ltd.	499 Cottage Grove Dr. Woodbury, MN 55125	Pit and plant	Washington.
Unimin Corp.	258 Elm St. New Canaan, CT 06840	Pits and plants	Le Sueur and Scott.
Slag iron and steel:			
International Mill Service Co.	1818 Market St. Philadelphia, PA 19103	Plant	Washington.
Stone (1987):			
Crushed:			
Granite:			
Meridian Aggregates Co.	Box 69 St. Cloud, MN 56301	Quarries and plants	Stearns and Yellow Medicine.
Limestone and dolomite:			
Bryan Rock Products Inc.	Box 215 Shakopee, MN 55379	do.	Scott and Washington.
Hardrives Inc.	7200 North Hemlock Ln. Maple Grove, MN 55369	do.	Scott.
Holm Brothers Construction Co.	Box 235 Goodhue, MN 55027	do.	Goodhue and Wabasha.
Mankato Aglime & Rock Co.	Box 254 Mankato, MN 56001	Quarry and plant	Blue Earth.
Mathy Construction Co., Patterson Quarries Div.	Route 3, Box 15 St. Charles, MN 55972	Quarries and plants	Houston, Olmsted, Wabasha, Winona.
Midwest Asphalt Corp., River Warren Aggregates Inc.	Box 338 Hopkins, MN 55343	Quarry and plant	Scott.
Quarve & Anderson Co.	2430 Marion Rd. SE. Rochester, MN 55901	Quarries and plants	Dodge, Goodhue, Olmsted.
J. L. Shiely Co.	1101 North Snelling Ave. St. Paul, MN 55108	do.	Scott and Washington.

TABLE 7—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone (1987):—Continued			
Crushed:			
Quartzite:			
New Ulm Quartzite Quarries Inc.	Route 5, Box 21 New Ulm, MN 56073	Quarry and plant	Nicollet.
Traprock (basalt):			
Arrowhead Blacktop Co.	Box 6568 Duluth, MN 55806	do.	St. Louis.
Dimension:			
Granite:			
Cold Spring Granite Co.	Cold Spring, MN 56320	Quarries	Big Stone, Mille Lacs, Renville.
Do.		Quarries and plant	Stearns.
Field Granite International Ltd.	3434 Heritage Dr. Edina, MN 55435	Quarry and plant	Lac Qui Parle.
Limestone:			
Biesanz Stone Co. Inc.	Box 768 Winona, MN 55987	do.	Winona.
Minnesota Quarries Inc.	Box 1358 Mankato, MN 56002	do.	Blue Earth.
Vetter Stone Co.	Route 5, Box 41 Mankato, MN 56001	Quarries and plant	Blue Earth and Le Sueur.
Sulfur (recovered):			
Ashland Petroleum Co., a division of Ashland Oil Inc.	Box 391 Ashland, KY 41101	Elemental sulfur recovered as a byproduct of oil refining	Washington.
Koch Refining Co., a division of Koch Industries Inc.	Box 2302 Wichita, KS 67201	do.	Dakota.
Vermiculite (exfoliated):			
W. R. Grace & Co., Construction Products Div.	62 Whittemore Ave. Cambridge, MA 02140	Processing plant	Hennepin.

THE MINERAL INDUSTRY OF MISSISSIPPI

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Bureau of Geology and Energy Resources, Mississippi Department of Natural Resources, for collecting information on all nonfuel minerals.

By Doss H. White, Jr.,[1] and Maylene E. Hubbard[2]

The value of Mississippi's 1988 nonfuel mineral production in 1988 was $103 million, a decrease of approximately $7 million from the reported 1987 production value. The total ranked the State 42d nationally. The industry reported growth only in the clay and portland cement sectors. Sales of sand and gravel (both construction and industrial), crushed stone, and portland cement fell $10 million below the 1987 figures, reflecting a decrease in construction activity.

Mississippi is not a major mining State, primarily because of the State's geographical location and geological setting. Coastal plain sediments—sands and gravels, clays, marls, and soft limestones—cover over four-fifths of the State; hard rock is exposed only in the northwestern corner. However, because of the occurrence of several clay-bearing formations, the State historically has ranked high in the production of specialty clays-ball clay and bentonite.

TRENDS AND DEVELOPMENTS

The State's mineral value remained stagnant throughout the 1980's; value was reported to be $103.9 million in 1980 and $103.4 million in 1988. In the early 1980's (1980–82), mineral output declined approximately $31 million as the nationwide recession had a devastating effect on Mississippi's mineral producers. During this period, clay output plummeted from 1.6 million short tons to 800,000 short tons, and sand and gravel demand decreased by 2.3 million short tons. Producers of other mineral commodities reported a similar slump in sales. The industry began to recover in 1983, and with the exception of a slight $1.7 million drop in sales in 1986, had continued a slow but steady climb to the record $110.1 million reported in 1987.

Shipments on the 234-mile Tennessee-Tombigbee Waterway, which dissects the northwestern part of the State, continued to escalate in 1988. The waterway recorded its fourth straight year of increased traffic, 9.9 million tons compared to slightly more than 4 million tons handled in 1987. The waterway handled only 1.7 million tons of shipments during 1985, the first year of operation. Severe drought conditions during the summer of 1988 drastically reduced the flow in the Mississippi River, stranding or delaying hundreds of barge shipments. A significant portion of the Mississippi River traffic was rerouted through the Tennessee-Tombigbee Waterway. Coal and crushed stone were two of the major commodities shipped through the waterway.

A variety of mineral commodities was shipped into the State as raw material for a number of industrial manufacturing processes. Among these were ilmenite, phosphate rock, perlite, pyrolusite, and salt.

During the year, several plants using mineral raw minerals as feed continued expansion work or announced plans for future expansion. Among these were E.I. du Pont de Nemours & Co., Kerr McGee Corp., and KemaNord Inc.

EMPLOYMENT

Although overall employment increased during 1988, it was not reflected by new jobs in the State's mineral industry. Unemployment for the State remained in single digits for the entire year after averaging in double digits over the last 5 years. The average unemployment for the year was approximately 8%. Mining employment remained near the 1987 level. However, employment in the construction, clay, primary metals, and stone sectors decreased slightly.

LEGISLATION AND GOVERNMENT PROGRAMS

In 1988, the Mississippi Bureau of

TABLE 1

NONFUEL MINERAL PRODUCTION IN MISSISSIPPI[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	short tons	927,716	$13,538	r838,826	r$13,044	1,093,316	$24,564
Gem stones		NA	1	NA	1	NA	1
Sand and gravel (construction)	thousand short tons	15,080	42,809	e14,700	e47,000	13,314	38,806
Stone (crushed)	do.	e1,600	e4,400	1,492	9,621	1,500	9,000
Combined value of cement, clays (ball clay and fuller's earth, 1986–87) and sand and gravel (industrial)		XX	40,347	XX	r40,413	XX	31,029
Total		**XX**	**101,095**	**XX**	**110,079**	**XX**	**103,400**

e Estimated. r Revised. NA Not available. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

Geology consisted of six sections: (1) Groundwater, (2) Mineral Lease, (3) Surface Geology, (4) Subsurface Geology, (5) Surface Mining, and (6) Environmental. During the year, the Bureau continued to maintain the Mississippi Automated Resource Information System, a resource data bank, and continued a cooperative program with the Water Resources Division of the U.S. Geological Survey. In addition, several dozen water test wells were logged. The Bureau continued to lease and inventory State lands. The Bureau also completed the final report on the geology of Tishomingo County and continued work on regional subsurface mapping of the Miocene of the Mississippi Gulf Coast. Mine inspection and mining permit review were ongoing as was development work on a computer data base on landfills and economic clay deposits.

The U.S. Bureau of Mines continued funding of the Mississippi Minerals Resources Institute (MMRI) with an additional $138,000. In July, the Bureau established a Marine Minerals Technology Center, a cooperative effort of MMRI and the University of Hawaii, with initial funding of $1,128,000. MMRI will be responsible for studies in the shallow waters of the Continental Shelf while the University of Hawaii will be responsible for deep ocean basin studies.[3]

The Bureau of Mines and Jackson State University signed an agreement to encourage cooperation between the two in the areas of minerals science education, research, and technical exchange. Cooperative programs at the university were to be conducted in the following areas: collaborative research; collaborative data collection and analysis; development of university faculty; minicourses and seminars at the university led by Bureau personnel; and exchange of samples, materials instruments, and components for testing.[4]

Bureau scientists at the Intermountain Field Operations Center in Denver, CO, reviewed several environmental impact statements covering planned construction activity instate. The reviews were to ensure that mineral reserves and existing mineral operations would not be adversely affected by the proposed actions.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Mississippi's mineral industry mined or manufactured 10 industrial minerals. Several minerals mined in other States or foreign countries were shipped into the State as feed for the manufacturing industries.

Cement.—Only one company, United Cement Co. of Artesia in Lowndes County, produced both portland and masonry cement. The plant began operation in early 1974. The company operated a one-kiln, wet-process facility using clay and chalk mined instate. The company marketed its cement in a nine-State area.[5]

Clays.—Mississippi's clay production accounted for almost one-fourth of the mineral value reported in 1988. The industry, which produced common clay, bentonite, and ball clay, consisted of 18 companies operating 18 mines in an 18-county area, primarily in the northern and northeastern parts of the State. Since 1982, clay production increased about 50%. However, production was below the record 1,960,000 tons established in 1978.

Common Clay.—Both the production and value of common clay increased by more than 6% compared with that of 1987. The State's common clay industry, 10 companies operating 10 mines in 10 counties, was the major producer of the clay tonnage reported in 1988. Principal production was from the Jackson and Columbus metropolitan areas, which included Hinds County in southwestern Mississippi and Kemper and Lowndes Counties in the northeastern part of the State. The three counties accounted for 34% of the output. All clay was mined by open pit methods and was processed into common brick (29%) or face brick (11%) or was used to manufacture concrete block (5%). Structural concrete and highway base accounted for the remainder.

Bentonite.—Compared with 1987 figures, the 1988 production and value of calcium bentonite, a clay with superior absorbent and green strength properties, had moderate increases. Three companies operated three bentonite mines in Monroe and Tippah Counties. Up to 130 feet of overburden was removed to recover 6 to 8 feet of clay. After processing, the bentonite was sold to the absorbent and animal feed industries.

Mexican imports of acid-activated bentonite have made inroads into bleaching and decolorizing markets that were historically serviced by Mississippi bentonite producers.

Kaiser Tech Ltd. sold its Harshaw-Filtrol Partnership to Engelhard Corp. early in 1988. Harshaw's principal operation in Jackson produced bentonite for purification and petrochemical refining.[6]

Ball Clay.—Ball clay, a highly plastic clay used in filler, tile, and whiteware applications, increased in both production and value from the 1987 levels. Ky-Tn Clay Co., Panola County, mined and processed ball clay for the tile and asphalt filler markets.[7] A second company mined ball clay intermittently and trucked the clay to Tennessee for processing.

Lime (Agricultural).—Mississippi's three State-owned lime plants in Macon, West Point, and Waynesboro, operated by the Mississippi Department of Agriculture and Commerce, were for sale during late summer. Two plants were sold to individuals and the third was sold to the Wayne County Govern-

ment; the Wayne County plant was later sold to an individual. The sale ended more than four decades of the State's involvement in the lime industry. Reasons reported for the plant sales were a decline in lime demand and government purchasing regulations that restrained the plants from being competitive with the private sector.[8]

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter thus contains actual data for 1986 and 1988 and estimates for 1987.

Mississippi construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data for the State's three districts.

Construction sand and gravel remained the leading industrial mineral produced in Mississippi, accounting for approximately 38% of the State's mineral value. The State's sand and gravel companies produced more than 13 million short tons valued at almost $39 million, both decreases from the estimated 1987 figures. Production was reported from 125 pits in 35 counties. Copiah, DeSoto, and Monroe Counties were the leading producers. The three leading end uses reported were concrete aggregate, asphaltic concrete, and road base cover and stabilization.

Industrial.—Two firms in Jackson and Tishomingo Counties produced sand for industrial uses. Principal sales were to the foundry and sand blasting markets.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter thus contains estimates for 1986 and 1988 and actual data for 1987.

In 1987, the last full year for which the stone industry reported, seven companies reported approximately 1.5 million short tons of stone production from seven quarries. Three of the quarries produced feed for the State's lime plants. The leading end-use markets reported were (1) riprap and jetty stone, followed closely by (2) agricultural limestone and (3) surface treatment road stone.

At midyear, the State's only hard rock crushed stone operation, Mississippi Stone Products, near Iuka, was purchased by Vulcan Materials Co., the Nation's largest producer of construction aggregates.[9]

Sulfur (Recovered).—Mississippi ranked third nationally in the output of sulfur recovered from petroleum and natural gas refining. Production of recovered sulfur was reported by five companies in four counties. Sulfur sold or used in 1988 totaled 773,000 metric tons and was valued at $67 million. These totals reflect a slight decrease in shipments and a $5 million decrease in value from that of 1987.

TABLE 2

MISSISSIPPI: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY USE MAJOR CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	3,726	$12,648	$3.39
Plaster and gunite sands	40	221	5.53
Concrete products (blocks, bricks, pipe, decorative, etc.)	33	130	3.94
Asphaltic concrete aggregates and other bituminous mixtures	1,177	4,478	3.80
Road base and coverings[1]	849	2,035	2.39
Fill	126	212	1.68
Other	249	678	2.72
Unspecified:[2]			
Actual	4,507	12,395	2.75
Estimated	2,606	6,011	2.30
Total[3] or average	**13,314**	**38,806**	**2.91**

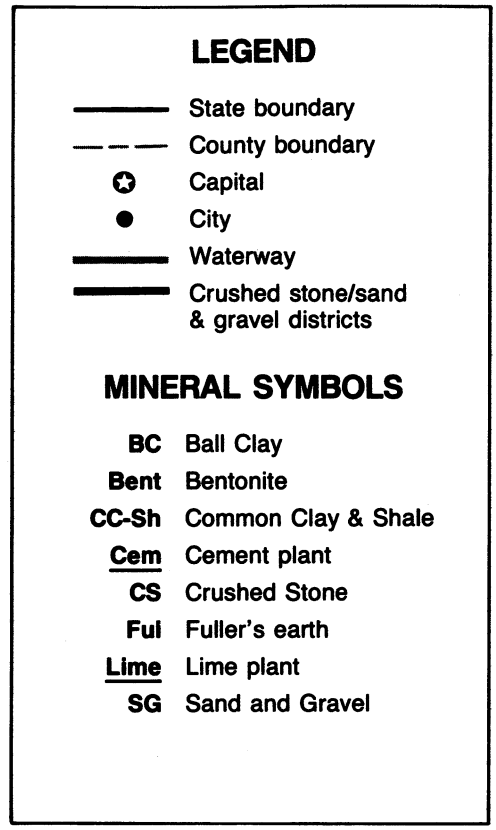
[1] Includes road and other stabilization (cement and lime).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

Other Industrial Minerals.—Several mineral commodities were shipped into Mississippi from other States or foreign countries for processing into higher value products. Ilmenite, a titanium mineral, was used by two Mississippi companies, E.I. du Pont de Nemours & Co. and Kerr-McGee Co., to manufacture titanium dioxide pigments.

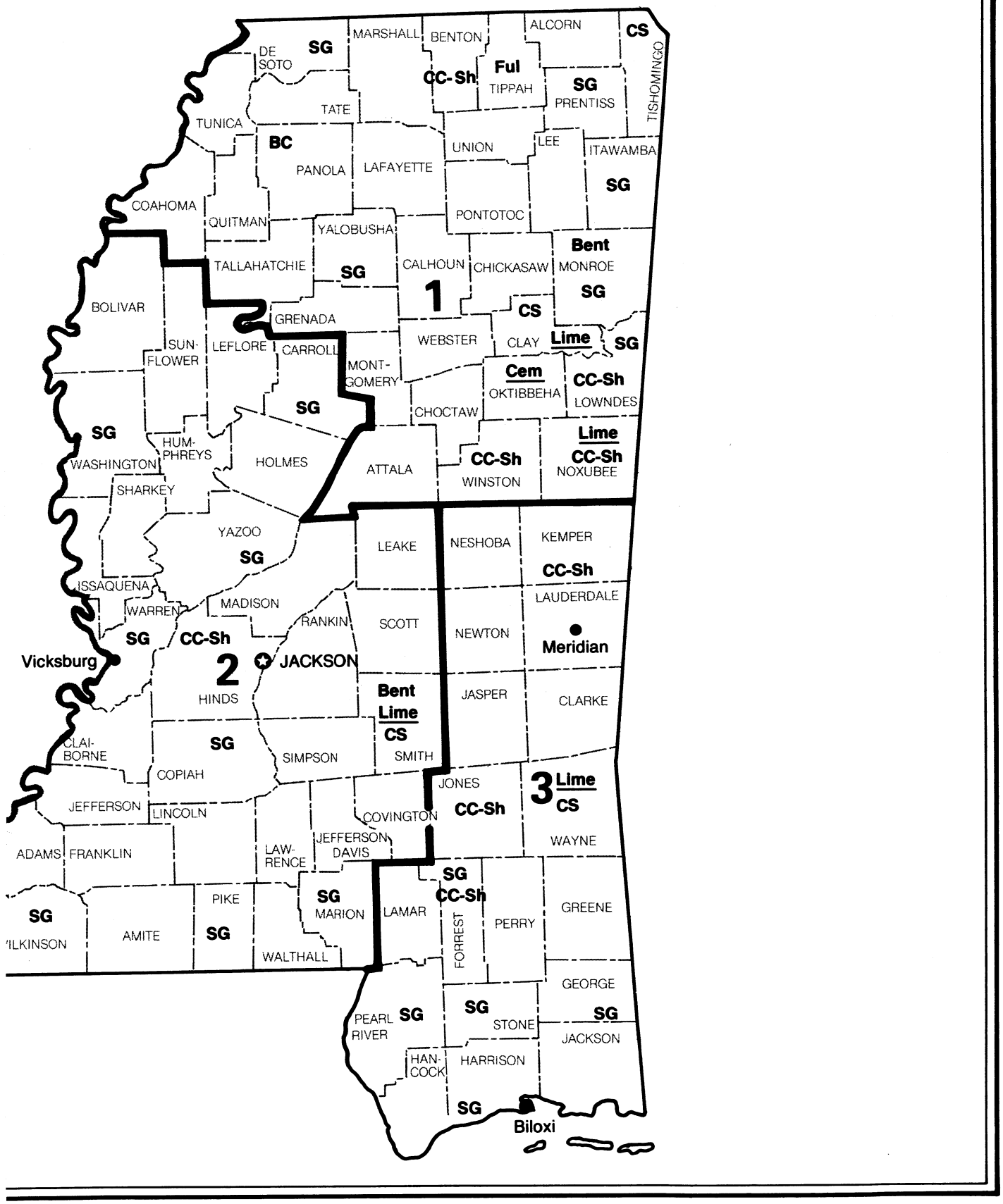
Du Pont announced plans to expand its De Lisle titanium dioxide pigment plant by approximately 100,000 short tons and, along with other modifications, bring the total plant capacity to 270,000 tons. The $10 million venture was scheduled for completion by 1990. During fiscal year 1988, 227,280 short tons of ilmenite from Australia was imported through the Port of Gulfport, destined for Du Pont's titanium dioxide operation. In fiscal year 1987, 215,226 tons was imported.[10]

Kerr-McGee Chemical Corp. continued expansion work at its titanium dioxide plant in Hamilton. The project will increase plant capacity to 106,000 short tons annually. Completion of the $45 million expansion was scheduled

MISSISSIPPI



Principal Mineral-Producing Localities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YALOBUSHA
PONTOTOC
Bent
TALLAHATCHIE
SG
CALHOUN
1
CHICKASAW
MONROE
SG
BOLIVAR
GRENADA
CS
WEBSTER
CLAY
Lime
SG
SUN-FLOWER
LEFLORE
CARROLL
MONT-GOMERY
Cem
CC-Sh
OKTIBBEHA
LOWNDES
SG
CHOCTAW
SG
HUM-PHREYS
Lime
WASHINGTON
HOLMES
ATTALA
CC-Sh
WINSTON
CC-Sh
NOXUBEE
SHARKEY
YAZOO
SG
LEAKE
NESHOBA
KEMPER
CC-Sh
ISSAQUENA
LAUDERDALE
WARREN
MADISON
RANKIN
SCOTT
NEWTON
SG
CC-Sh
Meridian
Vicksburg
2
JACKSON
HINDS
Bent
Lime
CS
JASPER
CLARKE
CLAI-BORNE
SG
SIMPSON
SMITH
COPIAH
JONES
3
Lime
CS
JEFFERSON
LINCOLN
CC-Sh
COVINGTON
WAYNE
ADAMS
FRANKLIN
LAW-RENCE
JEFFERSON DAVIS
SG
CC-Sh
SG
MARION
LAMAR
FORREST
PERRY
GREENE
SG
PIKE
AMITE
SG
WALTHALL
GEORGE
PEARL RIVER
SG
SG
STONE
SG
JACKSON
HAN-COCK
HARRISON
SG
Biloxi

TABLE 3

MISSISSIPPI: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	1,617	5,003	1,402	4,864	780	3,132
Asphaltic concrete aggregates and other bituminous mixtures	237	860	763	2,943	177	674
Road base and coverings[2]	372	971	395	883	83	180
Fill	51	101	19	54	56	57
Other miscellaneous	70	134	145	507	34	37
Other unspecified[3]	2,834	7,922	3,166	8,335	1,113	2,149
Total[4]	**5,181**	**14,992**	**5,890**	**17,585**	**2,243**	**6,230**

[1] Includes sand and gravel for gunite sands.
[2] Includes sand and gravel for road and other stabilization (cement and lime).
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data may not add to totals shown because of independent rounding.

for mid-1989. The company's synthetic rutile plant at Mobile, AL, provided feedstock for the Hamilton facility, which used ore from Australia and Florida. Kerr-McGee also produced electrolytic manganese at Hamilton.

Both Kerr-McGee and Du Pont were reportedly operating at full capacity in 1988 in an effort to satisfy an unprecedented high demand.

Mississippi Chemical Corp. manufactured anhydrous ammonia at Yazoo City using natural gas feedstock. Chevron Chemical Co.'s large ammonia plant at Pascagoula was idle.

Perlite, a volcanic rock that expands to about 20 times its original volume when heated, was shipped into the State from New Mexico. Two companies expanded the material for sales to the formed products roof and insulation board industries. Production and value increased over that reported in 1987. Mississippi ranked first among the 33 States with perlite-expanding firms.

Phosphate rock was shipped to Mississippi Chemical Corp. from Florida for fertilizer manufacture. Mississippi Chemical sold its Pascagoula phosphate fertilizer facility to Nu-West Industries Inc. for $27 million. Plans call for the expansion of the Pascagoula diammonium phosphate facility at a cost of $6 million. Nu-West also acquired a phosphate mine and 4,500 acres in Florida from Beker Phosphate Corp. for $4.75 million. Florida phosphate rock is scheduled to replace imported Moroccan rock. Nu-South, a Nu-West subsidiary, was created to run the Mississippi plant and the Florida properties.[11]

Rock salt, mined in Louisiana, was shipped to the KemaNord Inc. plant in Columbus for use in sodium chlorate production. KemaNord announced plans for a $25 million expansion at the Columbus plant, which would increase capacity by 80,000 short tons per year.[12]

Metals

Mississippi's small but significant primary metals industry contributed to the State economy and added several hundred jobs, both primary and secondary, to the State's work force.

Iron and Steel.—Birmingham Steel Corp.'s most modern minimill, located in Jackson, shipped a record 276,000 short tons of steel bar and rod and produced approximately 1,350 tons of finished product per worker-year. The facility had a melting capacity of 210,000 tons per year and an annual rolling capacity of 300,000 tons. The company conducted feasibility studies on the economics of expanding the minimill's melting capacity. An additional furnace could be operational as early as 1990.

Manganese.—Kerr-McGee operated an electrolytic manganese metal plant at Hamilton using ore imported from West Africa. The plant was located at the company's titanium dioxide pigment complex. Production from the plant, one of two in the United States, was sold primarily to the aluminum industry.

[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL.

[2] Editorial assistant, Bureau of Mines, Tuscaloosa, AL.

[3] American Metal Market. Universities Tapped for Marine Mining Research Projects. Aug. 5, 1988.

[4] Jackson Daily News. JSU, Mines Bureau Plan Joint Research. Aug. 1988.

[5] Jackson Times Leader. United Cement's Mississippi Roots. Apr. 11, 1988.

[6] Industrial Minerals (London). Engelhard Acquires Harshaw/Filtrol. Feb. 1988, p. 13.

[7] White, Doss H., Jr. Ball Clay in the United States. Paper in Proceedings of 24th Forum on the Geology of Industrial Minerals. South Carolina Geol. Survey, Columbia, SC. In press.

[8] Starkville Daily News. State To Sell 3 Lime Plants. July 28, 1988.

[9] Tupelo Daily Journal. Vulcan Materials Acquires Quarry Operation. July 5, 1988.

[10] Industrial Minerals (London). DuPont TiO_2 Expansion. Aug. 1988, p. 14.

[11] Biloxi Sun Herald. Mississippi Chemical Parent Firm Expands. June 5, 1988.

[12] Industrial Minerals (London). Increased Sodium Chlorate Capacity. Sept. 1988, p. 90.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
United Cement Co.	Box 185 Artesia, MS 39736	Plant	Lowndes.
Clays:			
International Minerals & Chemical Corp.	Box 346A Aberdeen, MS 39730	Mine	Monroe and Tippah.
Jackson Ready Mix Concrete, a division of Delta Industries Inc.	Box 1292 Jackson, MS 39205	do.	Hinds.
Oil-Dri Production Co.	Box 476 Ripley, MS 38663	Mine and plant	Tippah.
Presley Construction Inc.	Box 46 Shuqualak, MS 39361	Mines	Noxubee.
Sand and gravel:			
American Sand & Gravel Co.	Box 272 Hattiesburg, MS 39401	Stationary plant	Forrest.
Blain Gravel Co.	Box 278 Mount Olive, MS 39119	Stationary plants	Clay, Copiah, Itawamba, Marion.
Hammett Gravel Co.	Box 207 Lexington, MS 39095	Mines and plants	Holmes, Marion, Pike.
Stone (crushed, 1987):			
Mississippi Stone Products	Box 338 Iuka, MS 38852	Quarry	Tishomingo.
State Department of Agriculture and Commerce	Box 1609 Jackson, MS 39205	Quarries	Clay, Noxubee, Wayne.
United Cement Co.	Box 185 Artesia, MS 39736	Quarry	Lowndes.

THE MINERAL INDUSTRY OF MISSOURI

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Missouri Department of Natural Resources, Division of Geology and Land Survey, for collecting information on all nonfuel minerals.

By Leon E. Esparza,[1] Laurence M. Nuelle,[2] and Ardel W. Rueff[2]

The value of nonfuel minerals produced in Missouri rose about 12% to nearly $968 million in 1988. The increase was due mostly to greater production of lead and zinc. Nationally, the State ranked 12th in nonfuel minerals production, down from 10th place in 1987, and accounted for 3% of the Nation's total. Missouri led all States in the production of fire clay and lead; was second in lime production; and third in barite, iron ore, crude iron oxide pigments, and zinc. Leading commodities produced in Missouri, in decreasing order of contribution to the total nonfuel mineral value in 1988, were lead, portland cement, crushed stone, lime, and zinc. The State's industrial minerals accounted for over $544 million or 56% of the total nonfuel mineral value. The per capita value of Missouri's nonfuel minerals production was $188 in 1988, compared with $122 nationally.

TRENDS AND DEVELOPMENTS

According to the Missouri Department of Labor, mining employment in 1988 totaled about 5,300 jobs. This decline of about 4% from 1987, marked 1988 as the third consecutive year of decline. Mining employment has dropped 15.9% since 1985; this reduction was partially due to staff reductions resulting from the 1986 merger of St. Joe Minerals Co. and Homestake Lead Co. of Missouri into the Doe Run Co.

Most of the State's industrial minerals production is used in construction. According to the U.S. Department of Commerce, the number of private and public residential units authorized in 1988 fell 19% to 23,473, and the value of nonresidential construction increased slightly less than 1% to about $1.5 billion. State road contract awards increased to $473 million during 1988.[3] This was nearly a 20% increase in value.

REGULATORY ISSUES

In 1988, the U.S. Forest Service (USFS) and U.S. Bureau of Land Management (BLM) continued to review options for mineral exploration and development in the Mark Twain National Forest. Explorationists view this area as a possible southern extension of the Viburnum Trend, the most productive lead-

TABLE 1

NONFUEL MINERAL PRODUCTION IN MISSOURI[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Barite	thousand short tons	W	W	27	$2,030	26	$1,930
Cement:							
Masonry	do.	167	$7,816	167	10,027	153	6,310
Portland	do.	4,642	179,184	5,110	185,317	4,679	184,755
Clays[2]	short tons	1,320,767	6,650	1,475,837	10,414	1,581,864	12,171
Iron ore	thousand metric tons	816	W	756	W	816	W
Lead (recoverable content of ores, etc.)	metric tons	319,900	155,481	W	W	353,194	289,194
Sand and gravel:							
Construction	thousand short tons	9,746	24,065	e10,900	e30,400	11,217	32,941
Industrial	do.	517	6,230	622	7,786	744	9,876
Silver (recoverable content of ores, etc.)	troy ounces	1,459,185	7,982	1,180,584	8,276	1,460,271	9,550
Stone:							
Crushed	thousand short tons	e51,200	e170,500	54,910	184,824	e52,100	e183,000
Dimension	short tons	W	W	3,212	454	e3,644	e547
Zinc (recoverable content of ores, etc.)	metric tons	37,919	31,767	34,956	32,306	41,322	54,842
Combined value of clays (fuller's earth), copper, gem stones, iron oxide pigments (crude), lime, and values indicated by symbol W		XX	158,910	XX	391,206	XX	182,833
Total		**XX**	**748,585**	**XX**	**863,040**	**XX**	**967,949**

e Estimated. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kinds and values included with "Combined value" data.

zinc region in the United States. At issue are Doe Run's preference-right lease applications to explore for lead deposits near Winona. Opponents to the two leases cited the potential damage (should a viable deposit be discovered and mined) to regional aquifers by mine waste as sufficient reason to deny further mineral exploration and development. The hotly debated issue resulted in a USFS Record of Decision in December that granted Doe Run the leases with certain conditions. The conditions included a requirement that, if a minable deposit were discovered and the company decided to pursue it, a detailed mining plan and environmental impact statement would have to be submitted with an application for a mining lease.

Initially, the decision was accepted by the mining and environmental organizations. Later, however, the Sierra Club, the Coalition for the Environment, and others indicated plans to file an appeal with the USFS. The dissent focused on alleged inadequacies in the Federal environmental impact study on the Mark Twain National Forest in addressing pollution generated from mining activities. The USFS also was faulted because provisions of the Record of Decision were not among the list of options open earlier to public comment. A final decision by the BLM on the applications was expected in 1989.

Both Federal agencies were involved in the decision process because of their respective responsibilities. The USFS must ensure that mineral leases conform to the purpose for which the lands were acquired; the BLM is responsible for leasing minerals on acquired Federal lands. The United States Steel Corp. initially explored the area after permits were issued in November 1979. The permits were not legally renewable when they expired in November 1983.

The Environmental Protection Agency, at midyear, proposed placing the Jasper County Oronogo-Duenweg Mining Belt on the Superfund priority list for toxic waste cleanup. If the decision is confirmed, which was not expected until 1989, the area could qualify for long-term cleanup action under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act. The 3.2-kilometer-wide and 16-kilometer-long belt had an estimated 9 million metric tons of tailings containing cadmium, lead, and zinc resulting from lead mining that began in 1848 and ended 120 years later.

EXPLORATION ACTIVITIES

Exploration drilling for lead-zinc deposits continued in the Viburnum Trend of southeast Missouri. Cominco American Inc. explored near its Magmont West deposit. Because of difficulty in penetrating vuggy and silicified Cambrian Potosi Dolomite, Doe Run abandoned two drill holes in the Irish Wilderness excluded zone.

Partially because of studies in progress by the State Division of Geology and Land Survey, interest was generated in Missouri's Precambrian iron ore deposits as possible variants of the Olympic Dam-type deposit. Olympic Dam is an extremely large, high-grade copper, gold, silver, uranium, and rare-earth element (REE) deposit on the Stuart Shelf in South Australia. British Petroleum, Chevron Resources, Cominco, and unidentified clients of numerous consulting geologists indicated their interest through activities ranging from literature reviews to drilling.

LEGISLATION AND GOVERNMENT PROGRAMS

A Missouri House Interim Committee began hearings on mine wastes in September. The hearings focused on a bill introduced in the 1988 Legislature that, had it passed, would have provided for the management of waste from mining and beneficiation of metallic minerals and would have included penalties for infractions. Discussions were still under way at yearend. These sought to determine if long-closed mine tailings sites should be included in a substitute version of the bill, which was to be considered in the 1989 legislative session.

Revisions to the Air Conservation Act (House bill 1187) were signed into law. The Act provides (1) additional definitions and classification of air pollution sources and (2) reimbursement to the Department of Natural Resources through permit fees and hourly charges for time spent processing permits.

The U.S. Bureau of Mines Rolla Research Center continued studies on joining technology for advanced materials with the goal of improving bonding strengths and eliminating toxic constituents in the process. Zinc-base solders were found to eliminate the requirement for lead. Further advances were made in soft soldering aluminum. Work continued on developing a method to recover strategic and other metals and nonmetals from lead mill-tailings piles and ponds. If this effort is successful, these tailings would be rendered environmentally inert.

Late in the year, research was begun on enhancing recovery of byproduct REE from the Pea Ridge Iron Ore Co. Mine in Washington County. Preliminary results using single-state gravity tests indicated the breccia pipe material could be upgraded to nearly commercial grades with at least an 80% recovery. The research goal was to develop flow sheets of one or more concentration methods that would recover REE in commercial ore grades.

The U.S. Geological Survey (USGS) and 16 State geological surveys continued work on the Conterminous U.S. Mineral Assessment Program (CUSMAP). CUSMAP work integrates data from field geology, stratigraphy, geochemistry, sedimentary and igneous petrology, and geophysics to provide a multidisciplinary analysis of the mineral resource potential of an area. In its role on the program, the Missouri Depart-

ment of Natural Resources, Division of Geology and Land Survey (DGLS), continued work on the Harrison, Joplin, and Paducah 1° by 2° quadrangles.

In the Midcontinent Strategic and Critical Minerals Project, the USGS, in cooperation with 12 midcontinent States, evaluated the midcontinent area for strategic and critical minerals potential. Map and data compilations at a scale of 1:1,000,000 and related topical studies had been undertaken for a much larger area, from latitude 36° to 46° N. and from longitude 88° to 100° W. One task of the program, the Olympic Dam comparison project, was a joint USGS–DGLS effort. Program participants were evaluating Missouri Precambrian iron ore deposits as petrotectonic analogs to the Olympic Dam-type deposit. Preliminary results at yearend were encouraging.

Publication of the results of the CUSMAP studies on the Joplin and Harrison quadrangles and a symposium on the strategic and critical minerals potential of the midcontinent was scheduled for April 1989.

The DGLS published a new Mineral Resources and Industry Map of Missouri. The 1:500,000 scale map shows active mineral operations and areas of mineral resource potential. It also documents the economic significance of these resources. Also, the DGLS, in cooperation with the U.S. Bureau of Mines, published two reports on the ceramic properties of Missouri clays and shales.

The University of Missouri at Rolla Mining and Mineral Resources Research Institute (MMRRI) received $138,000 in fiscal year 1988 as an allotment grant from the U.S. Bureau of Mines under the provisions of Public Law 98–409. The MMRRI coordinates and administers training and research in mining, mineral resources, mineral development, and mineral processing. It also hosts the Generic Mineral Technology Center (GMTC) for Pyrometallurgy, of which seven universities are participating members.

The main thrust of the MMRRI program was graduate research in ceramic engineering, geological and petroleum engineering, geology and geophysics, metallurgical engineering, mining engineering, and nuclear engineering. Graduate research projects that were at least partially funded by the MMRRI included developing an automatic algorithm for quantitative mineral phase analysis, economic modeling to evaluate the aggregate potential of limestones from northern Missouri, and using stochastic methods to predict blast vibration in surficial mining. Research completed or in progress through the GMTC included the control of dross formation during lead refining, mineralogy of pyrometallurgical feeds and products, and solubility of zinc in solid and liquid iron and noncarbon alloys.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Abrasive Materials.—American Tripoli Co. produced finished tripoli at its Seneca plant in Newton County, from raw materials shipped from Oklahoma. Tripoli is a porous, siliceous, microcrystalline material which, because it lacks distinct edges, is useful as a mild abrasive. Tripoli is used in tooth polishing compounds, for buffing and polishing, automobile paint, and as filter media.

Barite.—Missouri, one of six barite-producing States, was the Nation's third largest producer in 1988, following Nevada and Georgia. The State produced nearly 6% of the total domestic output and accounted for about 12% of the total barite value. Missouri's barite production and value declined 4% and 5%, respectively, in 1988. The decline in production began in 1985 because of a continued slowdown in oil-well drilling activity. Barite is used as a drilling mud additive to prevent blowouts in wells and as a pigment and filler in the manufacture of paint and rubber. In 1988, three producers in Missouri operated six surface mines, north of Potosi, in Washington County.

In February, the Missouri barite operation of NL Industries Inc., Baroid Division, achieved a major safety milestone when it reached 2 million person-hours (19 years) with no lost-time injury.

Cement.—Missouri was the Nation's fifth leading producer of portland cement in 1988, accounting for about 6% of total domestic production. In spite of production declines of about 8%, portland cement was the second most valuable nonfuel mineral commodity produced in the State during 1988. Sales to ready-mixed concrete companies accounted for 81% of the total quantity sold, followed by 7% to highway contractors and 6% to concrete product manufacturers. Five companies produced Types I and II portland cement; three of these also produced Type III. Four companies produced masonry cement. Masonry cement production and value decreased more than 8% and 37%, respectively, from the previous year. These declines were at least partially due to lowered building construction as reflected in the 19% reduction in private and public residential units authorized in 1988.

In early May, River Cement Co. recalled 128 of its 180 workers who had been locked out since late April 1987 following a contract dispute. Replacements hired during the year-long dispute were dismissed. Members of the Cement, Lime, Gypsum, and Allied Workers Division of the International Boilermakers Union accepted a contract that was largely unchanged from the one originally proposed in 1987. The contract called for pay cuts, job reclassifications, cuts in overtime pay, vacation time, and holidays; it also provided for the use of contractors for some positions previously held by

union employees. Company officials indicated that contract concessions were necessary because low-cost foreign imports created profit pressures in the industry.[4]

In late April, River Cement announced plans to construct a hazardous-liquid-waste-burning facility at its Festus cement plant. At the facility, waste solvents generated by paint, coating, and ink manufacturers were to be burned in cement kilns. The company received approval from the Missouri Department of Natural Resources and began construction in early May. Construction was completed at yearend, and the company planned a January 1989 startup. Construction costs were not disclosed. Patchem Inc. of New Jersey, operator of several waste-to-energy facilities in the Eastern United States, was the project contractor.

Clays.—Production and value of clay, excluding fuller's earth, increased 7% and 17%, respectively, in 1988. Missouri was the Nation's leading producer of fire clay, accounting for 41% of total domestic production. For fuller's earth, production and value increased moderately from 1987 figures. For all types of clay, there were 49 pits mined by 14 companies in 14 counties. Fire clay was mined in 36 of these pits, common clay and shale in 11, and fuller's earth in 2. Clays typically were used in manufacturing portland cement, firebrick, oil and grease and pet waste absorbents, face brick, and common brick.

In early February, A.P. Green Industries Inc. was spun off from USG Corp. A.P. Green, with nine refractory and two lime plants nationwide, operated two refractory plants in the State, one of which was at its Mexico, MO, headquarters. A. P. Green manufactured, distributed, and installed refractory products both domestically and internationally.

Lime.—Total lime production and value increased about 11% and 4%, respectively, in 1988. Nationally, Missouri ranked second, after Ohio, of 34 lime-producing States. Hydrated lime and quicklime were produced by Ash Grove Cement Co., Greene County, and Mississippi Lime Co., Ste. Genevieve County. Mississippi Lime was the Nation's second largest lime producer; its Ste. Genevieve plant ranked number one among the 115 plants active in the United States in 1988. In addition to lime, the privately owned company produced precipitated calcium carbonate. Resco Products Inc. produced dolomitic quicklime at its Bonne Terre plant in St. Francois County. Missouri lime products were used for water treatment and oil refining and in the manufacture of paper and steel.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

Missouri construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data for the State's eight districts.

Construction sand and gravel production and value in 1988 increased 3% and 8%, respectively, and accounted for about 3% of the State's total nonfuel mineral value. Production was reported in 46 of 114 counties by 76 companies. The largest producer was St. Charles Sand Co. with operations in St. Louis County. A total of 110 pit operations using 26 stationary plants, 38 portable plants, and 21 dredging operations were active. A majority of the State's total production was from operations that produced less than 500,000 tons. About 30% of the commodity was used for concrete aggregate.

During 1988, a change implemented in State highway specifications for blended asphalt paving sand encouraged the use of sand processed from crushed stone.

Industrial.—The quantity and value

TABLE 2

MISSOURI: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	4,493	$15,375	$3.42
Plaster and gunite sands	78	229	2.94
Concrete products (blocks, bricks, pipe, decorative, etc.)	197	654	3.32
Asphaltic concrete aggregates and other bituminous mixtures	1,139	2,300	2.02
Road base and coverings[1]	518	1,917	3.70
Fill	606	1,198	1.98
Snow and ice control	W	W	3.46
Other	70	250	3.57
Unspecified:[2]			
Actual	3,291	8,982	2.73
Estimated	823	2,035	2.47
Total[3] or average	**11,217**	**32,941**	**2.94**

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1] Includes road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

TABLE 3

MISSOURI: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	W	W	—	—	W	W	1,048	2,816
Asphaltic concrete aggregates and road base and coverings[2]	W	W	—	—	—	—	190	511
Snow and ice control	—	—	—	—	W	W	W	W
Other miscellaneous	W	W	—	—	7	24	34	84
Other unspecified[3]	W	W	W	W	1,541	4,047	492	1,180
Total[4]	**W**	**W**	**W**	**W**	**1,548**	**4,072**	**1,763**	**4,591**
	District 5		District 6		District 7		District 8	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	3,199	11,775	W	W	166	700	316	816
Asphaltic concrete aggregates and road base and coverings[2]	1,414	3,156	61	184	138	504	449	986
Snow and ice control	W	W	6	W	W	W	W	W
Other miscellaneous	23	121	17	81	4	13	1	2
Other unspecified[3]	922	2,862	280	855	169	342	498	1,178
Total[4]	**5,558**	**17,914**	**364**	**1,120**	**477**	**1,559**	**1,263**	**2,982**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for plaster and gunite sands.
[2] Includes sand and gravel for road and other stabilization (cement).
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data may not add to totals shown because of independent rounding.

of industrial sand and gravel increased nearly 20% and 27%, respectively, in 1988. Four companies operated three pits in Jefferson and St. Louis Counties and one dredge in the Missouri River in east-central Missouri. In terms of value, the largest end use was in ground filler, followed by foundry molding and core sand and chemicals.

Slag (Steel).—International Mill Service Co. was the State's sole producer of steel slag, processing it from electric furnaces at Kansas City. Compared with 1987 figures, value increased about one-half, and production increased about two-thirds. Steel slag was sold for use in concrete aggregates, fill, railroad ballast, and road base.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter thus contains estimates for 1986 and 1988 and actual data for 1987. In 1988, crushed stone production and value were estimated to have fallen about 5% and 1%, respectively.

In major urban areas, markets were strong because of State road work and, to a lesser extent, slightly increased nonresidential construction. In rural areas, the general lack of road contracts caused market reductions for road base material. Additionally, aglime markets were depressed at least partially because of the severe drought.

Central Stone Co. of Quincy, IL, reopened the Fort Bellfontaine Quarry in northern St. Louis County. The quarry was previously operated by Missouri Portland Cement Co. and had been idle for many years. Its reopening was the first new crushed stone operation in the county in several decades.

Boone Quarries of Columbia joined the growing list of underground producers and associates offering to lease mined-out rooms as warehouse space. Companies in Carthage, Kansas City, Neosho, St. Louis, Springfield, and Warrenton have similar mining warehouse facilities. The underground storage space has advantages over traditional warehouses because the mines offer constant temperatures and require minimum maintenance. Additionally, parts of some facilities have free-trade zone status.

As in many areas of the Nation, plans by Missouri quarry operators to open or expand mines frequently ran into local opposition. Opponents often cited fears of potential declines in real

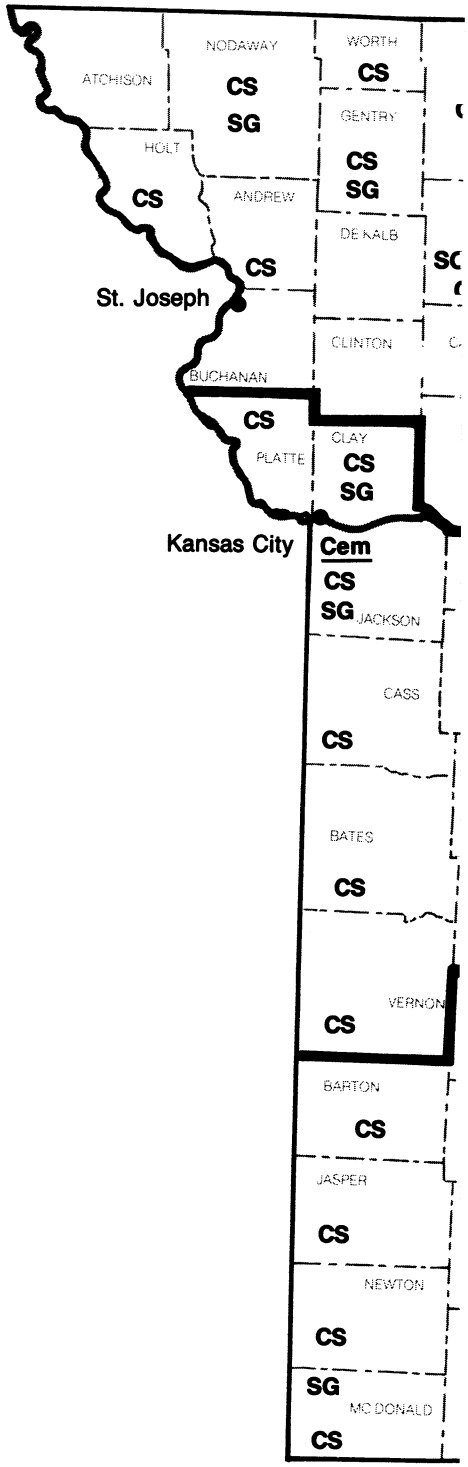
MISSOURI

LEGEND

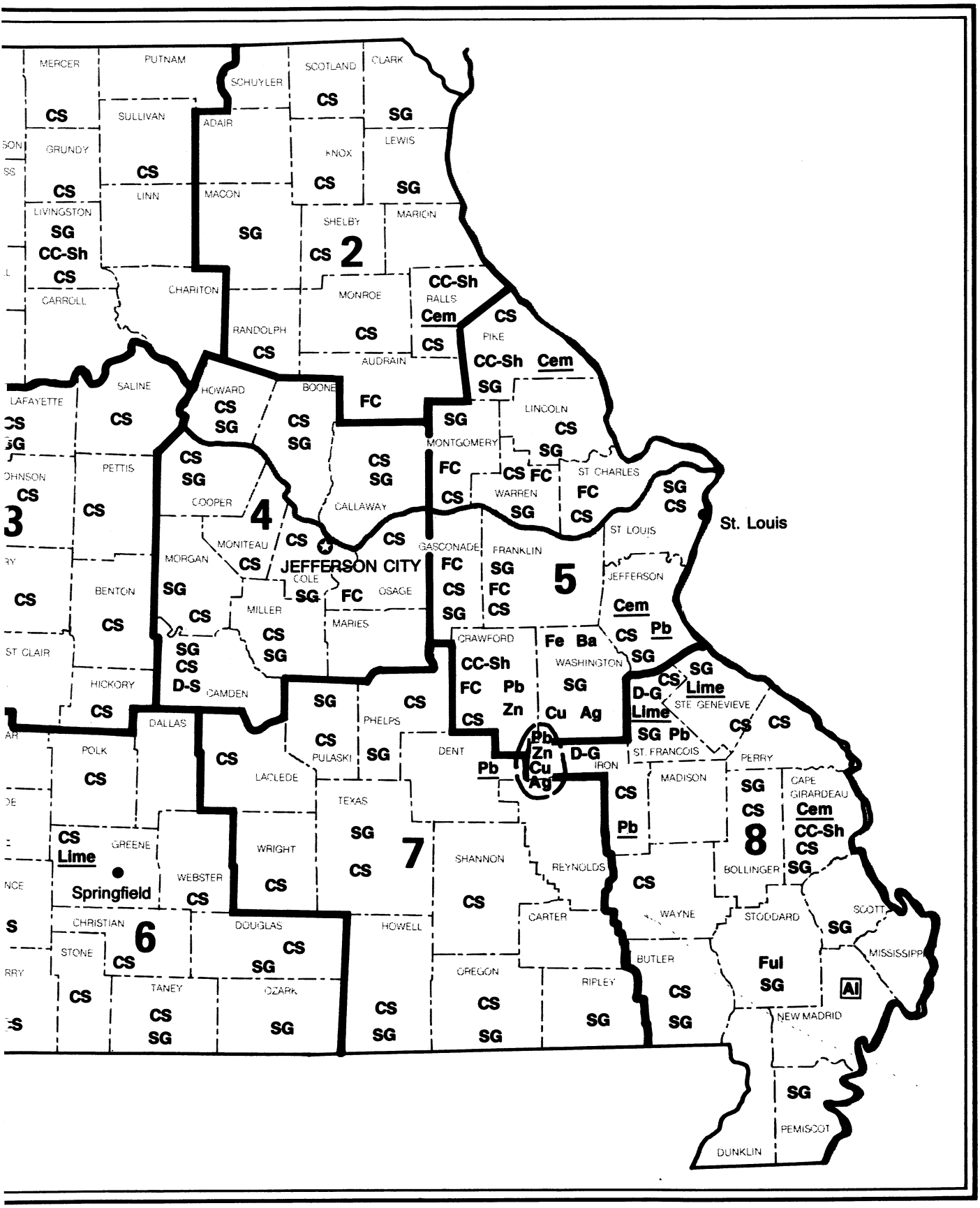
- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Ag	Silver
Al	Aluminum plant
Ba	Barite
CC-Sh	Common Clay & Shale
Cem	Cement plant
CS	Crushed Stone
Cu	Copper
D-G	Dimension Granite
D-S	Dimension Sandstone
FC	Fire Clay
Fe	Iron
Ful	Fuller's earth
Lime	Lime plant
Pb	Lead
Pb	Lead smelter
SG	Sand and Gravel
Zn	Zinc
	Concentration of mineral operations



Principal Mineral-Producing Localities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PUTNAM
SCHUYLER
SCOTLAND
CLARK
SULLIVAN
ADAIR
GRUNDY
KNOX
LEWIS
LINN
MACON
LIVINGSTON
SHELBY
MARION
CARROLL
CHARITON
MONROE
RALLS
PIKE
RANDOLPH
AUDRAIN
SALINE
HOWARD
BOONE
LAFAYETTE
LINCOLN
MONTGOMERY
PETTIS
ST CHARLES
COOPER
WARREN
CALLAWAY
ST LOUIS
St. Louis
MONITEAU
GASCONADE
FRANKLIN
MORGAN
JEFFERSON CITY
COLE
JEFFERSON
BENTON
OSAGE
MILLER
MARIES
CRAWFORD
WASHINGTON
ST CLAIR
HICKORY
CAMDEN
PHELPS
DALLAS
POLK
PULASKI
DENT
IRON
STE GENEVIEVE
PERRY
LACLEDE
MADISON
CAPE GIRARDEAU
TEXAS
GREENE
Springfield
WRIGHT
WEBSTER
SHANNON
REYNOLDS
BOLLINGER
CHRISTIAN
DOUGLAS
HOWELL
CARTER
WAYNE
STODDARD
SCOTT
STONE
OREGON
BUTLER
MISSISSIPPI
TANEY
OZARK
RIPLEY
NEW MADRID
PEMISCOT
DUNKLIN
2
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CS
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CC-Sh
FC
Cem
Lime
D-S
D-G
Pb
Zn
Cu
Ag
Fe
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estate values due to noise and air pollution, blasting vibrations, and increased heavy truck traffic.

The Green County Planning and Zoning Commission, after lengthy and intense local opposition, denied permission for Griesemer Stone Co. of Springfield to open a new underground quarry in Springfield.

Late in the year, Barber & Sons Quarry at Lees Summit ordered the largest jaw crusher built in the United States in 25 years. The 66- by 84-inch crusher, built by Kue-Ken Corp., was expected to be commissioned before mid-1989.

In 1988, Southeast Missouri Stone Co., Cape Girardeau, completed 8 years of operations (447,500 worker-hours) without a lost-time accident. In recognition of this, the company received the Joseph A. Holmes Safety Association Award in November from the Mine Safety and Health Administration (MSHA).

Riverstone Quarry at Villa Ridge in Franklin County received the 1988 MLPA Hillenkamp-Rush Safety Award. The award honored the limestone quarry operation with the best overall safety performance record in the State, as judged by the MSHA.

Metals

Aluminum.—The quantity and value of processed aluminum increased about 8% and 64%, respectively, in 1988. These increases were consistent with the significant nationwide improvements in the aluminum industry realized during 1988; these were attributed largely to both strong demand for primary and secondary aluminum and low inventories. The State's sole operator, Noranda Aluminum Inc., a subsidiary of Noranda Mines Ltd. of Toronto, Canada, received its bauxite raw material from offshore sources via barge up the Mississippi River. The New Madrid, MO, reduction plant had a rated capacity of 204,000 metric tons and produced primary aluminum and bare electrical conductors.

Copper, Lead, Silver, and Zinc.—Three companies in the Viburnum Trend of southeast Missouri produced copper, silver, and zinc as coproducts of lead mining and milling operations. In general, strong lead prices and record prices for copper and zinc resulted in significant increases in value for these commodities. Silver, riding the coattails of the strong lead market, increased in production and value in spite of slightly lower precious metals prices in 1988.

Lead production and value increased significantly in 1988 compared with 1987. Missouri ranked first of 10 lead-producing States with over 350,000 metric tons produced at a total value of nearly $290 million. Missouri accounted for 92% of the total domestic lead production. Lead accounted for 30% of Missouri's total production value of nonfuel minerals.

Zinc output contributed nearly 6% to the value of the State's total nonfuel mineral production in 1988 and accounted for almost 13% of the total domestic zinc production. The State ranked third of eight producing States. In 1988, Missouri's production and value of zinc increased 18% and 70%, respectively.

Copper yields decreased about 4%, but mineral value increased nearly 40% in 1988. Missouri contributed less than 1% of the total domestic copper production and ranked sixth of 12 producing States. Copper accounted for less than 5% of the State's total nonfuel mineral production value.

Silver production and value increased about 24% and 15%, respectively. The State accounted for less than 3% of the total domestic silver output and ranked seventh of 18 producing States. Silver output contributed less than 1% to Missouri's total nonfuel mineral production value.

Ore deposits in the Southeast Missouri Lead District occur in sedimentary rocks of Cambrian age along the flanks of the St. Francois Mountains. The largest deposits occur in the Cambrian Bonneterre Formation associated with open-space filling of strata-bound pore space, networks of vugs that transect strata, and solution collapse breccias.

The Doe Run Co., North America's largest integrated lead producer, owned six mines, four mills, and two smelters in southeast Missouri. Doe Run was a joint-venture partnership between Homestake Lead Co. of Missouri, a subsidiary of Homestake Mining Co., and St. Joe Minerals Co., a wholly owned subsidiary of Fluor Corp. The partnership was formed in November 1986 with St. Joe contributing five mines, three mills, and a smelter for a 57.5% interest; Homestake contributed its Buick Mine, mill, and smelter complex for a 42.5% interest.

Ore reserves were reported to be 74 million tons at an average grade of 5.1% lead, 0.9% zinc, and 0.3% copper.[5] Galena, lead sulfide, was the predominant mineral produced. Doe Run operations in 1988 produced 235,903 tons of lead concentrate, 85,071 tons of copper concentrate, and 46,417 tons of zinc concentrate.[6] About 90% of the concentrates produced at the mills, which had an aggregate daily capacity of 29,000 tons of ore, were hauled by railroad to the lead smelter on the Mississippi River at Herculaneum, MO. Concentrate from the Fletcher operations also was trucked to Herculaneum.

The volume of lead produced from the Herculaneum smelter accounted for about 18% of domestic production from primary and secondary sources in 1988,[7] as calculated from statistics in Homestake Mining Co.'s Annual Report to Stockholders. The Herculaneum operation also produced sulfuric acid, copper matte, and silver bullion.

In early 1988, Doe Run recommissioned its inactive Brushy Creek lead mill to produce copper concentrates from high-grade ore from company mines. In June, a new copper flotation circuit was completed at the Buick mill at a cost of $2.5 million. This circuit was to recover copper previously lost to tailings. Through these projects, the

company recovered an additional 9,749 short tons of copper metal.[8]

The Buick lead smelter near Boss, MO, with an annual capacity of 140,000 tons, operated as a backup to the Herculaneum smelter. The sinter plant at the Buick smelter was operated after an early July fire at the Herculaneum smelter sinter plant damaged equipment, including electrical wiring. A transformer was replaced, and the plant returned to operation by mid-month.

In February, Doe Run was cited by the Federal Occupational Safety and Health Administration (OSHA) for alleged infractions of 313 health and safety standards at its Herculaneum smelter. OSHA assessed a fine of $2.78 million, the third largest OSHA fine on record. Doe Run subsequently reached a settlement with OSHA for $1.25 million.

In late December, Doe Run announced tentative plans for constructing a $34 million lead recycling plant near its Buick smelter. Project progress depended on a final decision by Fluor and Homestake corporate officials, which was anticipated in early 1989. If approved, construction will begin in about 5 years, following receipt of required State and Federal permits. Doe Run reported that the state-of-the-art plant would employ about 125 people and have an annual capacity of 60,000 metric tons of recycled lead. Spent batteries and scrap would be processed, resulting in about a 90% recovery of lead. Also recovered would be plastic from battery casings and sulfuric acid which could be converted to sodium sulfate for use in laundry detergents.

In 1988, ASARCO Incorporated operated two mine-mill facilities in the Viburnum Trend. Asarco completed construction of a 14-foot-diameter ventilation shaft at its West Fork Mine in August and subsequently reached full production capacity. The company has reported limited production from the mine-mill complex since operations began in September 1985. The facility had a nominal annual capacity of 66,000 tons of lead, 14,500 tons of zinc, and 125,000 troy ounces of silver. Lead and zinc concentrates production at West Fork increased 76% in 1988 over the previous year's production. Contained metal production for 1988 totaled 49,400 tons of lead, 11,900 tons of zinc, and 269,000 troy ounces of silver. West Fork ore reserves were reported to be nearly 10.3 million tons grading 5.93% lead, 1.47% zinc, 0.30 ounce silver per ton, and 0.04% copper.[9]

The Sweetwater Mine, acquired by Asarco in late 1986 from Ozark Lead Co., started up in late December 1987 after a 4-year shutdown. The Sweetwater Mine, formerly known as the Milliken Mine, operated at 40% capacity in 1988 and expected a significant increase by early 1989. The mine and mill had an annual capacity of 75,000 tons of lead and 4,500 tons of zinc in concentrates. Contained metal production for 1988 from the Sweetwater operations totaled 20,900 tons of lead, 1,600 tons of zinc, and 61,000 troy ounces of silver. Sweetwater ore reserves totaled nearly 25 million tons, grading 4.84% lead and 0.59% zinc.[10]

Asarco also operated a smelter and refinery at Glover, MO. In 1988, the smelter produced 125,200 tons of lead bullion, slightly more than the plant's 120,000-ton defined capacity. The lead refinery produced 123,700 tons of lead, slightly less than the defined capacity of 125,000 tons.[11] In March, a new 3-year labor agreement was negotiated for the Glover smelter and refinery. Members of United Steelworkers Local 7450 ratified a new contract calling for increased benefits, including improvements in the company's pension, sickness, and accident plans. Salary scales were unchanged.

Cominco American Inc., a subsidiary of Cominco Ltd., and Dresser Industries Inc., in an equal-share joint venture, produced lead, zinc, and copper concentrates from its Magmont Mine and mill complex near Bixby. The Magmont-West ore body yielded one-half of the operation's production in 1988. Total tons of ore treated by the joint-venture companies were 1,103,900, grading 7.2% lead, 1.0% zinc, and 0.3% copper. Cominco's 50% share of the concentrate production was reported to be 49,500 tons of lead, 7,500 tons of zinc, and 800 tons of copper.[12] Ore reserves for the partners at yearend were reported to be 4.3 million tons, grading 6.8% lead, 1.1% zinc, and 0.3% copper. Cominco did not operate its own lead smelter in Missouri. Concentrates were hauled to the nearby Asarco smelter at Glover.

During 1988, interest was renewed in zinc deposits in the Joplin area, a part of the prolific Tri-State Mining District. Mattes Brothers Construction Co. Inc. (MBC) completed permitting procedures for its Hyde Park Mine near Duenweg. Projects in the area reportedly have been considered by several potential investors because of increased metals prices. MBC sought financing for the project at yearend. In addition to zinc, the company planned to market the cherty host rock for railroad ballast. Mineral deposits mined in the Tri-State District until the 1960's were composed of zinc and, to a lesser extent, lead. Sphalerite and galena, the only zinc and lead sulfide minerals mined, generally occurred in cherty limestone or alternating beds of chert and limestone. Host rocks were of Mississippian age represented mostly by the Keokuk Limestone and Warsaw Formation.

Iron Ore and Iron Oxide Pigments.—Iron ore shipments and value from Missouri's only iron ore mine increased about 8% and 18%, respectively, in 1988. About 816,000 metric tons was shipped from this mine, which was the Nation's only active underground iron ore mine. Throughout 1988, the Pea Ridge Iron Ore Co. operated the 24-year-old mine and pelletizing plant. Nearly 90% of the production consisted of olivine-enriched pellets made from magnetite concentrate. Pea Ridge pellets were sold to the Granite City Steel Division of National Steel Corp. at East St. Louis, IL.

A new pellet sales contract with Granite City in 1988 required Pea Ridge to increase personnel and add a second shift.

Pea Ridge was a wholly owned subsidiary of the San Francisco-based Fluor Corp. In 1987, Fluor announced intentions to sell Pea Ridge as it had many of its other natural resource investments, including holdings in various gold and zinc operations. Although Fluor entertained discussions with several potential buyers, it still owned Pea Ridge at yearend.

The Pea Ridge iron ore deposit received considerable interest by industry, academia, and Government when its association with rare-earth elements and gold was revealed. Precambrian volcanic rocks host the deposit with reported reserves of about 90 million tons. Production grades in 1988 averaged about 45% magnetic iron.[13]

Pea Ridge also produced crude iron oxide pigments. Production and value of these pigments increased 11% and 26%, respectively, in 1988. The pigments and ferrites produced by Pea Ridge were used in ceramic magnets. Other Pea Ridge products included heavy-medium magnetite used in coal cleaning and hematite concentrate produced on demand and used in well-drilling fluids. Columbian Chemicals of St. Louis produced finished iron oxide. The iron oxide pigments were used to manufacture paints and coatings, electronics, rubber, plastics, concrete products, paper, fertilizer, ceramics, and polishing compounds; they also were used as an iron source in glassmaking.

Iron and Steel.—Early in 1988, as announced late in 1987, the Midwestern Steel Division of Armco Inc. shut down part of the 100-year-old facility at Kansas City, including one melt shop and one merchant bar mill. Steel products, including coiled wire rods and grinding media for ore processing and cement plants, shipped in 1988 totaled nearly 800,000 tons.[14] The company also announced plans to spend $7 million to modernize and improve its rod and grinding media operations and to install a ladle arc refiner to increase operating efficiency and profitability. The improvements would increase capacity 20% to about 750,000 tons. Armco Inc. also sold its Union Wire Rope Division in April, for an undisclosed price, to Wire Rope Corp. of America. About 950 workers were affected by the shutdown and sale.

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[1] State Mineral Officer, Bureau of Mines, Minneapolis, MN.

[2] Geologist, Missouri Dept. of Nat. Resour., Div. of Geol. and Land Survey, Rolla, MO.

[3] Highway and Heavy Construction. Market Update: On the Road Again. V. 130, No. 6, June 1987, p. 36.

———. Highways: New State Revenue Cushions Falling Federal Aid. V. 131, No. 6, June 1988, p. 34.

[4] Ste. Genevieve Herald. Some River Cement Workers to Return to Jobs on May 9. May 4, 1988.

[5] Homestake Mining Co. 1988 Annual Report to Stockholders. 40 pp.

Fluor Corp. 10K Annual Report for 1988. p. 9.

[6] Works cited in footnote 5.

[7] Works cited in footnote 5.

[8] Works cited in footnote 5.

[9] ASARCO Incorporated, 1988 Annual Report to Stockholders. 36 pp.

[10] Work cited in footnote 9.

[11] Work cited in footnote 9.

[12] Cominco Ltd. 1988 Annual Report to Stockholders. 40 pp.

[13] Skillings' Mining Review. North American Iron Ore Industry in Major Recovery in 1988 to Reach Seven-Year Production Peak of 97.6 Million Gross Tons. V. 77, No. 31, July 30, 1988, p. 24.

[14] American Metal Market. Armco Upgrade Hikes Capacity at Facility in Kansas City, MO. V. 97, No. 20, Jan. 30, 1989, p. 5.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Noranda Aluminum Inc.	New Madrid, MO 63869	Plant (smelter)	New Madrid.
Barite:			
Desoto Mining Co.	Box 35 Richwoods, MO 63071	Mine and plant	Washington.
General Barite Co.	119 West Clement St. De Soto, MO 63020	Mines and plant	Do.
NL Industries Inc. Baroid Div.	Box 2808 St. Louis, MO 63111	do.	Do.
Cement:			
Continental Cement Co.	Box 71 Hannibal, MO 63401	Quarries, clay pit, plant	Ralls.
Dundee Cement Co., a division of Holder-bank Financiere Glaris SA.	Box 67 Clarksville, MO 63336	Quarry, clay pit, plant	Pike.
Lone Star Industries Inc.	Box 5050 Greenwich, CT 06836	Quarry and plant	Cape Girardeau.
Missouri Portland Cement Co., a subsidiary of Cementia Holdings, A.G.	7711 Carondelet Ave. Clayton, MO 63105	Plant	Jackson.
River Cement Co., a subsidiary of IFI International of Italy (Instituto Finanziario Industriale S.p.A.).	Box 14545 St. Louis, MO 63178	Quarry and plant	Jefferson.
Clays:			
Dillon Clay Mining Co.	Box 115 St. James, MO 66559	Pits	Crawford.
A.P. Green Industries Inc.	1018 East Breckenridge St. Mexico, MO 65265	Pits and plants	Audrain, Franklin, Gasconade, Maries, Osage.
Southern Clay Inc. (Lowe's Inc.)	Box 1086 Cape Girardeau, MO 63701	do.	Stoddard.
Iron ore:			
Pea Ridge Iron Ore Co., a subsidiary of St. Joe Minerals Corp.[1]	Route 4 Sullivan, MO 63080	Underground mine and plant	Washington.
Iron oxide pigments (finished):			
Columbian Chemicals Co.	1600 Parkwood Circle Suite 400 Atlanta, GA 30339	Plant	St. Louis.
Lead:			
ASARCO Incorporated[2]	Rt. 1, Box 202C Bunker, MO 63629		
Glover smelter		Smelter	Iron.
Sweetwater Unit		Underground mine and plant	Reynolds.
West Fork Unit		do.	Do.
Cominco American Incorporated Magmont Mine[2]	Bixby, MO 65439	Underground mine and plant	Iron.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
The Doe Run Co.[2]	11885 Lackland Rd. Suite 500 St. Louis, MO 63146		
Buick		Underground mine, plant, smelter.	Iron.
Casteel		Underground mine and plant	Do.
Fletcher		do.	Reynolds.
Herculaneum smelter		Smelter	Jefferson.
Viburnum No. 28		Underground mine and plant	Iron.
Viburnum No. 29		do.	Washington.
Lime:			
Ash Grove Cement Co.	8900 Indian Creek Parkway Suite 600 Overland Park, KS 66225	Plant Quarries	Greene. Greene, Jackson, Polk.
Mississippi Lime Co.	7 Alby St. Alton, IL 62002	Quarry and plant	St. Genevieve.
Resco Products of Missouri Inc.	Box 1110 Clearfield, PA 16830	Plant	St. Francois.
Perlite (expanded):			
Brouk Co.	1367 South Kingshighway Blvd. St. Louis, MO 63110	do.	St. Louis City.
Georgia-Pacific Corp.	133 Peachtree St., NE. Atlanta, GA 30303	do.	Crawford.
Sand and gravel:			
Construction:			
Holliday Sand & Gravel Co., a subsidiary of List & Clark Construction Co.	6811 West 63d St. Overland Park, KS 66204	Dredges and plants	Clay.
Limited Leasing Co., a subsidiary of St. Charles Sand Co.	Route 1, Box 158 Hazelwood, MO 63042	do.	St. Louis and St. Louis City.
Winters Bros. Material Co.	13098 Gravois Rd. St. Louis, MO 63127	Dredge and plan	St. Louis.
Industrial:			
All Purpose Sand Co., a subsidiary of St. Charles Sand Co.[3]	Rt. 1, Box 158 Hazelwood, MO 63042	Pit and plant	Do.
Masters Bros. Silica Sand Co., a subsidiary of Bussen Quarries Inc.	Rt. 1, Box 204 Pevely, MO 63070	Dredge and plant	Jefferson.
Unimin Corp.	258 Elm St. New Canaan, CT 06840	Mine and plant	Do.
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	Dredge and plant	St. Louis.
Slag—iron and steel:			
International Mill Service Co.	1818 Market St. Philadelphia, PA 19103	Plant	Jackson.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone (1987):			
Crushed:			
Granite:			
GAF Chemicals Corp.	Box 186 Annapolis, MD 20104	Quarry and plant	Iron.
Quality Aggregate Co.	Box 307 Piedmont, MO 63957	do.	Wayne.
Limestone-Dolomite:			
Martin Marietta Aggregates	Box 30013 Raleigh, NC 27622	Quarries and plants	Andrew, Daviess, Gentry, Harrison, Holt, Jackson, Mercer, Nodaway, Worth.
Moline Consumers Co.	313 16th St. Moline, IL 61265	do.	Jefferson, Knox, Ralls, Ste. Genevieve.
Tower Rock Stone Co.	Box 69 Columbia, IL 62236	Quarry and plant	Ste. Genevieve.
Fred Weber Inc.	7929 Alabama Ave. St. Louis, MO 63111	Quarries and plants	Jefferson, St. Charles, St. Louis.
West Lake Quarry & Material Co.	13570 St. Charles Rock Rd. Bridgeton, MO 63044	do.	Cape Girardeau, Jefferson, St. Louis.
Dimension:			
Granite:			
Granite Panelwall Co.	Box 898 Elberton, GA 30635	Quarry and plant	St. Francois.
Missouri Red Quarry Inc.	Box 516 Elberton, GA 30635	do.	Iron.
Sandstone:			
Beavers Stone Co.	Box 322 Camdenton, MO 65020	do.	Camden.
Vermiculite (exfoliated):			
Brouk Co.	1367 South Kingshighway Blvd. St. Louis, MO 63110	Plant	St. Louis.
W. R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	do.	Do.

[1] Also crude iron oxide pigments.
[2] Also copper, silver, and zinc.
[3] Also construction sand and gravel.

THE MINERAL INDUSTRY OF MONTANA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Montana Bureau of Mines and Geology for collecting information on all nonfuel minerals.

By W. L. Rice,[1] Robin B. McCulloch,[2] and Richard B. Berg[3]

Montana's nonfuel mineral production value again rose significantly, to $548.1 million in 1988, an increase of about 49% from 1987 and 130% over the 1986 total. A marked rise in the value of copper output and substantial increases in the value of gold, molybdenum, platinum-palladium production, and zinc were the primary factors that contributed to a 59% increase in the State's metallic mineral production value over that of 1987.

Copper was the leading commodity in terms of value, followed by gold, platinum-palladium, silver, and molybdenum. The metals—copper, gold, iron ore, lead, molybdenum, platinum-palladium, silver, and zinc—accounted for 83% of the State's nonfuel mineral production value, compared with 73% in 1987 and 58% in 1986. Montana ranked 18th in the Nation in the value of nonfuel minerals produced in 1988, up from its 24th position in 1987.

TRENDS AND DEVELOPMENTS

Under the incentive supplied by all-time high average copper prices, Montana Resources Inc. (MRI) moved into full-scale production at the Continental Mine in Butte and more than doubled the value of the State's copper production. According to the United Butte-Silver Bow County government, every job at the mine created another 2.6 jobs elsewhere in the area, for a spinoff effect that injected more than $50 million into the local economy.

The revitalized interest in gold mining in the western United States was expressed in Montana by greatly expanded exploration, by the opening of two significant new gold mines, and by the advancement of two other important gold mine projects to the construction stage.

Production at the only domestic platinum-group metals mine was expanded during the year, with further expansion and a second mine projected for the near future. Plans were completed for an on-site smelter that would eliminate export of platinum-palladium concentrates for treatment.

EMPLOYMENT

According to the Montana Department of Labor and Industry, overall mining employment, including petroleum and coal industry workers, rose to 6,200 from the 5,700 total reported in

TABLE 1

NONFUEL MINERAL PRODUCTION IN MONTANA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	221,819	$5,882	[2]28,879	[2]$98	[2]101,194	[2]$1,416
Gem stones		NA	480	NA	1,302	NA	1,602
Gold (recoverable content of ores, etc.)	troy ounces	W	W	234,365	104,984	294,976	129,291
Gypsum	thousand short tons	W	W	24	W	27	W
Lead (recoverable content of ores, etc.)	metric tons	W	W	W	W	8,266	6,768
Sand and gravel (construction)	do.	8,066	19,391	e6,800	e18,800	7,984	20,225
Silver (recoverable content of ores, etc.)	troy ounces	4,773,264	26,110	r5,937,155	r41,619	6,186,074	40,457
Stone (crushed)	thousand short tons	e[3]2,200	e[3]6,200	1,463	3,585	e1,800	e4,500
Talc and pyrophyllite	short tons	W	W	r356,231	r11,334	377,789	11,309
Zinc (recoverables content of ores, etc.)	metric tons	—	—	W	W	18,935	25,130
Combined value of barite (1987), cement, clay (fire clay, 1987–88), copper, graphite (natural 1988), iron ore, lime, molybdenum, peat, phosphate rock, platinum-group metals (1987–88), sand and gravel (industrial), stone (crushed traprock, 1986, dimension), vermiculite, zinc, and values indicated by symbol W		XX	179,870	XX	186,456	XX	307,463
Total		**XX**	**237,933**	**XX**	**368,178**	**XX**	**548,161**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

[3] Excludes certain stones; kind and value included with "Combined value" data.

1987. Metal mining employment, bolstered by the State's expanding precious metals industry, increased to 2,200 from the 1,700 employee total in 1987. Average weekly earnings for Montana's mineral industry workers increased to $564.04 from the $549.99 figure recorded in 1987. Mineral industry workers again were the highest paid group in the private nonfarm industries wage sector.

EXPLORATION ACTIVITIES

Most minerals exploration operations in 1988 were conducted for precious metals in the western and central parts of the State. Compared with 1987, fewer new exploration permit applications were filed, but applications for renewals increased substantially. The number of new operating plans filed with the U.S. Forest Service rose to 246, up from 116 in 1987. As of October 1, 12,013 new mining claims had been filed, contributing to a total of 52,212 active unpatented mining claims in the State.

In 1988, the Bureau of Land Management (BLM) granted 11 patents for 97 claims containing 1,700 acres, and as of October 1, applications for patents covering 3 lode claims, 1 mill site, and 14 placer claims had been filed. As of August, the cumulative total of Small Miner's Exclusion Statements was 1,266, with 47 of that total issued in 1988. A total of 192 State exploration licenses were active, with 47 new licenses granted during the year; there were approximately 480 active exploration projects in Montana in 1988.

Cominco American Resources Inc. drilled six deep holes in the Burnt Creek, Lampoo, 4th of July, and Clark Mountain areas in the Sylvanite District along the Yaak River, Lincoln County. Western Gold Mining Inc. drilled six holes on the Black Diamond property northwest of Troy, and ASARCO Incorporated drilled in the vicinity of the Troy Mine, Lincoln County.

In the Rock Creek drainage in Granite County, Meyer Exploration Inc. excavated 40 sample pits in the Scotchman-Sawpit area on upper Willow Creek, and Newhawk Gold Mines drilled in the Brewster Creek area. Valentine Gold Corp. conducted the first phase of a three-phase exploration program at the Mountain Ram property southwest of Philipsburg in Granite County, U.S. Borax & Chemical Corp. worked at the Maukey Gulch property, and Grand Trunk Resources explored at the San Francisco Mine near Philipsburg.

In Deer Lodge County, Asarco mapped and sampled on the surface and underground at the Gold Coin Mine, Magellan Montana Mining Properties discovered a new ore zone at the Southern Cross property, and U.S. Borax worked at the Golden Eagle Mine.

Freeport McMoRan Gold Co. continued its long-term exploration program in the Zosell District, near Deer Lodge in Powell County. In the greater Butte region of Silver Bow County, AMAX Exploration Inc. drilled eight holes in Flume Gulch, Western Energy Co. worked in Hensly Gulch, and Western Gold drilled in the Gold Hill area of the Highlands. Battle Mountain Exploration Co. explored on the north side of the Highlands and in Rochester Basin.

Near Sheridan in Madison County, Western Gold drilled four holes in Wet Georgia Gulch, and Noranda Exploration Inc. trenched near Bivens Creek in the vicinity of Copper Mountain. John Magnus drilled at the Green Campbell Mine, and Western Gold continued drilling at the Broadway Mine in the Silver Star District. Bethlehem Resources Co. planned an exploration program at the U.S. Grant Mine near Virginia City.

In the Argenta area in Beaverhead County, Noranda initiated a 70- to 80-hole drilling program on the Yellowband property, and U.S. Minerals Exploration Co. trenched at the Ermount Mine and on adjacent ground. In northern Beaverhead County, Sandhurst Mining Co. conducted placer and lode drilling on Ruby Creek.

Homestake Mining Co. and Mountain West Resources continued a long-term exploration program at the Tourmaline Queen Mine and No. 2 Pipe in the Elkhorn District in Jefferson County. Gold Fields Mining Corp. carried out a 100-hole drilling program near the town of Elkhorn. Elsewhere in Jefferson County, Silver King Mines Inc. drilled 30 holes on the Golden Assets property east of Pegasus Gold Inc.'s Montana Tunnels Mine, and Texasgulf Minerals and Metals Inc. worked on the Peerless and Blackhawk properties near the Pauper's Dream gold mine.

In Broadwater County, Pegasus explored on Miller Mountain and at the Diamond Hill Mine on upper Indian Creek, and Curator Gold Inc. planned a drilling program in the Miller Mountain area. FMC Gold Co. worked in the Slim Sam and Norris Gulch areas and planned a 25-hole drilling program. Molycorp explored and laid out a drilling program on the east side of the Elkhorn range.

Near Lincoln, in Lewis and Clark County, Western Energy continued drilling and trenching on the 7-Up Pete prospect, and Asarco drilled eight holes at its Heddleston copper property. Near Helena, Battle Mountain Gold drilled in Grizzly Gulch, and Western Gold drilled a total of 50 holes in Bar Gulch, Cave Gulch, and York Gulch.

Near White Sulphur Springs, Meagher County, the Cominco American Resources Inc.-BHP-Utah International Inc. joint venture announced a significant discovery of high-grade copper mineralization at the Sheep Creek massive sulfide exploration project. FMC Gold worked on its Buckingham project on the east side of the Little Belt Mountains, and Placer Dome Inc. drilled near Grendal Mountain.

In the Judith Mountains, Fergus County, AMAX Exploration Inc. drilled 12 holes in Chicago Gulch and put down 20 to 25 holes near Linister Peak. The FMC-Curator joint venture

drilled near the Tailholt Mine in the Judiths and worked in the north and south Moccasin Mountains.

The Cominco-Ernest K. Lehmann Assoc. joint venture explored on East Butte in the Sweetgrass Hills in Liberty County, and the Meridian Minerals Co.-Santa Fe Pacific joint venture worked on Middle Butte. At Cooke City in Park County, the Crown Butte Resources Ltd.-Noranda joint venture carried out a 25,000-foot drilling program to firm up gold-copper ore reserves at the McClaren and Glengarry properties.

REGULATORY ISSUES

The State of Montana revived a 4-year-old, $50 million lawsuit against The Anaconda Co. for alleged damages that its decades of mining and smelting operations caused throughout the Clark Fork River basin. Montana filed the suit in December 1983 under the Federal Superfund law, but had delayed pursuing the action during the initial stages of a study on Silver Bow Creek in the Clark Fork headwaters. According to a report from the Montana Departments of Health and Wildlife and Parks, the damage included three Superfund sites totaling more than 100 square miles and affected an estimated 30,000 people.

The Federal Environmental Protection Agency (EPA) claimed that it had spent more than $20 million so far to clean up contaminated soil and water in the Clark Fork River basin. Most of the expenditure—$9 million—was spent on the Silver Bow Creek-Butte site; another $4.1 million was expended at the town of Anaconda, site of the smelter and tailings ponds. EPA had spent $2.7 million on the Milltown Reservoir, contaminated with heavy metals from Butte and Anaconda, and an additional $1.3 million on studies along the Clark Fork River. The only nonmining-related expenditure was $2.9 million spent to cover costs at the defunct Montana Pole Treatment plant, where soil and water were contaminated with a wood preservative. Future cleanup costs have been privately estimated to exceed $1.5 billion.

In April, the Federal Occupational Safety and Health Administration (OSHA) levied a $1.6 million fine against Asarco's East Helena lead smelter, claiming that the company exposed its workers to unacceptably high levels of lead and arsenic. OSHA alleged that the smelter had committed 398 violations of health and safety standards. Asarco stated that it had not intentionally broken any OSHA rules and that it would contest many of the violations; the company immediately commenced work to correct any violations that did occur.

Also in April, the Montana State Board of Health adopted new and more stringent air pollution standards for particulate matter so that State regulations would match those of the Federal Government. During the remainder of the year, the State worked on developing an implementation plan acceptable to EPA. The State then would have a 3-year period in which to implement the new rules.

The EPA announced in March that Superfund cleanup of the East Helena lead smelter would be extended to areas within the town, owing to high levels of arsenic being found in shallow test wells. Arsenic levels at a test well outside the smelter site were 20 times the amount allowed in community water supplies.

LEGISLATION AND GOVERNMENT PROGRAMS

A compromise wilderness bill, sponsored by Democratic members of Montana's congressional delegation, was introduced in Congress in 1988. The bill called for an additional 1.48 million acres of national forest wilderness, 375,000 acres of national recreation area, 350,000 acres of additional study areas, and the release of 4 million acres of roadless lands to multiple-use management. The legislation, vociferously opposed by groups on both sides of the issue, passed Congress in October but was vetoed in early November.

Montana received a $5 million grant from the Federal Office of Surface Mining to clean up abandoned mine sites in 20 of the State's counties. About $1 million in grant money was expended to cap or fill 18 mine shafts and move mine dumps from within and near the city of Butte.

Mineral taxes collected by the State on nonfuel minerals, coal, oil, and natural gas amounted to $112 million, or an increase of 11% over the taxes collected in 1987. Mineral taxes represented about 20.8% of total Montana Department of Revenue collections in 1988.

Montana received $26.3 million from the U.S. Bureau of Land Management as the State's 1988 share of royalties from the Mineral Leasing Act.

The Mining and Mineral Resources Institute at the Montana College of Mineral Science and Technology, at Butte, received funding of $175,990 from the U.S. Bureau of Mines in fiscal year 1988. The institute has received a total of $2,575,715 since the inception of the program in 1978.

Montana received a $39,600 grant from the Federal Mine Safety and Health Administration for mine safety and health training in 1988. The funds were administered through the Montana Department of Labor and Industry.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Aluminum.—The quantity of Montana's aluminum production was down slightly, but value increased by about

50% from that of 1987. Columbia Falls Aluminum Co. (COFAC) operated its Flathead County reduction plant at the annual rated capacity of 180,000 short tons of metal in 1988.

In March, COFAC signed a tolling agreement with Shell Mining Co., a Shell Oil Co. subsidiary, that assured continued capacity operation of the smelter through 1995. Shell Mining contracted for 40% of the plant's capacity; Norsk Hydro Trading Co.'s tolling agreement covered the remaining 60% until yearend of 1995.

High aluminum prices throughout the year gave union employees at COFAC a substantial return on their profit-sharing agreement. Each employee received about $20,000 in bonus payments in 1988.

Antimony.—United States Antimony Corp. produced antimony oxide and sodium antimonate at its refinery near Thompson Falls, Sanders County; antimony sulfide concentrates were purchased on contract from the People's Republic of China.

Copper.—The incentive provided by a 40% rise in the average annual price of copper from that of 1987 led to a marked increase in Montana's production for 1988; it rose 47% in quantity and more than doubled in value over that of 1987. Copper production was reported from six mines in five counties; Montana ranked fourth in the Nation in copper output in 1988. The State's major producers were Montana Resources Inc. (MRI) at Butte in Silver Bow County, Asarco's Troy Unit silver-copper mine in Lincoln County, and Inspiration Mines Inc.'s Black Pine Mine in Granite County.

MRI increased its daily production of copper-molybdenum ore from 40,000 tons to 50,000 tons per day by yearend. Copper concentrates were rail shipped to Vancouver, WA, and loaded for ocean transport to smelters in the Republic of Korea and in Japan. According to The Montana Standard in Butte, MRI produced 53,200 short tons of copper and 14.1 million pounds of molybdenum in 1988. At yearend, ore reserves were estimated at 463 million tons grading 0.31% copper.

Gold.—Montana's gold production increased by nearly 26% to 295,000 troy ounces and 23% in value over that of 1987; the State again ranked fifth in the Nation for gold production. Production was reported from 16 lode mines in 9 counties, compared with output from 12 mines in 7 counties in 1987.

Pegasus Gold's seasonal Zortman-Landusky operation in the Little Rockies, Phillips County, ranked 1st in the State and 15th in the Nation in gold production for 1988. The 10th year of production at the open pit, heap-leach property set a record of 117,000 troy ounces of gold. The record output was made possible by increased mine production and an improvement in the leach system that allowed leaching to continue for 11 months. This duration was considerably longer than formerly feasible. Savings in mining costs reduced cash operating costs to $241 per ounce of gold in 1988. Exploration at the mine during the year added 27 million tons of reserves containing nearly 460,000 ounces of gold.

Placer Dome Inc.'s Golden Sunlight Mine, near Whitehall in Jefferson County, was the State's second-ranked gold producer. The mine ranked 18th nationally in production for the year. According to Placer's 1988 annual report, gold production increased 4% to 93,417 ounces recovered from 2.5 million tons of ore, and grading 0.047 ounce of gold per ton. Mill recovery rate was 81.39%; continued improvement in the sand tailings retreatment circuit resulted in an average mill throughput of 6,725 tons per day. Total production costs dropped to $257 per ounce of gold recovered. Ore reserves at yearend were 36.2 million tons grading 0.057 ounce of gold per ton, sufficient for more than 14 years of operation at the current rate.

Pegasus achieved planned production levels at its polymetallic Montana Tunnels open pit mine, Jefferson County. Production in 1988 comprised 70,400 ounces of gold, 1.05 million ounces of silver, 36.8 million pounds of zinc, and 16.8 million pounds of lead. A recovery process that produced dore bullion was successfully modified to one that produced gold and silver in zinc and lead concentrate.

Pangea Resources Ltd. mined an initial 500,000 tons of ore at its Pauper's Dream property, Jefferson County. The company expected to recover about 19,000 ounces of gold in 1988 and to produce between 25,000 and 30,000 ounces annually during an additional 4- to 7-year period.

Canyon Resources Corp. began production at the Kendall Mine in early October. The open pit, heap-leach operation, near Lewistown in Fergus County, was expected to produce more than 60,000 ounces of gold from October 1988 through yearend 1989.

The 2900 Development Corp. brought the Atlantic-Pacific Mine near Pony in Madison County into pilot-scale heap leach production. If tests proved positive, a production facility would be built.

Blue Range Engineering operated the Gies Mine and a 150-ton-per-day flotation plant in Fergus County.

Following a closure in July, Gulf Titanium Ltd.'s Cruse-Belmont Mine, Lewis and Clark County, was reopened and shipped ore to Asarco's East Helena smelter. The company planned to construct a mill and begin full production in late summer 1989.

Construction started in the spring on the Mineral Hill Mine at Jardine, Park County. The $32.4 million underground mine, a joint venture of American Copper & Nickel Co. and Homestake Mining Co., was to begin production in June 1989. The mine was expected to produce 40,000 ounces of gold annually over a mine life of at least 20 years.

Pegasus commenced construction in June at the Beal Mountain gold mine,

Silver Bow County. The $10 million open pit, heap-leach mine was expected to begin production in 1989, producing between 32,000 and 35,000 ounces of gold and about 25,000 ounces of silver annually over a 10-year period.

Development of Sunshine Mining Co.'s proposed Big Blackfoot open pit, heap-leach gold mine near Lincoln, Lewis and Clark County, was further delayed near yearend by the U.S. Forest Service's review of the need for an environmental impact statement. The Forest Service and the Montana Department of State Lands were concerned about the mine's effect on water quality. Sunshine's project was expected to produce about 15,000 ounces of gold per year.

Mark V Petroleum & Mines Ltd. continued development on its Baghdad Mine, Granite County. Plans to start a 200-ton-per-day operation awaited results of an environmental impact statement and subsequent permits.

CoCa Mines Inc. continued development drilling on its Hog Heaven gold-silver project in Lake County. Construction was planned to start in 1989, with production scheduled for mid-1990. Expected first-year production was 12,500 ounces of gold and 1.5 million ounces of silver.

According to the Montana Bureau of Mines and Geology, placer gold production occurred at several localities. Some of the larger placer operations were on Sauerkraut Creek in Lincoln Gulch, Jefferson Creek in the Lincoln area, Grasshopper Creek near Bannock, Indian Creek near Townsend, Washington Gulch near Avon, and Gold Creek in the Deer Lodge area. Placer production continued in the vicinity of Superior, with the majority of work being done in the Quartz Creek, Oregon Creek, and Lost Creek drainages.

Iron Ore.—Hallet Minerals Co. produced iron ore from the Black Butte Mine near White Sulphur Springs, Meagher County. Production increased by about 36%, and value more than doubled over the 1987 figures. The product was used in-State in the manufacture of cement.

Lead.—Montana's lead production increased sharply to 8,266 metric tons from the 1987 output; the State ranked fourth nationally in 1988. Lead was recovered as byproduct from four base and precious metal mines in four counties, although most of the production came from Pegasus Gold's Montana Tunnels Mine, Jefferson County.

Output of lead bullion at Asarco's East Helena smelter was affected by a fire on June 11, which destroyed an ore storage and handling facility and shut down operations for 7 days. Work on a new $16 million ore unloading and storage facility began, with completion scheduled for 1989. Despite the shutdown, the 75,000-ton-per-year-capacity lead bullion smelter produced 63,600 tons of product in 1988, up significantly from the 54,700-ton output for 1987.

Molybdenum.—Molybdenum production rose substantially, by about 73% in quantity and 79% in value, from that of 1987. The increase resulted from stepped up production at Montana Resources' Butte copper operation, where molybdenum was recovered as a significant byproduct. Montana Resources was the State's sole molybdenum producer; concentrates were shipped to foreign facilities for treatment.

Platinum-Palladium.—The first full year of production was achieved by the Stillwater Mining Co. (SMC) at its underground platinum-palladium mine in the Stillwater Complex near Nye, Stillwater County. Production increased about 27% in quantity and by nearly 46% in value over 1987 levels. According to published estimates, SMC produced about 40,000 ounces of platinum and about 120,000 ounces of palladium in 1988. SMC's late 1987 ore production rate of 610 tons per day was increased to 700 tons per day by mid-1988. A production rate of 1,000 tons per day was planned by 1990.

By mid-1988, SMC's ore reserves were 431,000 tons grading 0.79 ounce of platinum-palladium per ton, with additional possible reserves of 1.6 million tons grading 0.93 ounce per ton of platinum-palladium. The company's 5.5 mile strike length at the platinum-group metals zone in the Complex was estimated to contain about 225 million ounces of platinum-palladium. A 13.5-foot-diameter tunnel-boring machine was put into service in March to drive footwall laterals that develop the ore zone at 200-feet intervals; SMC's current mining plan called for 160,000 lineal feet of footwall lateral drifting. The company completed test work for a proposed $6 million on-site smelter; concentrates were being sent to Belgium for treatment. In September, SMC announced plans for a second platinum-palladium mine and mill to be sited about 15 miles from the present mine; the new operation, scheduled to start production in 1991, would boost the company's annual output to 250,000 ounces. In November, Chevron Corp. and Manville Corp. purchased Lac Minerals Ltd.'s one-third interest in SMC for $40 million; this purchase gave Chevron and Manville each a 50% share in the company.

Silver.—Montana's silver production rose by about 4% to 6.2 million troy ounces, but decreased slightly in value from that of 1987. The State produced nearly 8% of the Nation's silver and retained a third place ranking. Output was reported from 14 mines in 8 counties, compared with production from 11 mines in 7 counties in 1987.

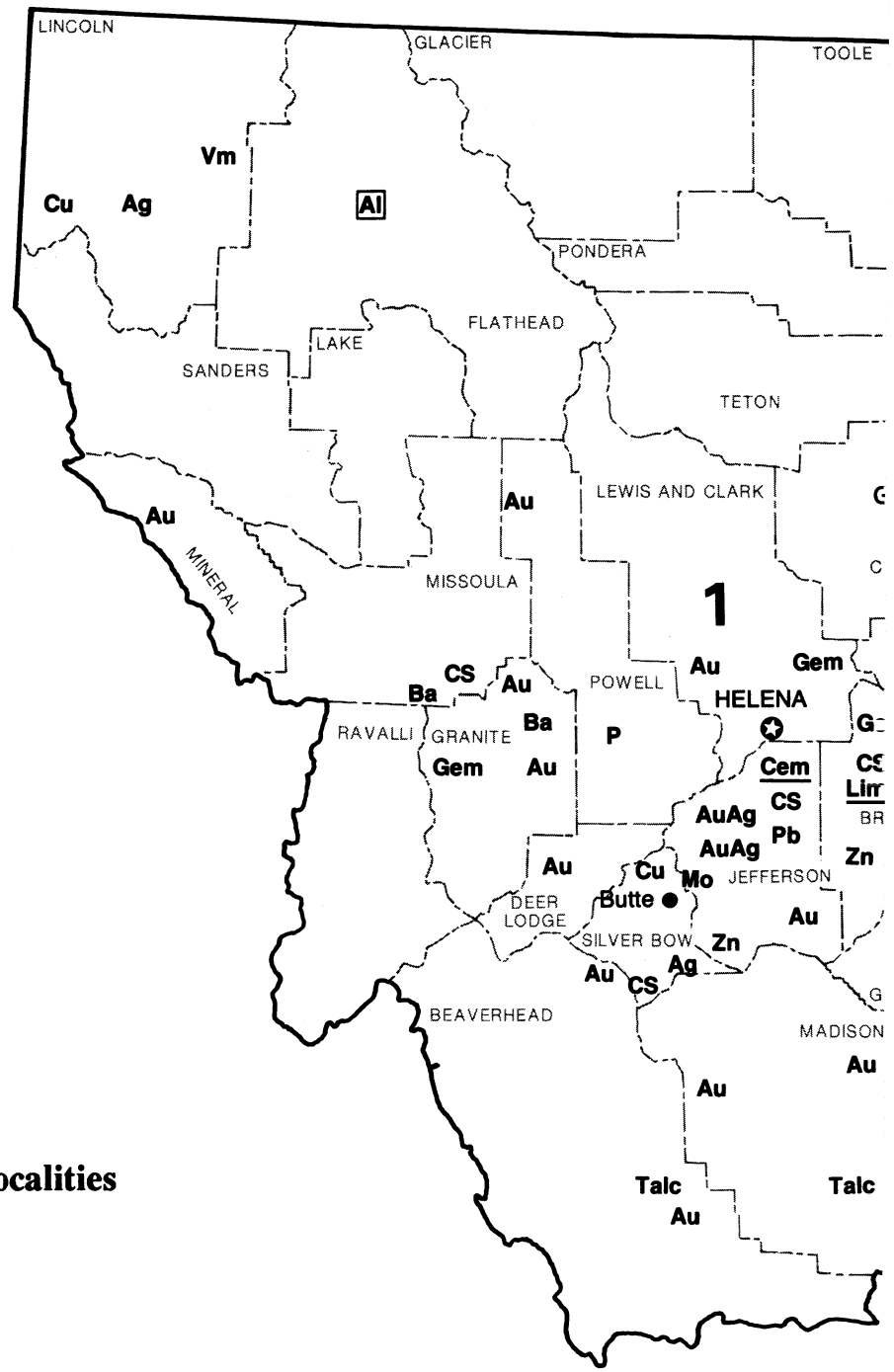
Asarco's Troy silver-copper mine in Lincoln County again was Montana's top silver producer and the fourth-ranked producing mine in the Nation. According to Asarco's 1988 annual report, the Troy Mine produced 3,871,000 ounces of silver and 16,500 tons of copper from 2,823,000 tons of ore, com-

LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

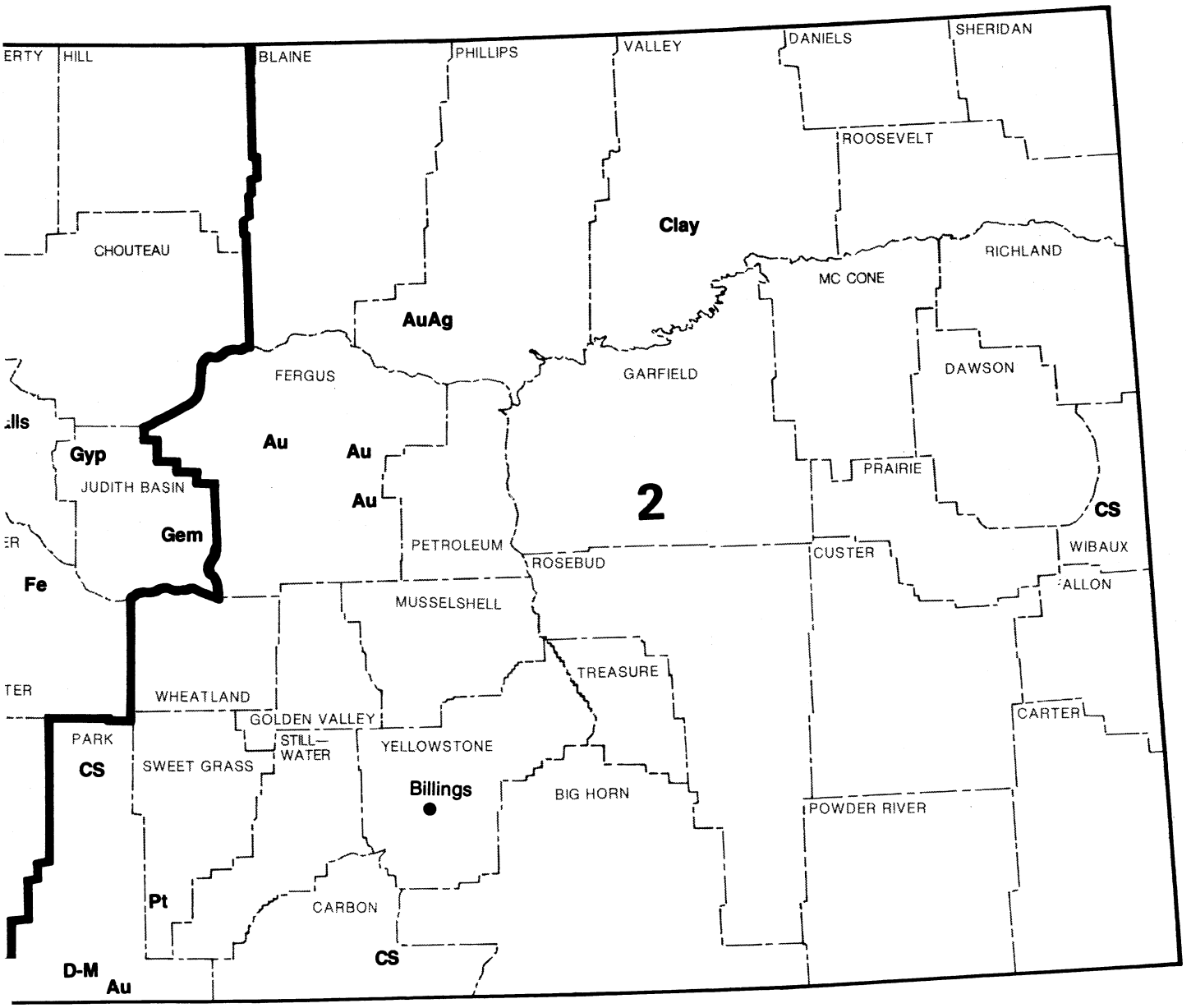
MINERAL SYMBOLS

Ag	Silver
Al	Aluminum plant
Au	Gold
Ba	Barite
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper
D-M	Dimension Marble
Fe	Iron
Gem	Gemstones
Gyp	Gypsum
Lime	Lime plant
Mo	Molybdenum
P	Phosphate rock
Pb	Lead
Pt	Platinum group metals
Talc	Talc minerals
Vm	Vermiculite
Zn	Zinc



Principal Mineral-Producing Localities

ANA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SWEET GRASS
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pared with 3,144,000 ounces of silver and 18,500 tons of copper in 1987. Mill recovery averaged 86.5% in 1988. Ore reserves at yearend were about 35.7 million tons grading 15 ounces of silver per ton and 0.74% copper.

Pegasus Gold's Zortman-Landusky gold mine again gained the second ranking for State silver production, and Pegasus' Montana Tunnels polymetallic mine ranked third. Montana Resources' Continental Mine at Butte produced a significant amount of silver as byproduct from copper-molybdenum production.

Owing to low silver prices, operations were suspended in late February at Black Pine Mining Co.'s Black Pine silver-copper mine, near Philipsburg, Granite County. Closure was not expected to be permanent, but reopening depended on a substantial rise in the price of silver.

The Montana Reserves Co.-Noranda Minerals Inc. joint venture announced plans to develop the Rock Lake stratabound silver-copper deposit in the Cabinet Mountains Wilderness, Sanders County. Montana Reserves previously had optioned the property for $94 million from U.S. Borax and affiliates. Acquisition and development costs were expected to exceed $250 million. The deposit was estimated to contain at least 300 million ounces of silver and 2.5 billion pounds of copper. The proposed room-and-pillar underground mine was expected to produce about 15 million ounces of silver per year for at least 20 years. By yearend, work was well underway to secure needed permits and financing.

Work on Asarco's proposed stratabound silver-copper mine in the Cabinet Mountains was delayed pending approval of the tailings dam design by State and Federal regulatory officials. The proposed underground mine was to produce more than 5 million ounces of silver annually over a 30-year mine life.

New Butte Mining Inc. developed silver-gold-zinc-lead deposits in the Chief Joseph vein system and in the area around the Missoula Mine at Butte. A crosscut was driven from the Lexington Tunnel and a surface decline was being driven at yearend to access the Chief Joseph ore body. The company planned to achieve a 1,000-ton-per-day production rate in 1989; ore was to be milled in the MRI concentrator at Butte.

Zinc.—Montana's zinc production nearly tripled in quantity and more than quadrupled in value over that of 1987. The State ranked fourth nationally in zinc production in 1988. Pegasus Gold's Montana Tunnels gold-silver-zinc-lead mine was Montana's sole zinc producer in 1988.

The zinc fuming plant at Asarco's East Helena lead smelter did not operate in 1988; it had been on standby status since 1982.

Industrial Minerals

Barite.—Mountain Minerals Co. Ltd. mined barite from its underground mine in the Garnet Range, Missoula County. The mined product was shipped for processing to the company's mill at Lethbridge, Ontario, Canada. Mountain Minerals conducted an underground drilling program during 1988 to expand ore reserves.

Cement.—Cement production increased about 12% in quantity and by 6% in value over that of 1987. Portland cement was produced by Ash Grove Cement West Inc. at Montana City, Jefferson County, and by Ideal Basic Industries Inc. at Trident, Gallatin County; Ash Grove also produced masonry cement. The bulk of the cement produced was general use, moderate heat Types I and II gray portland cement. Lesser amounts of Type III high early strength, Type V high sulfate resistant, and oil well cements also were produced. Portland cement produced in the State was used by ready-mixed concrete companies (57%), other contractors (16%), miscellaneous customers (11%), concrete products manufacturers (9%), and highway contractors, building material dealers, and government agencies (7%). Raw materials consumed in cement manufacture were locally mined cement rock, clay, gypsum, iron ore, sandstone, and silica. Both of the one-kiln, wet process plants used natural gas and coal for fuel and purchased electricity for energy.

Chlorite.—Cyprus Industrial Minerals Co. mined high-purity chlorite at the Golden Antler Mine near Silver Star, Madison County. The chlorite was sold for many of the same industrial applications for which talc was used.

Clays.—The resumption of limited-scale bentonite mining led to nearly a quadruple increase in the State's total clay production and a value increase of more than 13 times the 1987 level. Bentonite was produced by two companies from eight pits in Carter County. Common clay, produced by three companies from three pits in Gallatin and Jefferson Counties, was used in cement and pottery. Fire clay was produced from one operation in Deer Lodge County. Kanta Products mined shale from pits in Jefferson and Gallatin Counties and operated an expanded shale and construction products plant at Three Forks.

Gem Stones.—The State ranked fifth in the Nation in natural gem stone production in 1988. Vortex Mining Co. and Roncor Inc. mined sapphires from the Yogo deposit in Judith Basin County. Roncor operated its washing plant on Yogo Creek, processing sapphire-bearing material from the west side of the creek and running old tailings from the American Mine. Vortex sunk a shaft on a newly discovered sapphire-bearing breccia south of the American Mine. The company reclaimed its washing plant site and planned to construct a new facility closer to the mine in 1989. The Eldorado Bar, French Bar, and Spokane Bar placer sapphire deposits on the Missouri River,

Lewis and Clark County, were open to the public for fee digging. The Gem Mountain sapphire placer near Philipsburg, Granite County, also operated on a fee-digging basis.

Gypsum.—Montana's gypsum production increased by about 13% in quantity and by 12% in value over that of 1987. Maronick Construction Co. Inc. mined gypsum from a surface operation at Raynesford, Judith Basin County. The product was shipped to the Ash Grove Cement plant at Montana City and to the Ideal Basic cement plant at Trident.

Lime.—Lime production increased by 9% in quantity and 5% in value over that of 1987. Continental Lime Inc., Holly Sugar Corp., and The Great Western Sugar Co. produced quicklime in Broadwater, Richland, and Yellowstone Counties, respectively.

Peat.—Peat production in 1988 was equal in quantity but dropped by 16% in value from that of 1987. Martins Peat Inc. produced bulk peat at Swan Lake, Flathead County, and Farmer's Plant Aid Corp. marketed a dried and packaged product from Beaverhead County.

Phosphate Rock.—After a 6-month closure, Cominco American Inc. resumed production in the first quarter of 1988 at its underground Warm Springs phosphate mine near Garrison, Powell County. Production in 1988 more than doubled in tonnage and value from the levels of 1987. Construction of new loading facilities and a washing and dry-grinding plant was completed during the downtime. The company stated that the new plant vastly improved operating efficiency in producing a dry product grading 30% to 31% P_2O_5. The product was rail shipped to Cominco's fertilizer plant at Warfield, British Columbia, Canada, where sulfuric acid from the company's nearby Trail zinc smelter was used to make phosphate fertilizer. In 1989, Cominco planned to increase production at Warm Springs to twice the tonnage achieved in 1988.

Stauffer Chemical Co. operated its Silver Bow elemental phosphorus plant, west of Butte, at capacity in 1988. The plant processed phosphate rock rail shipped in from the company's Wooley Valley Mine in southeastern Idaho.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987. The 1988 output of construction sand and gravel in Montana decreased 1% in quantity but value rose about 4% from that reported in the 1986 canvass.

Montana construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data for the State's two districts. In 1988, the major producing counties were Yellowstone, Flathead, Cascade, and Gallatin. Major uses were for road base stabilization (31%), asphaltic concrete (12%), and concrete aggregate (8%). The bulk of construction sand and gravel was transported by truck.

Industrial.—Industrial sand and gravel production was reported by Stauffer Chemical from Maiden Rock, Beaverhead County; the product was used as flux at the company's Silver Bow elemental phosphorus plant.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

Crushed.—Estimated 1988 crushed stone production increased by about 23% in quantity and by nearly 26% in value from 1987 levels.

TABLE 2

MONTANA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	658	$2,567	$3.90
Plaster and gunite sands	5	15	3.00
Asphaltic concrete aggregates and other bituminous mixtures	955	2,348	2.46
Road base and coverings[1]	2,438	5,293	2.17
Fill	152	213	1.40
Snow and ice control	70	167	2.39
Railroad ballast	W	W	1.75
Other	101	284	2.81
Unspecified:[2]			
Actual	1,164	3,076	2.64
Estimated	2,441	6,262	2.57
Total or average	**7,984**	**20,225**	**2.53**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.

TABLE 3

MONTANA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2	
	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	458	1,951	200	616
Plaster and gunite sands	3	5	2	10
Asphaltic concrete aggregates and other bituminous mixtures	185	807	770	1,541
Road base and coverings[1]	1,298	3,133	1,140	2,160
Fill	87	94	65	119
Snow and ice control	58	139	12	28
Railroad ballast	W	W	—	—
Other miscellaneous	48	159	53	125
Other unspecified[2]	1,791	4,902	1,814	4,436
Total[3]	**3,928**	**11,191**	**4,056**	**9,034**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (cement).
[2] Includes production reported without breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

Dimension.—Travertine building stone was produced by the Livingston Marble & Granite Works from quarries north of Gardiner, Park County, and marketed from the company plant at Livingston.

Sulfur.—Montana Sulphur & Chemical Co. and Farmers Union Central Exchange recovered sulfur as a byproduct from petroleum refining at Laurel, Yellowstone County. The quantity of sulfur produced increased by nearly 33%, and the value rose by about 22% over 1987.

Talc.—Montana again ranked first in the Nation for the tonnage and value of its talc production. The 1988 output increased by about 6% in quantity, but decreased slightly in value. Production came from three surface mines and one underground operation in the Ruby and Gravelly Ranges, Madison County.

Cyprus Industrial Minerals produced cosmetic-grade talc from the underground Beaverhead Mine in the Ruby Range; ore was sorted at a company facility on the railhead at Alder. Cyprus attained record talc production at the Yellowstone surface mine, and announced a planned $3 to $6 million expansion to increase recoveries and lower mining costs. The company operated its talc mill throughout the year at Three Forks, Gallatin County, and applied for an operating permit to open a new talc mine, the MP Project, 15 miles east of Dillon in Madison County.

Pfizer Inc. increased overburden stripping and accelerated talc production at the Treasure Chest Mine; ore was processed at the Barretts mill near Dillon. Montana Talc Co. operated the Johnny Gulch Mine in the Gravelly Range and a mill at Sappington, west of Three Forks. Montana Talc applied for an operating permit for the proposed Mineral King II talc mine, about 12 miles southeast of Dillon. The new mine was expected to produce 624,000 tons of talc during an 8-year operating period.

Vermiculite.—Montana retained its second ranking nationally for vermiculite production in 1988; quantity decreased by about 3%, but value rose slightly over that of 1987. Production in 1988 was 80% of the yearly average for the 5-year period (1984–87); value of the production was about 87% of the average for the period. W. R. Grace & Co. mined and milled vermiculite at the Rainy Creek Mine near Libby. The company continued to operate on an alternating work schedule, with one week of mining followed by one week of milling.

The opening of Stansbury Mining Corp.'s proposed vermiculite mine near Hamilton, Lavalle County, was delayed owing to health concerns over possible asbestos in the ore. The U.S. Forest Service and the Montana Department of State Lands decided to require preparation of an environmental impact statement; this procedure would delay startup of the mine for 1 year or longer.

Robinson Insulation Co. of Great Falls, Cascade County, produced exfoliated vermiculite, which was sold for block insulation, loose fill insulation, agricultural soil conditioner, concrete aggregate, horticultural applications, and as fireproofing material.

[1] State Mineral Officer, Bureau of Mines, Spokane, WA.

[2] Staff field agent, Montana Bureau of Mines and Geology, Butte, MT.

[3] Geologist, Montana Bureau of Mines and Geology, Butte, MT.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Columbia Falls Aluminum Co.	Columbia Falls, MT 59912	Reduction plant	Flathead.
Cement:			
Ash Grove Cement West Inc.	5550 SW. Macadam Ave. Suite 300 Portland, OR 97201	Plant and quarry	Jefferson.
Ideal Basic Industries, Cement Div.	Box 8789 Denver, CO 80201	do.	Gallatin.
Copper:			
ASARCO Incorporated	Box 868 Troy, MT 59935	Underground mine and plant	Lincoln.
Montana Resources Inc.	600 Shields Ave. Butte, MT 59701	Surface mine and plant	Silver Bow.
Gem stones:			
Roncor Inc.	2056 S. Barrington Ave. Los Angeles, CA 90025	do.	Judith Basin.
Vortex Mining Co.	Utica, MT 59452	do.	Do.
Gold:			
Golden Sunlight Mines Inc., a subsidiary of Placer Dome Inc.	Box 678 Whitehall, MT 59759	do.	Jefferson.
Pegasus Gold Inc.	North 9 Post Suite 400 Spokane, WA 99201	Surface mines and leach plant	Phillips.
		Surface mine and plant	Jefferson.
Gypsum:			
Maronick Construction Co. Inc.	East Helena, MT 59635	Surface mine	Judith Basin.
Lead:			
Pegasus Gold Inc.	North 9 Post Suite 400 Spokane, WA 99201	Surface mine and plant	Jefferson.
Lime:			
Continental Lime Co.	268 West 400 South Suite 201 Salt Lake City, UT 84101	Surface mine	Broadwater.
Great Western Sugar Co.	3020 State Ave. Box 30878 Billings, MT 59107	Surface mine and plant	Yellowstone.
Holly Sugar Corp.	Box 1052 Colorado Springs, CO 80901	do.	Richland.
Phosphate rock:			
Cominco American Incorporated.	Box 638 Garrison, MT 59731	Underground mine and plant	Powell.
Platinum-palladium:			
Stillwater Mining Co.	Star Route Box 365 Nye, MT 59061	do.	Stillwater.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel (construction):			
Empire Sand & Gravel Co.	Box 440 Forsyth, MT 59327	Pit and plant	Yellowstone.
Fisher Sand & Gravel Co.	Box 1034 Dickinson, ND 58601	Pits	Dawson and Richland.
Sletten Construction Co.	Box 2467 Great Falls, MT 59403	do.	Cascade.
Western Materials Div. of United Industrial Inc.	Box 2790 Missoula, MT 59806	do.	Missoula and Yellowstone.
Silver:			
ASARCO Incorporated	Box 868 Troy, MT 59935	Underground mine and plant	Lincoln.
Montana Resources Inc.	600 Shields Ave. Butte, MT 59701	Surface mine and plant	Silver Bow.
Pegasus Gold Inc.	North 9 Post Suite 400 Spokane, WA 99201	do.	Jefferson.
Stone (dimension):			
Livingston Marble and Granite Works	Box 851 Livingston, MT 59047	Quarries and plant	Park.
Sulfur (recovered):			
Montana Sulphur & Chemical Co.	Box 31118 Billings, MT 59107	Plant	Yellowstone.
Talc:			
Cyprus Industrial Minerals Co.	Box 3299 7000 South Yosemite Englewood, CO 80155	Plant, surface, and underground mines	Gallatin and Madison.
Montana Talc Co.	28769 Sappington Rd. Three Forks, MT 59752	Plant and surface mine	Do.
Pfizer Inc.	Box 1147 Dillon, MT 59725	do.	Beaverhead and Madison.
Vermiculite:			
W.R. Grace & Co., Zonolite Div.	1114 Avenue of the Americas New York, NY 10036	do.	Lincoln.
Zinc:			
Pegasus Gold Inc.	North 9 Post Suite 400 Spokane, WA 99201	do.	Jefferson.

THE MINERAL INDUSTRY OF NEBRASKA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Conservation and Survey Division of the University of Nebraska (Nebraska Geological Survey) for collecting information on all nonfuel minerals.

By Leon E. Esparza[1] and Raymond R. Burchett[2]

Nebraska's 1988 nonfuel mineral production value increased about 2% over that of 1987 to $91.2 million, thus reversing a 2-year slide. Increases in production and value of clays, construction and industrial sand and gravel, and crushed stone accounted for the higher State value. Nebraska ranked 43d in the Nation in production of nonfuel minerals.

Most of the State's nonfuel minerals were used in construction. A total of 5,739 residential units authorized in 1988, according to the U.S. Department of Commerce, was up from 4,902 permits issued in 1987. Nonresidential construction value increased 14% to a total of $301.5 million. Awards for State road contracts increased 69% over 1987 figures to $268 million.[3]

Mining employment decreased by 8% and totaled 1,582 jobs, according to the Nebraska Department of Labor.

LEGISLATION AND GOVERNMENT PROGRAMS

In November, Nebraska voters decided overwhelmingly to keep the State in the Central Interstate Low Level Radioactive Waste Compact. The Compact is composed of five States: Arkansas, Kansas, Louisiana, Nebraska, and Oklahoma. At issue on the November ballot was withdrawal of the State from the siting process for a low-level radioactive waste disposal facility. In 1987, members of the Compact chose Nebraska as the host for the first disposal facility. By order of the U.S. Congress, the Compact was to have a disposal site in operation by January 1, 1993. U.S. Ecology, a unit of American Ecology Corp., was selected as the project contractor. The company was instructed to select three Nebraska locations for further study for a 300-acre disposal site by January 1, 1989. A final site was to be selected by U.S. Ecology in January 1990, after extensive geological studies. The hotly debated ballot issue attracted nationwide interest as concern grew about potential impacts on siting controversies in other regions throughout the Nation.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

In 1988, Nebraska had 28 limestone quarries; 641 sand, gravel, and silt or siltstone pits; 7 clay or shale pits; and 18 sandstone pits. These 694 active mining operations disturbed 454 acres and reclaimed 208 acres during the year.[4]

Cement.—Production of both masonry and portland cement increased over 1987 figures; however, total value declined for both products because of lower unit sales prices. Value of cement produced in Nebraska accounted for nearly one-half of the total nonfuel mineral value.

Clays.—Production and value of clays increased about 6% and 9%, respectively. The production by four companies from five pits in five counties was used mostly in brick manufacturing.

Lime.—The quantity of lime sold or used decreased 13%, and its value decreased about 60%. Western Sugar Co. shipped limestone from its quarries in Wyoming to plants in Morrill and Scotts Bluff Counties for conversion to quicklime for use in sugar refining.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

For some States, construction sand and gravel statistics are compiled by districts. Table 3 presents end-use data for this commodity in Nebraska as

TABLE 1

NONFUEL MINERAL PRODUCTION IN NEBRASKA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	221,153	$668	223,728	$721	237,459	$786
Gem stones		NA	10	NA	10	NA	10
Sand and gravel (construction)	thousand short tons	9,675	23,912	e10,300	e26,300	11,229	28,928
Stone (crushed)	do.	e4,000	e17,900	4,316	19,461	e4,900	e22,000
Combined value of cement, lime, and sand and gravel (industrial)		XX	51,598	XX	43,256	XX	39,468
Total		**XX**	**94,088**	**XX**	**89,748**	**XX**	**91,192**

e Estimated. NA Not available. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

depicted in the centerfold map.

Construction sand and gravel accounted for about 32% of the State's total value of nonfuel mineral production. Compared with figures estimated for 1987, production and attendant value increased about 9% and 10%, respectively.

Overland Sand & Gravel Co. won first place in Class F competition in the 1988 National Aggregates Association Annual Safety Contest. Class F competition was for operations producing 60,000 tons or less per year. Factors considered in judging included tons produced, total worker hours, and number of accidents. Overland has operations in Merrick, Polk, and York Counties.

Industrial.—Western Sand & Gravel Co., the State's sole producer of industrial sand, operated one pit in Saunders County. Production was sold for cement manufacture, filtration, sandblasting, and traction.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for

TABLE 2

NEBRASKA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	1,480	$3,912	$2.64
Plaster and gunite sands	60	153	2.55
Concrete products (blocks, brick, pipe, decorative, etc.)	94	271	2.88
Asphaltic concrete aggregates and other bituminous mixtures	738	1,956	2.65
Road base and coverings[1]	3,033	7,765	2.56
Fill	443	1,010	2.28
Snow and ice control	56	140	2.50
Other	60	259	4.32
Unspecified:[2]			
Actual	471	1,450	3.08
Estimated	4,793	12,012	2.51
Total or average	**[3]11,229**	**28,928**	**2.58**

[1] Includes road and other stabilization (cement and lime).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data do not add to total shown because of independent rounding.

TABLE 3

NEBRASKA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	335	674	461	1,080	683	2,159
Plaster and gunite sands	10	34	30	68	20	51
Concrete products (blocks, brick, etc.)	8	18	W	W	W	W
Asphaltic concrete aggregates and other bituminous mixtures	382	1,059	239	602	118	296
Road base and coverings[1]	1,681	3,973	978	2,796	374	995
Fill	99	220	214	443	130	347
Snow and ice control	25	60	18	51	12	29
Other miscellaneous	42	194	23	51	82	266
Other unspecified[2]	703	1,544	1,577	3,880	2,985	8,038
Total[3]	**3,284**	**7,775**	**3,540**	**8,971**	**4,404**	**12,182**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (cement and lime).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Metals

Ferret Exploration Co. of Nebraska Inc. continued construction of its Crow Butte uranium in situ leach project near Crawford. Full startup of the project was expected by late 1989 or early 1990 with an initial annual production rate of 500,000 pounds of uranium oxide.

Antimony oxide, bismuth, and lead were processed from lead bullion by ASARCO Incorporated at its Omaha refinery. The bullion was supplied from company smelters at Glover, MO, and East Helena, MT. Defined capacity of the Omaha refinery is 156,000 short tons per year. During 1988, the refinery operated at 47% of defined capacity and processed 73,500 short tons of lead bullion.[5]

[1] State Mineral Officer, Bureau of Mines, Minneapolis, MN.

[2] Research geologist, Conservation and Survey Division of the University of Nebraska (Nebraska Geological Survey), Lincoln, NE.

[3] Highway and Heavy Construction Magazine. Highways: New State Revenue Cushions Falling Federal Aid. June 1988, p. 34.

[4] Burchett, R. R., and D. A. Eversoll. Nebraska Mineral Operations Review, 1988. Nebraska Geol. Survey, Conserv. and Survey Div., Inst. of Agriculture and Nat. Resourc., The Univ. of Nebraska, Lincoln, NE, 15 pp.

[5] ASARCO Incorporated 1988 Annual Report. 17 pp.

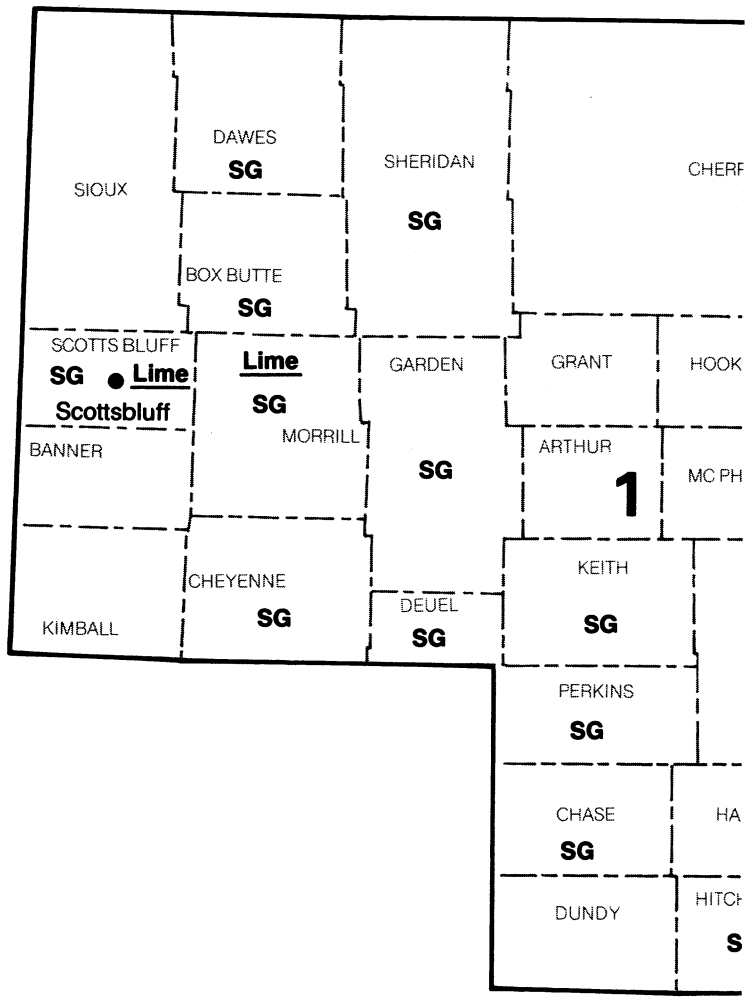
NEBR

LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

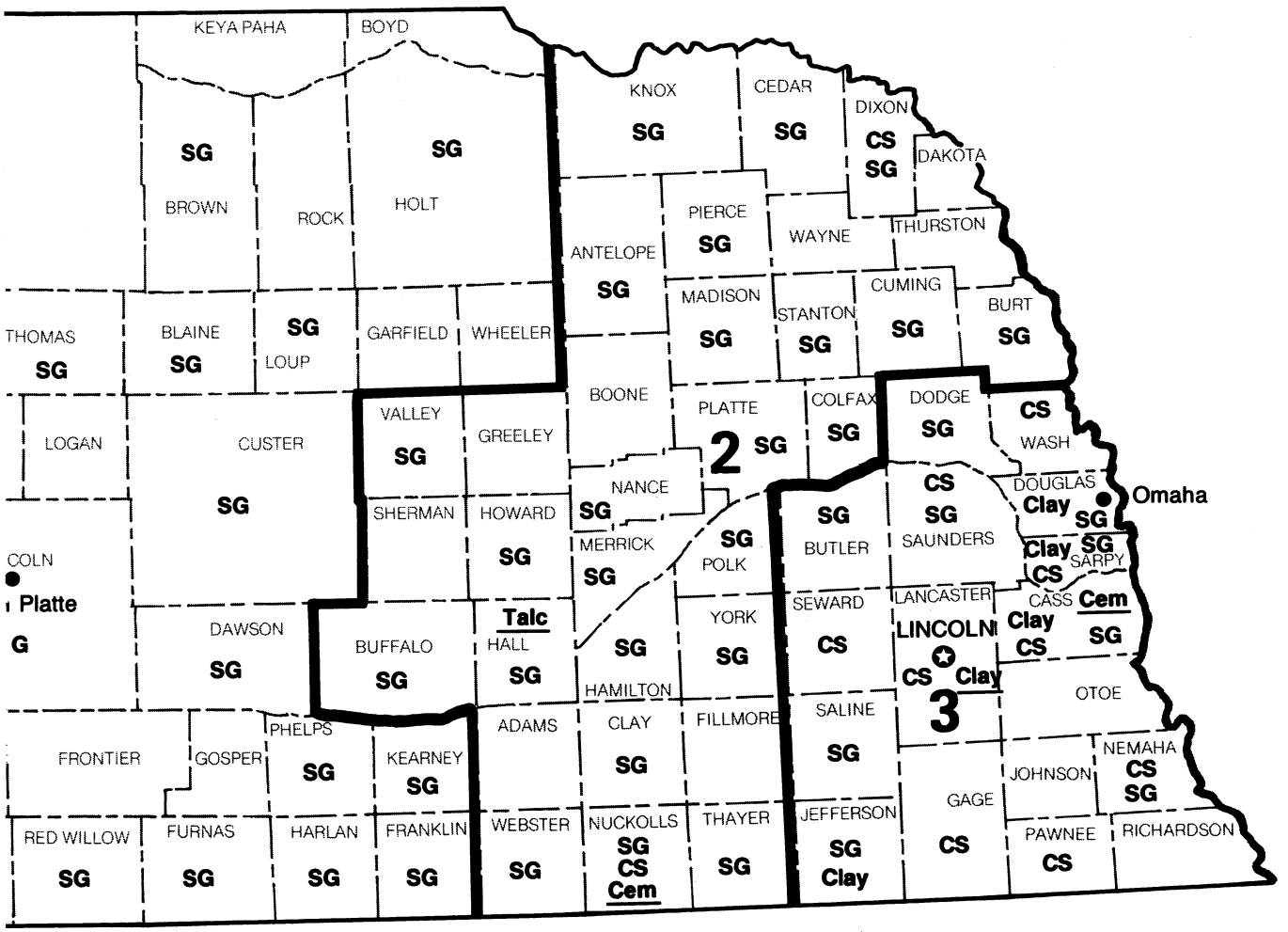
MINERAL SYMBOLS

Cem	Cement plant
Clay	Clay
Clay	Clay products
CS	Crushed Stone
Lime	Lime plant
SG	Sand and Gravel
Talc	Talc plant



Principal Mineral-Producing Localities

SKA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CUSTER
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Clay
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Omaha
SHERMAN
HOWARD
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MERRICK
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POLK
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BUTLER
SAUNDERS
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Talc
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YORK
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SEWARD
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LANCASTER
LINCOLN
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ADAMS
CLAY
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GOSPER
KEARNEY
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NEMAHA
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RED WILLOW
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FURNAS
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HARLAN
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THAYER
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JEFFERSON
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Clay
PAWNEE
CS
RICHARDSON

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Ash Grove Cement Co.	Box 25900 Overland Park, KS 66225	Quarry, clay pit, plant	Cass.
Ideal Basic Industries Inc., a subsidiary of Holderbank Financiers Glaris SA.	Box 8789 Denver, CO 80201	Stockpile shipments	Nuckolls.
Clays:			
Endicott Clay Products Co.	Box 17 Fairbury, NE 68352	Pit and plant	Jefferson.
Yankee Hill Brick Manufacturing Co.	Route 1 Lincoln, NE 68502	do.	Lancaster.
Lime:			
Western Sugar Co.	Anaconda Towers, Suite 1400 555 17th St. Denver, CO 80202	Plants	Morrill and Scotts Bluff.
Sand and gravel (construction):			
Central Paving Sand & Gravel Co. Inc.	Box 626 Columbus, NE 68601	Pits and plants	Butler, Madison, Nance, Platte, Stanton.
Hartford Sand & Gravel Co.	Box Z Valley, NE 68064	Dredges and pits	Douglas and Hall.
Lyman-Richey Sand & Gravel Corp.	4315 Cuming St. Omaha, NE 68131	Pits and plants	Cass, Douglas, Platte, Saunders.
Western Sand & Gravel Co.[1]	Box 28 Ashland, NE 68003	Dredges and pits	Cass, Dodge, Saunders.
Stone (crushed, 1987):			
Fort Calhoun Stone Co.	1255 South St. Blair, NE 68008	Quarries and plants	Washington.
Kerford Limestone Co.	Box 449 Weeping Water, NE 68463	Quarry and plant	Cass.
Martin Marietta Aggregates, Central Div.	Box 30013 Raleigh, NC 27622	Quarries and plants	Cass, Nemaha, Nuckolls, Pawnee, Saunders.
Vermiculite (exfoliated):			
W. R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	Plant	Douglas.

[1] Also industrial sand in Saunders County.

THE MINERAL INDUSTRY OF NEVADA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Nevada Bureau of Mines and Geology for collecting information on all nonfuel minerals.

By F. V. Carrillo[1] and Jonathan G. Price[2]

The value of Nevada's nonfuel mineral production in 1988 was $1.95 billion, representing an increase of $498 million or approximately 34% more than production in 1987. Nevada ranked 3d nationally in the value of its nonfuel mineral production.

Nevada continued to lead the Nation in the production of barite, gold, mercury, and silver. It was the sole producer of mined magnesite. Gold production accounted for more than 80% of the total nonfuel mineral value produced in the State in 1988. Silver, mostly as a byproduct of gold production, accounted for an additional 7%.

TRENDS AND DEVELOPMENTS

Precious metals production increased again, with more than 10 additional mine openings during the year. Nevada continued to be the leading gold-producing state in the Nation. It was also the leading silver producer for the second year in a row, with production principally from open pit disseminated gold deposits. Heap-leaching recovery methods were important in the production of at least 50 operations throughout the State.

Nevada remained the principal mercury producing state, reporting production of more than 90% of the Nation's primary mercury. The State's major mercury mine, Placer Dome U.S. Inc.'s McDermitt Mine in Humboldt County, furnished most of the Nation's mercury after reopening in March. Nevada also was the leading silver-producing State in the U.S. in 1988, with output increasing 60% over the previous year. The increase was attributed to more byproduct silver from the State's expanding gold operations. By the end of 1988, Cyprus Minerals Company began reopening of the former Anaconda molybdenum mining operations near Tonopah.

In response to a booming population growth plus increased demand from California, production improved significantly for sand and gravel, crushed stone, and gypsum. Lime production also increased as a result of heightened activity in the gold industry, which requires high-calcium lime for pH control of heap-leaching solutions.

EMPLOYMENT

According to the Nevada Employment Security Department, employment in the Nevada mining industry reached 12,000 persons by December 1988, with an annual average of 11,056 jobs. Mining added more than 2,800

TABLE 1

NONFUEL MINERAL PRODUCTION IN NEVADA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Barite	thousand short tons	184	$3,005	308	$4,778	319	$5,053
Clays[2]	short tons	10,313	584	r11,799	r810	28,865	2,143
Gem stones		NA	213	NA	280	NA	280
Gold (recoverable content of ores, etc.)	troy ounces	2,098,980	r772,928	2,679,470	1,200,269	3,675,526	1,611,020
Gypsum	thousand short tons	1,236	8,221	W	W	W	W
Perlite	do.	4	122	W	W	5	142
Sand and gravel:							
Construction	do.	12,197	35,692	e10,600	e30,700	15,729	50,928
Industrial	do.	518	W	578	W	602	W
Silver (recoverable content of ores, etc.)	troy ounces	6,408,783	35,056	r12,186,692	r85,429	19,535,223	127,760
Stone (crushed)	thousand short tons	e1,500	e7,000	31,264	35,700	e31,300	e35,700
Combined value of cement (portland), clays (fuller's earth (1986–87), kaolin), copper (1986, 1988), diatomite, fluorspar, iron ore (1986), lime, lithium minerals, magnesite, mercury, salt, stone (crushed dolomite, 1987–88), and values indicated by symbol W		XX	114,529	XX	r118,825	XX	141,540
Total		**XX**	**977,350**	**XX**	**1,446,791**	**XX**	**1,944,566**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

[3] Excludes certain stones; kind and value included with "Combined value" data.

jobs statewide during the year, a 30% increase. Metal mining employment averaged 9,852 workers during the year. The largest number of employees was in precious metals operations, followed by the sand and gravel industry.

LEGISLATION AND GOVERNMENT PROGRAMS

The U.S. Bureau of Land Management (BLM) announced in September that more than 500,000 certificates of mining claim locations had been filed in Nevada, a total that far exceeded the filings in any other public land state. In June, BLM released 25 mineral reports prepared by the U.S. Bureau of Mines and the U.S. Geological Survey on Nevada Wilderness Study Areas.

The U.S. General Services Administration approved $11.5 million in grants to the University of Nevada at Reno to establish a center for strategic minerals research and policy study and to construct the Paul Laxalt Mineral Research Center at the Mackey School of Mines.

The Nevada Bureau of Mines and Geology published Special Publication MI-1988, "The Nevada Mineral Industry," which included production statistics; exploration for and development of minerals, petroleum, and geothermal resources; discoveries of ore bodies; new mine openings; expansion and other activities of existing mines; statistics of known bulk mineable gold and silver deposits, including grades and reserves; and directories of mines and plants. The Nevada Bureau of Mines and Geology also published the bulletin, "Tungsten Deposits in Nevada."

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Gold.—Nevada ranked first among the States in the amount and value of gold produced in 1988, accounting for 67% of the total amount produced in the United States. Production increased for the ninth consecutive year to 3,675,526 troy ounces, valued at $1.6 billion. Exploration activities continued throughout the State, focusing on deeper deposits in the Carlin Trend area of northeastern Nevada.

More than 10 additional gold mines were opened in 1988, principally in the northern half of the State. The most significant of which were Newmont Gold Co.'s Rain and Rawhide deposits in Elko County, Hycroft Resource and Development Corp.'s Crofoot Mine, and USMX Inc.'s Green Springs Mine in White Pine County. Horizon Gold Shares Inc. and Fischer Watt Gold Company Inc. began initial production in late October at the Tuscarora Gold Mines property in Elko County. The Nevada Goldfields Aurora Mine, in Mineral County near Hawthorne, began production in January.

The Adelaide Crown property in Humboldt County was developed by Icarus Exploration Co. and Grand Teton Industries Inc. and reportedly began mining during the year. Battle Mountain Gold Co.'s Canyon Placer operation, next to the company's Fortitude/Surprise Mine, began operations in Lander County. The Green Hill placer mine in Washoe County was opened in mid-1988 by Canaustra Gold Exploration Ltd. and Cliff Resources Corp., and reportedly poured its first test gold in November.

Newmont Gold Company's expansion program continued through 1988 as two new mills, Mill Number 3 and Mill Number 5, were commissioned during the year. Work continued on Mill Number 4, under construction near the Post Mine. During the year, Newmont sold nearly 900,000 ounces of gold, compared with sales of nearly 600,000 ounces in 1987. Newmont produced gold from four mines during the year—Gold Quarry, Genesis, Rain, and Blue Star. The company processed 30.3 million tons of ore from 100.4 million tons of material mined, including waste. Some stockpiled ore from the Carlin, North Star, and Post deposits were also processed.

In September, American Barrick Resources (ABR) poured the first bar of gold at its new mill at the Goldstrike Mine north of Carlin. Near the end of 1988, ABR announced a $365 million development plan to recover 10.4 million ounces of gold from the Post and Betze surface reserves during 1989–2000. The plan is fully financed with a 1.05 million-ounce gold loan. FMC began full-scale heap-leach production at its Paradise Peak Mine in Nye County near Gabbs. The new $25 million, 4,500-ton-per-day, carbon-in-leach mill was commissioned at the property in August, adding about 10% to gold production and 2% to silver production. Continued exploration drilling around the mine in the Ketchup Flat area found almost enough reserves to replace ore mined during the year.

Work proceeded on a $131 million expansion plan due for completion in 1989 at the Round Mountain Mine in Nye County, the world's largest open pit, heap-leach gold mine. Round Mountain, owned by Echo Bay, Homestake, and Case Pomeroy & Co., produced nearly 235,000 ounces of gold during the year. The expansion program was expected to increase production to 300,000 ounces of gold in 1989. Components of the expansion program include enlarging the pit; building a new ore-crushing and stacking system; building new, reusable leach pads; building a new carbon-recovery plant; and constructing a new townsite.

Freeport-McMoRan Gold Co.'s Jerritt Canyon Mine in Elko County began a $43 million expansion program, which included the installation of a fluid-bed roasting system capable of handling 3,500 tons per day. Expansion was planned to increase mill capacity from the current 4,000 tons per day to 7,000 tons per day.

AMAX Gold Inc.'s Sleeper Mine in Humboldt County underwent a planned $7 million expansion to increase mill

production from 1,000 to 1,500 tons per day and to increase heap-leaching production from 4.5 million to 5 million tons per year.

The Cortez Mine, a joint venture of Placer Dome U.S. Inc., Vernon F. Taylor, Jr., and B.P. Minerals America, began installation of a fluid-bed roasting facility to process carbonaceous ore from the Horse Canyon Gold Acres properties.

Construction of additional capacity designed to enhance utilization of the refractory ore fraction proceeded at several mines. The following facilities were included in these construction programs: the Tonkin Springs Mine in White Pine County, where operations were suspended during the year while the company installed one of the Nation's first commercial bioleaching plants designed to prepare sulfide ores for conventional leaching; the Cortez Gold Mines Ltd. in Lander County, which added a fluid-bed roasting facility to increase gold recovery from sulfide and carbonaceous ores from its Horse Canyon and Gold Acres deposits; and the Getchell gold mine of First Miss Gold Co. in Humboldt County, a subsidiary of First Mississippi Corp., where construction of the mine/mill complex continued during the year.

Consolidated Gold Fields Mining Corp. continued exploration of its Humboldt County Chimney Creek Mine. In late 1988, a new gold reserve of 2.1 million ounces in addition to the previous 2.5 million ounces, was announced. The new reserve consists of sulfide mineralization lying beneath the South Pit area, where work was underway to bring an upper oxide ore body into production.

Exploration activity continued unabated throughout the State despite somewhat lower gold prices. Exploration was reported at the Fireball Ridge property in Churchill County. In Elko County, exploration was reported at the Antelope Creek, Emigrant Springs, and Kingsly Mountain Trout Creek properties; the Hollister deposit; and the Tuscarora Mine. The Tonkin Springs Mine, Buckhorn Mine, and Gold Bar property in Eureka County all conducted exploration programs. Exploration was reported in Humboldt County at the Chimney Creek Mine, Dean Mine, Marigold project, North Creek property, Rabbit Creek property, and Freegold Recovery Inc. Slumbering Hills project. Lander County exploration was reported by Battle Mountain Gold Company in the Fortitude and Surprise areas, the Toiyabe property, the Robertson property, and Echo Bay Mines Ltd.'s McCoy/Cove Mines. An exploration drilling program was conducted on the Delamar property in Lincoln County. Mineral County exploration was reported at the Aurora Mine, Borealis Mine, Cedar Mountain property, and Mindora property. Nye County exploration continued in the Paradise Peak Mine area; at Round Mountain Mine, Sterling Mine, and the Mother Lode deposit; and in the area of the Manhattan Mine. Pershing County exploration was reported at the Florida Canyon Mine and the Barrel Springs property. Asamera Minerals Inc. began exploring the Curtis-Wright property surrounding the Gooseberry Mine in Storey County. Exploration in White Pine County was reported at the Casino, Winrock, Mount Hamilton, and Robinson properties and at the Green Springs, Little Bald Mountain, and White Pine mines.

Mercury.—Nevada was the principal source of primary mercury production in the United States. The McDermitt Mine in Humboldt County, the main U.S producer for several prior years, resumed mining operations in March. In its annual report, Placer Dome Inc. reported 1988 production of approximately 11,000 flasks of mercury. Byproduct mercury from six gold mines in Eureka, Humboldt, Mineral, Nye, Washoe, and White Pine Counties accounted for 33% of Nevada's total mercury production.

Silver.—Nevada continued to be the Nation's leading silver-producing State in 1988, reporting production of 19,535,223 troy ounces, up 60% from 1987. Production value at $127,565,000 was 50% higher, despite the lower average price of $6.53 per ounce for 1988. The rise was attributed to the increasing byproduct silver from Nevada's burgeoning gold mining industry and full production at the Rochester, Candeleria, and Trinity Mines.

Three open pit, heap-leach operations and one byproduct gold mine were the State's largest silver producers. Coeur d'Alene Mines Corp.'s Rochester Mine in Humboldt County was the leading producer; the mine reported production of 5,010,581 ounces of silver and 52,386 ounces of gold during 1988. NERCO Minerals Co.'s Candelaria Mine in Mineral County and U.S. Borax and Chemical Company's Trinity Mine in Pershing County were also important silver producers from heap-leach operations. FMC expanded operations at its Paradise Peak mine in Nye County, becoming the second largest silver producer in Nevada; FMC's silver is a byproduct of its gold operations. Heap leaching was instituted to complement the existing 4,000-ton-per-day mill, resulting in the production of almost 100,000 additional ounces of silver.

In February, Coeur d'Alene assumed full operation of the Rochester Mine, replacing Morrison-Knudsen Co., the contract mining company that had been the mine's operator. In March, Coeur d'Alene acquired the remaining 52% interest in Royal Apex Silver Inc., giving it full ownership of Rochester.

Corona Corp.'s Santa Fe open pit, heap-leach mine began production in November. The Gooseberry Mine, which had been closed since late 1985, was reopened. It produced silver and gold concentrates using conventional flotation processing.

NERCO acquired Silver King Mines Inc.'s 50% interest in the Taylor Mine in White Pine County near mid-1988, although the mine was not reopened in 1988. The acquisition gave NERCO

total ownership of the mine, which had been maintained on a caretaker basis since January 1985.

Industrial Minerals

Barite.—Nevada retained its status as the leading U.S. barite-producing state with an increase in production of primary barite to 320,000 short tons valued at more than $5 million. The production increase reversed a downward trend that had started in 1982. Most mining and grinding operations continued to operate on minimal production schedules to address the industry overcapacity in a firming, but volatile market situation.

The State had five primary barite operations and four crushing plants located in Churchill, Humboldt, Lander, and Nye Counties. Leading Nevada barite producers were Milpark Drilling Fluids, a Baker Hughes Inc. company; NL Baroid, a division of NL Petroleum Services Inc.; M-J Drilling Fluids Co., a Dresser/Haliburton Company; and Standard Slag Co.

Cement.—The Centex Corp. plant at Fernley was the only producer of cement in Nevada in 1988. The Las Vegas Cement Co. Inc.'s Loganberry plant had been slated for startup in 1988, but construction work on the site was not completed and the plant did not open.

Gifford-Hill Co., a California cement producer, acquired Bonanza Materials Inc., a large producer of sand and gravel in the Las Vegas area, and Bonanza Ready Mix Inc.

Diatomite.—Nevada ranked second among the five States producing diatomite in 1988. Production was reported from five operations in Churchill, Esmeralda, Lyon, Pershing, and Storey Counties. Diatomite production dropped almost 5% lower than 1987's output. Eagle-Pitcher Industries, Inc. was the largest Nevada producer, mining from three separate areas in northern Nevada for beneficiation at plants near Lovelock and Reno.

Gypsum.—Gypsum production in Nevada increased 15% in 1988, mainly due to continued construction industry strength in California and Nevada. All four Nevada wallboard plants ran at capacity during 1988. Pabco Gypsum, which mines Pliocene sediments near Lake Mead, was the State's largest gypsum producer.

Homestead Minerals acquired the Art Wilson Co., a producer of gypsum in Lyon County, a few miles east of Carson City.

Lime.—Lime production was up in 1988 because of increased use of high-calcium lime for pH control of leach fluids in the western States' growing precious-metal mining industry. Chemstar, Inc., the only Nevada lime producer, makes high calcium lime at its Apex plant 15 miles northeast of Las Vegas and lime for use in construction products at its Henderson plant.

Lithium Compounds.—Cyprus Mining Company bought controlling interest in Foote Mineral Co., which produced lithium carbonate from brine in Esmeralda County. Cyprus later changed the name of these operations to Cyprus Foote Mineral Co. Production at the brine operations remained steady.

***Sand and Gravel* (Construction).**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates computed before yearend. Therefore, this chapter contains only estimates for 1987.

Nevada's 1988 sand and gravel production increased nearly 30% over production in 1986, the last year a full survey of sand and gravel was conducted.

Industrial.—Nevada produced just over 600,000 short tons of industrial sand and gravel in 1988, about 4% more

TABLE 2

NEVADA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	3,458	$15,091	$4.36
Plaster and gunite sands	54	237	4.39
Asphaltic concrete aggregates and other bituminous mixtures	2,342	8,481	3.62
Road base and coverings[1]	3,201	9,257	2.89
Fill	923	2,484	2.69
Snow and ice control	37	118	3.19
Other	533	1,436	2.69
Unspecified:[2]			
Actual	4,180	10,862	2.60
Estimated	1,001	2,961	2.96
Total or average	**15,729**	**[3]50,928**	**3.24**

[1] Includes road and other stabilization (cement and lime).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data do not add to total shown because of independent rounding.

TABLE 3

NEVADA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2	
	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	962	3,303	2,496	11,789
Plaster and gunite sands	—	—	54	237
Asphaltic concrete aggregates and other bituminous mixtures	973	3,706	1,369	4,774
Road base and coverings[1]	1,358	4,064	1,843	5,193
Fill	412	1,139	511	1,346
Snow and ice control	17	66	21	52
Other miscellaneous	3	10	530	1,426
Other unspecified[2]	1,365	4,229	3,816	9,594
Total[3]	**5,089**	**16,516**	**10,640**	**34,412**

[1] Includes sand and gravel for road and other stabilization (cement and lime).
[2] Includes sand and gravel reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

than the 578,000 tons reported in 1987. Simplot Industries' Clark County pit was the major industrial sand operation in Nevada, supplying the majority of the sand for glassmaking.

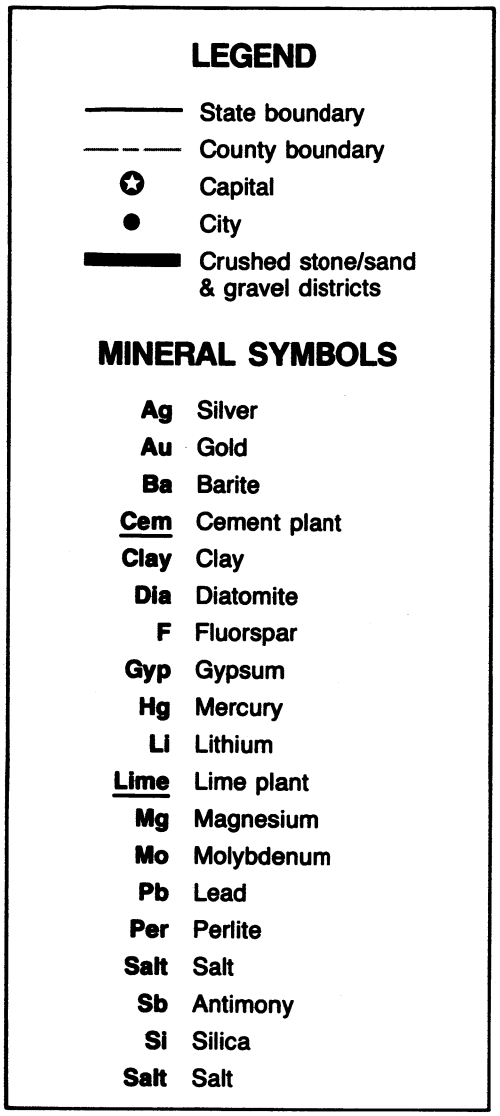
Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates computed before yearend. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Nevada crushed stone sold or used by producers in the State was estimated at 1,300,000 short tons and valued at $5.7 million. Output was estimated to be slightly higher than that of 1987, the last year a full survey of crushed stone producers was conducted. Limestone, the principal crushed stone produced in the State, was used in cement manufacture, lime manufacture, and agricultural uses.

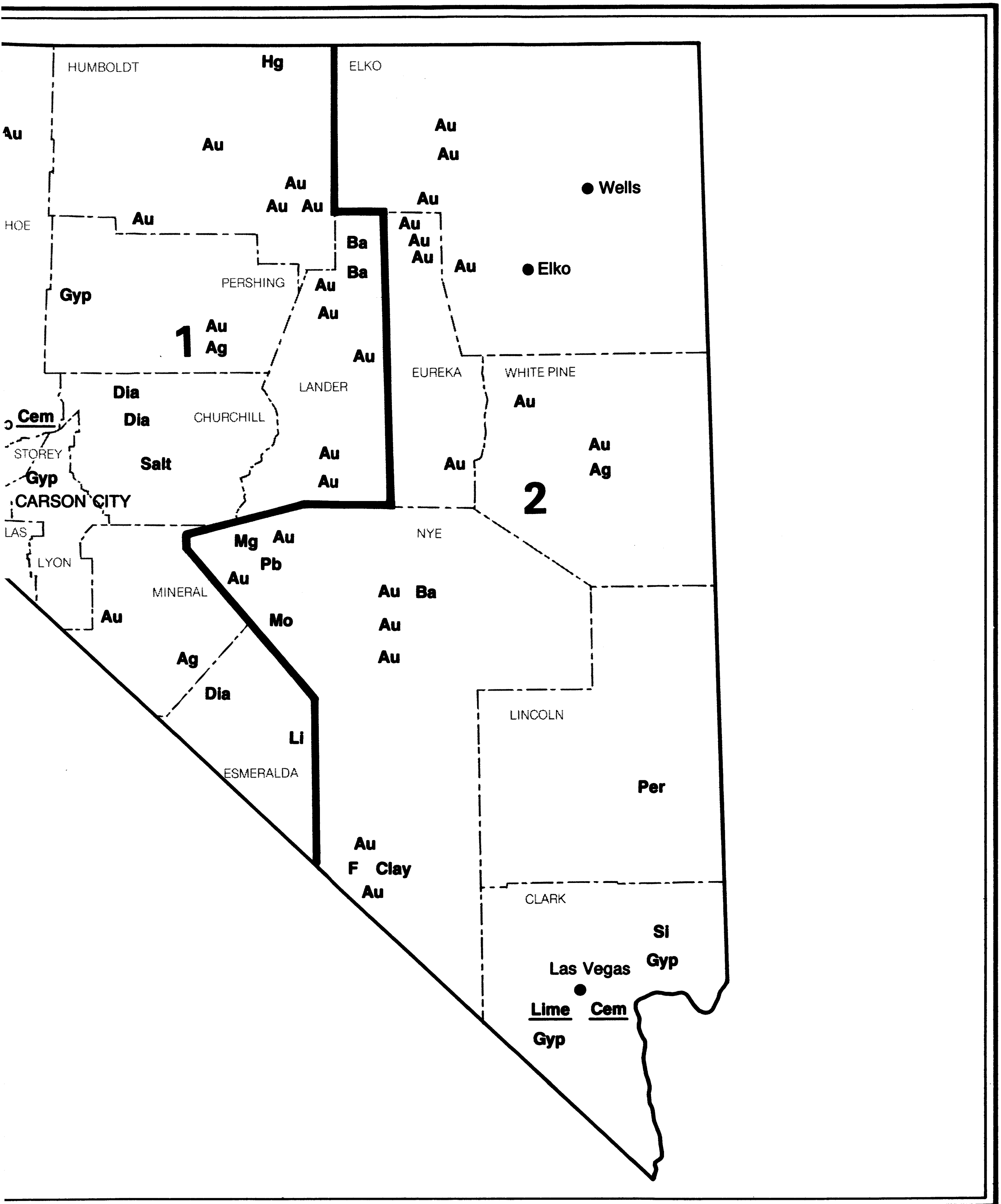
Other Industrial Minerals.—Nevada clay production of 62,689 short tons, down slightly from 1987, was principally bentonite, fuller's earth, and kaolin. Nevada was second only to Illinois in the production of fluorspar in the United States. Crowell Daisey Company in Nye County was the State's only fluorspar producer. Nevada's gem stone production, predominately opal and turquoise, was estimated at $280,000 in 1988. Basic Inc.'s Nye County operation was the sole producer of mined magnesite in the United States.

[1] State Mineral Officer, Bureau of Mines, Reno, NV.
[2] State geologist, Nevada Bureau of Mines and Geology, Reno, NV.

NEVADA



Principal Mineral-Producing Localities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F
Clay
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CLARK
Si
Gyp
Las Vegas
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Cem
Gyp

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Barite:			
Milpark Drilling Fluids Co.	Box 370 Battle Mountain, NV 89820	Surface mine and mill	Lander.
NL Baroid Inc.	Box 141 Battle Mountain, NV 89820	do.	Nye.
Cement:			
Centex Corp., Nevada Cement Co.	Box 895 Fernley, NV 89408	Plant	Lyon.
Clays:			
Industrial Mineral Ventures Inc.	1800 East Sahara Ave. Suite 107 Las Vegas, NV 89104	Surface mine and mill	Nye.
Copper:			
Battle Mountain Gold Co.	Box 1627 Battle Mountain, NV 89820	do.	Lander.
Diatomite:			
Eagle-Pitcher Industries Inc., Minerals Div.	Box 12130 Reno, NV 89510	Surface mine and plants	Lyon, Pershing, Storey.
Grefco Inc., Dicolite Div.	Box 288 Mina, NV 89422	Surface mine and plant	Esmeralda.
Fluorspar:			
J. Irving Crowell, Jr., and Son	Box 96 Beatty, NV 89003	Underground mine	Nye.
Gold:			
Battle Mountain Gold Co.	Box 1627 Battle Mountain, NV 89820	Surface mine and mill	Lander.
FMC Corp.	Box 1237 Hawthorne, NV 89415	Surface mine and plant	Nye.
Freeport-McMoRan Gold Co.	Mountain City Star Route Elko, NV 89801	do.	Elko.
Nevada Gold Mining Inc. (AMAX)	Box 1820 Winnemucca, NV 89445	Surface mine and mill	Humboldt.
Newmont Gold Co., a subsidiary of Newmont Mining Corp.	Box 979 Carlin, NV 89822	Surface mine, mill, refinery	Eureka.
Round Mountain Gold Corp.	Box 480 Round Mountain, NV 89045	do.	Nye.
Gypsum:			
Pacific Coast Building Products Inc.	Box 405 Newark, CA 94560	Surface mine and plant	Do.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do.	Pershing.
Lime:			
Chemstar Inc.	901 Mariner's Island Blvd. Suite 425 San Mateo, CA 94404	do.	Clark.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Lithium compounds:			
Foote Mineral Co.	Route 100 Exton, PA 19341	Dry lake brines and plant	Esmeralda.
Magnesite:			
Basic Inc.	845 Hanna Bldg. Cleveland, OH 44115	Surface mine and mill	Nye.
Mercury:			
FMC Corp.	Box 1237 Hawthorne, NV 89415	Surface mine and plant	Do.
Placer Dome U.S. Inc., Joint Venture	Box 497 McDermitt, NV 89421	do.	Humboldt.
Perlite (expanded):			
USG Corp.	Empire, NV 89405	Plant	Washoe.
Salt:			
Leslie Salt Co., Huck Salt Co.	895 Harrigan Rd. Fallon, NV 89406	Solar evaporation plant	Churchill.
Sand and gravel (construction):			
ARC Materials Corp., WMK Transit	Box 14697 Las Vegas, NV 89114	Pits and mills	Clark.
Eagle Valley Construction Co.	5894 Sheep Dr. Carson City, NV 89701	Pits and mill	Carson City, Douglas, Lyon, Storey.
Granite Construction Co.	Box 2087 Sparks, NV 89432	Pits and mills	Washoe.
Robert L. Helms Construction Co.	Drawer 608 Sparks, NV 89432-0608	do.	Lander and Washoe.
Las Vegas Building Materials Inc.	Box 530 Las Vegas, NV 89125	Pit	Clark.
Las Vegas Paving Corp.	1770 South Industrial Rd. Las Vegas, NV 89102	do.	Do.
Paiute Pit Aggregates Inc.	Box 159 Wadsworth, NV 89442	Pit and mill	Washoe.
Silver:			
Coeur-Rochester Inc.	Box 1057 Lovelock, NV 89419	Surface mine and plant	Pershing.
FMC Corp.	Box 1237 Hawthorne, NV 89415	do.	Nye.
NERCO Minerals Co.	Box 1246 Hawthorne, NV 89415	do.	Mineral.
Stone:			
Centex Corp., Nevada Cement Co.	Box 895 Fernley, NV 89408	Quarry	Lyon.
Chemstar Inc.	901 Mariner's Island Blvd. Suite 425 San Mateo, CA 94404	Quarries	Clark.
Harney Rock & Paving Inc.	Box 800 Hines, OR 97738	Quarry	Elko.

THE MINERAL INDUSTRY OF NEW HAMPSHIRE

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the New Hampshire Department of Environmental Services for collecting information on all nonfuel minerals.

By Donald K. Harrison[1]

The value of nonfuel mineral production in New Hampshire in 1988 was $53.1 million, a $1.6 million decrease compared to that of 1987. Construction sand and gravel and crushed and dimension stone accounted for most of the State's mineral production; common clay and a small amount of gem stones accounted for the remainder. Gypsum imported into the State was calcined and made into wallboard at one plant in the State.

Building permits, a prime indicator of construction activity in the State, increased in 1988. Although the number of residential building permits was down 15.6% during the first 11 months of 1988, this was offset by a 68% increase in value in nonresidential building permits. These latter rose from $249 million in 1987 to $417 million in 1988. This is in sharp contrast to the five other New England States, which registered a net gain of only 5.3% in the value of nonresidential permits during the same period. Since 99% of New Hampshire's mineral industry (sand and gravel and stone) is used primarily by the construction industry, the strength of this industry has continued to benefit many mineral producers in the State.

EXPLORATION ACTIVITIES

The U.S. Forest Service studied whether to approve the approximately 34 applications from companies and individuals to prospect for copper, semiprecious gems, gold, lead, silver, tin, uranium, and zinc within the White Mountain National Forest. The applications involved prospecting on tracts involving 65,000 acres. At least two large mineral firms, Texasgulf Industries and Noranda Exploration, applied for mineral exploration permits.

REGULATORY ISSUES

Acid rain, solid waste disposal, the public's exposure to radon, and local control of mining were key environmental issues addressed in 1988. In the case of acid rain, New Hampshire joined eight other States (Connecticut, Maine, Massachusetts, Minnesota, New Jersey, New York, Rhode Island, and Vermont) in filing suit against the Environmental Protection Agency (EPA) to force it to order new pollution controls for the Midwest States. The suit contended that coal-burning plants and factories in the Midwest were to blame for emitting the gaseous substances that caused acid rain. The Canadian Province of Ontario and two environmental organizations filed a similar lawsuit.

LEGISLATION AND GOVERNMENT PROGRAMS

New Hampshire followed other Northeastern States (notably New York and New Jersey) by passing legislation to establish a State policy of waste reduction and recycling. House bill 862 (Chapter 227) requires State agencies to use and purchase products made with recycled material whenever feasible. It also requires municipalities and solid waste management districts to submit plans addressing solid waste disposal over a 20-year period.

House bill 850 (Chapter 285) was

TABLE 1

NONFUEL MINERAL PRODUCTION IN NEW HAMPSHIRE[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	W	NA	$310	NA	$100
Sand and gravel (construction)	thousand short tons	8,418	$26,089	e9,100	e33,300	9,089	32,614
Stone:							
Crushed	do.	e1,800	e5,900	2,479	10,386	e2,400	e9,800
Dimension	short tons	e82,294	e6,451	67,479	10,684	e73,393	e10,546
Combined value of other industrial minerals		XX	137	XX	[2]	XX	[2]
Total		**XX**	**38,577**	**XX**	**[3]54,680**	**XX**	**[3]53,060**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Value data excluded from total is included on "Undistributed States" table.

[3] Partial total; excludes values that must be concealed to avoid disclosing company proprietary data.

signed into law in May. It exempts motor vehicles carrying washed sand, screened loam, and crushed stone to be used in construction from regulation by the New Hampshire Public Utilities Commission. One provision of the law specifies that "the State shall have the power to regulate extraction of minerals including the removal of dimension stone. The municipalities shall have the power to regulate the removal of earth to be used for construction aggregate." Under the law, the State still regulates permitting and mining of minerals other than sand and gravel and crushed stone used to produce construction aggregate. The "local control" wording in House bill 850 is significant since more than 85% of the State's mineral production value consists of construction sand and gravel and crushed stone. Mining operators now must deal with local community ordinances, which vary from town to town.

Senate bill 326 (Chapter 273) established the New Hampshire Rivers Management and Protection Program in the Office of Planning, Department of Environmental Services. The program provides a mechanism for protecting those rivers, river stretches, and streams that represent significant examples of scenic, recreational, wildlife, cultural, historical, archaeological, hydrologic, and geologic resources.

Radon, a naturally occurring daughter product of uranium minerals decay, has become a major environmental concern, since exposure to the invisible gas can lead to serious lung disease. Following recent enactment of legislation in New Jersey and Pennsylvania, the State of New Hampshire enacted Senate bill 260. The bill requires the Division of Public Health Services (PHS) to conduct home inspections, upon request, for the presence of radon. The PHS also was directed to (1) provide educational services and technical consultations and (2) make recommendations to ameliorate identified problems.

New Hampshire House bill 1184-FN, concerned with the revision of the State's mining law (RSA-12E), was placed in interim study status by the Legislature in 1988. This required forming a study committee within the House Committee on Environment and Agriculture. Testimony was also provided for the Senate bill 300 Study Committee, which examined aggregate production independent of the House Committee.

Under cooperative agreements with the U.S. Geological Survey (USGS), the New Hampshire Geological Survey (NHGS) continued the detailed mapping (1:24,000) of surficial deposits in the State. These surficial maps should provide critical information for land use planning, ground water resources and protection, and waste management strategy. During the year, emphasis was on mapping in the coastal-southeast marine embayment where blankets of relatively impervious clay occur. Used in situ or transported, this clay is the only important reserve of low-permeable material in the State.

During the year, the NHGS worked with the New Hampshire Division of Resources and Economic Development in administering the State's mining law (RSA-12E). The NHGS helped monitor the opening of the Little Rattlesnake Hill aggregate quarry approved under State jurisdiction; it provided assistance in the permitting of a gold exploration project near Lisbon. The NHGS also participated in a project, carried out in cooperation with the State Department of Transportation, related to the removal and relocation of 100,000 cubic yards of uranium-rich granite on I-89 near New London. Specifically, the NHGS helped prepare the excavation plan to protect workers and to devise a relocation strategy to prevent the leaching of uranium from the broken rock into ground water.

The USGS also was mapping marshes and wetlands during the year to establish the volume, quality, and geochemical character of peat in the State. Based on the rate of discovery in the areas completed, it was estimated that peat reserves in the State could total in excess of 100 million tons.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Clays.—Kane-Gonic Brick Corp., the State's only clay producer, mined common clay at a pit in Gonic, Strafford County. The clay was used to manufacture face brick and was marketed primarily in the Boston, MA, area.

Gypsum.—National Gypsum Co. operated a wallboard manufacturing plant at Portsmouth, Rockingham County. Crude gypsum was imported from the company's subsidiary in Canada, through the Port of Portsmouth. The plant was one of only two gypsum wallboard plants in New England.

After receiving approval for site plan alterations from the local planning board, Domar Inc., a Canadian-based company, announced plans to build a new gypsum wallboard manufacturing plant along the Piscataqua River in Newington. The $35 million plant, slated to reach full capacity in spring 1990, will employ 80 workers and create 50 related jobs in the trucking industry. The gypsum used to make the wallboard will be shipped from Domar's Flat Bay Quarry, Nova Scotia, in 35,000-ton ships, unloaded at the C. H. Sprague & Sons Co. terminal, and trucked to the Domar facility. Domar is the third largest producer of gypsum products in North America; it operates five plants in Canada and eight in the United States.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This

chapter thus contains actual data for 1986 and 1988 and estimates for 1987.

Construction sand and gravel was the State's leading mineral commodity in terms of value, accounting for 61% of the State's value. In 1988, 38 companies mined construction sand and gravel from 44 operations in all of the State's counties. Leading counties in order of output were Belknap, Merrimack, and Hillsborough. Major uses of construction sand and gravel were for concrete aggregate, road base and coverings, and asphaltic concrete aggregates.

In March, Cement Roadstone Holdings (CRH), Dublin, Ireland, purchased the assets of Pike Industries, Tilton, for $77 million. Pike Industries was one of the State's largest highway pavers, operating four quarries, six sand and gravel plants, and 30 asphalt plants—15 in New Hampshire, 10 in Vermont, and 5 in Maine. Since the early 1970's, CRH, the largest cement producer in Ireland, has acquired 20 American aggregate companies.

In August, a study of the impact of sand and gravel mining on local water supplies, funded by Ossipee Aggregates, a subsidiary of Boston Sand and Gravel was released. The study, based upon review of 18 mining operations in the State, found little or no deleterious effects caused by sand and gravel mining on aquifers and ground water. This conclusion was opposed by both environmentalists and the New Hampshire Municipal Association. The industry-financed study, together with other sources of information, was under review near yearend by the Committee to Study Available Sand and Gravel Resources in the State, a joint committee of State Senate and House members. After Committee members hold a final workshop, they will suggest that the Legislature relax, stiffen, or continue current stipulations for sand and gravel mining.

TABLE 2

NEW HAMPSHIRE: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	1,571	$6,184	$3.94
Plaster and gunite sands	71	471	6.63
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	8.94
Asphaltic concrete aggregates and other bituminous mixtures	1,067	4,930	4.62
Road base and coverings	1,052	3,816	3.63
Fill	751	1,362	1.81
Snow and ice control	300	726	2.42
Railroad ballast	W	W	6.09
Other	80	530	6.62
Unspecified: [1]			
Actual	446	2,436	5.46
Estimated	3,751	12,159	3.24
Total or average	**9,089**	**32,614**	**3.59**

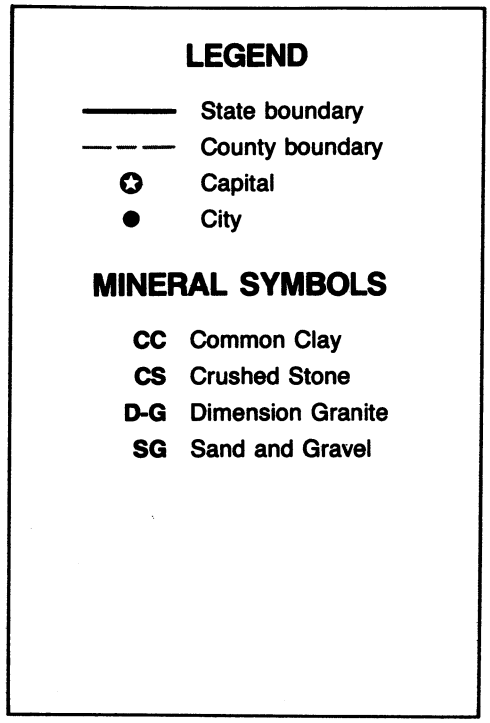
W Withheld to avoid disclosing company proprietary data; included with "Other."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter thus contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—Crushed stone was the State's third leading mineral commodity following construction sand and gravel and dimension stone. Estimated crushed stone production remained essentially the same as that of 1987. Both traprock and granite were produced by 9 companies at 10 quarries in 5 counties. Leading counties in order of output were Merrimack, Hillsborough, Grafton, Cheshire, and Rockingham. Crushed stone was used mostly for bituminous aggregate, road surfacing, road base, and fill.

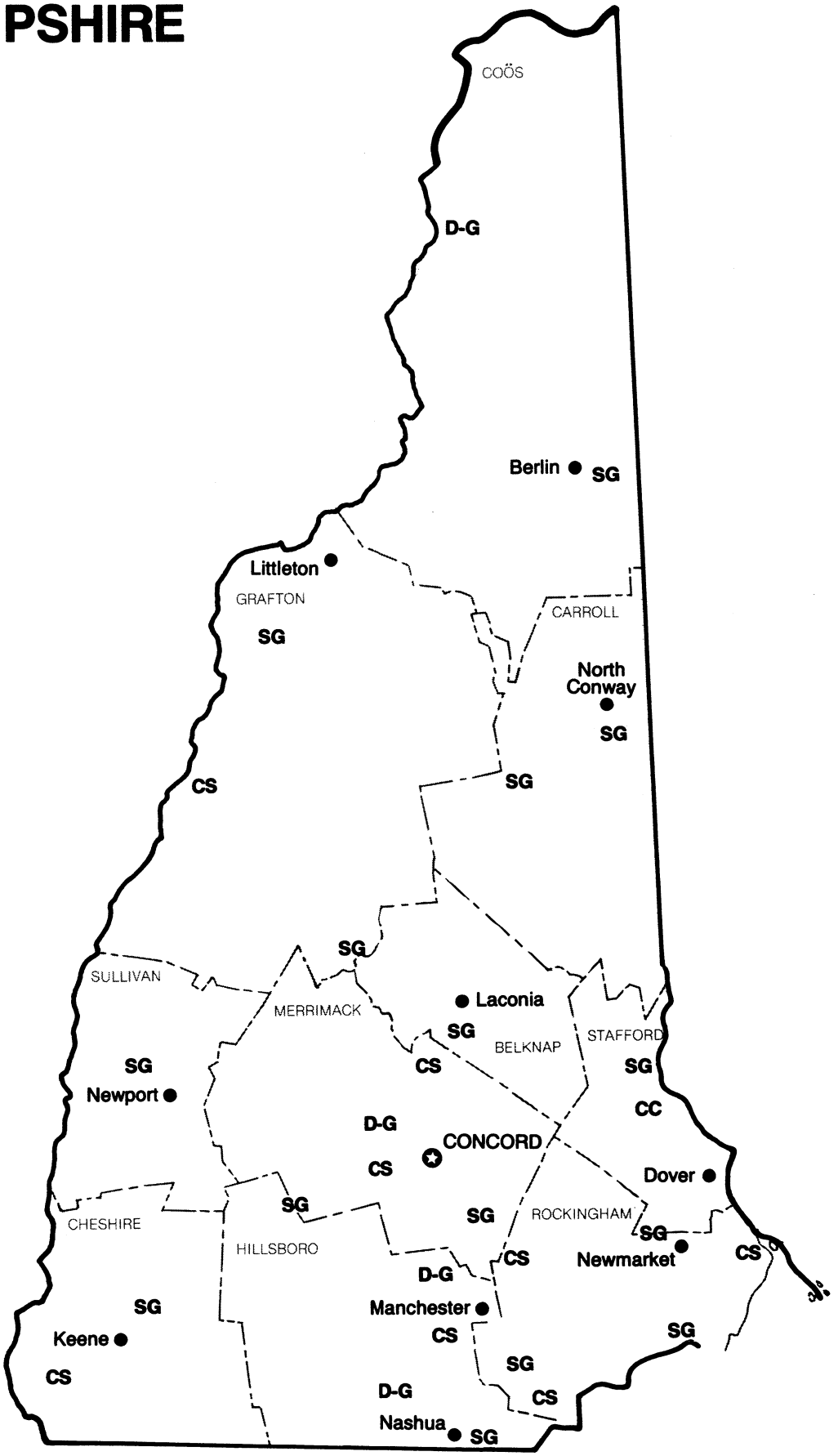
Dimension.—New Hampshire ranked fourth of 35 States that produced dimension stone in 1988. Dimension granite was mined by five companies at five operations in Coos, Hillsborough, and Merrimack Counties. Primary uses were for curbing, rough blocks, and monumental stone.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA.



Principal Mineral-Producing Localities

PSHIRE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Laconia
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BELKNAP
STAFFORD
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CHESHIRE
SG
HILLSBORO
CS
Newmarket
CS
D-G
SG
Manchester
Keene
CS
SG
CS
SG
D-G
CS
Nashua
SG

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Clays:			
Kane-Gonic Brick Corp.	Gonic, NH 03867	Pit	Strafford.
Gypsum (calcined):			
National Gypsum Co.	4100 First International Bldg. Dallas, TX 75270	Plant	Rockingham.
Sand and gravel:			
Alvin J. Coleman & Sons Inc.	Route 16 Conway, NH 03818	Pit	Carroll.
Nashua Sand & Gravel Co.	Route 130 Nashua, NH 03060	Pit	Hillsborough.
Plourde Sand & Gravel Co. Inc.	Suncook, NH 03275	Pit and plant	Merrimack.
Torromeo Trucking Co.	33 Old Ferry Rd. Methuen, MA 01844	Pit	Rockingham.
A. Whitcomb Inc.[1]	Lancaster Rd. Gorham, NH 03581	Pits	Belknap, Carroll, Cheshire, Coos, Grafton.
F. W. Whitcomb Construction Corp.[1]	Box 429 Bellows Falls, VT 05101	Pit	Cheshire.
Stone:			
Crushed:			
Continental Paving Inc.	150 Lowell Rd. Hudson, NH 03051	Quarry	Hillsborough.
Lebanon Crushed Stone Co.	Plainfield Rd. West Lebanon, NH 03784	do.	Grafton.
Manchester Sand, Gravel, & Cement Co.	150 Causeway St. Boston, MA 02114	do.	Merrimack.
Pike Industries Inc.	Route 3, RFD 2, Box 91 Tilton, NH 03276	do.	Do.
F. W. Whitcomb Construction Corp.	Box 429 Bellows Falls, VT 05101	do.	Cheshire.
Dimension:			
Leo Belisle Granite Co.	315 Hackett Hill Rd. Hooksett, NH 03106	do.	Merrimack.
Kitledge Granite Corp.	Armory Rd. Milford, NH 03055	do.	Hillsborough.
Maine-New Hampshire Granite Corp.	Box 135, Groton Rd. West Chelmsford, MA 01863	do.	Do.
Rock of Ages Corp.	Box 482 Barre, VT 05641	do.	Coos.
J. Swenson Granite Co.	North State St. Concord, NH 03301	do.	Merrimack.

[1] Also crushed stone.

THE MINERAL INDUSTRY OF NEW JERSEY

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Geological Survey, Division of Water Resources, New Jersey Department of Environmental Protection, for collecting information on all nonfuel minerals.

By Donald K. Harrison[1]

The value of nonfuel mineral production in 1988 was $242 million, a $28 million increase from 1987. The 1988 value represented an all-time high mineral value for the State. The combined value of crushed stone and of sand and gravel, the State's two leading mineral commodities, accounted for over four-fifths of the value of mineral production. Other commodities mined included clays, greensand, industrial sand, and peat. New Jersey produced virtually all of the Nation's output of greensand. In addition, New Jersey ranked fourth of 37 States that produced industrial sand and fourth in exfoliated vermiculite output.

TRENDS AND DEVELOPMENTS

Construction activity remained strong in New Jersey. This construction boom, which has created more than 70,000 new jobs since early 1983, has filled much of the void caused by the State's lagging performance in manufacturing over the past several years. Although overall building activity appeared to be reaching a plateau, the total value of construction contracts was up 2.6% from that of 1987. Nonresidential building contracts dropped 13% from that of 1987, but this decrease was offset by increases in residential building and public works contracts. Since the construction industry is highly dependent on the availability of construction aggregate (crushed stone, sand and gravel, and clay), producers of these commodities continued to benefit from the unprecedented building boom in the State. Increases in both output and value were reported for all of these commodities in 1988. Both output and value of crushed stone, the State's leading mineral product in terms of value, increased 10%. Output and value of construction sand and gravel rose slightly more than 20% over 1987 levels.

In the advanced minerals sector, Rutgers University, Piscataway, opened a $10 million Center for Ceramic Research. Research at the Center will focus on developing high-temperature superconductors, ceramic automotive engines, and ceramic processing systems. The $10 million needed to build the ceramics research center came from several sources: $9 million from New Jersey, $500,000 from the Federal government, and $500,000 from the university.

Rhône-Poulenc Inc., Princeton, in a move toward becoming an integrated producer of rare-earth alloys and metals, announced plans in October to buy Nucor Corp.'s Research Chemicals Division, Phoenix, AZ. Nucor manufactured a variety of rare-earth alloys and metals that went into a multitude of products, such as magnets for headphones, speakers, and computer peripherals. The transaction put Rhône-Poulenc, a subsidiary of Rhône-Poulenc SA, France, in a new segment of the rare-earth business, because the company previously supplied Nucor with the raw rare-earth materials.

Near the end of the year Magnesium Elektron Ltd. announced that it was spending $30 million to modernize and expand its production facilities at two plants, one in Flemington and the other in Manchester, U.K. The company, a division of Alcan Chemicals, manufactures high-purity zirconia and zirconium chemicals. The combined capacity of the two plants, which was several thousand tons per year in 1988, was to be increased by one-third.

TABLE 1

NONFUEL MINERAL PRODUCTION IN NEW JERSEY[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	132,524	$2,066	[2]5,985	[2]$140	[2]16,484	[2]$368
Gem stones		NA	3	NA	3	NA	3
Peat	thousand short tons	W	542	32	614	43	797
Sand and gravel:							
Construction	do.	13,999	53,746	[e]15,200	[e]61,200	18,318	74,183
Industrial	do.	2,341	29,878	2,112	27,872	1,860	25,437
Stone (crushed)	do.	[e]15,300	[e]95,400	[3]17,576	[3]111,951	[e 3]19,300	[e 3]123,500
Combined value of other industrial minerals		XX	4,613	XX	12,444	XX	17,544
Total		**XX**	**186,248**	**XX**	**214,224**	**XX**	**241,832**

[e] Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Excludes common clays; value included with "Combined value" data.
[3] Excludes crushed limestone; value included with "Combined value" data.

LEGISLATION AND GOVERNMENT PROGRAMS

In July, the Governor signed into law A-1340/S-140, which directed the New Jersey Department of Environmental Protection (DEP) to develop a methodology to identify and map aquifer recharge zones, develop "best management practices" for administration of aquifer recharge zones, and map the recharge zones for major aquifers of the State. The bill appropriated $1 million to conduct this program over a 4-year period.

In March, the U.S. Environmental Protection Agency began work on a hazardous waste site under the Federal Superfund program at the former International Metallurgical Services plant in Newark. Among the wastes discovered at the site were acids, bases, oxidizers, cyanides, and spent photographic film. After the wastes were packaged for disposal, they were to be shipped to an off-site disposal facility. International Metallurgical, which became bankrupt, was a precious metals refiner that recovered silver from photographic film and gold from printed circuit boards.

In December, the DEP issued directives to several former chromate manufacturers to devise emergency measures for dealing with chromium contamination at about 148 sites throughout Hudson County. The directives were issued to Allied Signal Inc., PPG Industries Inc., Occidental Chemical Corp., and Maxus Energy Corp., all owners at one time or another, of chromate processing plants in Hudson County. The contamination was believed to have been caused by the use of chromium slag as fill and diking material for residential, commercial, and industrial areas. If the companies did not respond in 30 days to the order issued by the DEP, the agency was to carry out interim steps, including covering, fencing, or otherwise containing contaminated sites to protect the public from exposure. If New Jersey was forced to spend public dollars on the effort to clean up the chromium contamination, the companies were to reimburse the State.

The first waste-to-energy plant in New Jersey was dedicated in Warren County on September 28. When fully operational, the Warren County Resource Recovery Facility was to convert up to 400 tons of waste per day into 13.5 megawatts of electricity, power for 10,000 homes and businesses. Under the State's "Mandatory Source Recycling Act of 1987," each county was required to limit or recycle most of its solid waste. The end result was expected to be more than a 90% reduction in solid waste that previously would have been disposed of in sanitary landfills.

The New Jersey Geological Survey (NJGS), part of the DEP, continued to be the primary agency responsible for investigating the State's mineral resources and ground water. During the year, a reorganization within the DEP Division of Water Resources placed surface and ground water monitoring (Bureau of Monitoring Management) and marine water monitoring and shellfish resource control (Bureau of Marine Water Classification and Analysis) under the NJGS and transferred ground water pollution analysis functions (Bureau of Ground Water Pollution Analysis) to regulatory agencies.

The NJGS was preparing a display for the National Mining Hall of Fame and Museum in Leadville, CO. The display featured rock and ore samples from abandoned iron, copper, mica, and graphite mines of New Jersey. There was also a suite of minerals, which included the primary ore minerals franklinite, zincite, and willemite, and less common fluorescent minerals, from New Jersey Zinc Co.'s Sterling Mine in Ogdensburg, Sussex County. The text for the display covered the history of mining in New Jersey from the beginning of the bog iron industry in the 1700's to the present. The underground workings of a 1940's magnetite mine were illustrated with photographs from the permanent Survey collection, and the mining history of each commodity was discussed. The present status of mining in the State was also summarized, including sand and gravel, crushed stone, glauconite, and peat mining.

Also during the year, approximately 30,000 feet of representative drill core from the Sterling Mine was moved to the joint NJGS and State University core library at Rutgers. The Sterling Mine, the last of the base metals mines in New Jersey, was closed in 1986.

During fiscal 1988, the U.S. Bureau of Mines awarded contracts totaling $75,700 to four private firms in the State for mineral-related studies.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Clays.—Two companies produced clay in the State. New Jersey Shale Brick & Tile Corp. produced common clay and shale at an operation in Somerset County, and The Morie Co. Inc. mined fire clay in Cumberland County. Output of common clay was used primarily for manufacturing common brick; fire clay was used primarily in foundries.

Near yearend, the New Jersey Shale Brick & Tile Corp. submitted a proposal to the town of Somerville to rezone 357 acres to allow the company to expand its clay mining operations. If the rezoning was approved, the town Board Chairman said that excavation would be limited to 3 to 5 acres at any given time. Rezoning the land to allow additional mining would increase the plant's life expectancy to 35 to 40 years, according to the company. A public hearing on the zoning changes was expected in the early part of 1989.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of

Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

For some States, construction sand and gravel statistics are compiled by districts. Table 3 presents end-use data for the commodity in New Jersey districts as depicted in the centerfold map.

Construction sand and gravel was the second leading mineral commodity produced in the State, accounting for 31% of the State's mineral value. Construction sand and gravel was produced by 58 companies at 73 pits in 15 of the State's 21 counties and was used primarily for concrete aggregate, asphaltic concrete aggregates, fill, and road base and coverings.

The Morie Co., one of the largest sand producers in the State, purchased additional properties near Port Elizabeth, Cumberland County. The properties are expected to extend Morie's reserves in the area for up to 30 years. The properties, previously owned separately by George F. Pettinos Inc., Ardmore, PA, and Owens-Illinois Inc. of Ohio, will be combined into a single operation. The Morie Co. also has active sand and gravel operations in Camden, Cape May, and Cumberland Counties in South Jersey. The company also operates in Tennessee, Alabama, and Georgia.

In March, the Bureau of Environmental Quality of the DEP announced that it had erred when it set a fine of $50,000 against McCormack Aggregates for an alleged air pollution code violation in 1987. The original complaint alleged that the firm allowed sand from a pile at least 20 feet high to blow over neighbors' properties. The Bureau representatives said that the fine should have been $15,000 rather than $50,000. McCormack Aggregates dredged sand from New York Harbor and processed the sand in South Amboy.

TABLE 2

NEW JERSEY: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	3,719	$18,301	$4.92
Plaster and gunite sands	160	828	5.18
Concrete products (blocks, brick, pipe, decorative, etc.)	73	383	5.25
Asphaltic concrete aggregates and other bituminous mixtures	485	2,468	5.09
Road base and coverings[1]	1,281	3,941	3.08
Fill	902	3,389	3.76
Snow and ice control	134	502	3.75
Other	33	245	7.42
Unspecified:[2]			
Actual	8,906	33,293	3.74
Estimated	2,626	10,834	4.13
Total[3] or average	**18,318**	**74,183**	**4.05**

[1] Includes road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

Industrial.—Nationally, New Jersey ranked fourth in industrial sand production in 1988. A total of 7 companies operated 19 pits in 7 counties and produced 1.9 million short tons, valued at $25.4 million. Principal uses for industrial sand were glass products, molds and cores, and sandblasting.

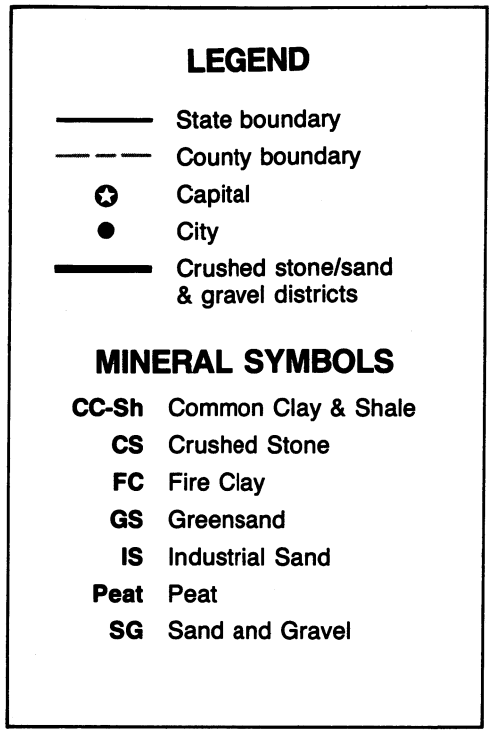
Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Crushed stone, the State's leading mineral commodity, accounted for 51% of the State's total mineral value. Estimated crushed stone production totaled 19.3 million short tons, valued at $123.5 million. Leading counties in order of output were Somerset, Mercer, Sussex, and Morris. Major uses of crushed stone were for concrete aggregates, road base and coverings, and bituminous aggregates.

After nearly 5 years of legal disputes concerning a controversial 216-acre quarry within the West Amwell Township, the owners of the property chose not to renew the Washington Rock Boy Scout Camp lease that the Scouts had held for a number of years. The Scouts had been allowed continued use of the property under a 6-month renewable lease that was to expire in 1998. In 1983, Fort Commanche Inc. had purchased the former scout camp for $606,000 for use as a quarry, but in 1986 the township's Board of Adjustment denied the company's request to operate a quarry there. In 1987, a Superior Court judge ruled in favor of the Board's decision, but the case was still tied up in court at yearend.

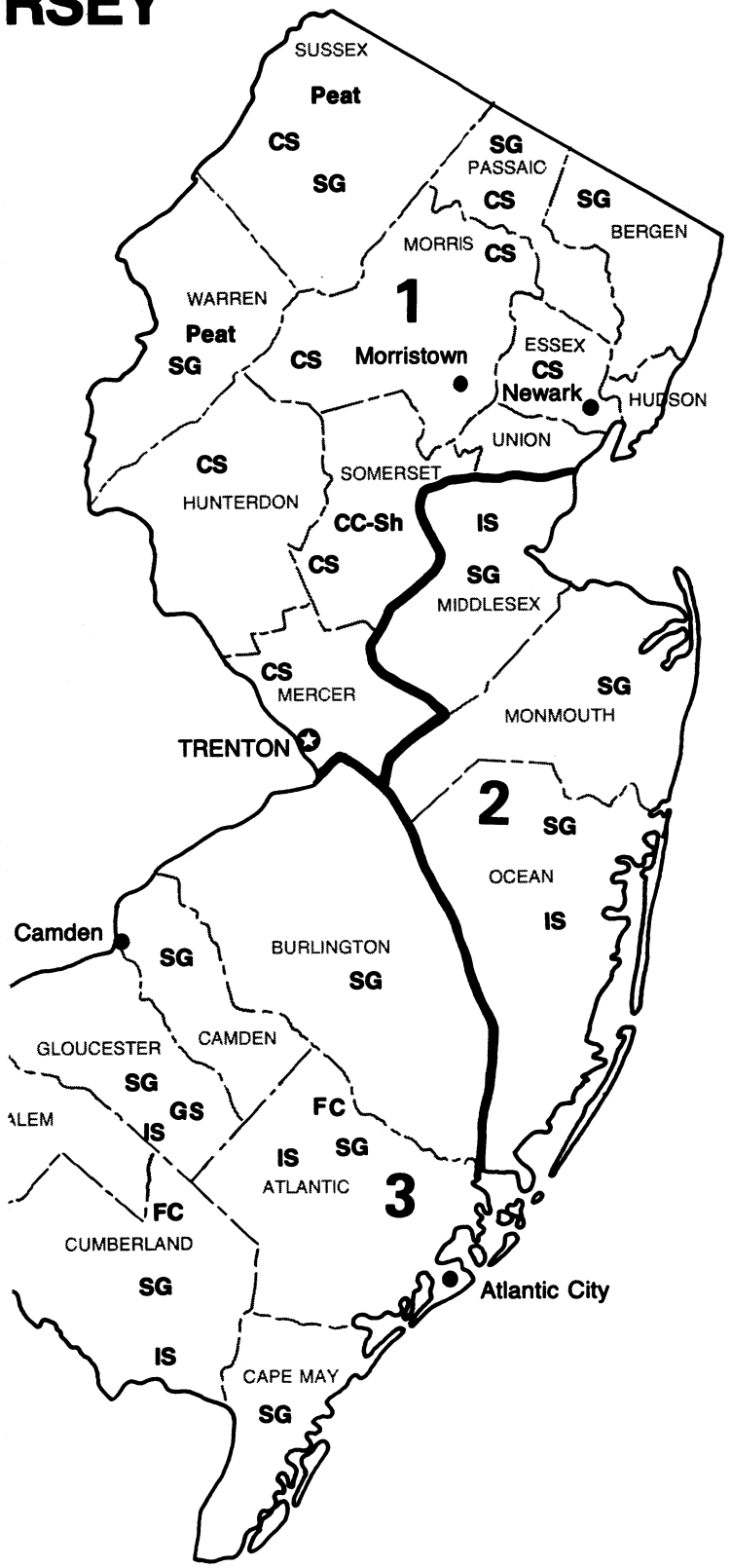
Other Industrial Minerals.—The Inversand Co., a subsidiary of Hungerford and Terry Inc., hydraulically mined greensand marl near Clayton. Inversand was one of two companies that mined greensand in the United States, accounting for the majority of

NEW



Principal Mineral-Producing Localities

RSEY


SUSSEX
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ESSEX
CS
Newark
HUDSON
UNION
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ATLANTIC
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CUMBERLAND
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IS
Atlantic City
CAPE MAY
SG

TABLE 3

NEW JERSEY: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	1,673	10,545	916	3,889	1,129	3,868
Plaster and gunite sands	W	W	W	W	—	—
Concrete products (blocks, bricks, etc.)	73	383	—	—	—	—
Asphaltic concrete aggregates and other bituminous mixtures	245	1,472	W	W	W	W
Road base and coverings[1]	483	2,232	22	95	775	1,614
Fill	556	2,640	88	300	258	449
Snow and ice control	119	402	W	W	W	W
Other miscellaneous	95	518	163	718	190	932
Other unspecified[2]	1,671	9,872	4,062	14,806	5,798	19,448
Total[3]	**4,915**	**28,065**	**5,251**	**19,807**	**8,152**	**26,311**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (cement).
[2] Includes sand and gravel reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

the Nation's total production of this commodity. The greensand was processed and sold mainly as a filtration medium to remove soluble iron and manganese from well water. Four companies mined peat in 1988, three in Sussex County and one in Warren County. Most of the output was used for general soil improvement and as an ingredient in potting soil. Mineral Recoveries Inc. recovered zircon and lecontite from tailings piles at the former ASARCO Incorporated titanium plant in Lakehurst.

Manufactured and Processed Minerals

In addition to the commodities mined and listed in table 1, the production and value of some processed or manufactured mineral commodities were also surveyed by the U.S. Bureau of Mines.

Industrial Minerals.—CCF Inc. Research Laboratory produced high-modulus synthetic graphite fibers at a plant in Summit. Gypsum, imported from Nova Scotia, Canada, was calcined by the National Gypsum Co., Burlington County, and by Domtar Gypsum, Camden County. The calcined gypsum was used primarily in manufacturing wallboard. Crude iodine was shipped into New Jersey by seven companies to manufacture various iodine-containing compounds. The compounds were used as laboratory reagents and in sanitation, pharmaceuticals, and specialty organic and inorganic compounds. Rowan Industries Inc., Monmouth County, used cultured quartz crystal primarily for electronic applications. Crude perlite from out-of-State sources was expanded by The Schundler Co., Edison, and used for roof insulation, plaster aggregate, insulation, and masonry and as a soil conditioner. Elemental sulfur was recovered as a nondiscretionary byproduct at two refineries in the State. The sulfur was used in the manufacture of sulfuric acid, fertilizers, plastics, and other products. Crude talc was shipped in and processed by Cyprus Industrial Minerals Inc., South Plainfield. Crude vermiculite was exfoliated at W. R. Grace & Co., Construction Products Division, Trenton, and by Schundler in Edison. Its principal uses included fireproofing, loose fill, block insulation, and horticultural agents.

Metals.—Alumet Smelting Corp., a fully integrated secondary aluminum smelter in Newark, resumed operations after being closed for a year. AMAX Inc., Specialty Coppers, produced special high-conductivity copper and copper alloys at a plant in Carteret. Shieldalloy Corp., a subsidiary of Metallurg Inc., produced ferroalloys of aluminum, boron, columbium, titanium, and vanadium at an electric and metallothermic furnace in Newfield, Gloucester County. Two companies in Camden produced finished iron oxide pigments. New Jersey Steel Corp. produced steel at the electric-furnace minimill in Sayreville. Nearly all of the production was rebar. Raritan River Steel Co., a leading producer of wire rod, operated a plant in Perth Amboy, Middlesex County.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Clays:			
The Morie Co. Inc.[1]	1201 North High St. Millville, NJ 08322	Pit	Cumberland.
New Jersey Shale Brick and Tile Corp.	Box 490 Somerville, NJ 08876	Pit	Somerset.
Greensand:			
Inversand Co., a subsidiary of Hungerford and Terry Inc.	Box 45 Clayton, NJ 08312	Pit	Gloucester.
Gypsum (calcined):			
Domtar Gypsum Inc.	1101 South Front St. Camden, NJ 08103	Plant	Camden.
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	do.	Burlington.
Iron oxide pigments (finished):			
American Minerals Inc.	Box 677 Camden, NJ 08101	do.	Camden.
Columbian Chemicals Co.	Box 37 Tulsa, OK 74102	do.	Middlesex.
Peat:			
Glacial Soils Lab	346 Grand Ave. Englewood, NJ 07631	Bog	Sussex.
Hyponex Corp.	2013 South Anthony Blvd. Fort Wayne, IN 46803	Bog	Do.
Kelsey Humus Co.	Kelsey Park Great Meadows, NJ 07838	Bog	Warren.
Stan's Soils	R.D. 2, Box 129 Sussex, NJ 07461	Bog	Sussex.
Perlite (expanded):			
The Schundler Co.[2]	Box 251 Metuchen, NJ 08840	Plant	Middlesex.
Sand and gravel:			
Construction:			
Clayton Sand Co.	P.O. Box 928 Lakewood, NJ 08701	Pit and plants	Burlington and Ocean.
Continental Somerset Sand & Gravel Co.	P.O. Box 1475 Blackwood, NJ 08012	Pit and plant	Camden.
Dallenback Sand Co. Inc.	Box 333 Dayton, NJ 08810	Dredge	Middlesex.
The Morie Co. Inc.	1201 N. High St Millville, NJ 08332	Pits	Atlantic, Cape May, Cumberland.
South State Inc.	P.O. Box 68 Bridgeton, NJ 08302	Pit and dredge	Burlington and Ocean.
Industrial:			
Unimin Corp., Dividing Creek Plant	258 Elm St. New Canaan, CT 06840	Pit	Do.
U.S. Silica Co.	Box 458 Newport, NJ 08345	Pit	Cumberland.
Whitehead Bros. Co.	Box 259, River Rd. Leesburg, NJ 08327	Pits	Do.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone:			
Granite (crushed and broken):			
Mt. Hope Rock Products Inc.	625 Mt. Hope Rd. Wharton, NJ 07885	Quarry	Morris.
Riverdale Quarry Co.	125 Hamburg Turnpike Riverdale, NJ 07457	do.	Do.
Tri-County Asphalt Corp.	Route 15 Hopatcong, NJ 07843	do.	Sussex.
Traprock (basalt, crushed and broken):			
Little Ferry Asphalt Corp.	650 Valley Rd. Clifton, NJ 07643	do.	Passaic.
Millington Quarry Inc.	Box 407 Millington, NJ 07946	do.	Somerset.
Stavola Construction Materials Inc.	Box 482 Red Bank, NJ 07701	do.	Do.
Trap Rock Industries Inc.	Box 419 Kingston, NJ 08528	Quarries	Hunterdon, Mercer, Somerset.
Sulfur (recovered):			
Exxon Co. U.S.A	Box 23 Linden, NJ 07036	Refinery	Union.
Mobil Oil Corp.	Paulsboro, NJ 08066	do.	Gloucester.
Vermiculite (exfoliated):			
W. R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	Plant	Mercer.

[1] Also industrial sand.
[2] Also exfoliated vermiculite.

THE MINERAL INDUSTRY OF NEW MEXICO

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the New Mexico Bureau of Mines and Mineral Resources for collecting information on all nonfuel minerals.

By Michael N. Greeley[1] and Robert W. Eveleth[2]

New Mexico ranked 10th nationally in the production of nonfuel minerals in 1988. The value of output rose to a record high of $1.019 billion, about 38% more than that of 1987. Toward yearend, the New Mexico Mining Association began preparations to celebrate this record of mineral production and the association's 50th anniversary in 1989.

Metal production in 1988 accounted for more than 70% of the mineral value, with copper, gold, and silver as the principal contributors. The State also produced important quantities of mica, perlite, Portland cement, potassium salts, and pumice.

TRENDS AND DEVELOPMENTS

As prices remained relatively high for copper and gold during the year, the value of nonfuel mineral production increased accordingly. A substantial rise in the value of potassium salts also enhanced total production value.

Decreases in the value of cement, gypsum, and crushed stone merely reflected the continued decline in construction activity. In dollar value for all categories of construction contracts, there was about 7.5% less construction in 1988 than in 1987.[3] New Mexico's construction industry has experienced a general decline for 5 consecutive years.

EXPLORATION ACTIVITIES

In addition to general, ongoing interest in the precious-metals potential of southwestern New Mexico, gold exploration was fairly active in the Ortiz Mountains of Santa Fe County and the Sierra Blanca Mountains of Lincoln County. Records maintained by the Bureau of Land Management ranked the State 10th in the Nation during 1988 in the number of active claims for all commodities.

EMPLOYMENT

According to the U.S. Department of Commerce, Bureau of Economic Analysis, the extractive industry of the State employed an average of 15,400 workers during 1988. This figure, an increase of more than 3% over that of 1987, included employees in the mineral fuels sector. Total earnings increased more than 4% to $527 million.

There were approximately 5,400 employees in the nonfuel minerals industry, according to the New Mexico Energy, Minerals, and Natural Resources Department (EMNRD). In 1988, the industrial minerals sector employed about 57% of the workers; the metals

TABLE 1

NONFUEL MINERAL PRODUCTION IN NEW MEXICO[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	60,184	$170	51,248	$141	31,476	$83
Copper (recoverable content of ores, etc.)	metric tons	W	W	r246,532	r448,373	258,660	687,182
Gem stones		NA	200	NA	200	NA	200
Gold (recoverable content of ores, etc.)	troy ounces	39,856	14,677	W	W	W	W
Lead (recoverable content of ores, etc.)	metric tons	10	5	W	W	W	W
Perlite	thousand short tons	433	13,727	437	13,611	458	14,294
Potassium salts	thousand metric tons	987	132,900	1,323	174,200	1,271	213,800
Pumice	thousand short tons	255	2,370	87	991	84	852
Sand and gravel (construction)	do.	8,471	25,862	e8,600	e31,000	8,787	31,367
Stone:							
Crushed	do.	e3,900	e15,300	4,503	15,919	e3,500	e13,900
Dimension	short tons	e21,615	e378	21,893	626	e21,893	e626
Combined value of cement, gypsum, helium (Grade-A), iron ore (includes byproduct material), mica (scrap), molybdenum, pyrites (1987), salt, silver, and values indicated by symbol W		XX	r406,723	XX	r52,783	XX	56,228
Total		**XX**	**r612,312**	**XX**	**r737,844**	**XX**	**1,018,532**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

sector employed the balance. During the year, the average weekly earnings of a worker in the nonfuel minerals industry was $613.

REGULATORY ISSUES

During the year, Grefco Inc. conducted analyses and studies of crystalline silica in its perlite ores to update company materials safety data sheets and customer records. Results indicated that crystalline silica occurred as quartz in some of the New Mexico perlite, but was less than 1% by volume.

In 1988, the New Mexico Mining Association established a committee to monitor development of Federal regulation of solid waste disposal under the Resource Conservation and Recovery Act (RCRA). Through the EMNRD, the committee maintained contact with the Western Governors Association and provided assistance in the evaluation of RCRA proposals.

LEGISLATION AND GOVERNMENT PROGRAMS

The Senate Joint Memorial 22, entitled "Extractive Resource Memorial," called for the Economic Development and Tourism Department to promote and revitalize New Mexico's extractive industries. The department was directed to coordinate the generation of reports and information on the State's mining industry using resources of the New Mexico Bureau of Mines and Mineral Resources (BMMR) and the New Mexico EMNRD's Mining and Minerals Division.

Early detection and prevention of ground water contamination by private and public entities has been identified as the most cost-effective way to prevent widespread ground water pollution. State Senate bill 190 appropriated $90,000 for the Health and Environment Department to conduct a statewide ground water quality investigation and education program.

The U.S. Bureau of Mines continued to supervise the administration of the New Mexico Mining and Mineral Resources Research Institute (MMRRI) during 1988. The Institute was housed at the New Mexico Institute of Mining and Technology and was administered by a faculty member of the Department of Materials and Metallurgical Engineering. Total funds allocated by the Bureau to the MMRRI was $138,000.

During the year, the Bureau issued nine open file reports addressing mineral land assessments in New Mexico. These reports summarized mineral evaluations of wilderness study areas under the jurisdiction of the Bureau of Land Management.

The New Mexico BMMR, the U.S. Geological Survey, and the U.S. Bureau of Mines reached an agreement-in-principle to study the characteristics, geochemistry, and resources of Great Plains Margin deposits in New Mexico. Begun in 1988, this work was to concentrate on rare-earth elements in alkalic intrusive rocks.

Established in 1988 by the BMMR at its office complex in Socorro, the perlite lab continued to evaluate materials on a demand basis. The facility is the only laboratory in the Nation open to the public for bench-scale testing of perlite samples.

The BMMR issued several open file reports and maps during the year that addressed mineral resources in the State. Reports included OF-228, "A Preliminary Mineral Resources Potential of Northwestern New Mexico, Introduction;" OF-232, "A Preliminary Mineral Resources Potential of San Juan County;" and OF-324, "REE, Niobium, and Thorium Districts and Occurrences in New Mexico." Published maps included RM-14, "Active Mines and Mills Map," and RM-17, "Sand and Gravel Producers Map."

In 1988, a major new study, the Energy and Minerals Economic Development Strategy, was formulated jointly by the New Mexico EMNRD's Mining and Minerals Division and the University of New Mexico's Institute for Public Policy. The focus of the project was to examine the extractive industries and their relationship to long-term economic development in the State.

As part of its ongoing function, the Mining and Minerals Division published its "Annual Resources Report" for 1987. The report contains tables and discussions of statistics on New Mexico's extractive resources. Also issued in 1988 was an open file report entitled "New Mexico Biological Mine Water Treatment" and a report of investigation entitled "Bibliography of Uranium In Situ Leach Technology, 1952–June 1988, With New Mexico Papers Highlighted."

During the year, the New Mexico EMNRD assumed the role of facilitator in a project to establish a center for potash research. Discussions were held between the EMNRD, the State universities, the potash industry, and the U.S. Bureau of Mines. The center would focus on studying the extraction and raw processing of potash ores from the Carlsbad district. The New Mexico Institute of Mining and Technology announced its intention to establish the center on its campus in Socorro.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Copper.—New Mexico was the second largest producer of copper in the United States during 1988. Although State production of copper rose only about 5% over that of 1987, an increase in the average price of the metal from $0.81 to $1.20 per pound resulted in a 53% rise in the total value of copper production. This value represented more than two-thirds of the total

value of New Mexico's nonfuel mineral production.

Annual mine capacity in New Mexico was about 316,000 metric tons of recoverable copper, approximately 19% of the total operating capacity in the Nation. The Tyrone and Chino Mines in Grant County were, respectively, the third and fourth leading primary copper producers in the country.

According to the 1988 annual report of the Phelps Dodge Corp., 141,300 tons of recoverable copper were produced at the Tyrone Mine. Approximately 26% was electrowon copper. Initially completed in 1984, the solvent extraction-electrowinning (SX-EW) plant has been expanded three times from an original annual capacity of 14,000 tons to 50,000 tons.

A new SX-EW plant at the Chino Mine was completed at a cost of $55 million and commissioned in August 1988. It is capable of producing 41,000 tons of copper annually. During the year, the mine's output of copper for the account of Phelps Dodge was 73,000 tons. A partner, the MC Minerals Corp. (Mitsubishi), received one-third of the total copper and byproduct production from the mine at Santa Rita and the smelter at Hurley.

The Chino facility was inundated by unusually heavy rainfall during the summer of 1988. Because of the lack of sufficient water containment capacity and the unusual weather, the Chino Mines Co. was forced to release the stormwater runoff mixed with mine process water into a nearby natural drainage. This action was the subject of review by the New Mexico Environmental Improvement Division (EID) and the EPA.

At the copper smelter owned by Phelps Dodge in Hidalgo County, the company began to carry out an agreement with the EID to abate potential ground water contamination that may result from discharge of acid-plant blowdown water into an evaporation pond located nearby.

The underground Pinos Altos Mine (Grant County), owned by the Cyprus Minerals Co., produced about 4,700 tons of copper, according to the Goldfield Corp. in its annual report for 1988. Goldfield's wholly owned subsidiary, the St. Cloud Mining Co., processed Pinos Altos ore at its mill near Winston, NM, under a joint-venture agreement with Cyprus. Goldfield reported that the ore milled during the year averaged 4.73% copper, 5.01 ounces of silver per ton, and 0.017 ounce of gold per ton. An additional tonnage of siliceous ore, shipped as smelter flux from Pinos Altos, contained 2.39% copper, 3.61 ounces of silver per ton, and 0.010 ounce of gold per ton.

In 1988, the Challenge Mining Co. operated the Eberle copper mine and adjacent properties in Catron County. The company shipped concentrates to a smelter for the recovery of copper, gold, and silver.

Gold.—Although New Mexico's output of gold in 1988 increased more than 70% over that of 1987, the total production was low compared to other states. Most of the addition was attributed to nearly year-round production at the Westar Mine in Hidalgo County and improved output at the State's copper mines. The total value of production in New Mexico increased more than 66%.

The Westar Mine (formerly Banner Mine), operated by the WESTAR Corp., is an open pit, heap-leach property that began full production in January 1988. It was the largest primary source of gold in the State until operations were suspended in September. In October, the company filed according to regulations of chapter 11 for relief and protection under the Federal Bankruptcy Code.

The largest amount of gold produced in New Mexico originated as a byproduct from processing copper ores and metal-bearing silica flux materials. The copper ores mined at Chino and Tyrone and fluxing ores mined at St. Cloud (Sierra County) were significant contributors to total production. Additional gold was won from direct smelting ore shipped by the Mount Royal Mining and Exploration Co. This firm operated the underground Center Mine (Grant County) which also produced copper, lead, and silver.

Molybdenum.—During 1988, the only production of molybdenum was as a byproduct of copper mining at the Chino Mine in Grant County. Production in the State declined about 12% from the previous year, but the total value dropped only slightly owing to increased metal prices.

New Mexico ranked sixth out of seven States that reported molybdenum production. The Questa Mine in Taos County, a primary producer, remained on standby during the year.

Silver.—The State maintained its position as the sixth largest producer of silver in the country during 1988. Total production increased nearly 60% since 1987.

Among a total of about 142 silver lode mines nationwide, 3 of the top 25 are in Grant County. Silver was recovered at all three properties as a byproduct of primary copper ore.

Another source of silver byproduct mined in the State was the St. Cloud Mine. This mine, operated by the St. Cloud Mining Co., a subsidiary of the Goldfield Corp., produced siliceous convertor flux that was shipped to ASARCO Incorporated's copper smelter in El Paso, TX. According to the Goldfield annual report for 1988, St. Cloud sold 13,934 tons of flux containing 0.44% copper, 7.68 ounces of silver per ton, and 0.19 ounce of gold per ton.

Other Metals.—The Sharon Steel Corp. continued to ship a small amount of magnetite stockpiled at its Continental Mine (Grant County). The iron ore was originally recovered as a byproduct of copper production.

The Center Mine (Grant County)

and the St. Cloud Mine (Sierra County) produced lead as a byproduct during 1988. Although small compared to total domestic production, New Mexico's output more than doubled over the previous year.

The State produced approximately 17% of the Nation's uranium in 1988. Production was derived from 12 separate properties operated by 4 companies. Recovery was either by conventional milling of ores or by low-cost, ion-exchange techniques applied to uranium-bearing mine waters.

Industrial Minerals

Cement.—The production of cement continued to trend downward in 1988. Portland cement output was off more than 6% from that of 1987, and masonry cement was down about 29%. Low construction levels and weak cement consumption, as well as high levels of imported cement, were frequently cited as the principal factors causing this decline.

Owing to considerable excess production capacity in New Mexico, average Portland cement prices fell 17% to about $51.82 per ton. This price was approximately 18% less than the national average. Masonry cement prices decreased slightly during the year.

Ideal Basic Industries Inc., the only producer in the State, operated a distribution terminal in Albuquerque and a cement plant in Tijeras (Bernalillo County). The plant has a rated capacity of 500,000 tons of cement annually.

Gypsum.—The decline in production of gypsum continued in 1988. Crude gypsum output dropped almost 10% from the previous year and calcined gypsum dropped more than 11%. Prices of these two materials fell more than 12% and 38%, respectively.

The Centex American Gypsum Co., a subsidiary of the Centex Corp., commenced construction of a new gypsum wallboard plant in Bernalillo, a few miles north of the company's original plant in Albuquerque. The new plant, which will more than double Centex's current production capacity, is projected to be among the lowest cost producers in the industry.

Mica.—New Mexico is one of only two States in the West that mined mica in 1988. Mineral Industrial Commodities of America Inc. produced muscovite and sericite at its MICA Mine (formerly Tojo Mine) in Taos County and beneficiated the mica at its mill in Velarde (Rio Arriba County). Although production for the year was one-third lower than that of 1987, the New Mexico mica was ranked as one of the highest unit-value micas in the country.

Perlite.—Having mined nearly 85% of the Nation's perlite in 1988, New Mexico producers continued to dominate the domestic industry. An increase in sales of about 5% was registered during the year as production was derived from four surface mines. The average price per short ton was $31.21.

Potash.—New Mexico was responsible for more than 89% of the Nation's production of potash in 1988. The value of this production, $213.8 million, represented approximately 21% of the total nonfuel mineral production in the State. More than $2.5 million in revenues were generated for New Mexico by potash leasing on State and Federal lands during the 1988 fiscal year.[4]

The large potash deposit in southeast New Mexico supported six mining and processing operations. All of the operating properties comprised underground mines and ancillary facilities near Carlsbad in Eddy County. With more than 1,800 workers, the Carlsbad Basin potash industry employed more than 42% of the State's nonfuel, mineral work force during the year.

Average potash prices in 1988 soared almost 28% over those of the previous year to $168 per metric ton. In large part, this strengthening of the market was due to an antidumping agreement with Canada. The 5-year agreement, signed in January 1988 by Canadian potash producers and the U.S. Government, prohibits Canada from selling potash in the U.S. market at prices below average production costs. Removal of restraints on domestic crop production, imposed earlier because of drought conditions, also encouraged potash sales late in the year.

The marked improvement in the potash industry prompted the Mississippi Chemical Corp. to reopen its mine, idle since 1983, in October. This property contains the largest known and developed potash reserves in the United States. The company announced that it would also restart the compaction facilities of a plant once operated by the National Potash Co.

AMAX Inc.'s AMAX Potash Corp., which was expected to close its mine in 1989, instead extended operations another 2 to 5 years. In addition, the company began developing a new ore zone during the year. According to its Form 10-K, AMAX produced 518,000 tons of muriate of potash in 1988.

Trans-Resources Inc., a New York holding company, entered the Carlsbad potash district with its acquisition of the New Mexico Potash Corp. via the purchase of the Cedar Chemical Corp. from Fermenta AB of Sweden. Trans-Resources also bought the mine and assets of the bankrupt Lundberg Industries Ltd. from the previous owner, Ideal Basic Industries Inc. The Lundberg operation was renamed Eddy Potash Inc.

Two other potash producers, IMC Fertilizer Group Inc. and Western Ag-Minerals Co., operated mines in the Carlsbad area during the year. In its Form 10-K, IMC Fertilizer stated that the firm's mine in New Mexico produced 866,400 tons of potash during the fiscal year completed June 30, 1988. This output represented an increase of 25% over that of the previous fiscal year. The company also reported

that this operation was the largest domestic producer of double sulfate of potash magnesia (langbeinite) and the largest manufacturer of sulfate of potash.

In 1988, officials of the city of Carlsbad and Eddy and Lea Counties formed a local transportation development district to encourage improved railroad access to eastern potash markets. Preliminary discussions centered on the feasibility of rehabilitating a connecting line owned by the Santa Fe Railway. The line runs from Carlsbad to Pecos, TX. This connection to the Southern Pacific system would be shorter than the existing route through Clovis, NM, and should be more efficient in terms of cost and time to transport the potash. The New Mexico State Transportation Authority initiated a review of these discussions during the year.

Pumice.—New Mexico maintained its position in 1988 as the second largest domestic producer of pumice. The combined output from the three mines operating in the State was equivalent to more than 21% of total U.S. production. In comparison to 1987, production dipped slightly and average prices fell about 11% to $10.14 per short ton.

Salt.—A small decrease in the price of salt during 1988 was offset by a modest increase in production of about 7%. Two companies recovered salt from potash tailings in Eddy County, and two others in Lea County employed solution mining to recover brines used by the petroleum industry.

Sand and Gravel.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1987. Data for odd-numbered years are based on annual company estimates.

For some States, construction sand and gravel statistics are compiled by districts. Table 3 presents end-use data for this commodity in New Mexico districts as depicted in figure 1.

Compared to the estimated production in 1987, the State registered little more than a 2% increase in output of construction sand and gravel in 1988. The average price, $3.57 per short ton, was essentially unchanged. Sand and gravel district 1, encompassing the two principal population centers of Albuquerque and Santa Fe, produced slightly more than 60% of New Mexico's total output.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

Estimated crushed stone production fell more than 22% from production reported for 1987. This decline was attributed to significant reduction of construction activity in the State.

Estimates suggest that production of dimension stone remained unchanged during 1988.

Other Industrial Minerals.—Common clay and shale production in New Mexico during 1988 declined about 6% from that of 1987. The output of fire clay, required by the State's copper smelters for plugging furnaces, increased more than 11%, however.

Gem stones and gem materials produced in the State included agate, azurite, fluorite, smithsonite, and turquoise.

New Mexico is one of only four States that produced Grade-A helium. Production within the State was comparatively small and declined slightly from 1987.

Humate, derived from weathered coal and associated carbonaceous shales and claystones, has become an important nonfuel mineral commodity

TABLE 2

NEW MEXICO: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	1,357	$5,085	$3.75
Plaster and gunite sands	156	548	3.52
Concrete products (blocks, brick, pipe, decorative, etc.)	W	W	3.37
Asphaltic concrete aggregates and other bituminous mixtures	577	1,472	2.55
Road base and coverings[1]	1,644	6,254	3.80
Fill	357	688	1.92
Snow and ice control	W	W	2.11
Railroad ballast	W	W	1.50
Other	106	3.73	3.51
Unspecified:[2]			
Actual	533	1,365	2.56
Estimated	4,057	15,582	3.84
Total or average	**8,787**	**31,367**	**3.57**

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1] Includes road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.

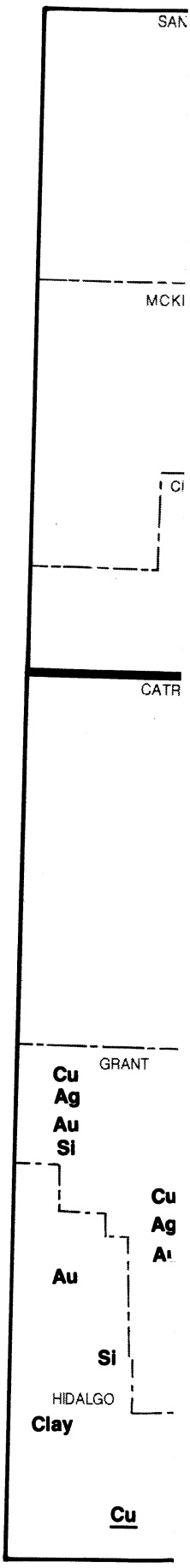
NEW MEXICO

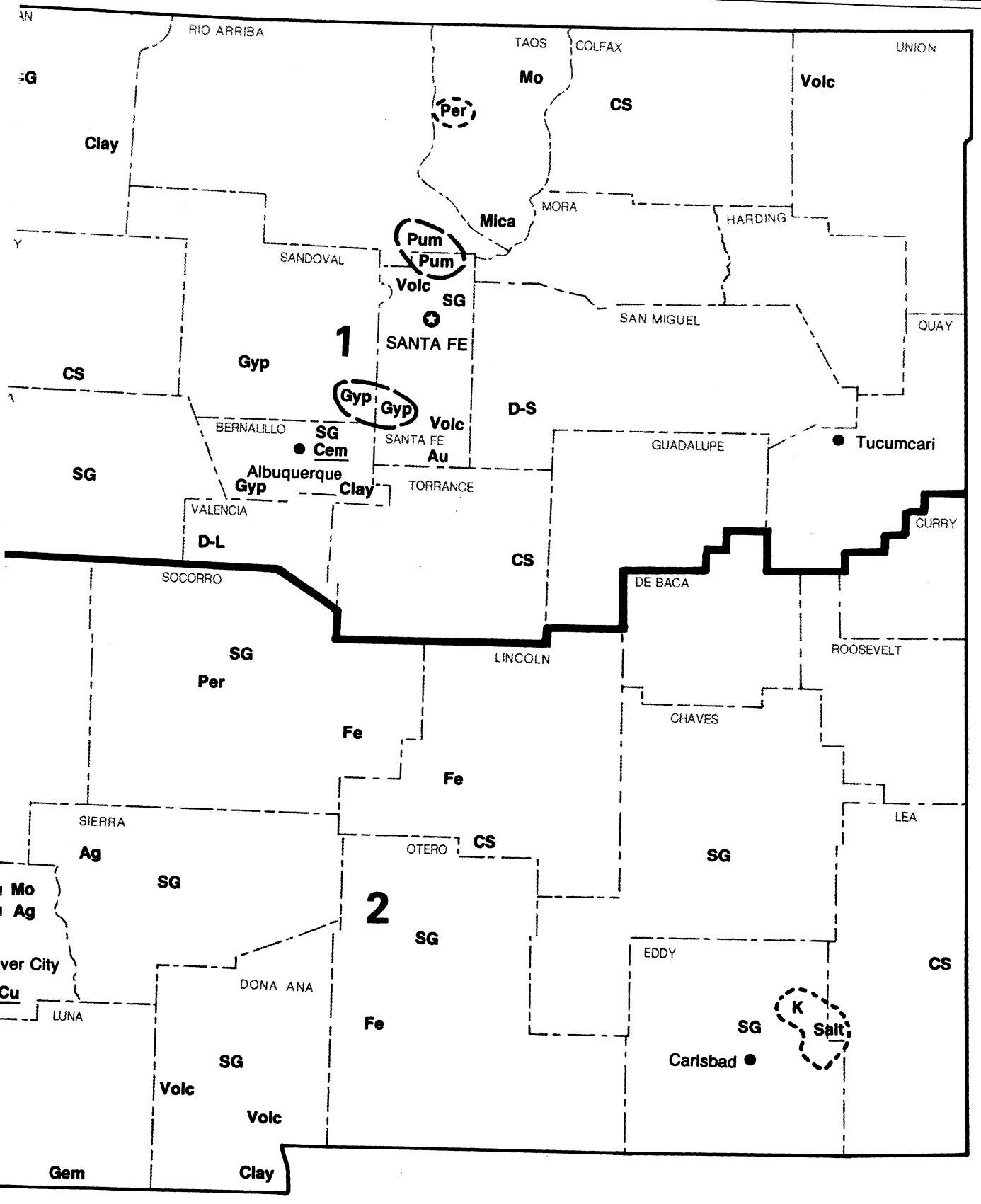
LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Ag	Silver
Au	Gold
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper
Cu	Copper plant
D-L	Dimension Limestone
D-S	Dimension Sandstone
Fe	Iron
Gem	Gemstones
Gyp	Gypsum
K	Potash
Mica	Mica
Mo	Molybdenum
Per	Perlite
Pum	Pumice
Salt	Salt
SG	Sand and Gravel
Si	Silica
Volc	Volcanic cinder
	Concentration of mineral operations




RIO ARRIBA
TAOS
COLFAX
UNION
Clay
Per
Mo
CS
Volc
Mica
MORA
HARDING
SANDOVAL
Pum
Pum
Volc
SG
SAN MIGUEL
QUAY
1
SANTA FE
Gyp
CS
Gyp
Gyp
D-S
BERNALILLO
SG
Cem
Volc
SANTA FE
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GUADALUPE
Tucumcari
SG
Albuquerque
Gyp
Clay
TORRANCE
VALENCIA
CURRY
D-L
CS
SOCORRO
DE BACA
SG
LINCOLN
ROOSEVELT
Per
CHAVES
Fe
Fe
SIERRA
LEA
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OTERO
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EDDY
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iver City
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DONA ANA
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LUNA
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SG
Volc
Volc
Gem
Clay

TABLE 3

NEW MEXICO: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	Ditrict 1		District 2	
	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	630	2,040	727	3,045
Plaster and gunite sands	110	399	46	149
Concrete products (blocks, brick, pipe, decorative, etc.)	W	W	—	—
Asphaltic concrete aggregates and other bituminous mixtures	472	1,165	104	307
Road base and coverings[1]	755	2,418	889	3,837
Fill	93	240	264	448
Snow and ice control	W	W	—	—
Railroad ballast	—	—	W	W
Other miscellaneous	100	363	7	10
Other unspecified[2]	3,176	11,622	1,414	5,325
Total	**5,336**	**[3]18,246**	**3,451**	**13,121**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data do not add to total shown because of independent rounding.

in the State. More than 11 billion tons of the humic-acid-rich material was identified by BMMR principally in the San Juan Basin of northwestern New Mexico. In addition to the traditional use of humate as an additive to drilling muds and soil conditioners, research is being conducted on the suitability of using humate to remove pesticides and herbicides from contaminated waters. Two humate mines were in operation during 1988.

Elemental sulfur, recovered as a byproduct of natural gas production, declined slightly in 1988 from the previous year. Total shipment for the State was about 44,000 metric tons valued at $2.8 million. Most of this production was in southeastern New Mexico.

The State was the second largest domestic producer of sulfuric acid, recovered as a byproduct of the smelting and roasting of base metals. All acid produced in this manner in New Mexico was obtained at two copper smelters operated by Phelps Dodge. Although production decreased slightly from that of 1987, the total value reported showed an increase in 1988 of more than 73%.

[1] State Mineral Officer, Bureau of Mines, Tucson, AZ.

[2] Mining engineer, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM.

[3] New Mexico Progress. Economic Review of 1988. V. 6, 1988, 64 pp.

[4] New Mexico Energy, Minerals, and Natural Resources Department, Annu. Resour. Rep. Jan. 1989, 119 pp.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Ideal Basic Industries Inc., Ideal Cement Co.	Box 100 Tijeras, NM 87059	Dry process, 2 rotary-kiln plants.	Bernalillo.
Clays:			
El Paso Brick Co. Inc.	Box 12336 El Paso, TX 79913	Pit	Dona Ana.
Garcia & Sons Inc.[1]	Box 841 Farmington, NM 87401	do.	San Juan.
Mathis & Mathis Mining & Exploration Co.[1]	Box 2577 Silver City, NM 88062	do.	Luna.
New Mexico Brick Co. Inc. (doing business as Kinney Brick Co. Inc.).	Box 1804 Albuquerque, NM 87103	do.	Bernalillo.
Copper:			
Burro Chief Copper Co., a subsidiary of Phelps Dodge Corp.	Drawer B Tyrone, NM 88065	Solvent-extraction electrowinning plant.	Grant.
Challenge Mining Co. Inc.	Drawer 1220 Deming, NM 88031	Surface mine and mill	Catron.
Chino Mines Co., a subsidiary of Phelps Dodge Corp.-Mitsubishi Metal Corp. partnership.[2 3]	Box 7 Hurley, NM 88043	Surface mine, flotation mill, precipitation plant, smelter.	Grant
Cyprus Pinos Altos Corp.[3]	Box 2198 Silver City, NM 88062	Underground mine and mill	Do.
Phelps Dodge Corp.:			
Hidalgo Smelter[4]	Box 67 Playas, NM 88009	Smelter	Hidalgo.
Tyrone Branch[3]	Drawer B Tyrone, NM 88065	Surface mine, mill, solvent extraction-electrowinning plant.	Grant.
Gold:			
Mount Royal Mining & Exploration Co. (formerly Summit Minerals Inc.).[5]	100 Mesquite Ave. Duncan, AZ 85534	Underground mine	Do.
WESTAR Corp.	Drawer D Lordsburg, NM 88045	Surface mine and heap-leach operation.	Hidalgo.
Gypsum:			
Centex American Gypsum Co.	Box 6345, Station B Albuquerque, NM 87197	Pit and plant	Bernalillo and Sandoval.
Ernst Teeter Trucking Inc.	Box 27317 Albuquerque, NM 87125	Pit	Sandoval.
Western Gypsum	Box 2636 Santa Fe, NM 87501	Pit and plant	Santa Fe.
Humate:			
Agronics Inc.	701 Madison Street, NE. Albuquerque, NM 87110	Surface mine	Sandoval.
Mesa Verde Resources	Box 8632 Albuquerque, NM 87199	Surface mine and mill	Mckinley and Sandoval.
Mica:			
Mineral Industrial Commodities of America Inc.	Box 2403 Santa Fe, NM 87504	Pit and mill	Rio Arriba and Taos.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Perlite:			
Grefco Inc., Mineral Div., a subsidiary of General Refractories Co.	Box 308 Antonito, CO 81120	Surface mines; crushing, screening, air separation	Socorro and Taos.
Manville Sales Corp., a division of Manville Products Corp.	Box 338 Antonito, CO 81120	do.	Taos.
Silbrico Corp.	Box 367 Antonito, CO 81120	Surface mine	Do.
United States Gypsum Co., a subsidiary of USG Corp.	Box 216 Grants, NM 87020	Surface mine and crushing plant.	Cibola.
Potash:			
AMAX Potash Corp., a subsidiary of AMAX Inc.	Box 279 Carlsbad, NM 88220	Underground mine and plant	Eddy.
Eddy Potash Inc., a subsidiary of Trans-Resources Inc.	Box 31 Carlsbad, NM 88220	do.	Do.
IMC Fertilizer Inc. (formerly a subsidiary of International Minerals & Chemical Corp.).	Box 71 Carlsbad, NM 88220	do.	Do.
Mississippi Chemical Corp.	Box 101 Carlsbad, NM 88220	do.	Do.
New Mexico Potash Corp., a subsidiary of Trans-Resources Inc.[6]	Box 610 Hobbs, NM 88240	do.	Do.
Western Ag-Minerals Co., a partnership of Warburg-Pincus Capital Partners & Rayrock Resources Ltd.	Box 511 Carlsbad, NM 88220	do.	Do.
Pumice:			
American Pumice Co., a division of Continental Equities Corp.	Box 4305 Santa Fe, NM 87502	Mill	Santa Fe.
Copar Pumice Co. Inc.	Box 38 Espanola, NM 87532	Surface mine	Do.
General Pumice Corp.	Box 5135 Santa Fe, NM 87502	Surface mine and crushing and screening plant.	Rio Arriba and Santa Fe.
Utility Block Co.	Box 6036 Albuquerque, NM 87197	Surface mines and crushing and screening plants.	Bernalillo and Sandoval.
Salt:			
New Mexico Salt & Minerals Corp.	Box 2262 Carsbad, NM 88220	Tailings treatment	Eddy.
Unichem International Co.	Box 1659 Eunice, NM 88321	Solution mining	Lea.
United Salt Corp., Carlsbad Div.	Box SS Carlsbad, NM 88220	Tailings treatment	Eddy.
Williams Brine Co.	2501 Dona Ana Carlsbad, NM 88220	Solution mining	Lea.
Sand and gravel:			
Aggregate Specialists of New Mexico	4825 Jefferson, NE. Albuquerque, NM 87109	Pit and plant	Sandoval.
Albuquerque Gravel Products Co.	Box 829 Albuquerque, NM 87103	Dredge and plant	Bernalillo.
Albuquerque Materials Inc.	Box 6098, Station B Albuquerque, NM 87197	Pit and plant	Do.
Armstrong & Armstrong	Box 1873 Roswell, NM 88201	do.	Chaves.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Connie H. Danley Construction Inc.	Drawer K Alamogordo, NM 88310	Pit and plant	Otero.
J. R. Hale Contracting Co. Inc.	Box 25667 Albuquerque, NM 87125	do.	Sandoval.
S & S Aggregates Inc.	Box 14379 Albuquerque, NM 87191	do.	Bernalillo.
Springer Building Materials Corp.[1]	Box 572 Albuquerque, NM 87103	do.	Do.
Silver:			
St. Cloud Mining Co.[7]	Box 1670 Truth or Consequences, NM 87901	Underground and surface mines and mill.	Sierra.
Stone (Crushed):			
G. F. Atkinson Co. of Monterey Construction Co.	Box 2248 Carlsbad, NM 88221	Quarries	Eddy.
Beavers Sand & Gravel Inc.	Box 887 Ruidoso Downs, MN 88346	Quarry	Lincoln.
Big Chief Stone Inc.	900 North Morton Lane Las Cruces, NM 88005	Quarries	Colfax, Dona Ana, Santa Fe.
El Paso Sand Products Inc.	Box 9008 El Paso, TX 79982	Quarry	Dona Ana.
K & B Constructors Inc.	1437 Furneaux Rd. Marysville, CA 95901	do.	Socorro.
Rock Products Inc. (doing business as Bee Bee Contractors).	Box 154 Encino, NM 88321	do.	Torrance.
Rose Gravel Co.	Box 220 Carlsbad, NM 88220	Quarries	Chaves and Eddy.
Thompson Construction Co.	Box 339 Hobbs, NM 88240	Quarry	Lea.
Stone (Dimension):			
Apache Springs Co.	Radium Springs, NM 88054	do.	Dona Ana.
Daniel F. Guillen Construction Inc.	4007 Mission Bell Las Cruces, MN 88001	do.	Do.
Rocky Mountain Stone Co.	Box 6608 Albuquerque, NM 87197	Quarries	Socorro and Valencia.
Uranium-Vanadium:			
Chevron Resources Co.	Box 1150 Grants, NM 87020	Underground mine	Cibola.
Homestake Mining Co.	Box 98 Grants, NM 87020	Underground mines, concentrator, ion-exchange from mine waters.	Cibola and McKinley.
Quivira Mining Co., a subsidiary of Kerr-McGee Corp.	Box 218 Grants, NM 87020	do.	Do.
Ray L. Williams Mining Co.	7 Road 5455 Farmington, NM 87401	Underground mine	San Juan.

[1] Also stone.
[2] Also byproduct molybdenum.
[3] Also gold and silver.
[4] Also fire clay and quartzite.
[5] Also copper, lead, and silver.
[6] Also salt.
[7] Also copper, gold, and lead.

THE MINERAL INDUSTRY OF NEW YORK

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the New York State Education Department, New York Geological Survey, for collecting information on all nonfuel minerals.

By Donald K. Harrison[1] and William M. Kelly[2]

The value of nonfuel mineral production in New York in 1988 was $695.7 million, a $45.3 million increase over that of 1987. Leading mineral commodities produced in terms of value were crushed stone, portland cement, salt, construction sand and gravel, and zinc.

Nationally, the State ranked 15th in the value of nonfuel minerals it produced. New York was the only State in the country that produced emery and wollastonite. The State ranked second in its output of garnet, synthetic graphite, and zinc; third in salt production; fourth in crude talc; and fifth in primary aluminum production.

LEGISLATION AND GOVERNMENT PROGRAMS

In May, a comprehensive solid waste management bill, focusing on source separation of recyclables and the development of markets for recyclables, was signed into law. The new law (The Solid Waste Management Act of 1988, Chapter 70, Laws of 1988) established a State policy creating a hierarchy of solid waste management practices. By September 1992, each municipality will be required to institute a source separation program. A newly created Bureau of Waste Reduction and Recycling within the Department of Environmental Conservation (DEC) was established to assist in the promotion, development, and implementation of local waste reduction, source separation, and recycling programs. In June, the DEC announced that it had issued two regulations to address the solid waste issue. These regulations (6NYCRR Part 360 and 6NYCRR Part 219) were expected to increase significantly State regulation of solid waste disposal with an emphasis on recycling.

About 10 Syracuse area foundries may have to scale down or close their operations due to a DEC order that closed the only area landfill that accepted phenol-contaminated sands. The foundries had been dumping phenol-contaminated sand, a DEC-regulated industrial waste, at the Dewitt landfill for several years. The DEC order placed a ban on this dumping in response to a concern that the phenol would leak through the landfill and contaminate the ground water. The foundries, which employ about 1,000 workers, met and will continue to meet with the DEC to work out a compromise.

During the year, the New York State Science and Technology Foundation (NYSSTF) established two new research centers to conduct studies on superconducting ceramics and other advanced materials. One was the Center for Advanced Materials Processing at Clarkson University, Potsdam; the other was the Center for Advanced

TABLE 1

NONFUEL MINERAL PRODUCTION IN NEW YORK[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	short tons	618,968	$3,075	672,635	$3,562	607,786	$3,654
Emery	do.	2,878	W	1,945	W	W	W
Gem stones		NA	100	NA	135	NA	200
Peat	thousand short tons	W	W	1	34	W	W
Salt	do.	5,071	122,601	4,918	119,962	4,614	127,994
Sand and gravel:							
Construction	do.	31,172	103,748	e31,400	e112,900	33,884	124,341
Industrial	do.	59	1,164	58	651	53	625
Stone:							
Crushed	do.	e40,600	e196,600	38,103	188,694	e39,900	e193,500
Dimension	short tons	e15,637	e3,002	38,553	5,822	e30,751	e4,333
Combined value of cement, garnet (abrasive), gypsum, iron ore (includes byproduct material, 1988), lead, silver, talc pyrophyllite, wollastonite, zinc, and values indicated by symbol W		XX	247,272	XX	218,620	XX	241,053
Total		**XX**	**677,562**	**XX**	**650,380**	**XX**	**695,700**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kinds and values included with "Combined value" data.

Ceramics Technology at Alfred University in Alfred. The addition of these two research centers brought the total of NYSSTF centers operating throughout the State to nine. For each center, New York State is to provide $1 million annually; the centers are expected to match that amount with funds from industry.

In 1988, the New York Geological Survey performed two basic functions. First, it provided geological information for government agencies, the mineral industry, and the public; second, it acted as the geological research agency of the New York State Museum. In 1988, the Survey was involved in 14 major projects, 3 of which related to environmental and engineering geology and 11 to regional geologic and mineral-resource studies. Individual project topics included a statewide landslide inventory, beach erosion studies on Long Island, bedrock and surficial quadrangle mapping of the Adirondack Mountains, and paleontologic-stratigraphic investigations in western New York and the Taconic Mountains.

The New York Geological Survey also embarked upon a program to study the aggregate and heavy-mineral resources in Long Island Sound and on the continental shelf south of Long Island. Vibracores of up to 20 feet in length were processed to determine course and fine aggregate content and composition, as well as the presence and amount of economic heavy minerals such as ilmenite, rutile, leucoxene, zircon, and monazite. Percentages of industrial minerals present (i.e., aluminosilicates, garnet, staurolite, and magnetite) were also quantified. Studies completed to date in Long Island Sound identified no ore-grade heavy-mineral placers, but shoals containing up to 45% coarse sand and gravel are present in the western Sound.

Under the ongoing State Mining and Mineral Resources Research Institute Program Act, the U.S. Bureau of Mines allotted a grant of $138,000 to Columbia University's Henry Krumb School of Mines to conduct research and training in the mineral-related disciplines. The State was required to match this grant on a 2-to-1 basis. The Bureau also awarded a $123,604 contract to a private firm in the State for mineral-related work.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Four companies operated four cement plants in the State. Both portland and masonry cement were produced by Atlantic Cement Co. Inc. at Ravena, Lehigh Portland Cement Co. at Cementon, and the Glens Falls Portland Cement Co. Inc. at Glens Falls. Only portland cement was produced at the Independent Cement Corp. plant at Catskill. In 1988, the shipments and value of portland cement each fell 4% compared with that of 1987. The shipments and value of masonry cement, on the other hand, rose 30% and 21%, respectively. Most of the cement was shipped by barge; rail and truck accounted for the remainder.

In July, Dyckerhoff AG, Wiesbaden, of the Federal Republic of Germany purchased the Glens Falls Cement Co. plant as well as its Howes Cave terminal for $67.3 million. The 550,000-short-ton-per-year cement plant was purchased from Southdown Corp., which had obtained the plant from Moore McCormack Resources just 3 months earlier.

In August, Independent Cement announced plans to build a $190 million, 1-million-ton-per-year plant on the site of the former Universal Atlas Cement plant in Greenport. The Atlas plant closed in 1976, and Independent Cement's parent company, St. Lawrence Cement Inc., purchased the property a year later with the intention of eventually opening a new manufacturing plant. The new plant was expected to come into production in 1993.

Clays.—In 1988, production of common clay decreased 10% from that of 1987. Common clay was produced by six companies in five counties. Leading counties, in order of output, were Albany, Ulster, Orange, Onondaga, and Erie. The clay was used principally in the manufacture of portland cement, face brick, and lightweight aggregate for use in structural concrete and block.

Emery.—New York was the only State that produced emery. One company, John Leardi Emery Mine, operated a mine near Peekskill in Westchester County. The crude material was processed by two out-of-State companies and used principally as an abrasive aggregate for nonskid wear-resistant floors, pavements, and stair treads. In September, the mine was sold to Croton Dam Road Corp., which operated the mine as a crushed stone producer; it did not produce emery.

Garnet.—Of the five domestic garnet producers active in 1988, three were in New York. Barton Mines Corp. operated a surface mine near North Creek, Warren County; its output was used in coated abrasives, glass grinding and polishing, and metal lapping. The NYCO Div. of Processed Minerals Inc. recovered crude garnet concentrate as a byproduct at its wollastonite mining operation. This material was sold to a domestic garnet producer for refinement and sale. Finally, International Garnet Abrasives Inc. began production in July at a plant in Clinton County. This garnet was used as a blasting and filtration media.

Gem Stones.—The value of gem stones and mineral specimens collected by mineral dealers and amateur collectors in New York in 1988 was estimated at $132,000. This 1988 estimate was based on a survey by the Curator of Mineralogy of the New York State Mu-

seum. Of this amount, approximately $92,000 entered the market as specimens and educational-grade samples; $40,000 remained in private collections and museums. Popular gem- and mineral-collecting areas included Gore Mountain near North Creek, Warren County; refuse areas of talc and zinc mines operating near Balmat, St. Lawrence County; and southern Herkimer and western Montgomery Counties where "Herkimer diamonds," doubly terminated clear quartz crystals, were found.

Gypsum.—USG Corp., the State's only gypsum producer, mined crude gypsum from an underground mine at Oakfield in Genesee County. Output remained essentially the same as that of 1987. The crude gypsum mined at Oakfield was calcined and made into wallboard at an adjoining plant.

Imported gypsum was also calcined at three plants in the State. USG calcined gypsum imported from Nova Scotia, Canada, at Stony Point, Rockland County. In terms of total output, the Stony Point plant ranked seventh of 72 plants that calcined gypsum in the United States. The two other companies that calcined gypsum using imported ore were National Gypsum Co., which operated a plant in Rensselaer, Rensselaer County, and Georgia-Pacific Corp., which operated a plant at Buchanan, Westchester County. Total gypsum calcined in the State in 1988 was 1.1 million short tons valued at $19.3 million.

Peat.—Two companies produced peat at two operations, one of which was in Broome County; the other was in Seneca County. Both sphagnum and humus were sold for soil improvement and as an ingredient in potting soils.

Salt.—New York ranked third in the Nation in salt sold or used; it was first in value. Salt sold or used totaled 4.6 million short tons (19% of the Nation's total) and was valued at nearly $128 million. Rock salt was produced by Cargill Inc. in Tompkins County and by International Salt Co. (ISC) in Livingston County. Both companies also produced evaporated salt at plants in Schuyler County; Morton Thiokol Inc. also produced evaporated salt in Wyoming County.

In October, the U.S. District Court in Rochester, NY, blocked a proposal by Geostow New York Holdings Inc. to dispose of ash from coal-fired powerplants and solid waste incinerators in underground salt mines in Livingston County. The legal issue before the judge concerned who owned the miles of mine tunnels that run under the Livingston County towns of Leicester, York, and Geneseo—ISC or the owners of the property on the surface. The court ruled that the tunnels were still the property of ISC, which had secured the mining rights decades ago from the people who owned the land above the salt deposits. The court did not address the environmental impact of the project.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter thus contains actual data for 1986 and 1988 and estimates for 1987.

New York construction sand and gravel statistics are compiled by geographical districts as depicted in the certerfold map. Table 3 presents end-use data for the commodity in the eight New York districts.

Construction sand and gravel, New York's fourth leading commodity in terms of value, accounted for nearly one-fifth of total State mineral value. In 1988, more than 360 companies mined construction sand and gravel from 382 operations in 53 counties. The leading counties in order of output were Suffolk, Dutchess, and Rensselaer. Construction sand and gravel was used mostly for road base and cover-

TABLE 2

NEW YORK: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand) short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	6,812	$27,633	$4.06
Plaster and gunite sands	108	543	5.03
Concrete products (blocks, bricks, pipe, decorative, etc.)	393	1,567	3.99
Asphaltic concrete aggregates and other bituminous mixtures	1,950	8,673	4.45
Road base and coverings[1]	4,860	16,475	3.39
Fill	3,448	7,048	2.04
Snow and ice control	1,324	4,955	3.74
Railroad ballast	16	54	3.38
Other[2]	185	980	5.30
Unspecified:[3]			
Actual	6,820	28,491	4.18
Estimated	7,968	27,920	3.50
Total or average	**33,884**	**[4]124,341**	**3.67**

[1] Includes road and other stabilization (lime).
[2] Includes roofing granules.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data do not add to total shown because of independent rounding.

TABLE 3

NEW YORK: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	3,215	11,577	754	4,027	1,119	3,881	267	1,029
Plaster and gunite sands	W	W	W	W	40	W	3	15
Concrete products (blocks, bricks, etc.)	—	—	W	W	30	W	92	130
Asphaltic concrete aggregates and other bituminous mixtures	W	W	309	2,020	291	1,001	213	458
Road base and covering[1]	17	50	753	2,855	790	1,788	436	1,178
Fill	939	2,392	246	711	1,449	2,223	353	538
Snow and ice control	20	98	312	1,849	233	556	182	445
Railroad ballast	—	—	—	—	—	—	—	—
Other miscellaneous[2]	126	232	101	703	6	334	(3)	(3)
Other unspecified[4]	631	4,209	2,958	14,826	2,521	7,696	1,059	3,229
Total[5]	**4,948**	**18,557**	**5,433**	**26,990**	**6,478**	**17,479**	**2,606**	**7,023**

	District 5		District 6		District 7		District 8	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	253	717	529	2,904	303	1,331	372	2,168
Plaster and gunite sands	W	W	W	W	W	W	W	W
Concrete products (blocks, bricks, etc.)	W	W	83	464	W	W	W	W
Asphaltic concrete aggregates and other bituminous mixtures	W	W	542	3,347	102	473	366	1,124
Road base and coverings[1]	429	1,080	767	2,457	506	1,178	1,162	5,889
Fill	206	320	101	416	53	144	102	304
Snow and ice control	172	304	227	933	124	511	54	260
Railroad ballast	W	W	W	W	14	42	—	—
Other miscellaneous[2]	16	56	41	262	245	998	32	160
Other unspecified[4]	901	2,640	2,566	9,611	2,181	6,954	1,970	7,245
Total[5]	**1,977**	**5,117**	**4,856**	**20,394**	**3,528**	**11,631**	**4,057**	**17,149**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (lime).
[2] Includes sand and gravel for roofing granules.
[3] Less than 1/2 unit.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to total shown because of independent rounding.

ings, concrete aggregates, and fill.

Industrial.—Whitehead Bros. Co. was the only industrial sand producer in New York in 1988. The company operated one pit in Saratoga County and another in Oneida County. Major uses of industrial sand were for glassmaking, moldings, and foundry purposes.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter thus contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—Crushed stone production was the State's leading mineral commodity produced and accounted for 27% of the State's total. Limestone was the primary type of crushed stone produced. Other types included dolomite, granite, sandstone, and traprock. The crushed stone was used mainly for road base, bituminous aggregate, cement manufacture, and fill.

Dimension.—The majority of New York dimension stone production was in Washington County. Both output and value fell, compared with 1987. Most of the stone quarried was sandstone, which was followed by lesser quantities of granite, limestone, quartzite, and slate.

Talc.—New York ranked fourth of 11 States that produced talc in 1988. The Gouverneur Talc Co., a subsidiary of R. T. Vanderbilt Co. Inc., mined the talc from both a surface and an underground operation; both mines were in Lawrence County. The ore was ground and processed at an on-site mill and used primarily for ceramics and paint additives.

Wollastonite.—New York, the only State in the Nation that produced wollastonite, supplied all of the North American market. About 40% of the material mined in the State was exported to Europe and Japan. Two companies mined wollastonite in 1988. NYCO operated the Lewis surface mine 14 miles west of Willsboro, Essex County. In 1988, NYCO proved additional reserves of 3 million short tons of high-quality ore near the Lewis Mine. The company announced that production capacity would be increased 25%, from 55,000 to 68,000 short tons per year, in 1989. NYCO also indicated that it would spend $8.5 million to build a 1,200-short-tons-per-year facility for its Wollastokup line of surface modified products.[3]

R. T. Vanderbilt, the State's other producer, operated an underground mine near Harrisville, Lewis County, through its talc mining subsidiary, Gouverneur Talc Co. Inc. The ore differed from that of NYCO material in that garnet was not present in the deposit. Major uses of wollastonite are as a filler in ceramic tile, marine wallboard paint, plastics, and refractory liners in steel mills.

Manufactured or Processed Minerals

In addition to the commodities listed in table 1, the production and value of certain processed or manufactured mineral commodities were surveyed by the U.S. Bureau of Mines.

High-purity fused aluminum oxide was produced by Electro Minerals (US) Inc. and by General Abrasives Division of Dresser Industries Inc., both in Niagara Falls. General Abrasives also produced regular fused aluminum oxide. Cut wire shot used for abrasives was produced by Pellets Inc. at a plant in Tonawanda, Erie County.

New York ranked second of the 13 States that produced graphite. During 1988, four companies, all in Niagara County, produced and shipped graphite. Principal uses of graphite were for anodes, cathodes, electrodes, and crucibles and vessels.

Indium Corp. of America, one of two indium producers in the United States, announced that it would boost its output by more than 1 million troy ounces and open a new refinery in Utica to meet an expected rise in worldwide indium demand.

Crude iodine was shipped into New York by RSA Corp., Westchester County, and by Sterling Organics US, Rensselaer County. RSA used the iodine to produce specialty organic chemicals. Sterling used it in the manufacture of pharmaceuticals, catalysts, and sanitation products.

Electric furnace-fused mullite was produced by Electro-Minerals (US) Inc. at Niagara Falls. The mullite was used primarily by the steel industry for furnace linings.

Crude perlite shipped in from other States was expanded by Scolite International Corp., Rensselaer County, and sold for loose fill insulation and soil conditioning.

Buffalo Crushed Stone Corp., Buffalo, processed air-cooled iron slag and sold the material for road base and asphaltic concrete aggregate.

Buffalo Tungsten, Inc., a subsidiary of Cleveland Tungsten, Inc., Cleveland, OH, began operations in March at a new tungsten processing plant in Depew. The company converted ammonium paratungstate into tungsten carbide powder for use in drill bits and cutting tools.

W. R. Grace & Co. exfoliated vermiculite concentrate shipped in from out of State at a plant in Weedsport, Cayuga County. The exfoliated vermiculite was used for concrete and plaster aggregate, loose fill and block insulation, and soil conditioning.

Metals

Aluminum.—In 1988, New York ranked fifth in both primary aluminum output and value, down from second place in 1987. Two companies, both in Massena, St. Lawrence County, operated primary aluminum plants at full capacity. Reynolds Metals Co. operated a 123,000-metric-ton-per-year smelter and Aluminum Co. of America (Alcoa) operated a 127,000-metric-ton-per-year plant.

Iron and Steel.—Bethlehem Steel Corp. announced its intention to spend approximately $45 million over the next 5 years at its Lackawanna steel plant. Bethlehem, which shuttered most of the Lackawanna operations in 1983, will spend the money on its three remaining operations at the plant. These operations, which employed 1,400 workers, included coke ovens, a galvanizing line, and a 13-inch bar mill.

AMB Technology Inc. began construction of a $25 million minimill on the site of the former Allied Chemical Co. plant in Solvay, a suburb of Syracuse. The minimill, called Liberty Steel, will use the latest technology and, according to the company, will produce 150,000 tons of steel per year at up to $40 per ton less than other steel mills in the Nation. The plant, which was expected to be completed by the spring of 1990, will manufacture H-beams and I-beams used in construction and will employ 180 people.

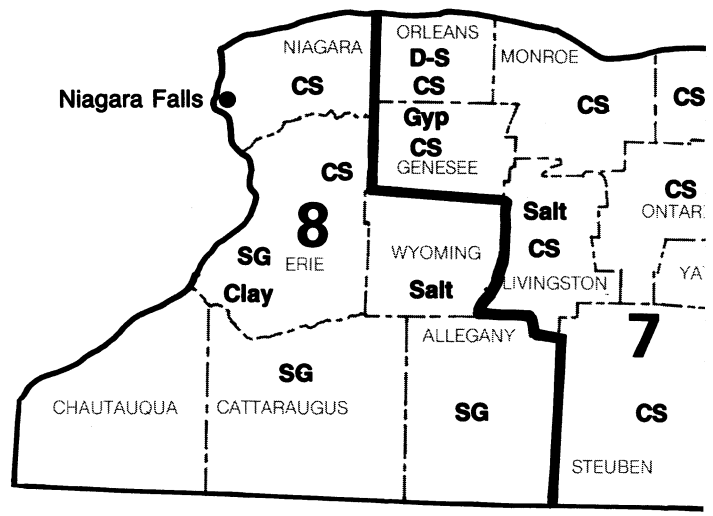
Steelmaking equipment at the closed Roblin Steel Co. Dunkirk plant was

LEGEND

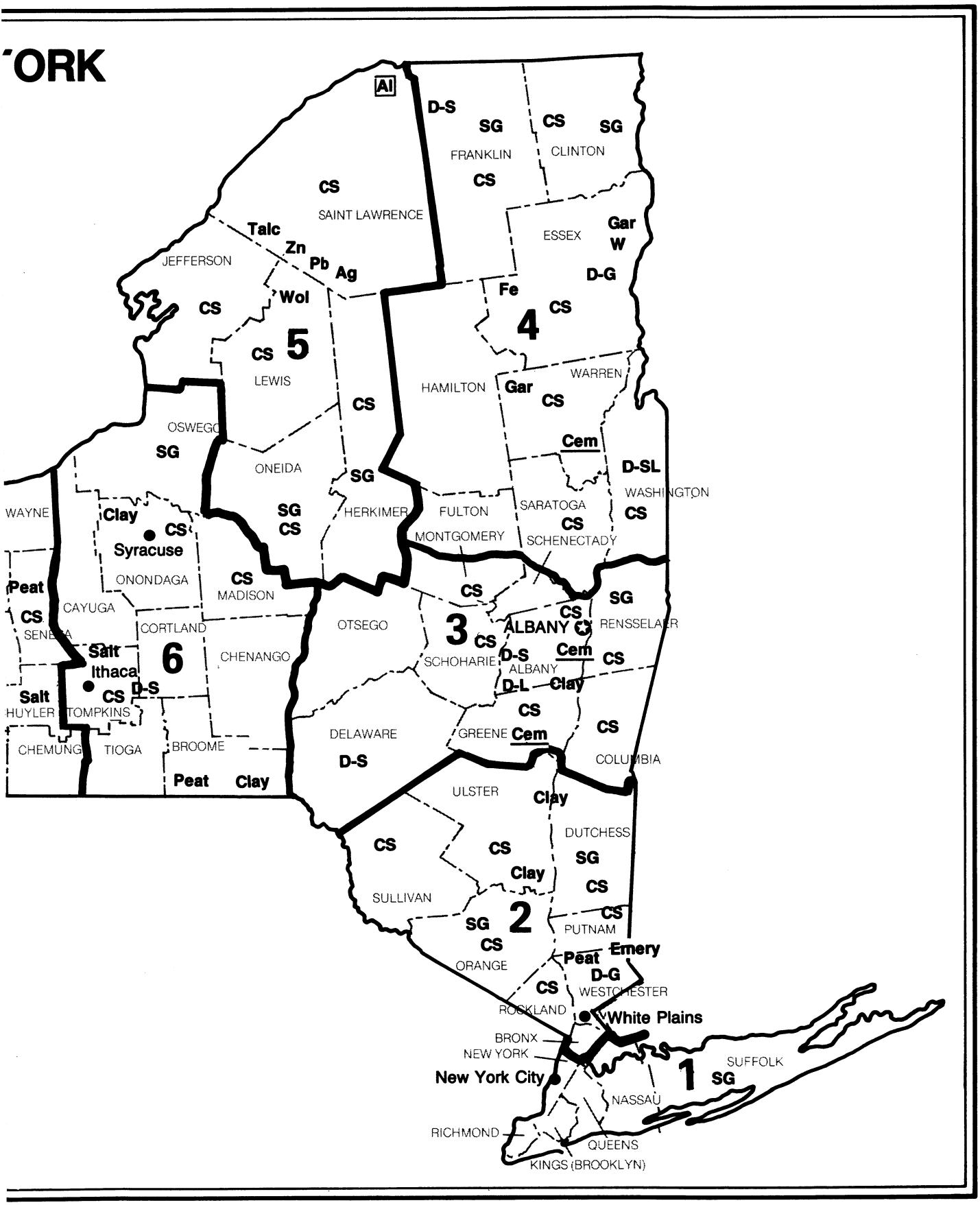
- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Ag	Silver
Al	Aluminum plant
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-G	Dimension Granite
D-L	Dimension Limestone
D-S	Dimension Sandstone
D-SL	Dimension Slate
E	Emery
Fe	Iron
Gar	Garnet
Gyp	Gypsum
Pb	Lead
Peat	Peat
Salt	Salt
SG	Sand and Gravel
Talc	Talc minerals
Wol	Wollastonite
Zn	Zinc



Principal Mineral-Producing Localities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MONTGOMERY
SCHENECTADY
Syracuse
Peat
ONONDAGA
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MADISON
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HUYLER
TOMPKINS
DELAWARE
GREENE
Cem
CS
D-S
COLUMBIA
CHEMUNG
TIOGA
BROOME
Peat
Clay
ULSTER
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SULLIVAN
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PUTNAM
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Peat
Emery
ORANGE
D-G
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WESTCHESTER
ROCKLAND
White Plains
BRONX
NEW YORK
SUFFOLK
New York City
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SG
NASSAU
RICHMOND
QUEENS
KINGS (BROOKLYN)

sold to an unidentified Chinese company that planned to move the machinery to China. Roblin Steel, a subsidiary of Roblin Industries Inc., and a former producer of carbon and alloy billets and bars, closed in 1986. The company had filed for chapter 11 creditor protection in 1985.

Lead and Silver.—Lead and silver were recovered as byproducts at the Zinc Corp. of America's zinc operations in St. Lawrence County.

Zinc.—New York ranked second in the Nation, after Tennessee, in zinc output and value. In 1988, zinc production and value increased 8% and 55%, respectively. Zinc Corp. of America (formerly St. Joe Resources Co.) was the only producer in the State. It operated two mines (Balmat and Pierrepont) and a 3,900-metric-ton-per-day mill at Balmat, St. Lawrence County. In 1988, the Pierrepont Mine was the Nation's second leading zinc mine in terms of total output; the Balmat Mine ranked sixth.

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[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA.

[2] Senior scientist, New York Geological Survey, Albany, NY.

[3] Mining Engineering. Industrial Minerals, 1988. V. 41, No. 6, June 1989, p. 424–25.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Abrasives (manufactured):			
Electro Minerals (US) Inc.	1801 Buffalo Ave., Box 423 Niagara Falls, NY 14302	Plant	Niagara.
General Abrasives Div. of Dresser Industries Inc.	2000 College Ave. Niagara Falls, NY 14305	do.	Do.
Pellets Inc.	531 South Niagara St. Tonawanda, NY 14150	do.	Erie.
Aluminum (primary):			
Aluminum Co. of America	1210 Alcoa Bldg. Pittsburgh, PA 15222	Smelter	St. Lawrence.
Reynolds Metals Co.	Box 27003–2A Richmond, VA 23215	do.	Do.
Cement:			
Atlantic Cement Co. Inc., a subsidiary of Newmont Mining Corp.[1 2]	Box 3 Ravena, NY 12143	Quarry and plant	Albany.
The Glens Falls Portland Cement Co. Inc., a subsidiary of Moore McCormack Resources Inc.[1]	Box 440 Glens Falls, NY 12801	Quarries and plants	Schoharie and Warren.
Independent Cement Corp.	Box 12–310 Albany, NY 12212	Quarry and plant	Greene.
Lehigh Portland Cement Co.[1]	718 Hamilton Mall Allentown, PA 18105	do.	Do.
Clays:			
Norlite Corp., a subsidiary of P. J. Keating Co.	Box 367 Fitchburg, MA 01420	Pit	Albany.
Northeast Solite Corp., a subsidiary of Solite Corp.	Box 27211 Richmond, VA 23261	Pit	Ulster.
Powell & Minnock Brick Works Inc.	Route 144 Coeymans, NY 12045	Pit	Do.
Emery:			
John Leardi Emery Mine	Gillman Ln. Peekskill, NY 10566	Pit	Westchester.
Garnet:			
Barton Mines Corp.	North Creek, NY 12853	Pit	Warren.
Gypsum:			
Calcined:			
Georgia-Pacific Corp.	Box 105605 133 Peachtree St., NE. Atlanta, GA 30348	Plant	Westchester.
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	do.	Rensselaer.
Crude:			
USG Corp.[3]	101 South Wacker Dr. Chicago, IL 60606	Underground mines and plant	Genessee and Rockland.
Iron ore:			
NL Chemicals Inc.	Tahawus, NY 12879	Pit	Essex.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Peat:			
Malcuria Bros. Inc.	1436 Gates Rd. Geneva, NY 14456	Bog	Seneca.
Bob Murphy Inc.	3129 Vestal Rd. Vestal, NY 13850	Bog	Broome.
Perlite (expanded):			
Scolite International Corp.	6 Madison St. Troy, NY 12181	Plant	Rensselaer.
Salt:			
Cargill Inc.	Box 5621 Minneapolis, MN 55440	Underground mine	Tompkins.
International Salt Co.	Abington Executive Park Clarks Summit, PA 18411	Underground mines	Livingston and Schuyler.
Morton Thiokol Inc.	110 North Wacker Dr. Chicago, IL 60606	Well	Wyoming.
Sand and gravel:			
Broad Hollow Estates Inc.	Box 483 Farmingdale, NY 11735	Pit	Suffolk.
Clemente Latham Concrete Corp.	RD #5, Box 56 Troy, NY 12180	Pits	Albany and Rensselaer.
William M. Larned & Sons Inc.	RD #3 Box 200A, Burdeck St. Schenectady, NY 12306	Pits and plant	Albany and Schenectady.
Slag (iron):			
Buffalo Crushed Stone Corp.[2]	2544 Clinton St. Buffalo, NY 14224	Plant	Erie.
Stone:			
Crushed:			
Blue Circle Atlantic Inc.	Box 3 Ravena, NY 12143	Quarry	Albany.
Callahan Industries Inc.	South St. South Bethlehem, NY 12161	Quarries	Albany, Madison, Rensselaer, Ulster.
Dolomite Products Inc.	1150 Penfield Rd. Rochester, NY 14625	do.	Genesee and Ulster.
The General Crushed Stone Co., a subsidiary of Koppers Co. Inc.	Box 231 Easton, PA 18042	do.	Herkimer, Jefferson, Livingston, Onondaga, Ontario, Wayne.
New York Trap Rock Corp., a subsidiary of Lone Star Industries Inc.	Box 432 Montvale, NJ 07645	Quarry	Rockland.
Peckham Materials Corp.	20 Haarlem Ave. White Plains, NY 10603	Quarries	Greene, Putnam, Warren, Washington.
Tilcon Quarries Inc.	Box 362 Haverstown, NY 10927	do.	Rockland and Ulster.
Dimension:			
Champlain Stone Ltd.	Box 852 Glens Falls, NY 12801	Quarry	Washington.
Finger Lakes Stone Co. Inc.	Box 401 Ithaca, NY 14850	do.	Tompkins.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone:			
Dimension:			
Lake Placid Granite Co.	202 South 3d Ave. Cold Spring, MN 56320	do.	Essex.
Medina Sandstone Quarry Inc.	8875 Quarry Rd. Niagara Falls, NY 14304	do.	Orleans.
New York Quarries Inc.	Box 43, Route 111 Alcove, NY 12007	Quarries	Albany and Delaware.
Rainbow Quarries Inc.	132 E. Main St. Malone, NY 12953	Quarry	Franklin.
Talc:			
Gouverneur Talc Co. Inc., a subsidiary of R. T. Vanderbilt Co. Inc.	Box 89 Gouverneur, NY 13642	Underground and surface mine.	St. Lawrence.
Vermiculite:			
W. R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	Plant	Cayuga.
Wollastonite:			
NYCO Div. of Processed Minerals Inc.[4]	Box 368 Willsboro, NY 12996	Surface mine	Essex.
R. T. Vanderbilt Co. Inc.	30 Winfield St. Norwalk, CT 06855	Underground mine	Lewis.
Zinc:			
Zinc Corp. of America[5]	Balmat, NY 13607	Underground mines	St. Lawrence.

[1] Also clays.
[2] Also stone.
[3] Also calcined gypsum.
[4] Also garnet.
[5] Also byproduct lead and silver.

THE MINERAL INDUSTRY OF NORTH CAROLINA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Division of Land Resources, North Carolina Department of Environment, Health, and Natural Resources, for collecting information on all nonfuel minerals.

By Doss H. White, Jr.,[1] and P. Albert Carpenter, III[2]

North Carolina's nonfuel mineral production value in 1988 totaled $529 million, a $52.5 million increase over 1987 levels. The State ranked 19th nationally in the output of all minerals. Value increased for all minerals mined in-State, with the exceptions of mica, dimension stone, olivine, and peat. North Carolina continued to lead the Nation in the output of feldspar, mica, olivine, pyrophyllite, and lithium (spodumene) and ranked second in the production of common clay, crushed granite, and phosphate rock.

TRENDS AND DEVELOPMENTS

In 1988, the State's mineral production exceeded $500 million for the first time, and North Carolina was the fourth of the seven southeastern States to reach the half-billion-dollar level. The sale of construction mineral commodities, clay, construction sand and gravel, and crushed stone accounted for more than 58% of the mineral output in 1988. The demand for these three mineral commodities exceeded the previous year's tonnage by 4 million short tons, reflecting the State's third-place ranking in the Southeast in both residential and commercial construction.

Activity in the industrial minerals sector continued to dominate mineral operations in the State. Texasgulf Inc., the State's only phosphate producer, began overburden removal with bucket-wheel excavators, which replaced dredges used since the mines opened in the 1960's. The company also began construction of a high-purity phosphoric acid plant. Cyprus Minerals Co. purchased Foote Mineral Co.'s lithium carbonate mine and beneficiation complex at Kings Mountain. Mannington Ceramic Tile began tile production at a plant in Mt. Gilead, and Summitville Tiles Inc. broke ground for a plant near Glen Alpine. One of the State's gem mines produced what was billed as "the largest blue star sapphire in the world," weighing more than 1,000 carats. Applied Industrial Minerals Corp. permanently closed its olivine mine near Sylva, and mine reclamation was underway by the end of 1988.

In the metals sector, Niagara Capital Corp. of Canada announced plans to reopen the Silver Hill polymetallic mine in Davidson County. Imperial Mining Co., McDowell County, began construction of a new sand-gold-rare earth separation plant. Teledyne Alvac announced plans to install a plasma cold-hearth melting system at its Monroe plant, and a North Carolina and a South Carolina steel producer agreed to share information on continuous steelmaking technology for the basic oxygen furnace.

TABLE 1

NONFUEL MINERAL PRODUCTION IN NORTH CAROLINA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	2,657,679	$10,970	3,229,053	$15,282	3,174,766	$16,349
Feldspar	do.	526,672	15,568	512,386	15,562	507,986	17,312
Gem stones		NA	551	NA	550	NA	688
Gold (recoverable content of ores, etc.)	troy ounces	12	4	—	—	—	—
Mica (scrap)	thousand short tons	89	4,641	100	5,607	87	4,512
Peat	do.	15	W	W	W	21	W
Sand and gravel:							
Construction	do.	7,543	23,127	e8,600	e30,100	11,076	38,459
Industrial	do.	1,464	16,656	1,184	15,329	1,246	15,953
Stone:							
Crushed	do.	e43,500	e206,500	48,847	237,181	e50,500	e250,000
Dimension	short tons	e41,418	e6,633	32,669	5,128	e31,977	e5,026
Talc and pyrophyllite	do.	82,694	1,552	W	W	W	W
Combined value of lithium minerals, olivine, phosphate rock, and values indicated by symbol W		XX	180,528	XX	152,178	XX	181,135
Total		**XX**	**466,730**	**XX**	**476,917**	**XX**	**529,434**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

EXPLORATION ACTIVITIES

Texasgulf Minerals and Metals Inc. of Golden, CO, conducted an exploration program at the Portis gold mine in Franklin County. The mine at one time had been the most productive gold mine in the State, but had been closed since 1936. Imperial Mining Corp. in McDowell County conducted a limited surface sampling program for gold and rare earths. There was renewed interest in the State's talc resources.

REGULATORY ISSUES

The community of Hillsborough on the Eno River in the north-central part of the State was investigating a plan to pump the town's treated wastewater through both a textile plant and Piedmont Minerals Co.'s pyrophyllite processing plant and then return the water to Hillsborough's water treatment plant. If feasible and adopted, the plan would reduce water usage from the Eno River by 500,000 gallons a day, and the reprocessing would remove dyes from textile wastewater released into the river.

The State's only phosphate rock producer, Texasgulf Inc., began preliminary work on a $20 million waste water recycling system at its 3,000-acre mine and fertilizer manufacturing complex near Aurora in Beaufort County. At yearend, the company applied for a U.S. Corps of Engineers permit to mine 234 acres of wetland near its current operation.

LEGISLATION AND GOVERNMENT PROGRAMS

No bills that directly affected the mineral industry were enacted during the 1988 meeting of the State's General Assembly. However, a 1986 North Carolina Supreme Court ruling that denied State regulatory agencies the right to set fines could have helped Texasgulf fight a $5.7 million fine. The State Division of Environmental Management cited Texasgulf for air pollution violations at its Aurora fertilizer complex in 1986. The company appealed, and the case was scheduled to be argued before an administrative law judge in January 1989.

A "Mine Reclamation and Mining and Mineral Resources" workshop, funded by a $10,000 grant from the Mathematics and Science Education Network, was held for teachers at Appalachian State University in Boone. The new $12 million Natural Resources Research Center at North Carolina State University in Raleigh was to have a 62-foot long, $82,000 geologic map of the State built into the front plaza. The map was to contain 14 different rock types depicting the major geologic belts underlying the State.

The North Carolina Geological Survey (NCGS), a section of the Division of Land Resources, completed several projects during 1988. Among these were two geologic maps and reports concerning an area the U.S. Department of Energy designated as potentially suitable for storage of high-level nuclear waste. A supplement to the report (published separately) documented the nonsuitability of the site for long-term storage of high-level radioactive wastes.

Other publications released during the year included Open-file Report 88-1 describing the NCGS repository of core, cuttings, and well logs and Open-file Report 88-2(a-f) consisting of a series of data base maps showing core hole locations in the Coastal Plain and the Deep River Triassic basin.

North Carolina was selected as the next host state for a disposal facility for the Southeast Interstate Low-Level Radioactive Waste Management Compact. The NCGS continued to play a significant support role to both the newly created State agency (Authority) charged with establishing the facility and to the State agency responsible for licensing and regulatory oversight. The NCGS staff was to review relevant sections of the site characterization plan and license application. The NCGS was to provide (1) long-term storage and curatorial services for geological and geotechnical samples acquired in site studies and (2) geological assistance to local government review committees and/or their contractors.

The NCGS was a lead agency in the State's feasibility study and proposal for the Superconducting Super Collider. The NCGS staff continued work on the project after the North Carolina site was placed on the "Best Qualified List" in January 1988.

Geologic framework studies of the Pamlico-Albemarle Sound area were continued under the American Association of State Geologists and U.S. Minerals Management Service cooperative program. Ongoing investigations included biostratigraphic and geophysical research on several deep oil test wells and seismic lines contributed by private industry. The program's direction was to change in 1989, when an assessment of hard minerals on the Continental Shelf was scheduled to begin.

The Land Quality Section of the Division of Land Resources administered the State Mining Act. During the year, the section issued permits for 80 new mines. Of the new mines, 59 were sand and gravel operations, 9 were clay and shale, 10 were crushed stone, 1 was gold, and 1 was dimension stone. Data for total acres affected by mining in North Carolina were not available for 1988. At the end of 1987, approximately 24,420 acres were affected. Approximately 500 acres of mined land was reclaimed during the year. Permits were issued for a total of 2,130 new acres during 1987, and 1,840 acres were affected by mining during the year.

The North Carolina Mining Commission's first annual reclamation awards were presented to the S. T. Wooten Company of Wilson and to Vulcan Materials Co. of Winston-Salem. Wooten was se-

lected for the best reclamation of a mining site under 10 acres in size, and Vulcan was selected for its reclamation of a site exceeding 10 acres. The winners were selected from nominations by State mine inspectors. Mines were judged on the degree of difficulty of reclamation, innovative land-use planning and groundcover, long- and short-term stability of the site, and compliance with the North Carolina Mining Act over the past 2 years.

The North Carolina Mineral Laboratory in Asheville, part of North Carolina State University, continued projects on andalusite, glass sand, gold, heavy minerals, iron ore, kaolin (calcined), olivine, quartz, silicon carbide, spodumene, talc, tripoli, vermiculite, wollastonite, and zinc. Several projects focused on foreign ores.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

North Carolina's $529 million mineral production in 1988 consisted entirely of industrial minerals, representing an increase in value of $52.5 million over production values reported in 1987.

Clays.—North Carolina's clay industry, which included 20 companies operating 35 mines in 21 counties, mined 3.2 million tons of clay-phyllite valued at $16 million. Common clay-phyllite was mined by 18 companies at 33 mines in 19 of the State's 100 counties. Two companies recovered kaolin during mica beneficiation at operations in Avery and Cleveland Counties.

More than 90% of the common clay-phyllite, which is used in the manufacture of brick, was mined from a 13-county area in the central part of the State. The area is underlain by residual clays developed from weathering of strata of the Carolina slate belt. Lesser amounts of clay-phyllite were produced from weathered Triassic shales in Lee and Moore Counties in central North Carolina and in Halifax, Harnett, Henderson, and Sampson Counties.

Historically, North Carolina has been the Nation's leading State in the manufacture of brick; the State held this position again in 1988.

Summitville Tiles Inc., an Ohio-based manufacturing firm of commercial and residential tile, broke ground in August for a new, 160,000-square-foot plant in western North Carolina near Glen Alpine, Burke County. The plant, scheduled to be in operation by late 1989, was designed to produce 21,000 square feet of glazed tile daily.

The facility is to contain two 1,400-ton presses and a continuous roller-hearth kiln designed to produce tiles in less than 1 hour at temperatures in excess of 2,000 °C. The plant is to employ 50 workers initially.[3]

In November, Mannington Ceramic Tile began production of monocottura tile in the new expansion of its Mt. Gilead plant. Monocottura, a single-fired glazed ceramic tile, is used primarily for indoor flooring in both residential and commercial applications. The 117,000-square-foot monocottura plant expansion contains one kiln with an annual capacity of 12 million square feet of tile. The expansion, including state-of-the-art line equipment, cost $10 million. Initially the Mt. Gilead plant produced only red-body quarry tile.[4]

Feldspar.—For the past four decades, North Carolina's feldspar producers have led the Nation in output of the anhydrous aluminum silicate used as a flux and alumina source in glass and ceramics manufacture. It is also used as an abrasive and as a component of scouring powders and soaps. In 1988, the State's feldspar producers accounted for more than 60% of the United States total, although output decreased almost 5,000 short tons below the level reported by industry in 1987. An increase in both residential and commercial housing starts and the associated demand for the whiteware, tile, and glass fiber insulation accounted for an upswing in sales.

The State's feldspar industry consisted of three companies that mined feldspar-bearing rock, two companies that recovered a feldspar-silica concentrate as a coproduct of lithium and mica beneficiation, and one company that recovered potash feldspar from a weathered deposit. The three primary feldspar producers were located in the Spruce Pine mining district in the western part of the State. The three, The Feldspar Corp., Indusmin Inc., and Unimin Corp., mined alaskite containing approximately 65% feldspar. They used three-stage acid-circuit flotation, a process developed by the U.S. Bureau of Mines, to recover a feldspar concentrate. Byproduct mica and silica were recovered during the first and third flotation steps; the second step removed iron-bearing minerals. The flotation cake was dried, ground, and bagged for shipping.

Two companies in the Kings Mountain-Cherryville area, Cyprus Foote Mineral Co. and Lithium Corp. of America, recovered a feldspar-silica concentrate during mica and lithium beneficiation. KMC Minerals Inc. recovered potash, feldspar, mica, silica, sand, and kaolin.

Gem Stones.—North Carolina ranked first in the eastern United States in the number of mines and businesses in gem stone and mineral specimen sales. Several dozen small commerical mining operations in the western and southwestern part of the State provided places for hobbyists to collect a variety of precious and semiprecious specimens. The largest concentration of hobbyist operations was in the Cowee Valley north of Franklin. At a typical operation, gem-bearing materials were mined with a bulldozer or front-end loader. The mined material was split into 2.5 gallon buckets and sold to the hobbyist, who screened the material to remove soil at an on-site flume.

After screening, any gem stones present were handpicked from the gravel.

The principal counties where gem-collecting occurred and gem stones were found were Alexander County (emeralds and hiddenite), Macon County (rubies, sapphires, and rhodolite garnets), and Mitchell County (emeralds and aquamarine). During the year, a 1,025-carat blue star sapphire, described as "the world's largest," was discovered by two gem hunters at the old Presley mica mine near Canton.

Lithium.—North Carolina was one of two States with lithium production in 1988. Lithium sales ranked third in the State for the year in terms of mineral value. Lithium Corp. of America (Lithco) operated an open pit mine in a spodumene pegmatite, a beneficiation plant, and a lithium carbonate and lithium metal facility near Cherryville in the southern part of the State. Foote Mineral Co. maintained a spodumene pegmatite mine and beneficiation plant and a lithium carbonate plant at Kings Mountain. The Lithco facility used flotation to produce a lithium concentrate from the spodumene ore. A feldspar-silica concentrate was recovered as a coproduct of the flotation and shipped to South Carolina for processing. The lithium concentrate was processed into lithium carbonate, lithium metal, and other lithium compounds.

During the year, Cyprus Minerals Co. purchased the Foote lithium operation at Kings Mountain. The new company, Cyprus Foote Mineral Co., produced a limited amount of lithium concentrate during 1988.

Mica.—The State's mica industry produced 61% of the total tonnage of mica mined in the United States in 1988; 66% of the Nation's mica value was derived from sales of North Carolina mica. The State's primary mica industry, consisting of four companies in the Spruce Pine-Kings Mountain area, produced 87,000 short tons, valued at $4.5 million. Production decreased 13,000 short tons over the year despite the completion of the J. M. Huber mine and plant in the Kings Mountain area.

Both wet- and dry-ground mica products were produced and were used in the manufacture of cosmetics, paints, and plastic (wet ground) and in joint cement, wallboard, and oil-well drilling mud (dry ground).

Several companies processed mica purchased from other sources: two firms fabricated mica shapes from imported sheet mica, and one firm produced sericite as a coproduct of pyrophyllite mining.

Olivine.—In 1984, four companies produced olivine in western North Carolina, and the State led the Nation in output. At yearend, the industry consisted of just one company operating one mine. The decline was due primarily to competition from foreign imports. North Caroline olivine, shipped by rail, could not compete with less expensive, foreign-mined olivine shipped by water.

Applied Industrial Minerals Corp. (AIMCOR) closed its Addie Mine near Sylva in 1988, while continuing to mine at the Day Book Mine near Green Mountain. The company continued to ship olivine for blast furnace use from stockpiled material at the Addie Mine. The Day Book operation produced olivine that was milled to granular-size for foundry sand applications.

During the year AIMCOR entered into a sales and processing agreement with Franzefoss Brak A/S of Norway to market Norwegian olivine in North America.

Phosphate Rock.—North Carolina continued to maintain its second-place national ranking in phosphate rock production. Florida was the leading phosphate rock-producing State. Texasgulf Inc. operated a surface mine, beneficiation, and acid-manufacturing complex at Lee Creek in Beaufort County. During the year, Texasgulf began operating bucket-wheel excavators for stripping the upper 35 feet of overburden. The excavators were obtained when Texasgulf purchased North Carolina Phosphate Corp. in the mid-1980's; the excavators replaced dredges that had previously removed the upper section of overburden.

The company used draglines to remove the lower 60 feet of overburden and to mine the phosphate rock. The ore was slurried to a beneficiation plant where sand, clay, and other impurities were removed. The rock was then used in the manufacture of phosphoric acid. During the year, work began on a new 120,000-short-ton-per-year, high-purity phosphoric acid plant. Output was to be used in the manufacture of soft drinks, food products, and industrial detergents. The plant was a joint venture between Texasgulf, Albright and Wilson, and the Olin Corp. Texasgulf was constructing and will operate the plant using Albright and Wilson technology. Olin was to use much of the acid at its Joliet, IL, plant. Albright and Wilson Americas will market additional quantities. Both low- and high-sodium acid grades were to be produced; plant completion was scheduled for 1989.[5]

The company began work on plans for a $20 million wastewater recycling plant to be completed in the 1990's. Wastewater from the manufacturing complex was to be recycled. Fresh water recovered during mine dewatering would continue to be discharged into the Pamlico River.

Toward the end of 1988, Texasgulf sought permission to mine 234 acres of wetland. The acreage lies south of the Pamlico River within 4,300 acres that the company hopes to mine between 1990 and 2010. Local environmental groups opposed the issuing of a wetlands mining permit, and the controversy had not been resolved by the end of the year.

Pyrophyllite.—In 1988, North Carolina ranked first among three North

American producers in the output of pyrophyllite, a hydrous aluminous silicate used in the ceramics and refractories markets. Pyrophyllite is also used by the filler, insecticide, and paint industries. California and Newfoundland, Canada, were the other two producers.

Three companies comprised the State's pyrophyllite industry during 1988. The largest was the R. T. Vanderbilt Co. Inc. subsidiary, Standard Minerals Co. Inc., which operated two mines, at Glendon and Robbins in Moore County. Ripper-equipped bulldozers were used to mine the ore at both mines. Crude ore was transported to a plant at Robbins, where it was dried, screened, and ground, using both ball and pebble mills.

A second Moore County producer, Glendon Pyrophyllite Co., mined a steeply dipping ore body from the surface to produce feed for a plant at Glendon. The ore was ground in a Raymond mill to produce a product marketed primarily as a joint-compound filler. Minor quantities were sold to the ceramics and refractories industries.

The third company, Piedmont Minerals Division of Resio Products Inc., operated the Hillsborough surface mine, developed in an andalusite-pyrophyllite ore body in Orange County. Ore was trucked to a plant adjacent to the ore body, where it was crushed, screened, and upgraded by heavy media separation. Concentrate from the plant was trucked to Greensboro for refractories manufacture and for the ceramics market. Sericite and quartzite recovered during mining and beneficiation were marketed as a brick-clay additive and as an aggregate.

Sand and Gravel.—In 1988, North Carolina sand and gravel sales of 12.3 million short tons were valued at $54.4 million. Sand and gravel value ranked fourth among the extractive minerals produced in the State during 1988.

Construction.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

North Carolina construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents these statistics for the three North Carolina districts. District 3, which includes the eastern half of the State, accounted for almost 50% of the total value. The Anson-Richmond area in District 2 has the largest sand and gravel reserves.

Industrial.—North Carolina ranked ninth among the 37 industrial sand and gravel-producing States in 1988. Production was reported to the U.S. Bureau of Mines by six companies operating six mines in four counties. The contiguous, two-county Anson-Richmond area accounted for approximately 90% of the State's total tonnage. Mines in Cleveland and Harnett Counties supplied the remainder. Additional tonnages of industrial sand not included in table 1 were recovered as a coproduct with feldspar beneficiation in Avery, Mitchell, and Yancey Counties and with lithium beneficiation in Cleveland County. The majority of industrial sand sales was to the flat glass and glass container industries. Other sales were to the ferrosilicon, filtration, sandblasting, and traction industries.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

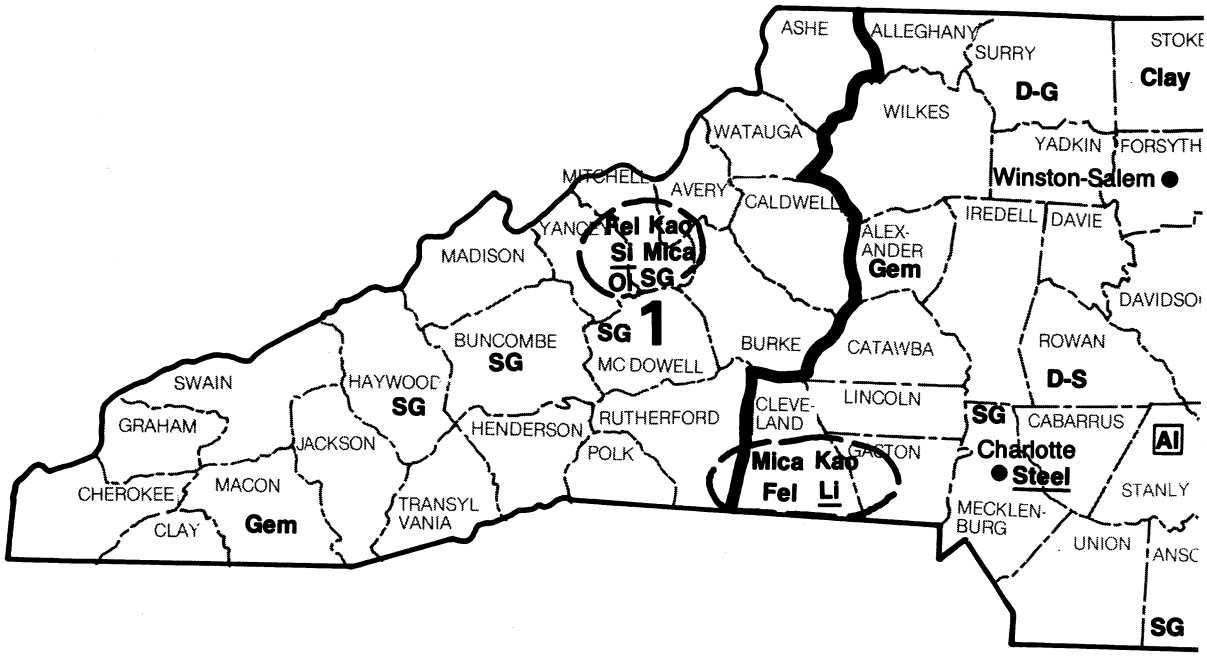
Crushed.—In 1987, the last year with a 12-month industry report, 31 companies operated 78 quarries in 53 counties. The top five companies—Martin Marietta, Vulcan Materials Co.,

TABLE 2

NORTH CAROLINA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	3,864	$15,922	$4.12
Plaster and gunite sands	541	1,764	3.26
Concrete products (blocks, bricks, pipe, decorative, etc.)	71	367	5.17
Asphaltic concrete aggregates and other bituminous mixtures	1,130	4,139	3.66
Road base and coverings[1]	515	1,748	3.39
Fill	641	973	1.52
Snow and ice control	17	45	2.65
Other[2]	172	433	2.52
Unspecified:[3]			
Actual	2,650	9,028	3.41
Estimated	1,474	4,041	2.74
Total[4] or average	**11,076**	**38,459**	**3.47**

[1] Includes road and other stabilization (lime).
[2] Includes roofing granules.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data may not add to totals shown because of independent rounding.



NORTH

L

State boundary

County boundary

Capital

City

Crushed stone/sand & gravel districts

MINER

Al Alum

Clay Clay

Co Cob

CS Crus

D-G Dim

D-S Dime

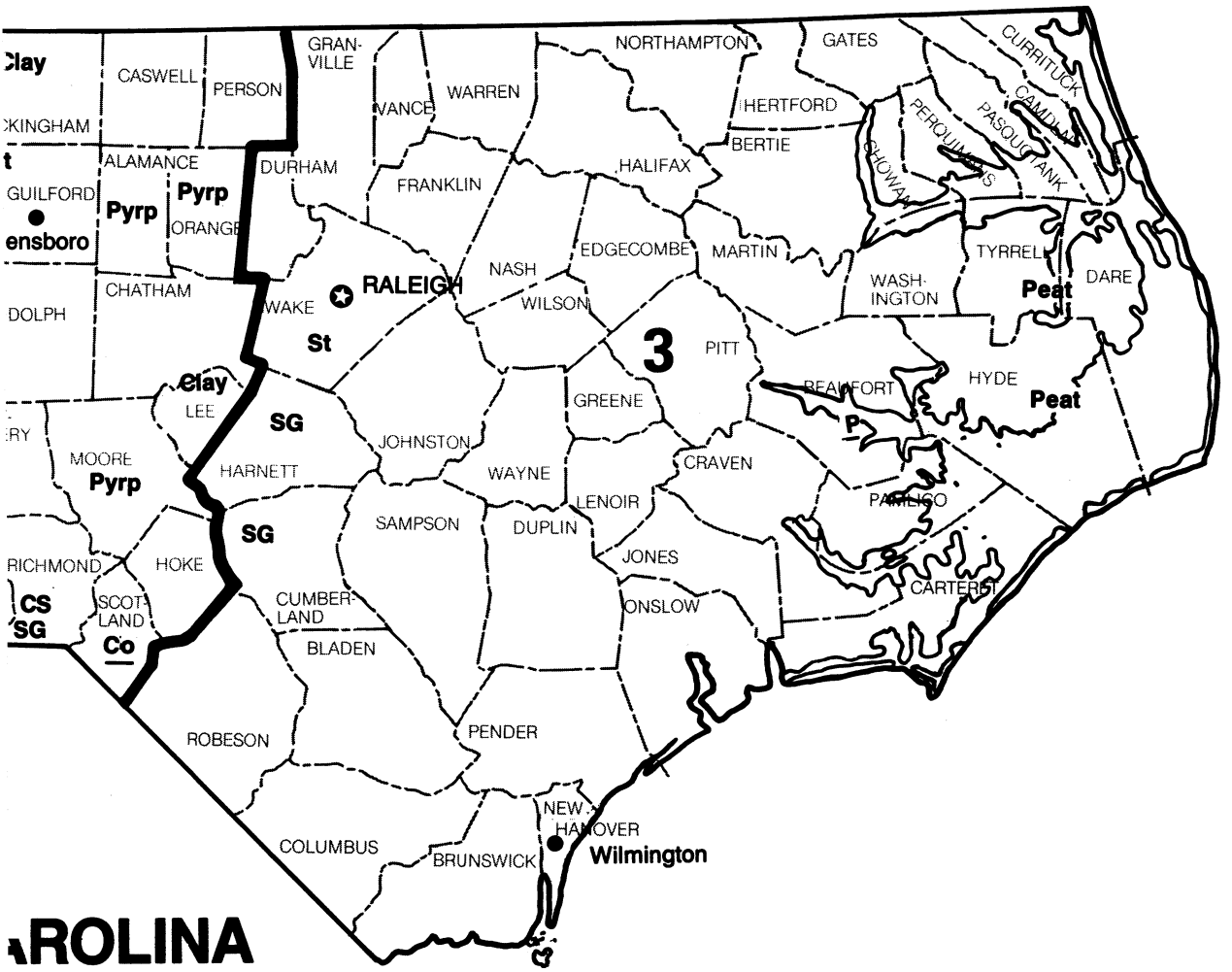
Fel Feld

Gem Gem

Kao Kaoli

Li Lithi

Principal Mineral-Producing Localities



ROLINA

D

YMBOLS

lant

ne

ranite

andstone

and plant

Mica	**Mica**
Ol	**Olivine**
P	**Phosphate rock**
Peat	**Peat**
Pyrp	**Pyrophyllite**
SG	**Sand and Gravel**
Sl	**Silica plant**
St	**Stone**
Steel	**Iron and Steel plant**
	Concentration of mineral operations

TABLE 3

NORTH CAROLINA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	121	473	2,180	10,760	2,176	6,820
Asphaltic concrete aggregates and other bituminous mixtures	25	97	454	2,148	651	1,893
Road base and coverings	321	1,476	—	—	194	272
Fill	W	W	38	183	W	W
Snow and ice control	W	W	—	—	W	W
Railroad ballast	—	—	—	—	—	—
Other miscellaneous[2]	20	60	60	84	712	1,125
Other unspecified[3]	1,053	4,273	995	1,879	2,076	6,917
Total	**1,540**	**6,379**	**3,727**	**[4]15,053**	**5,809**	**17,027**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for plaster and gunite sands.
[2] Includes sand and gravel for roofing granules.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data do not add to total shown because of independent rounding.

Koppers Co., Wake Stone Co., and Ashland Oil Inc.—operated 52 quarries and produced 86% of the tonnage. Production exceeded 1 million tons in 12 counties; the top 5 were Wake, Mecklenburg, Guilford, Forsyth, and Buncombe, which accounted for almost 40% of the State's total.

Dimension.—North Carolina ranked 13th out of 35 States in dimension stone production. Granite was quarried by five companies and sandstone, argillite, and marble were quarried by one company each. The Mt. Airy Granite Co. operated the world's largest granite quarry at Mt. Airy, 35 miles northwest of Winston-Salem. Flagstone was produced by several small companies in Mitchell, McDowell, and Cherokee Counties.

Other Industrial Minerals.—Several industrial minerals mined in other countries or States or produced as a byproduct of in-State minerals manufacturing were marketed or processed into a higher value product. Their tonnage and value are included in the data for the country or State in which the commodity was mined and are not included in table 1 for North Carolina.

Two boron-rich minerals mined in Turkey, colemanite and ulexite, were imported by PPG Industries Inc. for fiberglass manufacture. The boron minerals were shipped through the Port of Charleston and then by rail to a custom grinding mill owned by Industrial Minerals Inc. at Kings Creek, SC. The ground mineral was shipped to North Carolina fiberglass plants. PPG also imported boric acid from California for its fiberglass manufacturing facilities at Lexington and Shelby.

Atlantic Cement Co. operated a 675-short-ton cement distribution terminal in Durham. The terminal served markets in central and eastern North Carolina and in southern Virginia. Atlantic Cement is owned by Blue Circle.

Synthetic graphite products were manufactured at plants in Morganton and Dunn. The Morganton plant in Burke County was operated by Great Lakes Carbon Corp., a subsidiary of Horsehead Industries. The Burke County facility produced anodes, electrodes, unmachined shapes, and bulk graphite materials. Petroleum coke and pitch, obtained from oil refining, were ground, sized, heated, and extruded. The extruded materials were fired and heated in an electric resistance oven to produce a synthetic graphite product. Morganite Inc. in Dunn manufactured carbon brushed bearings and seals.

Gypsum was imported from Nova Scotia by National Gypsum Co. for wallboard manufacture at a plant in Wilmington. Texasgulf produced byproduct gypsum during acid manufacture at its Beaufort County operation at Lee Creek. A limited tonnage was sold to area farmers. Much of the remainder was blended with clay and used in mine backfilling.

Slag, a byproduct of steelmaking at Florida Steel Corp.'s plant in Charlotte, was sold to a local firm to be marketed as an aggregate.

Metals

North Carolina's last metal mine, the Tungsten Queen in Vance County, closed in 1971. In 1988, one company recovered a minor amount of gold as a coproduct of sand beneficiation. However, a variety of foreign and domestic ores, intermediate metal substances, and scrap were processed into a higher value finished product.

Aluminum.—The Aluminum Company of America operated a 115,000-metric-ton-per-year smelter at Badin; the smelter operated at full capacity during 1988. Power for the smelter was supplied by several hydroelectric generators.

Cobalt.—Cobalt metal was imported from Zaire and processed into extra-fine cobalt powder at a plant near Laurinburg. Carolmet Inc., a subsidiary of Metallurgie Hoboken-Overpelt (SA) of Belgium, operated the plant. Plant feed was purchased from La Generale des Carrieres et des Mines (Gecamines) of Zaire. The Laurinburg plant was one of two extra-fine cobalt powder facilities in the United States; output was used in the manufacture of tungsten carbide. The plant also has the capacity to produce cobalt chloride and cobalt nitrate.

Gold.—Imperial Mining Co. in McDowell County recovered a limited amount of gold as a coproduct of sand beneficiation. During the year, the company began work on a new plant, which, in addition to sand, would recover gold and rare earths.

Steel.—Florida Steel Co. operated a minimill at Charlotte; the mill included two electric furnaces and two 2-stand continuous casters. Florida Steel and Nucor Corp., a South Carolina steel producer, agreed to share information on technology designed to apply continuous steelmaking to electric arc furnaces. A savings of $10 to $15 per ton of steel could result from a successful continuous steelmaking operation.

Nucor's Darlington, SC, mill was retrofitted with a prototype of the continuous steelmaking process, but it was deactivated after a year because of problems, most of which were traced to the retrofit.

During 1988, Florida Steel constructed a "greenfields" facility at Charlotte; the facility was designed to overcome the retrofit problem experienced by Nucor.[6] A new 70-ton-capacity electric arc furnace and a ladle refining station were to be part of the new construction. A 9-year-old furnace was to be sold or dismantled and another furnace was to remain in operation.[7]

Other Metals.—A chromium chemical plant, operated by Occidental Chemical Corp. at Castle Hayne, was one of just two chromium chemical plants in the United States. A powdered-copper plant in Durham was operated by SCM Co., Glidden Metals Division. The 5,000-pound-annual-capacity facility used copper scrap for feed and produced powder used principally in the manufacture of aircraft brakes and transmission parts. Lithium metal was produced by Lithium Corp. of America at Cherryville. The company used molten salt electrolysis to produce lithium metal ingots, wire, shot, and dispersions. Silver emulsions were recovered from waste photographic film at a plant in Arden. Silver halide emulsion was separated from unprocessed film waste obtained from the company's photo systems and electronics products departments in Brevard. The diluted emulsion was returned to Brevard, where it was processed into powder and sold to silver recyclers. Titanium alloys and nickel-base superalloys were produced at a plant in Monroe by Teledyne Allvac, a subsidiary of Teledyne Inc. Titanium alloys were used by aerospace, chemical, and biomedical industries, and nickel superalloys were used in parts fabricated for jet and gas turbine engines, in chemical processing plants, and for sour gas deep-drilling applications. The company announced plans in May to install a new plasma cold-hearth melting system that was to boost its titanium melt capacity by 60%.[8] In July, the company fired up two new vacuum-arc remelting furnaces, enhancing the facility's melt capacity by 25%. The units could produce 24- to 36-inch nickel- and iron-base alloy ingots up to 136 inches long and weighing as much as 40,000 pounds.[9]

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[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL.

[2] Geologist, North Carolina Geological Survey Section, Raleigh, NC.

[3] The Asheville Citizen. New Plant to Help in Diversification. Aug. 30, 1988.

[4] Montgomery Herald. Mannington Officially Opens New Mid-State Tile Facility. Dec. 3, 1988.

[5] TG Times. New Plant Brings Flexibility. Dec. 1988, p. 7.

[6] American Metals Market. Two Minimill Rivals Team Up to Give Consteel Another Try. Sept. 9, 1988.

[7] ———. Florida Steel Boosting North Carolina Minicapacity 30%. Feb. 22, 1988.

[8] ———. Teledyne to Up Titanium Capacity. June 15, 1988.

[9] ———. Teledyne Allvac Fires Two Furnaces. July 20, 1988.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum, smelter:			
Aluminum Company of America	1501 Alcoa Bldg. Pittsburgh, PA 15210	Plant	Stanly.
Clay:			
Hammill Construction Co.	Route 2, Box 33H Gold Hill, NC 28071	Open pit mines and plant	Cabarrus and Rowan.
Pine Hall Brick and Pipe Co.	Box 11044 Winston-Salem, NC 27105	do.	Rockingham and Stokes.
Virginia Solite Corp.	Box 27211 Richmond, VA 23261	do.	Rockingham and Stanly.
Feldspar:			
The Feldspar Corp.[1]	Box 99 Spruce Pine, NC 28777	do.	Mitchell.
Indusmin Inc.[1]	Box 309 Spruce Pine, NC 28777	do.	Do.
International Minerals and Chemical Corp.[1] (purchased by Unimin Corp. in 1986)	23157 Sanders Rd. Northbrook, IL 60062	do.	Do.
Lithium:			
Foote Mineral Co.[2]	Box 792 Kings Mountain, NC 28086	Open pit mine and plant	Cleveland.
Lithium Corp. of America Inc.[1 2]	449 North Cox Rd. Gastonia, NC 28052	do.	Gaston.
Mica:			
Deneen Mica Co.	Box 28 Micaville, NC 28755	Open pit mines	Yancey.
Harris Mining Co.[3] (purchased by Unimin Corp. in 1985)	Box 628 Spruce Pine, NC 28777	do.	Avery.
Kings Mountain Mica Co. Inc.[2] (name changed to KMG Minerals Inc. in 1986)	Box 729 King Mountain, NC 28086	do.	Cleveland.
Olivine:			
International Minerals and Chemical Corp. (purchased by AIMCOR in 1986)	Box 672 Spruce Pine, NC 28777	do.	Jackson and Yancey.
Perlite (expanded):			
Carolina Perlite Co. Inc.	Box 158 Gold Hill, NC 28071	Plant	Rowan.
Phosphate rock:			
Texasgulf Inc.[4]	Box 48 Aurora, NC 27806	Open pit mine and plant	Beaufort.
Pyrophyllite:			
Glendon Pyrophyllite Inc.	Box 306 Carthage, NC 28327	Open pit mines and plant	Alamance and Moore.
Piedmont Minerals Co.[5]	Box 7247 Greensboro, NC 27407	Open pit mine and plant	Orange.
Standard Minerals Co. Inc.	Box 278 Robbins, NC 27325	do.	Moore.
Sand and gravel (construction):			
Becker Sand and Gravel Co.	Box 698 Lillington, NC 27546	Pits	Harnett and Cumberland.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Industrial Unimin Corp.	258 Elm St. New Canaan, CT 06840	Open pit mine and plant	Richmond.
W. R. Bonsal Co.	Box 38 Lilesville, NC 28091	Pits	Anson.
B. V. Hedrick Gravel and Sand Co.[1]	Box 8 Lilesville, NC 28091	do.	Anson, Buncombe, McDowell.
Stone:			
Martin Marietta Corp.	Box 30013 Raleigh, NC 27622	do.	Various.
Nello L. Teer Co.	Box 1131 Durham, NC 27702	do.	Do.
Vulcan Materials Co., Mideast Div.	Box 7497 Winston-Salem, NC 27109	do.	Do.
Talc:			
Warner Corp.	Box 672 Murphy, NC 28906	Underground mine	Cherokee.
Vermiculite (exfoliated):			
W. R. Grace and Co.	62 Whittemore Ave. Cambridge, MA 02140	Plant	Guilford.

[1] Also mica.
[2] Also feldspar.
[3] Also clays.
[4] Also byproduct gypsum.
[5] Also sericite.

THE MINERAL INDUSTRY OF NORTH DAKOTA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the North Dakota Geological Survey for collecting information on all nonfuel minerals.

By Leon E. Esparza[1]

The value of nonfuel mineral production in North Dakota was $18.8 million, a decrease of about 29% compared with 1987 figures. The State ranked 48th nationally in nonfuel mineral production, providing less than 1% of the U.S. total. Construction sand and gravel contributed the greatest amount to the State's nonfuel mineral value, accounting for 43% of the total; the second largest contributor, lime, accounted for 38%. According to the North Dakota Lignite Council, 28.2 million short tons of lignite coal was produced in 1988. This record high production was attributed to increased demand for electricity to run air conditioners during the summer's heat and drought.

Most of the State's nonfuel mineral production was used in construction. According to the U.S. Department of Commerce, 1,815 residential units were authorized in 1988, a decrease of about 8% from the number issued in 1987. On the other hand, the value of nonresidential construction in 1988 was $93.4 million, an increase of slightly more than 5% over that of 1987. The value of State road contract awards also increased about 4%, rising to $98 million[2] during the period. Although nonfuel mining employment fell 12.5% to 350 jobs between 1987 and 1988, total mining employment posted an increase of slightly more than 1%.

LEGISLATION AND GOVERNMENT PROGRAMS

During the year, the North Dakota Public Service Commission revised the State's surface mining and reclamation regulations to conform to Federal regulations. At yearend, the Federal Office of Surface Mining Reclamation and Enforcement was accepting public comment and completing its review of these regulations. Most of the changes will not have a significant impact on mining operations; the regulations should be implemented in 1990. The Commission reviewed two other mining regulations during 1988. The first would simplify release of small land areas from bonding requirements, and the second would change guidelines for revegetation of mined areas.

The University of North Dakota Energy and Mineral Research Center (EMRC) at Grand Forks conducts basic research on the State's mineral and energy resources and innovative technologies for using these resources and their wastes. The center is funded through Federal Government and private sector contracts, grants, or other arrangements; it does not directly receive State funding. The EMRC is composed of three institutes—the Mining and Mineral Resources Research Institute (MMRRI), the Fuels and Process Chemistry Research Institute, and the Combustion and Environmental Systems Research Institute. In general, the three institutes work together to address such topics as mined land reclamation, mine waste disposal, ground water studies, coal gasification, and other fossil fuel related topics.

The MMRRI received a $293,280 grant from the U.S. Bureau of Mines to be shared with the North Dakota State University to expand research on mined land reclamation. Research began on ground water chemistry and vegetation around mined areas to determine ways to stabilize abandoned mines, in part through use of coal combustion fly ash.

Funding from other sources supported EMRC research on waste disposal of fly ash, solid waste disposal requirements, and the use of fly ash-soil mixtures to construct liners for waste disposal sites. Studies were also conducted to find uses for fly ash in various concrete mixes and structures

TABLE 1

NONFUEL MINERAL PRODUCTION IN NORTH DAKOTA[1]

Mineral		1986 Quantity	1986 Value (thousands)	1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)
Clays	short tons	W	W	50,101	$100	84,787	$147
Gem stones		NA	$2	NA	2	NA	2
Lime	thousand short tons	74	7,359	127	11,912	108	7,094
Sand and gravel (construction)	do.	5,135	10,741	e4,900	e10,200	3,772	8,079
Combined value of peat, salt, sand and gravel (industrial, 1986–87), stone (crushed miscellaneous), and value indicated by symbol W		XX	2,700	XX	4,097	XX	3,485
Total		**XX**	**20,802**	**XX**	**26,311**	**XX**	**18,807**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

NORTH

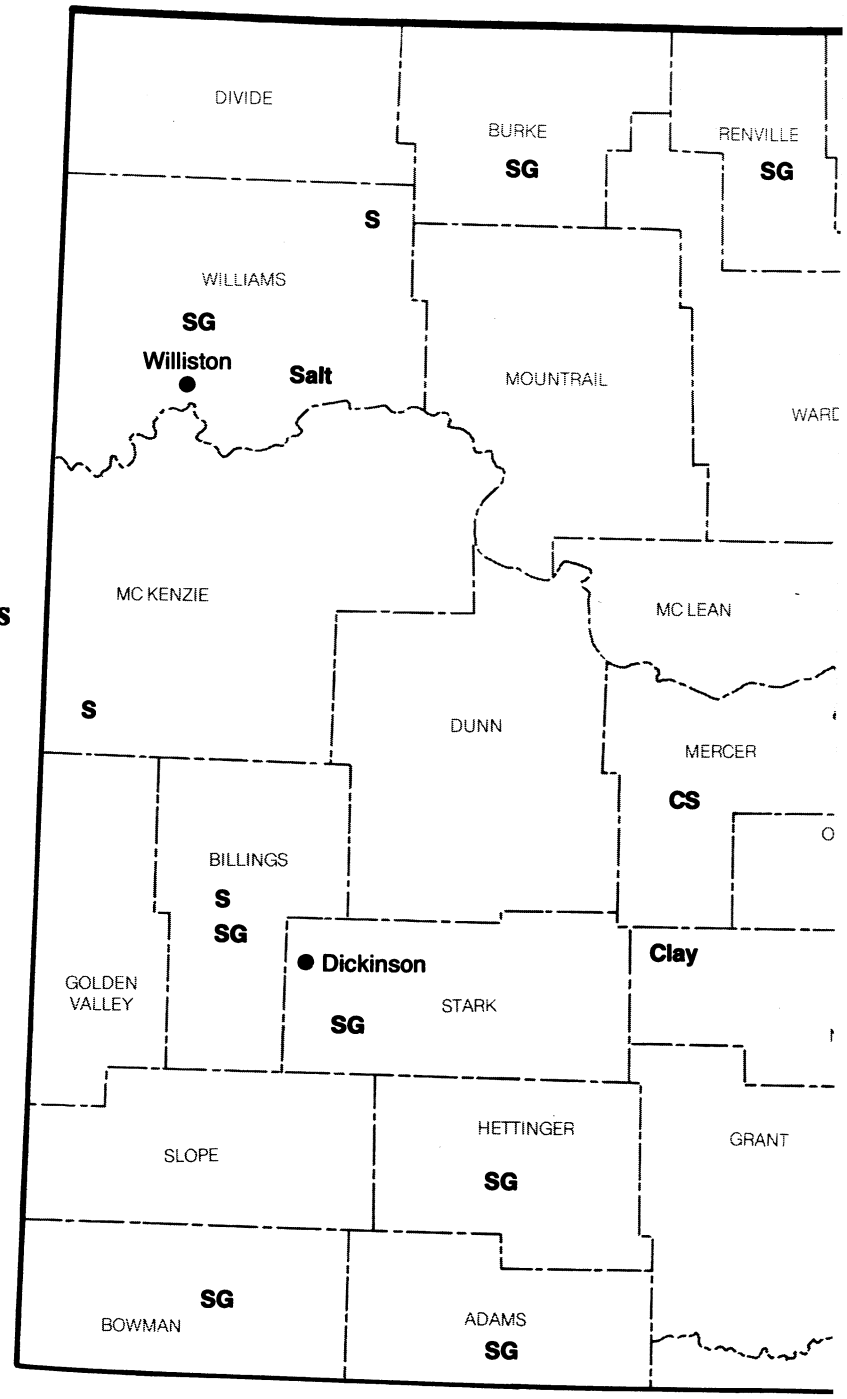
LEGEND

State boundary
County boundary
Capital
City

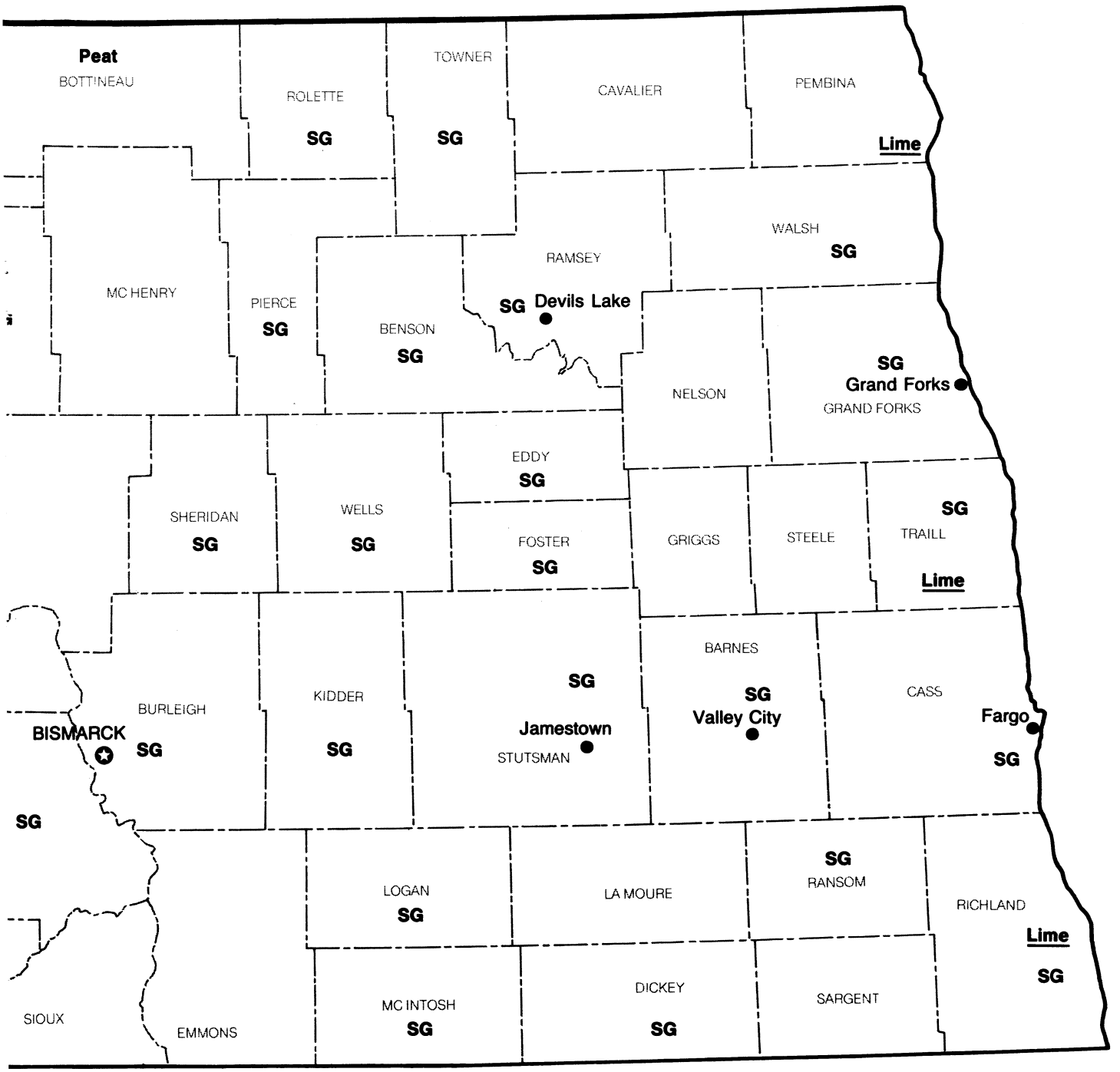
MINERAL SYMBOLS

Clay	Clay
CS	Crushed Stone
Lime	Lime plant
Peat	Peat
S	Sulfur
Salt	Salt
SG	Sand and Gravel

Principal Mineral-Producing Localities



AKOTA


Peat
BOTTINEAU
ROLETTE
SG
TOWNER
SG
CAVALIER
PEMBINA
Lime
WALSH
SG
MC HENRY
PIERCE
SG
RAMSEY
SG Devils Lake
BENSON
SG
NELSON
SG
Grand Forks
GRAND FORKS
EDDY
SG
SHERIDAN
SG
WELLS
SG
FOSTER
SG
GRIGGS
STEELE
SG
TRAILL
Lime
BARNES
SG
Valley City
CASS
Fargo
SG
BURLEIGH
BISMARCK
SG
KIDDER
SG
SG
Jamestown
STUTSMAN
SG
LOGAN
SG
LA MOURE
SG
RANSOM
RICHLAND
Lime
SG
DICKEY
SG
SARGENT
MC INTOSH
SG
SIOUX
EMMONS

such as paving and drain culverts. Field data were collected on leachate generation and movement in correlation with laboratory leaching studies to determine the potential negative impacts on ground water.

Another EMRC study focused on producing mineral wool for insulation from the molten slag stream from the boiler at the Coyote power station at Beulah. Mineral wool, made by blowing compressed air onto the slag flowing from a tank below the boiler, was tested in simulated home modules as a replacement for fiberglass insulation. Coal-fired powerplants in North Dakota produce 2.2 million short tons of residuals each year, and disposal costs range from $5 to $15 per ton. Discovery of a beneficial use of the residuals would increase the State's resource base and address potential environmental impacts of waste disposal.

Publications issued in 1988 by the North Dakota Geological Survey included new State geology maps of Precambrian structure and generalized bedrock and a map identifying the geology along State highways.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Sand and Gravel.—Sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter thus contains actual data for 1986 and 1988 and estimates for 1987.

Construction sand and gravel, the State's leading nonfuel mineral commodity, decreased in production and value about 23% and 21%, respectively, between 1987 and 1988. Production by 57 producers from 139 pits was reported to the Bureau. No sales of industrial sand were reported for 1988.

TABLE 2

NORTH DAKOTA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	63	$313	$4.97
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	3.50
Asphaltic concrete aggregates and other bituminous mixtures	297	862	2.90
Road base and coverings	2,022	3,732	1.85
Fill	60	77	1.28
Snow and ice control	8	11	1.38
Railroad ballast	W	W	1.91
Other	49	97	1.98
Unspecified: [1]			
Actual	451	773	1.71
Estimated	823	2,214	2.69
Total or average	**[2]3,772**	**8,079**	**2.14**

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[2] Data do not add to total shown because of independent rounding.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987. Crushed stone production and value were estimated to have decreased about 37% and 49%, respectively, in 1988.

Other Industrial Minerals.—The production and value of clay, produced for brick manufacturing in Morton County by Hebron Brick Co., increased over that reported in 1987. The production and value of lime decreased 15% and 40%, respectively, in 1988. Lime was produced by American Crystal Sugar Co. in Pembina and Traill Counties and Minn-Dak Farmers Co-op in Richland County; it was used entirely in sugar beet refining. Peat, produced by Peat Products Co. in Bottineau County from reed-sedge bogs, showed a 57% increase in sales, mostly to local markets, for 1988. Salt production and value decreased 19% and 13%, respectively, in 1988. In April, International Salt Co. purchased Diamond Crystal Salt Co., including its Williams County operations, for $65 million. In July, International Salt announced the shut down of its Williston area solution mining operations. International Salt Co. is a subsidiary of Akzo NV, a Dutch chemical corporation.

[1] State Mineral Officer, Bureau of Mines, Minneapolis, MN.

[2] Highway and Heavy Construction. Market Update: On the Road Again. June 1987, p. 36.

[3] ———. Highways: New State Revenue Cushions Falling Federal Aid. June 1988, p. 34.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Clays:			
Hebron Brick Co.	Box 5 Hebron, ND 58638	Pit and plant	Morton.
Lime:			
American Crystal Sugar Co.	Box 190 Drayton, ND 58225	Shaft kilns at beet sugar refineries.	Pembina and Traill.
Minn-Dak Farmers Co-op	Wahpeton, ND 58075	do.	Richland.
Peat:			
Peat Products Co.	821 4th St. Bismarck, ND 58501	Bog	Bottineau.
Salt:			
International Salt Co.	Clarks Summit, PA 18411	Solids and evaporated brines.	Williams.
Sand and gravel (construction):			
Bradshaw Gravel Supply	Box 1676 Grand Forks, ND 58206	Pits and plants	Grand Fork, Rolette, Walsh.
Lake Sand & Gravel Co.	Box 236 Lidgerwood, ND 58053	Pits	Richland.
Schriock Construction Inc.	3009 S. Broadway Minot, ND 58701	Pit and plant	Various.
Soper Bros. Construction Co.	Box 791 Devils Lake, ND 58301	Pits	Ramsey.
Susag Sand & Gravel Inc.	Box 23 Harvey, ND 58341	do.	Pierce, Wells, Williams.
Stone (crushed, 1987):			
Helm Bros. Inc.	Box 787 Mandan, ND 58554	Pit	Mercer.
The North American Coal Corp.	Box 299 Beulah, ND 58523	Pits	Do.
Sulfur (recovered):			
Chevron USA Inc.	Box 1589 Tulsa, OK 74101	Plant	Billings.
Koch Hydrocarbon Co.	Box 2256 Wichita, KS 67201	Plants	McKenzie and Williams.
Tioga Gas Plant Inc.	Box 2040 Tulsa, OK 74102	Plant	Williams.
Western Gas Processors Ltd.	10701 Melody Dr. Northglenn, CO 80234	do.	Billings.

THE MINERAL INDUSTRY OF OHIO

By L. J. Prosser, Jr.[1]

Nonfuel mineral production value in Ohio in 1988 was $737 million. Demand for industrial minerals in Ohio remained strong in 1988 despite a drop in value for the first time in 6 years. Lower unit prices, rather than decreased output, accounted for the $32 million drop in value of the State's nonfuel mineral production.

In 1988, lower unit prices were reported for lime, sand and gravel, and crushed stone, each of which declined by approximately 10%, compared with 1987 prices. The only significant decrease in production, which was for cement, resulted from a plant closing. Increased output was recorded for clays, lime, salt, and sand and gravel. Nationally, Ohio ranked 13th in the value of nonfuel mineral production.

TRENDS AND DEVELOPMENTS

During the 1980's, industrial minerals, in particular crushed stone and sand and gravel, replaced coal as the leading mineral commodities produced in Ohio. Historically, coal had been the dominant mineral, in terms of tonnage, produced in the State. Since 1985, yearly output of crushed stone has surpassed that of coal; beginning in 1986, sand and gravel production exceeded that of coal. For the past 4 years, crushed stone production has averaged 44.3 million short tons; sand and gravel, 38.1 million tons; and coal, 34 million tons. From 1980 through 1984, coal production averaged 37.5 million tons; crushed stone, 36.2 million tons; and sand and gravel, 30.6 million tons.

In Ohio, economic conditions since 1984 have benefited the nonfuel minerals industry. Low interest and inflation rates have resulted in strong and sustained demand, primarily by the construction industry, for industrial minerals.

In contrast, the coal industry in Ohio has faced increased competition from oil because of low international prices for that commodity. In addition, legislation to reduce sulfur dioxide emissions from coal-burning electric utility plants has been proposed by both the State and Federal Governments. The overall average sulfur content of Ohio coalbeds is about 3.5%; when burned, a typical Ohio coal produces 6.0 pounds of sulfur dioxide per million British thermal units of heat generated.[2] At utility plants installed between 1971 and 1979, sulfur dioxide emissions are limited to 1.2 pounds per million Btu. Emission limits are more stringent for those facilities built after 1979, as mandated in the National Ambient Air Quality Standard established under the Clean Air Act.

TABLE 1

NONFUEL MINERAL PRODUCTION IN OHIO[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	138	$11,540	139	$11,964	129	$11,140
Portland	do.	1,706	79,383	1,748	83,661	1,424	70,816
Clays	short tons	2,832,785	11,515	3,187,270	12,714	3,709,454	14,423
Gem stones		NA	10	NA	10	NA	10
Lime	thousand short tons	1,648	81,103	1,926	93,108	2,065	87,431
Peat	do.	6	W	W	W	W	W
Salt	do.	4,115	126,757	3,276	104,099	3,795	115,860
Sand and gravel:							
Construction	do.	36,806	126,747	e36,400	e136,900	46,104	156,318
Industrial	do.	1,221	21,183	1,249	21,292	1,361	23,441
Stone:							
Crushed	do.	e39,300	e147,300	51,590	300,096	e48,000	e252,000
Dimension	short tons	e35,698	e2,708	47,816	2,427	e38,300	e3,137
Combined value of abrasives gypsum, and values indicated by symbol W		XX	1,738	XX	2,510	XX	2,676
Total		**XX**	**609,984**	**XX**	**768,781**	**XX**	**737,252**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Because of the high sulfur content of Ohio coalbeds, a $100 million clean coal technology program was initiated in the State in 1985. Through the Ohio Coal Development Office, projects were conducted to develop technology to lower sulfur dioxide emissions from the burning of Ohio coals. Some of these projects included technology that required the use of lime or limestone. The status of continuing projects, as well as projects started in 1988, was described in the "Ohio Coal Development Agenda, 1988."[3]

EMPLOYMENT

Mining employment dropped to 19,500 in 1988, the lowest total in 20 years. In contrast, the employment of 183,600 workers in construction was the highest since 1969.[4]

LEGISLATION AND GOVERNMENT PROGRAMS

The Ohio Division of Geological Survey (DGS) was the primary State agency for mineral research and resource investigations. The 1988 DGS Report on Ohio Mineral Industries listed 275 active coal and 430 industrial minerals operators. These figures reflected 19 and 15 fewer operators, respectively, than in 1987.[5]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Ohio was again among the leading States in production of a number of industrial mineral commodities. In 1988, the State ranked first in lime output, accounting for 12% of the U.S total. About 10% of the Nation's salt was produced in Ohio, ranking the State fourth in salt output in the United States. Other commodities and national ranking were as follows: common clay, 1st; fire clay, 2d; industrial sand, 6th; and gypsum, 10th. Other industrial minerals produced included abrasives, portland and masonry cement, peat, construction sand and gravel, and crushed and dimension stone. Ohio also processed and manufactured industrial minerals including synthetic graphite, calcined gypsum, expanded perlite, iron oxide pigments, slag, and sulfur.

Cement.—Production of portland cement declined in 1988 primarily reflecting the closing of Lone Star Industries Inc.'s plant in Superior, Lawrence County. The decline was also attributed to greater use of imported finished cement.

Of the four operating cement plants in Ohio in 1988, three also produced masonry cement. About 2.1 million tons of limestone was used by the State's cement industry.

Lime.—More than one-half of the State's lime production was consumed by the steel industry. Improved conditions in the steel industry and the resulting production increases benefited the State's lime industry. Output of 2.1 million short tons was the highest since 1981. In 1988, eight companies operated nine plants, with Sandusky County leading the State in output. USG Corp.'s plant, which manufactured quicklime and hydrated lime, at Genoa, in Ottawa County, was for sale.

Also during the year, at its Millersville lime manufacturing operation, Ohio Lime Co. completed a test burn of a solvent waste fuel and coal mixed in a 50:50 ratio. The test burn indicated all organic hazardous materials were destroyed during the combustion process. However, particulate emissions exceeded State limits. Thus, an improved air pollution control system had to be installed before the company could receive a permit to burn the solvent waste regularly. A control system was expected to be installed in 1989.

Salt.—In 1988, salt output was nearly 16% higher than that of 1987, primarily because of increased demand for use in melting ice and snow. Ohio's salt production was also consumed, to a lesser extent, by food-related industries. During the year, International Salt Co. completed the acquisition of Diamond Salt Co. The purchase included Diamond's salt well in Akron, Summit County. International Salt is a subsidiary of Akzo NV of the Netherlands.

Sand and Gravel **(Construction).**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1987. Data for odd-numbered years are based on annual company estimates. Ohio construction sand and gravel statistics

TABLE 2

OHIO: LIME SOLD OR USED BY PRODUCERS, BY USE

Use	1987		1988	
	Quantity (Short tons)	Value (Thousands)	Quantity (Short tons)	Value (Thousands)
Steel, basic oxygen	1,104,219	$56,571	1,162,960	$47,139
Other[1]	821,713	36,537	902,808	40,292
Total	**1,925,932**	**93,108**	**2,065,768**	**87,431**

[1] Incldes agriculture, alkalies, calcium carbide and cyanamide, electric steel, finishing lime, glass, magnesia from sea water or brine, mason's lime, metallurgy (1988), open hearth steel, other chemical and industrial, other environmental, refractory, sewage treatment, soil stabilization, sugar refining, sulfur removal, and water purification.

are compiled by geographical districts as depicted in the centerfold map. Table 4 presents end-use data for the State's six districts.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

Construction Aggregates.—In 1988, Ohio produced about 94 million short tons of construction sand and gravel and crushed stone. About 70% of this production was used as construction aggregate. The combined output of these two commodities was the highest reported for Ohio since 1979.

One indication of the significance of construction aggregate in Ohio was evident from data on aggregate production and unemployment rates. Sand and gravel and crushed stone districts 1,3, and 4 in western Ohio comprised 40 of the State's 88 counties. These three districts accounted for about 65% of the State's stone and sand and gravel production. Of the 29 counties in Ohio with an unemployment rate below the average State rate of 5.4%, 22 were in the three western districts.

Other factors also contributed to the variation in county unemployment rates; the major one was the decline in coal mining in districts 5 and 6, where 29 of 31 counties reported unemployment rates higher than that of the State average rate. However, the relationship between production and employment indicated that unemployment rates were typically lower in the districts producing the most construction aggregate.

Metals

No metals were mined in Ohio in 1988. This section reports processed and manufactured metals.

TABLE 3

OHIO: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	9,465	$31,799	$3.36
Plaster and gunite sands	263	1,061	4.03
Concrete products (blocks, bricks, pipe, decorative, etc.)	526	1,655	3.15
Asphaltic concrete aggregates and other bituminous mixtures	5,692	19,369	3.40
Road base and coverings[1]	3,191	10,382	3.25
Fill	3,962	9,223	2.33
Snow and ice control	121	383	3.17
Railroad ballast	W	W	3.39
Other[2]	4,812	16,093	3.34
Unspecified:[3]			
Actual	15,454	57,533	3.72
Estimated	2,618	8,820	3.37
Total or average	**46,104**	**156,318**	**3.39**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes road and other stabilization (lime).
[2] Includes roofing granules and filtration.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.

Aluminum.—Ormet Corp. at Hannibal was the State's only producer of primary aluminum. The impact on the aluminum smelting industry of potential Federal legislation to reduce sulfur dioxide emissions would increase production costs at Hannibal, according to a Bureau of Mines study. Ohio and West Virginia smelters were expected to experience the highest cost increases, ranging from $.052 to $.077 per pound. The increased aluminum smelting costs at coal-fired utilities would result from an assumed electricity cost increase, brought on by the legislation to lower sulfur dioxide emissions.[6]

Iron and Steel.—Steel production increased for the fourth consecutive year, with output of 17.7 million short tons, the highest total since 1981, when 18.1 million tons were produced. Pig iron shipments were not reported to the Bureau of Mines in 1988 because some of the Nation's major producers declined to respond to the survey. However, for the last 6 years, steel production and pig iron shipments in Ohio have been reported at about a 1.5:1 ratio. Based on that ratio, pig iron shipments in 1988 were estimated at 11.5 million tons, an increase of 1.2 million tons compared with the 1987 total.

Late in the year, Kawasaki Steel Corp., Tokyo, signed an agreement in principle to purchase 40% of Armco Inc.'s Eastern Steel Division for $350 million and retained an option to increase its share of the division to 50%.[7] The Eastern Division included Armco's Middletown, OH, and Ashland, KY, operations that employed about 9,300 workers. Armco accepted the agreement, expected to be finalized in 1989, in order to gain access to Japanese technology in continuous casting, coating, and continuous cold rolling of steel. As a result of the joint venture, Armco was expected to increase sales to Japanese-owned automobile plants in Ohio, Kentucky, and Tennessee.

LTV Steel Co. Inc. sold its Warren

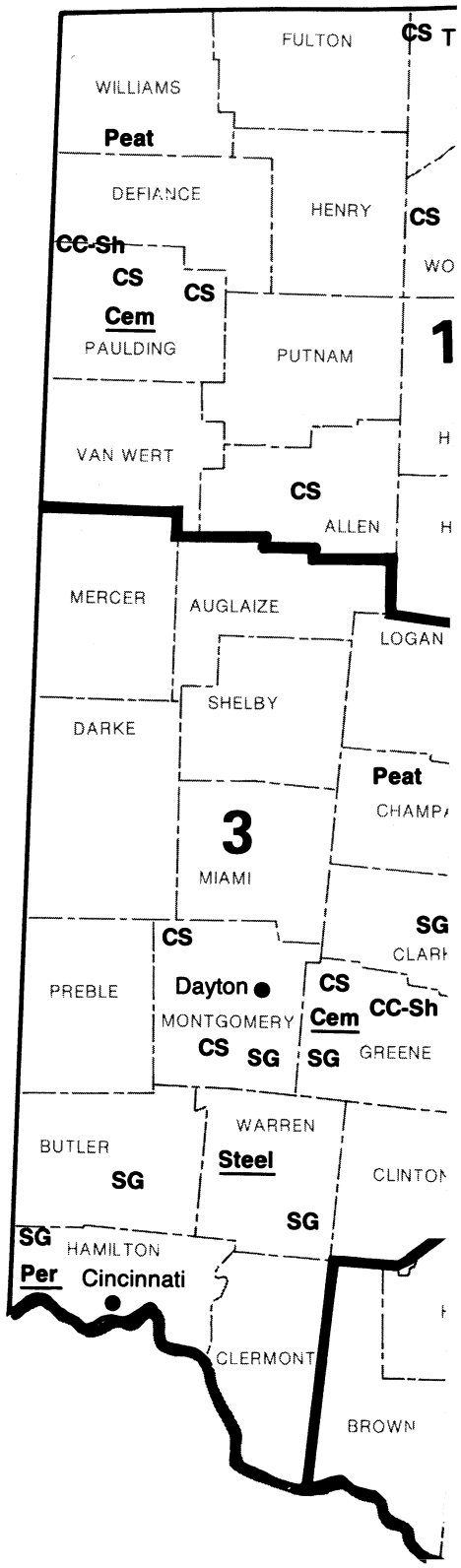
LEGEND

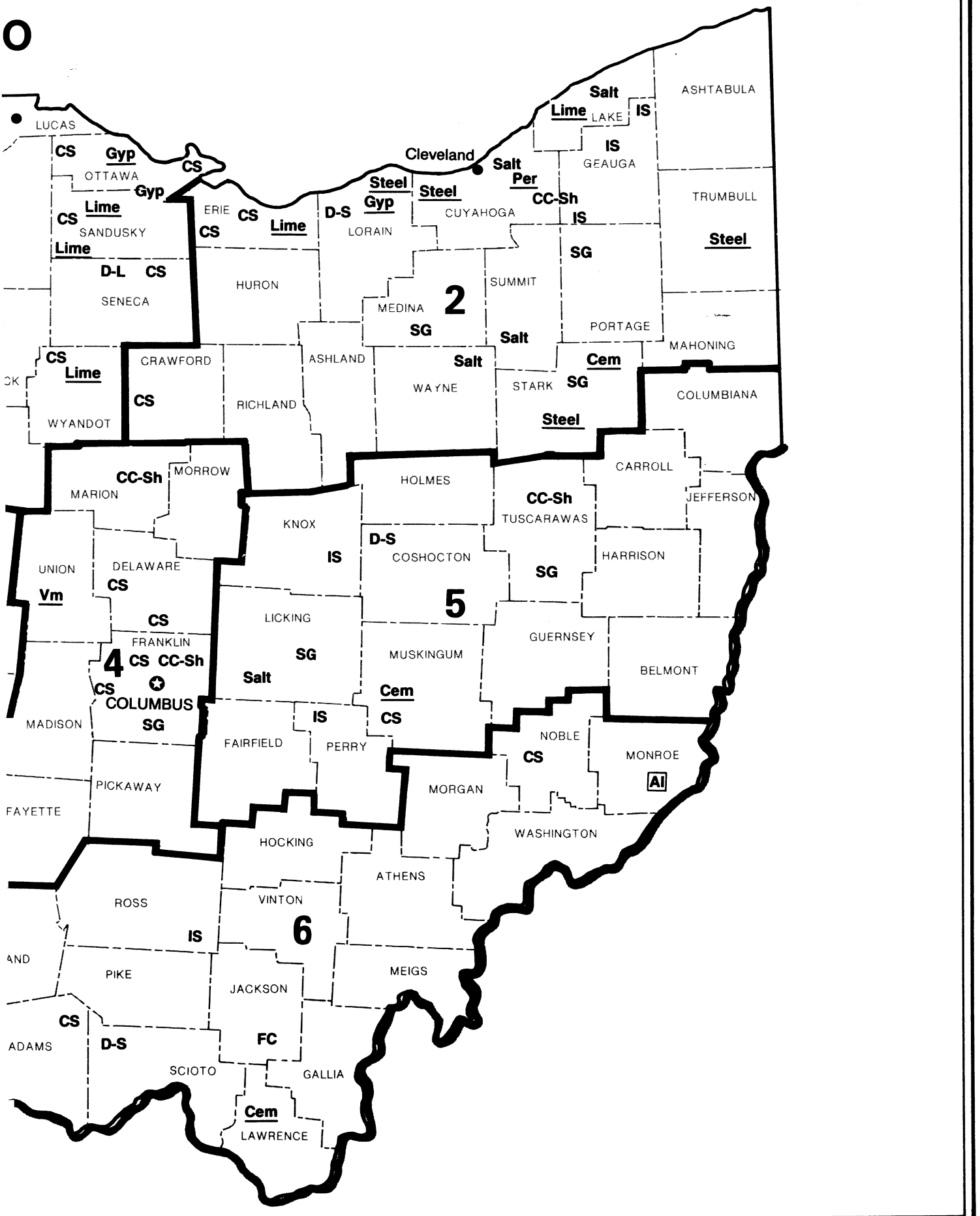
- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Al	Aluminum plant
CC-Sh	Common Clay & Shale
Cem	Cement plant
CS	Crushed Stone
D-L	Dimension Limestone
D-S	Dimension Sandstone
FC	Fire Clay
Gyp	Gypsum
Gyp	Gypsum plant
IS	Industrial Sand
Lime	Lime plant
Peat	Peat
Per	Perlite plant
Salt	Salt
SG	Sand and Gravel
Steel	Iron and Steel plant
Vm	Vermiculite plant

Principal Mineral-Producing Localities

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HURON
Cleveland
Steel
Gyp
D-S
LORAIN
Steel
CUYAHOGA
Salt
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CC-Sh
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LAKE
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IS
GEAUGA
ASHTABULA
TRUMBULL
Steel
SG
SUMMIT
MEDINA
2
SG
Salt
PORTAGE
MAHONING
CS
Lime
WYANDOT
CRAWFORD
CS
RICHLAND
ASHLAND
Salt
WAYNE
Cem
SG
STARK
Steel
COLUMBIANA
CC-Sh
MORROW
MARION
HOLMES
CC-Sh
TUSCARAWAS
CARROLL
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UNION
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DELAWARE
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FRANKLIN
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COLUMBUS
SG
LICKING
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Salt
MUSKINGUM
Cem
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GUERNSEY
BELMONT
MADISON
IS
FAIRFIELD
PERRY
NOBLE
CS
MONROE
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PICKAWAY
FAYETTE
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WASHINGTON
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ATHENS
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6
MEIGS
AND
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ADAMS
D-S
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GALLIA
Cem
LAWRENCE

TABLE 4

OHIO: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	603	2,409	3,426	12,081	3,048	10,424
Plaster and gunite sands	W	W	35	110	35	178
Concrete products (blocks, bricks, etc.)	—	—	156	508	307	903
Asphaltic concrete aggregates and other bituminous mixtures	303	1,011	1,327	5,097	1,546	W
Road base and coverings[1]	527	1,586	545	2,273	1,037	3,629
Fill	250	486	786	2,711	2,558	5,246
Snow and ice control	22	W	27	97	6	21
Railroad ballast	—	—	W	W	—	—
Other miscellaneous[2]	51	277	754	3,220	3,002	15,666
Other unspecified[3]	327	1,165	4,832	16,396	7,513	28,566
Total[4]	**2,083**	**6,934**	**11,887**	**42,493**	**19,051**	**64,633**

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	568	2,102	968	2,339	853	2,444
Plaster and gunite sands	3	14	W	W	W	W
Concrete products (blocks, bricks, etc.)	42	155	W	W	W	W
Asphaltic concrete aggregates and other bituminous mixtures	623	W	1,362	3,833	532	2,036
Road base and coverings[1]	124	464	889	2,162	70	268
Fill	62	194	257	490	50	95
Snow and ice control	4	W	62	169	—	—
Railroad ballast	—	—	—	—	—	—
Other miscellaneous[2]	(5)	2,733	170	482	1,045	2,051
Other unspecified[3]	3,196	13,507	1,992	5,971	213	749
Total[4]	**4,621**	**19,170**	**5,700**	**15,446**	**2,762**	**7,642**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (lime).
[2] Includes sand and gravel for roofing granules and filtration.
[3] Includes sand and gravel reported without a breakdown by end use and estimates for nonrespondents.
[4] Data may not add to totals shown because of independent rounding.
[5] Less than 1/2 unit.

Works to Renco Group Inc. in a transaction valued at $147 million.[8] The operation, with an annual capacity of 1.5 million short tons, was renamed Warren Consolidated Industries Inc. LTV Steel's coke plant in Warren was not included in the sale.

At the Cleveland Works, LTV Steel initiated a 7-year, $1.1 billion modernization program. Improvements considered under the program included construction of a vacuum decarburization-ladle metallurgy facility and a continuous annealing line, renovation of coke and byproducts operations, and relining of three blast furnaces.[9]

Titanium.—RMI Co. continued to produce about one-third of the Nation's titanium sponge metal at its Ashtabula facilities. In 1988, RMI began a program to test production of titanium using an electrolytic process developed in Italy. Testing was scheduled to continue in 1989, when a decision on using the electrolytic process at a 300,000- to 500,000-pound-capacity plant was expected. This electrolytic process reduces energy costs by about 30% in the manufacturing of titanium sponge.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA.

[2] Ohio Coal Development Agenda. Ohio Coal Development Office, Columbus, OH, Jan. 1988, pp. 3-5.

[3] Ohio Coal Development Agenda. Ohio Department of Development, Coal Office, 77 S. High Street, Box 100, Columbus, OH 43266-0101, Jan. 1988, p. 101.

[4] Ohio Labor Market Information, 1988 Annual Summary. Nonagricultural Wage and Salary Employment in Ohio, by Industrial Division, Since 1939. March 1988, p. 23.

[5] Lopez, S.L. 1988 Report on Ohio Mineral Industries. Dep. Nat. Res., Div. of Geol. Surv., 117 pp.

[6] U.S. Bureau of Mines. The Potential Impact of Acid Rain Legislation on the Domestic Aluminum Smelting Industry. BuMines OFR 58-88, 1988, 14 pp.

[7] Armco Inc. 88th Annual Report. p. 14.

[8] American Metal Market. Warren Focuses on High Carbon. V. 96, No. 183, Sept. 19, 1988, p. 1.

[9] The LTV Corp. 1988 Annual Report, p. 5.

TABLE 5

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Abrasives (natural):			
Cleveland Quarries Co.[1]	Quarry Rd. Amherst, OH 44001	Quarry and plant	Lorain.
Cement:			
Columbia Portland Cement	Box 1187 Uniontown, PA 15401	Plants	Muskingum and Stark.
General Portland Inc.[2]	Box 1019 Fort Wayne, IN 46801	Plant	Paulding.
Southwestern Portland Cement Co.[2]	Box 191 Fairborn, OH 45324	do.	Greene.
Clays:			
Common:			
Belden Brick Co.	Box 910 Canton, OH 44701	Pits	Tuscarawas.
Hydraulic Press Brick Co.	Box 7786 Independence, OH 44131	Pit	Cuyahoga.
Fire:			
Crescent Brick Co. Inc.	50 Portsmouth Rd., Box 368 Oak Hill, OH 45656	Pits	Jackson.
Gypsum:			
Crude:			
Celotex Corp.[3]	320 South Wayne Ave. Cincinnati, OH 45215	Pit and plant	Ottawa.
Calcined:			
National Gypsum Co.	1901 Henderson Dr. Lorain, OH 44052	Plant	Lorain.
USG Corp.	Gypsum, OH 43433	do.	Ottawa.
Lime:			
Huron Lime Co.	Box 451, 100 Meeker Huron, OH 44839	Quarry and plant	Erie.
LTV Steel Co. Inc.	Box 6778, Room 1629 Republic Bldg. Cleveland, OH 44101	Plant	Lake.
Martin Marietta Corp.[4]	755 Lime Rd. Woodsville, OH 43469	Quarry and plant	Sandusky.
Ohio Lime Co.	128 East Main St. Woodsville, OH 43469	Quarries and plants	Do.
Peat:			
Sphagnum Moss Peat Farm	9797 Thompson Rd., Rt. 1 West Liberty, OH 43357	Bog	Champaign.
Salt:			
International Salt Co.	Box 6920 Cleveland, OH 44101	Underground mine, well, and plants.	Cuyahoga and Summit.
Morton Thiokol Inc., Morton Salt Div.	Box 390 Painesville, OH 44077	Underground mine, wells, and plant.	Lake and Wayne.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Construction:			
American Aggregates Corp.	Drawer 160, Garst Ave. Greenville, OH 45331	Pits and plant (13 operations)	Butler, Champaign, Clark, Franklin, Greene, Hamilton, Montgomery, Warren.
Dravo Corp.	5253 Wooster Rd. Cincinnati, OH 45226	Pits and plants (8 operations)	Butler, Hamilton, Meigs, Warren.
Industrial:			
Best Silica Sand Co.	Box 87, 11830 Ravenna Rd. Chardon, OH 44024	Quarries and mill	Geauga.
Central Silica Co.	806 Market St. Zanesville, OH 43701	do.	Knox and Perry.
Stone:			
Crushed:			
American Aggregates Corp.[5]	Drawer 160, Garst Ave. Greenville, OH 45331	Quarries and plants	Clark, Darke, Delaware, Fayette, Franklin, Greene, Montgomery, Warren.
The France Stone Co.[1]	8130 Brint Rd., Box 278 Sylvania, OH 43560	do.	Lucas, Seneca, Wood.
National Lime & Stone Co.	First National Bank Bldg. Findlay, OH 45840	do.	Allen, Auglaize, Crawford, Delaware, Hancock, Marion, Putnam, Wyandot.
Sandusky Crushed Stone Co. Inc.	Box 527 Sandusky, OH 44870	Quarry and plant	Erie.
Stoneco Inc.	221 Allen St. Maumee, OH 43537	Quarries and plant	Lucas, Ottawa, Paulding, Van Wert, Wood.
Wagner Quarries Co.	4203 Milan Rd. Sandusky, OH 44870	do.	Do.
Dimension:			
Briar Hill Stone Co.	Box 398, State Rt. 520 Glenmont, OH 44628	do.	Coshocton, Holmes, Knox.
Waller Bros. Stone Quarry Co.	134 County Rd. McDermott, OH 45652	do.	Scioto.

[1] Also dimension stone.
[2] Also common clays.
[3] Also calcined gypsum.
[4] Also crushed stone.
[5] Also sand and gravel.

THE MINERAL INDUSTRY OF OKLAHOMA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Oklahoma Geological Survey for collecting information on all nonfuel minerals.

By Jane P. Ohl[1] and Robert H. Arndt[2]

Nonfuel minerals produced in Oklahoma were valued at $220 million in 1988, a decrease of about 1% from the 1987 value. Oklahoma ranked 35th in the Nation and accounted for less than 1% of the total value of the United States' nonfuel mineral production. Construction materials accounted for most of the $220 million, with significant decreases in total values of portland cement and construction sand and gravel. The leading commodities, in decreasing order of total values, were crushed stone, portland cement, construction and industrial sand and gravel, iodine, and crude gypsum. The greatest percentage increases in output during 1988 were reported for crude gypsum, iodine, lime, and crushed stone.

TRENDS AND DEVELOPMENTS

Total output of construction materials (portland cement, construction sand and gravel, and crushed stone) was little different from that of 1987 but showed a reduction of about 14% from total output of 1986. F. W. Dodge Division, McGraw Hill Information Systems Co., New York, reported that the value of all construction in the State decreased 24%, from $2.26 billion in 1987 to $1.72 billion in 1988. Value of building construction shrank by 13%; nonbuilding construction shrank by 40%. This trend was related to the downturn of the State's economy since 1986.

EMPLOYMENT

The number of workers employed in mining, excluding workers in oil and gas extraction, fell from 2,600 in December 1987 to 2,300 at yearend 1988. This decrease of more than 11%, according to the Oklahoma Employment Security Commission, reflected the depression in the construction industries. Overall civilian employment in the State was down 2.6%.

REGULATORY ISSUES

Approximately 142 acres of abandoned coal mine lands was reclaimed

TABLE 1

NONFUEL MINERAL PRODUCTION IN OKLAHOMA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	50	$3,198	41	$2,436	W	W
Portland	do.	1,579	69,075	1,415	54,870	1,432	$42,131
Clays	short tons	992,702	2,329	797,301	1,783	754,054	1,803
Gem stones		NA	2	NA	8	NA	18
Gypsum	thousand short tons	1,683	9,855	1,828	13,336	2,173	13,393
Iodine	pounds	W	W	W	W	2,238,152	W
Sand and gravel:							
Construction	do.	10,366	24,585	e10,500	e24,200	9,273	22,654
Industrial	do.	1,203	16,454	1,243	17,078	1,268	17,381
Stone:							
Crushed	do.	e30,900	e102,100	2 25,155	2 83,732	e 2 26,300	e 2 92,000
Dimension	short tons	e18,503	e913	8,311	861	e7,746	e785
Combined value of feldspar, lime, pumice (1986), salt, stone (crushed dolomite 1987–88), tripoli, and values indicated by symbol W		XX	18,504	XX	24,915	XX	29,972
Total		**XX**	**247,015**	**XX**	**223,219**	**XX**	**220,137**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain stones; kind and value included with "Combined value" data.

under the Abandoned Mine Land Reclamation Program of the Oklahoma Conservation Commission and the Rural Abandoned Mine Program of the U.S. Department of Agriculture Soil Conservation Service. The State of Oklahoma had been receiving $1 million to $2 million annually for mine land reclamation from the Federal Abandoned Mine Land Reclamation Fund. Since completion of the first reclamation project by the Conservation Commission in 1980, 73 projects involving 2,087 acres of abandoned mine land had been completed by the two agencies. As a consequence of applying these funds only to reclaiming sites that were demonstrated hazards to public health and safety, the prospects for reclaiming most of approximately 32,000 acres of nonhazardous, abandoned coal lands that were mined before 1977 remained poor. It was only in 1977 that the Surface Mining Control and Reclamation Act required coal companies to post a reclamation bond that is calculated as the cost of hiring a third party to reclaim a site.

The Office of Surface Mining Reclamation and Enforcement, in cooperation with the Abandoned Mine Land Division of the Oklahoma Conservation Commission and the Pittsburg County Conservation District, exercised emergency powers to fill surface subsidence over underground coal mine workings on the Hartshorne High School grounds after a collapse. Three similar collapses occurred in the town of Coalgate in Coal County. Grouting of underground voids through holes drilled from the surface was used to treat some collapses that involved buildings.

Grand River Dam Authority approved an initial spot purchase of 30,000 tons of Oklahoma coal from Hickory Coal Co. Oklahoma law requires that coal burned in Oklahoma powerplants contain at least 10% Oklahoma coal. The purchase price of the Oklahoma coal was $1.18 per million British thermal units (Btu) delivered, as contrasted with $1 per million Btu delivered for low-sulfur Wyoming coal. Emission controls at the Grand River Dam Authority powerplant near Chouteau included the use of lime from Sequoyah County in smokestack scrubbers. Applied Energy Services Inc. also expected to use lime from Sequoyah County in scrubbers at its cogeneration plant then being built near Shady Point in Le Flore County. Unlike other electricity-generating plants in Oklahoma, the Shady Point plant was designed to operate ultimately on Oklahoma coal, which contains 3.75% sulfur.

At Henryetta, the U.S. Environmental Protection Agency notified city officials that a slag pile on land at a closed zinc smelter probably would not be deemed hazardous enough to be placed on the Superfund cleanup list (Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and Amendments and Reauthorization Act of 1986, Public Laws 96-510 and 99-499). The land once belonged to Eagle-Picher Industries Inc., which closed a smelter in the area in 1974.

In November, the city of Sallisaw neared an agreement with St. Clair Lime Co. to have the remains of the company's former lime plant and debris piles removed from a 10.5-acre site adjacent to U.S. Highway 64 within the city limits. The plant had been abandoned for many years before a lawsuit was filed by the city in 1984 to have the plant remains declared a public nuisance.

EXPLORATION ACTIVITIES

NERCO Exploration Co. entered into a joint venture with Newmont Exploration Ltd. and American Copper & Nickel Co. to conduct drilling exploration for platinum in southern Kiowa County. Much of the area adjoins Lake Tom Steed, a U.S. Bureau of Reclamation installation for which mineral affairs are administered by the U.S. Bureau of Land Management. The identification of platinum in rock chip samples and stream sediments, collected during reconnaissance exploration of the Wichita Mountains by Anaconda Minerals Co. in 1982–83, was an incentive for mineral leasing and exploration in the area. Geological conditions closely resembled those of platinum-producing terrains in the Stillwater Complex of Montana and the more famous Bushveld Complex of South Africa.

LEGISLATION AND GOVERNMENT PROGRAMS

The governor signed House bill 1810, which reassigned the responsibility for collecting fees from mine operators. Fees formerly collected by the Oklahoma Department of Mines were thus to be collected by the Tax Commission. About $500,000 in fees collected by the Oklahoma Department of Mines from coal producers was added to the State budget in 1988.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Output and total values of crude gypsum, iodine, lime, industrial sand, crushed stone, and sulfuric acid increased moderately to significantly. However, many of the State's industrial mineral categories showed a decrease in output and value. Production figures reported for calcined gypsum and dimension stone were down as much as 10%. Even larger decreases in output and value were reported for feldspar, salt, construction sand and gravel, and tripoli. Statistics reported for common clay and shale and portland and masonry cements were mixed.

Cement.—Portland cement production capacity for plants in Oklahoma remained virtually unchanged at 77%.

Plants in Mayes, Pontotoc, and Rogers Counties increased output slightly, but total value fell from $54.9 million in 1987 to $42.1 million in 1988. The average price per short ton of portland cement was down from $43.75 in 1986 and $38.78 in 1987 to $29.43 in 1988. Masonry cement output and total value in 1988 plunged from figures reported in 1987 and 1986.

Blue Circle Inc. and Lone Star Industries Inc. operated a total of five dry-process kilns, and Ideal Basic Industries Inc. operated two wet-process kilns. Raw materials consumed in making portland cement were 2.3 million tons of limestone (about one-third more than in 1987), 0.7 million tons of domestic clinker, 0.2 million tons of cement rock, and smaller amounts of gypsum, iron ore, sand, and shale. Natural gas and small quantities of bituminous and anthracite coals were used as fuels.

The cement produced was primarily gray finished portland cement, with a very small quantity of white finished portland. The gray was classified as "general use, moderate heat type, early strength, very high sulfur resistance, and oil well cement." The average price of oil well cement, whose output was related to still-sluggish drilling activities, fell to $35.27 per ton, $4.10 less than in 1987 and $8.67 less than in 1986.

Portland cement was used by the following consumers, in decreasing order of shipments: ready-mixed concrete producers (62%), contractors, concrete product manufacturers, highway contractors, building materials dealers, and Federal, State, and other government agencies. Bulk shipments of portland cement from plant to terminal were transported by rail (97% of shipments) and by truck.

Feldspar.—A feldspar-silica mixture was produced at Muskogee by APAC Arkansas Inc. through beneficiation of river sands. The product was used specifically in manufacturing glass and pottery.

Gem Stones.—A fad for "healing" crystals resulted in many persons hunting for clear, quartz crystals in southeastern Oklahoma. Since 1985, about 2,000 mining claims for quartz crystals[3] have been filed on land in the Ouachita National Forest, parts of which lie in Arkansas as well as in Oklahoma.

Gypsum.—Output of crude gypsum increased 19%, but total value remained virtually unchanged from that of 1987. The production and value of calcined gypsum were down moderately.

Iodine.—Oklahoma was the Nation's sole domestic source of iodine production after producers in Michigan closed down in 1985. The State's position as the premier world source of iodine was enhanced by the startup of production at a second iodine plant in late 1987 by Iochem Corp. of Japan. Combined output of Iochem and Woodward Iodine Corp. increased the State's output 36% and its value 45% over 1987 levels. During 1988, Iochem produced an average of 20 tons of iodine per month at its new plant near Vici, Dewey County; the iodine was extracted from brines obtained from 10,000-foot-deep wells nearby. The increasing use of iodine in polymer materials was expected to increase its demand substantially. The price of iodine averaged $7.49 per pound.

North American Brine Resources began construction of northwest Oklahoma's third brine-processing plant in late December. Cost of the project was expected to reach $5 million. The plant was expected to come on-stream in May 1989 to process brine from four wells near Woodward in Harper County. Initial employment would be 6 to 14 persons. North American Brine was a joint venture of Beard Oil Co. (40% share) and two Japanese firms (Inorgchem Developments Inc. and Godoe USA Inc.).

Lime.—In anticipation of the lime needs of a new cogeneration coal-fired powerplant being erected in Le Flore County, construction of another lime plant was being considered for central-eastern Oklahoma. Pluss-Staufer Co. of Switzerland proposed to build the plant several miles north of Marble City in Sequoyah County, utilizing the St. Clair Lime Formation as its materials source. St. Clair Lime Co., currently the State's only lime producer, has obtained limestone from the St. Clair Formation at Marble City since the firm was established in 1943. St. Clair's present plant and underground mine were started up in 1966 in a location adjacent to its original quarry.

Lime output and total value increased significantly (13% and 12%) over figures for the preceding year. In response to legislation requiring that 10% of the coal used in the State's coal-fired powerplants be from Oklahoma high-sulfur coal mines, the market for lime used in scrubbers had grown rapidly in the previous 2 years; output and total value of lime were expected to increase further when a new powerplant was brought on-line. (See section on Regulatory Issues.)

Salt.—Salt output and total value fell precipitously, down 79% and 83%, respectively, from figures reported in 1987.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

The 1988 production value decreased a little more than 6% from the 1987 estimate and almost 8% from the 1986 survey.

Oklahoma construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 2 presents end-use data for this commodity in the State's five districts. District 2, which includes the cities of Oklahoma City and Tulsa, accounted for almost 35%

of the State's production value.

Industrial.—A very slight increase in industrial sand output and total value was reported in 1988.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—Crushed stone output and total value increased an estimated 5% and 10%, respectively, from figures reported for 1987.

Dimension.—A moderate reduction in dimension stone output and total value was reported for the year.

Sulfuric Acid.—Byproduct sulfuric acid was recovered from Zinc Corp. of America's smelter at Bartlesville in a slightly larger amount than that reported in 1987; its value, however, reportedly increased nearly 50% per short ton. Sulfuric acid is the most universally used mineral acid. The largest single end use of sulfuric acid is for the production of phosphatic fertilizers.

Tripoli.—Tripoli output decreased by nearly one-quarter from that reported in 1987. Crude tripoli was produced in Ottawa County. Because tripoli grains lack distinct edges, tripoli can be used as a mild abrasive in toothpaste and toothpolishing compounds, industrial soaps, metal and jewelry polishing compounds, and in buffing and polishing compounds for paint finishing by the automobile industry.

Vermiculite (Exfoliated).—W. R. Grace & Co. produced exfoliated vermiculite at its Oklahoma City plant from raw materials shipped in from out of State. Production and sales of the material were relatively unchanged from 1987 levels. Application of vermiculite in most uses declined, but use in concrete aggregates and soil conditioners rose. The total value of exfoliated vermiculite in Oklahoma remained relatively unchanged.

TABLE 2

OKLAHOMA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	4,053	$11,093	$2.74
Plaster and gunite sands	55	128	2.33
Concrete products (blocks, bricks, pipe, decorative, etc.)	43	203	4.72
Asphaltic concrete aggregates and other bituminous mixtures	439	902	2.05
Road base and coverings	1,185	2,711	2.29
Fill	928	1,301	1.40
Snow and ice control	11	34	3.09
Other	244	436	1.79
Unspecified:[1]			
Actual	722	2,086	2.89
Estimated	1,593	3,762	2.36
Total[2] or average	**9,273**	**[2]22,654**	**2.44**

[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[2] Data do not add to total shown because of independent rounding.

Metals

No metals were mined in Oklahoma, but several plants extracted metals from ores mined out of State.

Cadmium and Zinc.—St. Joe Resources Co., a subsidiary of Fluor Corp., which operated the electrolytic zinc refinery at Bartlesville, was sold to Horsehead Industries Inc., parent of New Jersey Zinc Co. New Jersey Zinc was then combined with St. Joe and renamed Zinc Corp. of America, becoming the largest domestic zinc producer. The Bartlesville plant had an estimated capacity of 60,000 metric tons of slab zinc per year. Additional processing of leached zinc electrolyte selectively precipitates cadmium, which is then filtered, briquetted, and further processed to produce commercial-grade cadmium ball anodes. Fabricated thin-filmed cadmium is used for photodetectors and transparent conductors, and cadmium compounds are used in batteries and other items.

Germanium.—Eagle-Picher Industries Inc. recovered primary germanium from zinc smelter residues (for example, from Chile), impure oxides, and scrap. The plant at Quapaw, Ottawa County, has the capacity to produce 30,000 kilograms of germanium per year in the form of germanium tetrachloride and dioxide, as well as polycrystalline and single-crystal germanium metal. About 75% of the total germanium consumption worldwide is used in infrared systems and fiber optics.

Uranium.—Kerr-McGee Corp. sold its Sequoyah Fuels Corp. subsidiary to GA Technologies Inc. (formerly called General Atomics) of San Diego, CA, in early November. The sale ended Oklahoma City-based Kerr-McGee's in-

volvement in the uranium industry. Sequoyah Fuels operated a plant at Gore at which it produced uranium hexafluoride and uranium tetrafluoride.

[1] State Mineral Officer, Bureau of Mines, Denver, CO.

[2] Director, Oklahoma Mining and Mineral Resource Research Institute, Oklahoma Geological Survey, Norman, OK.

[3] Journal Record (Oklahoma City, OK). Quartz Find May Pan Out as Arkansas Gold Mine. Aug. 2, 1988.

TABLE 3

OKLAHOMA:[1] CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[2]	838	2,660	1,646	3,513	403	676
Asphaltic concrete aggregates and road base and coverings	550	1,135	187	305	130	402
Fill	83	151	457	596	45	96
Snow and ice control	1	2	W	W	W	W
Other miscellaneous	2	3	93	156	37	108
Other unspecified[3]	56	218	1,350	3,044	273	665
Total[4]	**1,529**	**4,169**	**3,733**	**7,614**	**887**	**1,947**

	District 4		District 5	
	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[2]	935	3,163	330	1,413
Asphaltic concrete aggregates and road base and coverings	591	1,321	166	451
Fill	188	271	58	89
Snow and ice control	—	—	W	W
Other miscellaneous	117	178	6	22
Other unspecified[3]	389	1,243	249	677
Total[4]	**2,218**	**6,176**	**809**	**2,651**

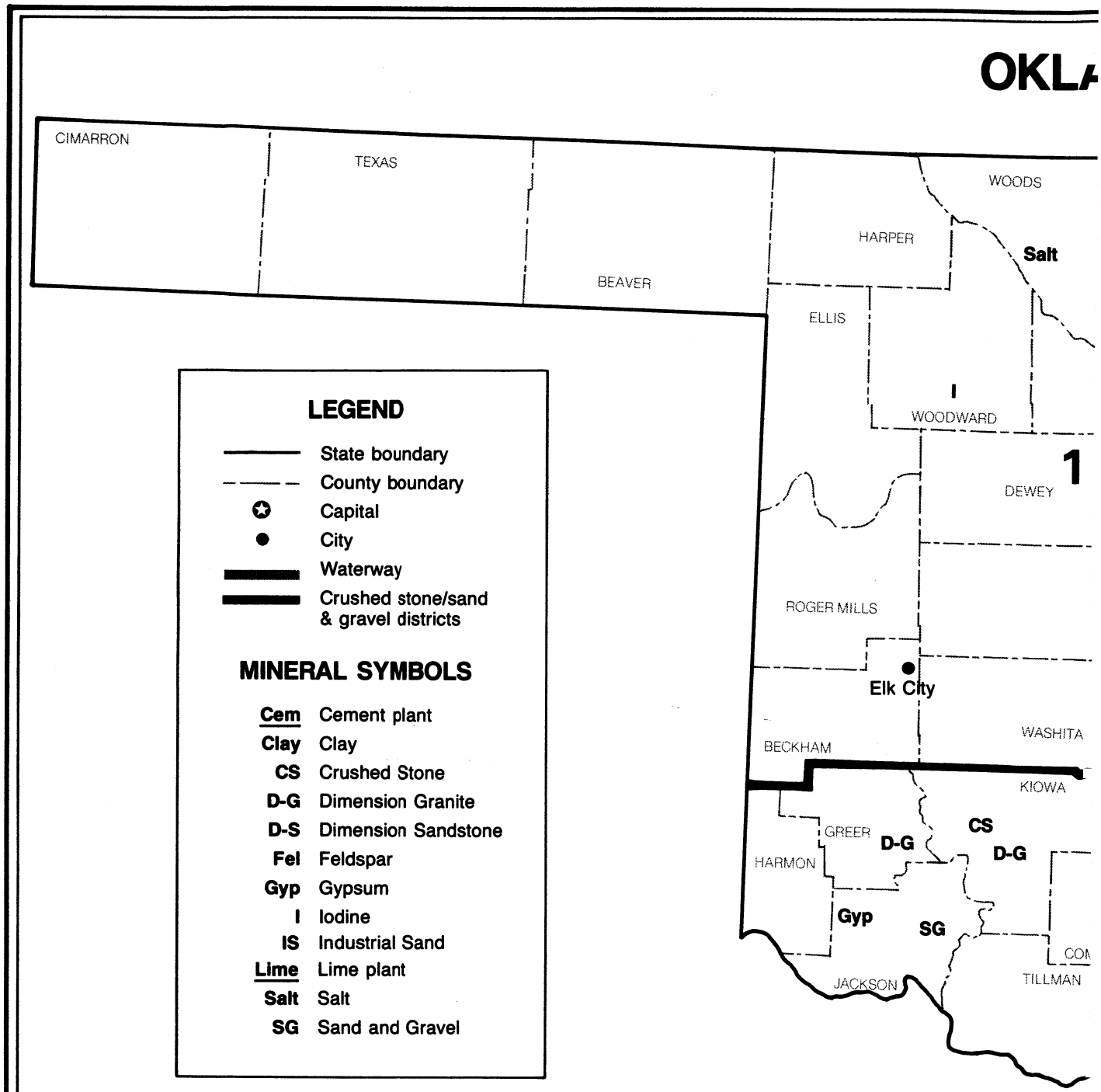
W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."

[1] Excludes 97,168 short tons valued at $97,168 not reported by county.

[2] Includes sand and gravel for plaster and gunite sands.

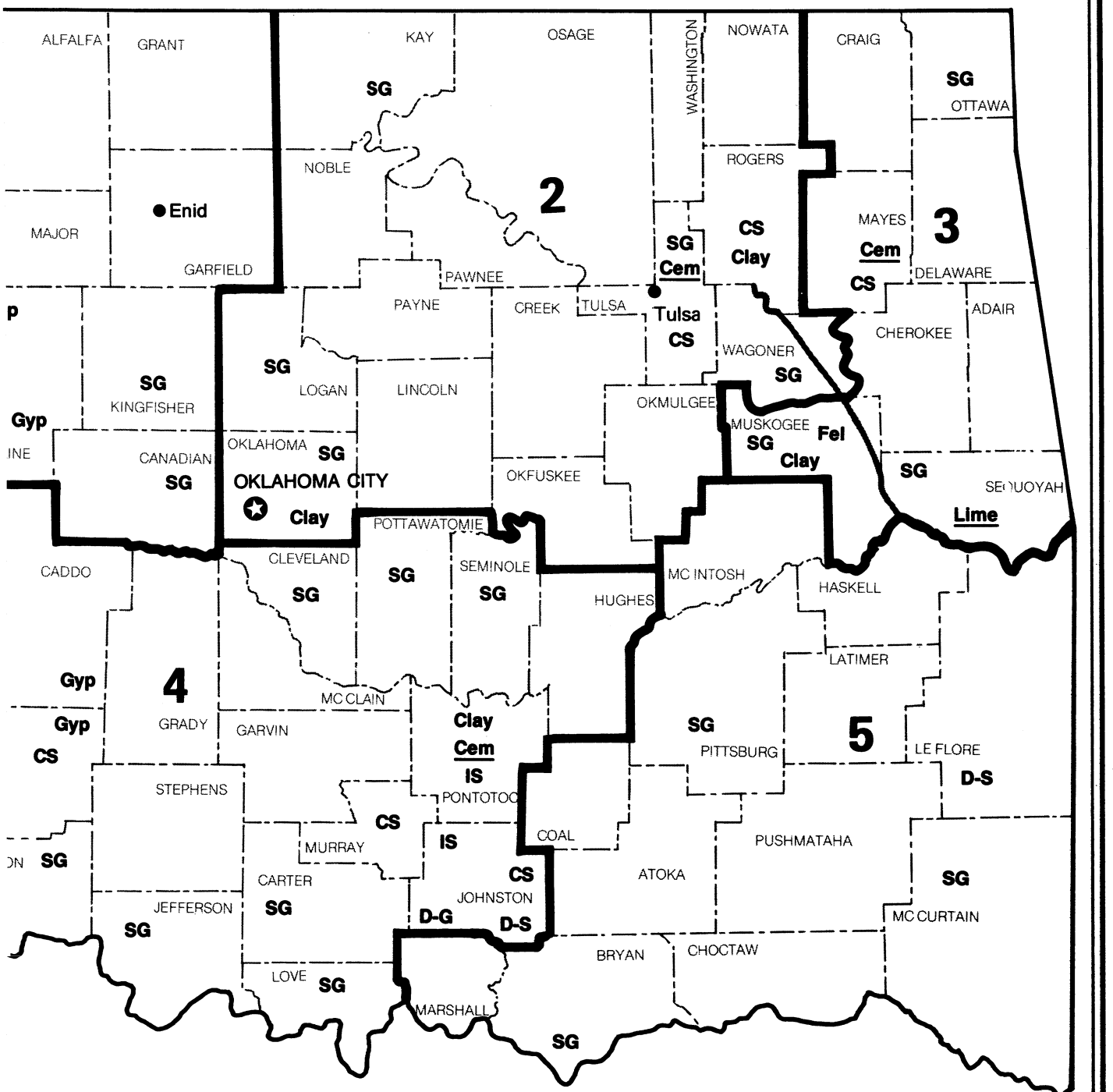
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.

[4] Data may not add to totals shown because of independent rounding.



Principal Mineral-Producing Localities

OMA


ALFALFA
GRANT
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WASHINGTON
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NOBLE
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Enid
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Cem
CS
Clay
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Cem
GARFIELD
PAWNEE
DELAWARE
CS
PAYNE
CREEK
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ADAIR
CHEROKEE
WAGONER
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LOGAN
LINCOLN
KINGFISHER
OKMULGEE
Gyp
MUSKOGEE
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Clay
CANADIAN
OKLAHOMA
SG
SG
OKLAHOMA CITY
OKFUSKEE
SG
Clay
POTTAWATOMIE
Lime
CLEVELAND
SG
SEMINOLE
SG
MC INTOSH
HASKELL
CADDO
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LE FLORE
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STEPHENS
PONTOTOC
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COAL
PUSHMATAHA
MURRAY
SG
CARTER
CS
ATOKA
SG
JOHNSTON
JEFFERSON
SG
D-G
D-S
MC CURTAIN
BRYAN
CHOCTAW
LOVE
SG
MARSHALL
SG

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Blue Circle Inc., a subsidiary of Blue Circle Industries Ltd.[1 2]	One Parkway Center 1850 Parkway Pl. Suite 1000 Marietta, GA 30067	Quarry and plant	Rogers.
Ideal Basic Industries Inc., Ideal Cement Co.[1 2]	Box 8789 Denver, CO 80201	do.	Pontotoc.
Lone Star Industries Inc.[1 2]	5110 Maryland Way Suite 222 Brentwood, TN 37027	do.	Mayes.
Clays:			
Acme Brick Co., a subsidiary of Justin Industries Inc.	Box 24012 Oklahoma City, OK 73124	Pits and plants	Oklahoma.
Chandler Materials Co.	5805 East 15th St. Tulsa, OK 74102	Pit and plant	Do.
Commercial Brick Corp.	Box 1382 Wewoka, OK 74884	do.	Seminole.
Oklahoma Brick Corp., a subsidiary of Merry Companies.	Box 75368 4300 NW 10th St. OKlahoma City, OK 73127	do.	Canadian and Muskogee.
Feldspar:			
Arkhola Sand and Gravel Co., a division of APAC-Arkansas Inc., a subsidiary of Ashland Oil Co.[2 3]	Box 1401 Muskogee, OK 74401	Dredge and plant	Muskogee.
Gallium and germanium:			
Eagle-Picher Industries Inc.	Box 737 Quapaw, OK 74363	Refinery	Ottawa.
Gypsum:			
Harrison Gypsum Co. Inc.	Box 336 Lindsay, OK 73052	Quarry	Caddo.
Heartland Cement Co.	12700 South Fork Rd. St. Louis, MO 63128	do.	Blaine.
Republic Gypsum Co.	Drawer C Duke, OK 73532	Quarry and plant	Jackson.
Temple-Inland Forest Products Corp.	Box 101 Fletcher, OK 73541	do.	Comanche.
United States Gypsum Co., a subsidiary of USG Corp.	Box 187 Southard, OK 73770	do.	Blaine.
Iodine:			
North American Brine Resources	c/o Beard Oil Co. 2000 Classen Center Bldg. Oklahoma City, OK 73106	Oilfield brines and plant.	Kingfisher.
Woodward Iodine Corp., a subsidiary of Asahi Glass Co. Ltd. and Ise Chemical Co.	Box 1245 Woodward, OK 73801	Brine field and plant	Woodward.
Lime:			
St. Clair Lime Co.	Box 894 Oklahoma City, OK 73101	Mine and plant	Sequoyah.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Pumice (volcanic ash):			
Axtell Mining Corp.	Box 92 Gate, OK 73844	Open pit	Beaver.
Salt:			
Cargill Inc.	Box 167 Freedom, OK 73842	Solar evaporation	Woods.
Sand and gravel:			
Construction:			
Anchor Stone Co., a division of Anchor Industries	3300 N. Mingo Valley Expressway Tulsa, OK 74116	Pits and plants	Tulsa and Wagoner.
C. H. Beazer Holdings PLC, parent of Gifford-Hills & Co. Inc.	518 E. Scott St. Gainesville, TX 76240	Pit	Love.
The Dolese Co.	20 N.W. 13th St. Oklahoma City, OK 73101	Plants	Canadian and Kingfisher.
Sand Springs Sand Co.	Rt. 4 Box 6 Sand Springs, OK 74063	Pit	Tulsa.
Industrial:			
UNIMIN Corp.	258 Elm St. New Canaan, CT 06840	Pit and plant	Pontotoc.
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	Pits and plant	Johnston.
Stone:			
Crushed:			
Amis Materials Co.	Box 168 Stringtown, OK 74568	Quarry	Atoka.
Anchor Stone Co. and Tulsa Rock Co., subsidiaries of Anchor Industries.	3300 North Mingo Valley Expressway Tulsa, OK 74116	do.	Rogers and Tulsa.
Bellco Materials Inc.[3]	Box 466 Nowata, OK 74048	Quarries	Nowata, Rogers, Washington.
Material Producers Inc.	Box 577 Norman, OK 73070	Quarry	Murray.
McNabb Stone Co., a division of McNabb Coal Co. Inc.	Drawer C Catoosa, OK 74015	Quarries	Rogers and Wagoner.
Meridian Aggregates Co., a subsidiary of Burlington Northern Railroad.	Box 86 Mill Creek, OK 74856	Quarry	Johnston.
The Quapaw Co.	Box 72 Drumright, OK 74030	Quarries	Creek and Pawnee.
Sooner Rock & Sand Co., a subsidiary of Hallett Construction Co.	Box 1549 Norman, OK 73070	Quarry	Murray.
Standard Industries, a division of APAC-Oklahoma Inc.	Box 580670 Tulsa, OK 74158	Quarries	Cherokee, Kay, Mayes, Tulsa.
Dimension:			
Bodie L. Anderson Quarries Inc.	Box 106 Mill Creek, OK 74858	Quarry	Johnston.
Miller Stone Co.	Rt. 1 Hackett, AR 72937	do.	Le Flore.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Pontotoc Stone Co.	1434 NW. 30th St. Oklahoma City, OK 73118	Quarry	Johnston.
J. R. Willis Granite Co. Inc.	Box 188 Granite, OK 73547	do.	Greer.
Tripoli:			
American Tripoli Co.	Box 489 Seneca, MO 64865	Mines	Ottawa.
Zinc:			
Zinc Corp. of America, a division of Horsehead Industries Inc.[4]	Box 579 Bartlesville, OK 74005	Electrolytic refinery	Washington.

[1] Also clays.
[2] Also stone.
[3] Also sand and gravel.
[4] Also sulfuric acid; copper, lead, and silver residues; and cadmium balls.

THE MINERAL INDUSTRY OF OREGON

By William L. Rice[1] and W. A. Lyons[2]

Nonfuel mineral production value in Oregon rose to $178 million in 1988, an increase of about 11% over that of 1987. Production value gains of cement, sand and gravel, and crushed stone were largely responsible for the increase. Industrial minerals accounted for nearly 99% of the nonfuel mineral production value reported. Crushed stone was the leading commodity in terms of value, followed by construction sand and gravel, cement, diatomite, and lime. Nationally, Oregon ranked first in pumice production, fourth in diatomite production, and was a significant processed zeolite producer. Of more than 600 active mineral operations in 1988, the majority, about 575, were sand and gravel and crushed stone producers. Oregon ranked 38th nationally in 1988 values of nonfuel minerals.

TRENDS AND DEVELOPMENTS

A major southeastern Oregon epithermal gold discovery highlighted a year of unprecedented large-scale exploration in a region previously thought to have a low potential for gold deposits. New mining claims covering hundreds of square miles were staked. Exploration continued through the winter months, in spite of heavy snow and subzero temperatures.

The economic recovery in Oregon's aluminum industry, begun in 1987, continued throughout the year. Improved international market conditions, higher prices, and continued low inventories led to the resumption of full-scale production at both of the State's reduction plants.

EXPLORATION ACTIVITIES

Exploration in 1988 was focused on gold. Efforts largely shifted from the old producing regions in the northeastern and southwestern parts of the State to the Basin and Range Provinces in southeastern Oregon, where over 5,000 new mining claims were located in Malheur County alone. Precious metal exploration increased during the year, with over 40 companies actively exploring by yearend. In 1988, nearly 12,000 new mining claims were filed, making 68,856 active unpatented mining claims in the State.

In late summer, Atlas Corp. announced a major high-grade epithermal gold deposit discovery at Grassy Mountain, in the Vale District, Malheur County. A first-stage drilling program on a 25,000-acre claim block outlined geological reserves of over 1 million ounces of gold, at an average grade of 0.065 ounce per ton. Despite heavy snows and subzero temperatures, Atlas drilled extensively through the winter and completed over 70 reverse-circulation holes by mid-November.

Much of the region surrounding Grassy Mountain underwent extensive exploration. Chevron Resources Co. completed a second year of drilling at Hope Butte, while Atlas drilled at Double Mountain and evaluated a Vale Buttes site. American Copper & Nickel Co. explored in Harper Basin, and ASARCO Incorporated worked at Shell Rock Butte. Chevron completed its third year of drilling at Quartz Mountain, drilled at Manville Corp.'s Mahogany property, and explored at the Bannock project and at Castle Rock. Manville drilled at the Katey

TABLE 1

NONFUEL MINERAL PRODUCTION IN OREGON[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	203,596	$289	267,824	$986	248,021	$1,049
Gem stones		NA	350	NA	350	NA	894
Nickel (content of ores and concentrates)	short tons	1,175	W	—	—	—	—
Sand and gravel (construction)	thousand short tons	13,441	42,597	e13,000	e42,200	14,880	52,657
Stone (crushed)	do.	e15,100	e53,400	20,663	73,902	e22,200	e77,600
Talc and pyrophyllite	short tons	58	41	150	14	W	W
Combined value of cement, diatomite, gold, lime, pumice, silver (1987–88), stone (dimension, 1986, 1988), and values indicated by symbol W		XX	29,755	XX	43,544	XX	45,988
Total		**XX**	**126,432**	**XX**	**160,996**	**XX**	**178,188**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

property discovered in 1987. Malheur Mining Co. did extensive exploration and development drilling at its Kerby property near Farewell Bend. A production feasibility study was ongoing at yearend.

Earth Search Services Inc. announced the discovery of gold mineralization in a 6,500-acre block of leased land near Malheur Reservoir in northern Malheur County; ongoing evaluation was conducted by its joint venture partner, Goldsearch Resources (U.S.) Inc. Golconda Mining Corp. also drilled a gold prospect near the reservoir. The McDermitt Joint Venture conducted gold exploration in the McDermitt area in southwestern Malheur County near the Nevada border. Noranda Exploration Inc. and Placer Dome (U.S.) Inc. also explored in Malheur County. According to the Oregon Department of Geology and Mineral Industries, Placer staked an entire wilderness study area south of the Owyhee Reservoir.

Large areas in Harney County received first-time attention by gold exploration companies. Cal-Ore Exploration Ventures explored in the Wagontire area, and Corona Gold and Reserve Industries explored and evaluated in the Drewsey vicinity. In southeastern Harney County, Lake Fork and Red Arrow Resources explored for gold in the Pueblo Mountains; Pegasus Gold Corp. evaluated property in the Whitehorse area; and Flagstaff Butte was the site of exploration by Geomex Minerals.

In Lake County, FMC Gold Co. drilled for a second year at its Salt Creek gold prospect, and the N. L. Degerstrom Inc.-Inland Gold & Silver Corp. joint venture explored a block of 224 claims near Paisley. Galactic Resources Ltd. drilled for gold in the old Glass Buttes mercury district, but later dropped the claims.

In the old gold-producing areas in Baker County, Hecla Mining Co. drilled at the Flagstaff Mine and Morrison-Knudsen Co. Inc. drilled for gold mineralization at the Gray Eagle antimony mine; both properties are in the Virtue District east of Baker. Colconda Mining returned for a second year of drilling at the old Record Mine in southwestern Baker County. Cable Cove Mining Co. conducted a small-scale gold and base metals exploration and development program at the Herculean Mine, and Cominco American Inc. explored at the East Eagle Mine in northeastern Baker County.

Goldsearch continued evaluation at the Prairie Diggings Mine, Grant County, and Asarco drilled for gold in Spanish Gulch, Wheeler County. Several companies were active in the Ochoco Mountains, largely in Crook County; Freeport McMoRan Gold Co. drilled on a property near Bear Creek Buttes, and Orbana continued gold exploration at the Ochoco Mine.

In the Klamath Mountains Province of southwestern Oregon, Formosa Resources Corp. continued a long-term exploration program at the Silver Peak Mine, Douglas County. In November, Formosa announced discovery of five sulfide ore bodies with approximately 460,000 tons of reserves grading 0.043 ounce per ton gold, 1.38 ounces per ton silver, 3.40% copper, and 2.83% zinc. Environmental and metallurgical studies were started by yearend. The Amselco-BP America joint venture continued gold, silver, and copper evaluation in the Goff Mine area on Grave Creek, Josephine County. Boise Cascade Corp. and Freeport explored a gold-silver-copper-platinum deposit at the Shamrock Mine, and Boise Cascade evaluated an old mercury mine for gold at Shale City; both properties are in Jackson County.

EMPLOYMENT

According to the Oregon Employment Division, Department of Human Resources, the State's 1988 mining and quarrying employment remained at 1,400 workers, identical to the figure recorded for 1986–87. Reflecting the revival of the domestic aluminum reduction industry that commenced in mid–1987, employment in the nonferrous metals segment of Oregon's primary metals industry increased to 3,800 from 3,700 in 1987 and 3,300 in 1986. Blast furnace and iron and steel foundry employment rose to 6,000 in 1988, an increase of about 400 over that of 1987. Weekly wages for primary metals industry workers averaged $510.30 for a 41.5-hour workweek.

REGULATORY ISSUES

An interim environmental cleanup was completed in May at the Bergsoe Metal Corp. secondary lead smelter site at St. Helens, Columbia County. The Environmental Protection Agency (EPA) monitored the $1 million cleanup, which took about 2 months and was undertaken to prevent the spread of lead and other hazardous materials until the site could be fully cleaned and the hazardous materials removed. EPA and the Oregon Department of Environmental Quality (DEQ) conducted a survey to determine ways to finance permanent site cleanup and closure. Estimates for Government-contracted cleanup were between $15 and $20 million.

EPA gave preliminary approval for a $6.7 million plan to clean up cyanide, fluoride, and sulfate contamination at the Northwest Aluminum Corp. smelter at The Dalles, Wasco County. These contaminants came from smelter wastes that had been stored and treated at the aluminum reduction plant for over two decades. Cleanup plans called for covering sludge ponds, enclosing a spent cathodes waste landfill, and treating the soil and ground water to reduce contaminant levels.

Teledyne Wah Chang Albany (TWCA) moved closer toward disposal of 100,000 cubic yards of slightly radioactive zirconium refinery process waste sludge, stored at its zirconium metal plant near

Albany, Linn County. Contractors began a $200,000 test well drilling and design program in mid-1988 at a potential disposal site about 1 mile north of the TWCA plant. If Federal and State agencies approve disposal plans as scheduled, TWCA could move the sludge by midsummer of 1989. Removal of sludge, now stored in holding ponds on the Willamette River floodplain, could cost TWCA up to $10 million.

LEGISLATION AND GOVERNMENT PROGRAMS

The Oregon Wild and Scenic Rivers bill became law on October 28. It was the most comprehensive wild rivers bill in the lower 48 States in the 20-year history of the Wild and Scenic Rivers Act. The law designated 40 wild and scenic rivers that run through 1,400 miles of lands administered by the U.S. Bureau of Land Management and U.S. Forest Service. Mineral development will not be permitted on these lands.

A joint Federal-State task force, established to evaluate known offshore black sand deposits containing chromium, titanium, zirconium, garnet, and gold, was to attempt to define the extent of black sand deposits off the Oregon coast and evaluate their economic and strategic importance. The ultimate goal was to give the State and the U.S. Department of the Interior the ability to make informal judgements regarding the feasibility of commercially extracting key minerals.

A National Oceanic and Atmospheric Administration exploration team discovered a new field of submarine hot springs bearing polymetallic sulfide minerals on the Gorda Ridge about 100 miles off the Oregon coast. Previously discovered polymetallic sulfides from the Gorda Ridge had concentrations as high as 43% zinc, 14% lead, 5% copper, and 680 parts per million of silver; the new area is as long as five city blocks.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Cement production in Oregon increased nearly 3% in volume and was up over 15% in value from that of 1987. The State's sole cement producer, Ash Grove Cement West Inc., operated a limestone quarry and cement plant throughout the year near Durkee, Baker County.

Most of the cement output was general use and moderate heat Types I and II gray portland cement; a small quantity of masonry cement was also produced. Portland cement produced in the State was used by ready-mixed concrete companies (76%); highway contractors (10%); concrete products manufacturers (9%); building materials dealers (2%); and other contractors, Government agencies, and miscellaneous customers (3%). Raw materials consumed in cement manufacture were locally quarried limestone, clay, shale, and imported iron ore and gypsum. At current production rates, Ash Grove Cement has sufficient reserves of limestone and shale on the property for more than 50 years. The one-kiln, dry-process cement plant used fuel oil and bituminous coal for fuel. All production from the Durkee operation leaves the plant in bulk by truck or rail. Cement to be packaged and shipped to customers is hauled 12 miles east to the old Oregon Portland Cement Co. plant at Linn.

Clays and Zeolite.—Oregon's 1988 clay production decreased by about 7% in quantity but increased 6% in value over that of 1987. Common clay, used chiefly in bricks, ceramic tile, and cement, was mined by three companies in Baker, Jackson, Klamath, Lane, and Multnomah Counties.

Teague Mineral Products Co. produced premium grade sodium bentonite near Adrian, Malheur County. The material was sold as a soil sealant for ponds, ditches, and hazardous waste disposal sites; for drilling mud; and as a binder in livestock feeds. According to Industrial Minerals Magazine, Teague mined about 17,000 metric tons of bentonite in 1988. Bentonite also was mined by Central Oregon Bentonite Co. and Oregon Sun Ranch Inc. from adjoining properties on Camp Creek, Crook County. Central Oregon Bentonite's production was used in drilling mud and pond sealant; the Oregon Sun Ranch bentonite was marketed for pet litter.

Teague produced the zeolite mineral clinoptilolite from a Succor Creek surface mine in Malheur County. The mineral was processed at the company's mill near Adrian and sold for pet litter, odor control, fungicide carriers, anticaking agents, and ammonia absorbent in aquarium systems. Teague also did research and development work on using high-purity zeolite as a filler for the paper industry.

The Norton Co. intermittently mined zeolite in Malheur County; the material was used in end-product manufacture for catalyst and cation absorption applications. Steelhead Specialty Minerals Inc. stockpiled 50,000 tons of potassium clinoptilolite at the Sheaville deposit, Malheur County. Market evaluation of the material was continuing, and a crushing and drying plant was being designed.

Diatomite.—Oregon's diatomite production rose by about 11% in quantity and 13% in value from that of 1987; the State again ranked fourth nationally for diatomite production. Eagle-Picher Industries Inc. operated its Celatom diatomite processing plant near Vale, Malheur County, for production of filler aids for water and food processing and pharmaceuticals. The company mined fresh water diatomite from a surface operation in the Juntura Basin, Harney and Malheur Counties, and trucked the material 70 miles to the plant. Diatomite from Eagle-Picher operations in Nevada was also

transported to Vale for processing.

Oil-Dri Production Co. continued diatomite production at a surface mine and processing plant in Christmas Valley, Lake County. The diatomite was processed without calcining and packaged as pet litter sold under various brand names by several companies.

Lime.—Lime production increased by nearly 9% in quantity and 5% in value from that of 1987. Ash Grove Cement at Portland, Multnomah County, and Amalgamated Sugar Co. at Nyssa, Malheur County, produced lime throughout the year. About 86% of the reported production was quicklime; Ash Grove produced all of the State's hydrated lime. The company barged in limestone from its quarry on Texada Island, British Columbia, Canada, and calcined it at the Portland plant; the production was consumed by local steel, chemical, and paper industry markets. Amalgamated Sugar's lime production was used in-house for beet-sugar refining. The company purchased raw limestone from Ash Grove at Durkee as feed for its plants at Nyssa, OR, and at Nampa, Paul, and Twin Falls, ID.

Perlite.—Supreme Perlite Co. manufactured expanded perlite at Portland, Multnomah County. Product quantities and values were down slightly from those of 1987.

Previously, most of Supreme Perlite's crude perlite was rail-shipped in from No Agua and Socorro, NM; however, the company was developing a perlite deposit on Dooley Mountain, Baker County. By late 1988, the company was processing perlite mostly from that location. The processed perlite was used for bricks for the aluminum reduction industry, in cement, for fireproof building materials, and in horticultural applications.

Pumice.—Oregon again ranked first nationally for pumice production, with quantities and values remaining essentially the same as in 1987. Cascade Pumice Co. and Central Oregon Pumice Co. operated surface mines and crushing and screening plants in the Bend area, Deschutes County. Processed pumice from the two operations was used for lightweight concrete aggregate (49%), building and decorative block (36%), landscaping (8%), road construction and maintenance (5%), and roofing (3%).

Cascade Pumice mined pumice from two open pits and operated a quarry producing red volcanic cinders. Central Oregon Pumice also produced pumice from two open pits and quarried red volcanic cinders from two additional sites.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1987. Data for odd-numbered years are based on annual company estimates.

The 1988 sand and gravel production, produced in 27 counties, increased slightly from that of 1986 and amounts estimated in 1987. Clackamas, Lane, Multnomah, and Marion were major producing counties. Major uses were for road base and cover (27%) and concrete aggregate (23%). The bulk of construction sand and gravel production was transported by truck; lesser quantities were moved by waterways and other methods.

Oregon construction sand and gravel statistics are compiled by geographical districts, as depicted on the centerfold map. Table 3 presents end-use data for construction sand and gravel produced in the four Oregon districts.

Industrial.—CooSand Corp. produced silica sand from sand dunes at Coos Bay, Coos County. The sand was rail-shipped to Portland and sold for sandblasting sand, railroad traction sand, and for the production of colored glass containers.

TABLE 2

OREGON: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	3,484	$13,019	$3.74
Plaster and gunite sands	79	384	4.86
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	3.97
Asphaltic concrete aggregates and other bituminous mixtures	2,830	11,108	3.93
Road base and coverings[1]	4,082	14,288	3.50
Fill	284	692	2.44
Snow and ice control	155	781	5.04
Railroad ballast	W	W	7.11
Other	611	2,363	3.87
Unspecified:[2]			
Actual	986	2,849	2.88
Estimated	2,369	7,174	3.02
Total or average	**14,880**	**[3]52,657**	**3.54**

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1] Includes road and other stabilization (cement and lime).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data do not add to total shown because of independent rounding.

TABLE 3

OREGON: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	2,965	10,932	511	1,985	5	19	141	704
Asphaltic concrete aggregates and other bituminous mixtures	2,155	8,412	576	2,321	—	—	99	374
Road base and coverings[2]	2,906	10,378	738	2,592	109	356	328	962
Fill	182	464	87	200	—	—	14	27
Snow and ice control	117	532	27	185	—	—	12	64
Railroad ballast	—	—	W	W	—	—	W	W
Other miscellaneous	369	900	9	38	—	—	173	1,186
Other unspecified[3]	2,917	8,804	438	1,218	—	—	1	1
Total[4]	**11,610**	**40,423**	**2,387**	**8,539**	**115**	**375**	**768**	**3,319**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for plaster and gunite sands.
[2] Includes sand and gravel for road and other stabilization (cement and lime).
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data may not add to totals shown because of independent rounding.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains actual data for 1985 and 1987, and estimates for 1986. Data for even-numbered years are based on annual company estimates. The estimated quantity and value of 1988 production increased over that of 1987.

Basalt was quarried by several operators in Multnomah and Washington Counties, serving the Portland metropolitan area. Bristol Silica and Limestone Co. produced crushed quartz for decorative granules, abrasives, poultry grit, and filtration medium from a Jackson County quarry.

Ash Grove Cement West produced crushed limestone sold to Amalgamated Sugar Co. for sugar-beet refining. The Ash Grove Durkee quarry, Baker County, supplied limestone for Amalgamated's four plants in southeastern Oregon and southern Idaho.

Talc (Soapstone).—Steatite of Southern Oregon Inc. produced high-grade, variegated-colored soapstone from the Hard Pull Claims in the Klamath Mountains of Jackson County. The soapstone was marketed worldwide for art carving and other specialty uses. Production for 1988 increased significantly in quantity and nearly doubled in value over that of 1987.

Metals

Aluminum.—Primary aluminum production in Oregon increased nearly 32% in quantity and more than doubled in value from 1987.

The aluminum industry's worldwide economic revival, which began in mid-1987, continued through 1988. The State's two aluminum smelters, operating at 92% of total annual rated ingot capacity in January, finished the year producing at 100% of their combined annual rated capacity of 220,000 short tons of ingot. Aluminum prices, which started the year at nearly 88 cents per pound, rose to about $1.06 per pound by yearend.

Reynolds Metals Co.'s Troutdale smelter, Multnomah County, operated throughout the year at its 130,000-short-ton-rated annual capacity. Northwest Aluminum Co. operated its tolling smelter at The Dalles, Wasco County, at a 72,000-ton-per-year rate until the fourth quarter, when production was increased to the plant's rated capacity of 92,000 tons of ingot. Northwest Aluminum toll-smelted imported alumina exclusively for Clarendon Ltd. during 1988.

Energy-saving modifications were implemented at both smelters under a $76 million Bonneville Power Administration (BPA) regional incentive electricity-reduction program. BPA agreed to pay participating companies one-half cent for every kilowatt hour of electricity saved in producing aluminum; however, smelter operation would have to improve and demonstrate energy savings. Plant renovation under way during the year was expected to be finished in 1991.

Columbium, Hafnium, Tantalum, Titanium, and Zirconium.—Teledyne Wah Chang Albany (TWCA) was listed among the major 1988 domestic

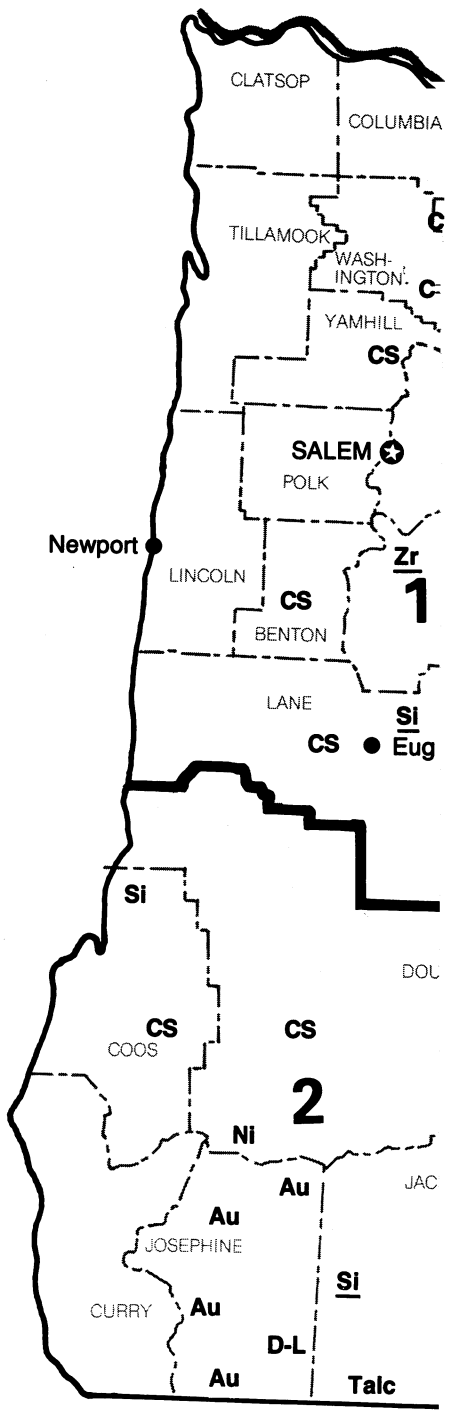
LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Al	Aluminum plant
Au	Gold
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-L	Dimension Limestone
Dia	Diatomite
Gem	Gemstones
Lime	Lime plant
Ni	Nickel
Per	Perlite
Per	Perlite plant
Pum	Pumice
SG	Sand and Gravel
Si	Silicon plant
Talc	Talc minerals
Ti	Titanium plant
Zeo	Zeolite
Zr	Zirconium plant

Principal Mineral-Producing Localities



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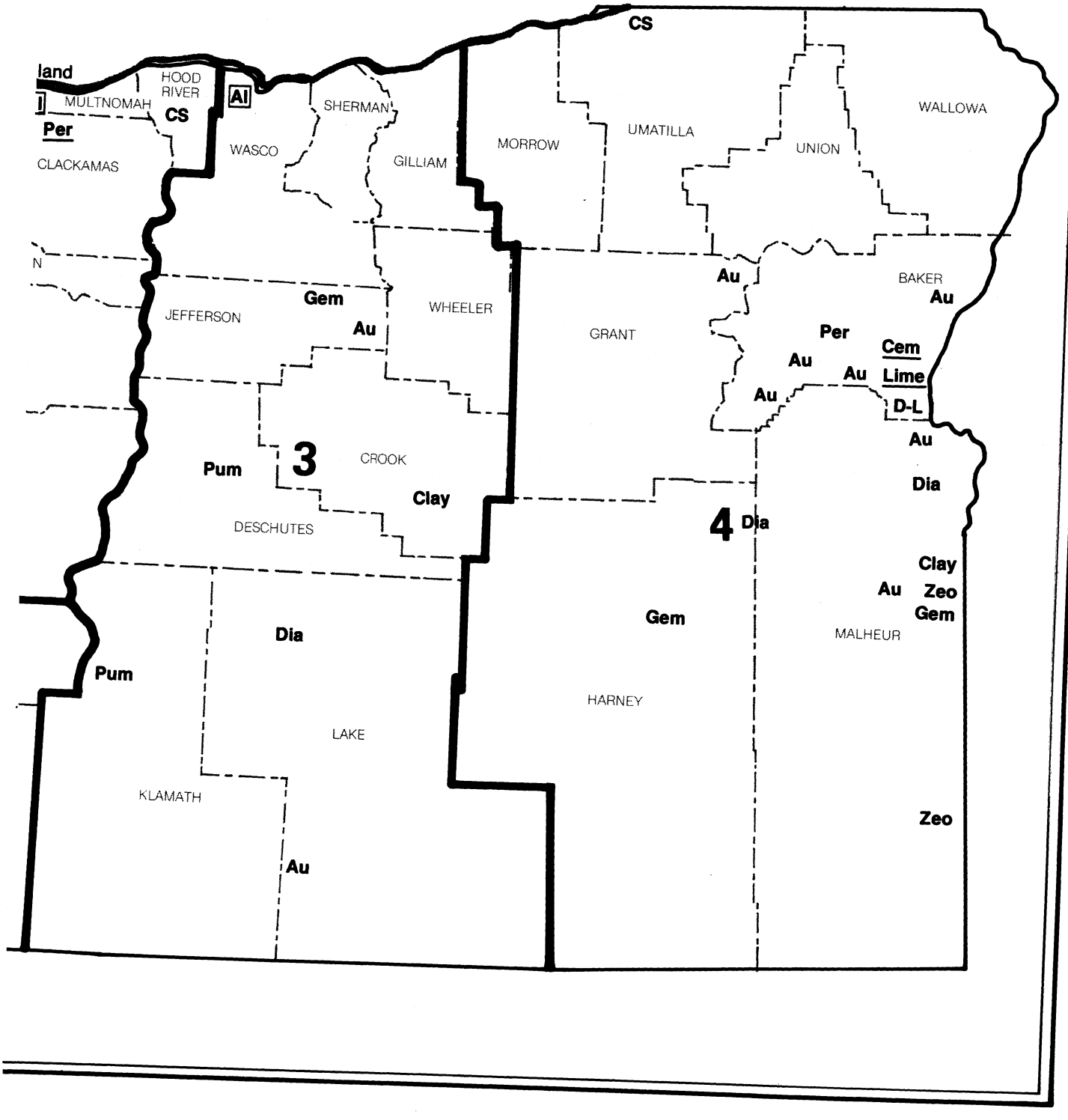
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columbium producers. The company produced high-purity columbium metal for use in superalloys-specialty alloys for jet engines and special alloys for aerospace, chemical processing, and super conductor applications. It also produced high-purity columbium pentoxide and ferrocolumbium.

Tantulum produced by TWCA was used primarily for aerospace engine components. TWCA was the leading domestic producer of zirconium, although sales dropped owing to decreased use by the nuclear energy industry. Hafnium, derived as a byproduct from zirconium production, was produced for use in control rods in nuclear reactors.

TWCA increased its 1988 titanium production. The company concentrated on new products, such as titanium tubing for golf club shafts.

Oregon Metallurgical Corp. (OREMET), at Albany, Linn County, set production records in 1988 for titanium sponge, ingot, billet, plate, and foundry products. According to the company's annual report, sales rose to $75,519,000, a 46% increase over the 1987 level. Over $6 million was invested in capital equipment in 1988 to modernize or enlarge production capabilities. OREMET also produced zirconium castings in 1988.

At yearend, Albany Titanium Inc. sought to liquidate its assets under a court order, less than a year after filing bankruptcy. The company's assets included a pilot plant with titanium and titanium powder-making capabilities, a laboratory, patent rights to a process for making titanium from ilmenite, and the rights to a process that converts titanium chloride into titanium metal and alloys.

Silicon Metal, Polycrystalline Silicon, and Ferrosilicon.—In October, Dow Corning Corp. reactivated its silicon metal plant in Springfield, Lane County. The 20-million-pound-per-year-capacity plant had been idle since September 1987, owing to a combination of high power costs and a massive lining failure in its electric furnace. BPA electric power rates reductions and raw material and labor costs reductions contributed to the decision to restart the plant. All the product is used in-house by Dow Corning; the plant supplies about 20% of the company's silicon metal needs for silicone product manufacturing.

Early in the year, Nippon Kokan KK indefinitely delayed completion of its $60 million polycrystalline silicon plant at Millersburg, Linn County. The company had planned to begin production in late 1988, but a slump in the demand for polycrystalline silicon for silicon semiconductor wafers led to the postponement decision. Resumption of construction depends on market recovery; about 80% of site preparation and preliminary foundation work was done before the halt was declared.

Nickel Mountain Resources, a subsidiary of Universal Consolidated Cos., was negotiating with BPA at yearend to obtain a favorable electric power rate for its ferrosilicon smelter at Riddle, Douglas County. The operation, once owned by Hanna Mining Co., produced ferronickel from 1954 to 1987. The facility has one ferrosilicon furnace that could produce 50 tons per day of 50% ferrosilicon and four large nickel-reduction furnaces.

Steel.—After several stagnant years, 1988 was the most profitable year in a decade for the Oregon steel industry. Oregon Steel Mills Inc., a Portland steel plate and pipe producer, reported that its production was about 360,000 tons, up from 300,000 tons in 1987. Oregon Steel Mills and California Steel Industries completed a preliminary study on a joint steel-slab venture which could produce up to 1 million tons of slab per year. The proposed $80 million to $100 million electric furnace plant would be in Oregon and would produce slab steel for California Steel's rolling mill and for outside marketing. The proposed plant would not be built for at least 3 years.

ESCO Corp. of Portland celebrated its 75th year in the electric-furnace steel casting business. The company is the largest independent domestic producer of steel and alloy castings for machines in construction, logging, mining, and the aerospace industry.

Cascade Steel Rolling Mills Inc. announced construction of a $20 million melt shop at its existing mill in McMinnville, Yamhill County. The new shop would double capacity at the existing melt shop to 610,000 tons of steel per year. The rolling mill has a present capacity of 450,000 tons per year; it would require two additional shifts per day to match the added melt shop capacity.

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[1]State Mineral Officer, Bureau of Mines, Spokane, WA.

[2]Editorial assistant, Bureau of Mines, Spokane, WA.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Northwest Aluminum Co.	3313 West 2d St. The Dalles, OR 97058	Smelter	Wasco.
Reynolds Metals Co.	5100 NE. Sundial Rd. Troutdale, OR 97060	do.	Multnomah.
Cement:			
Ash Grove Cement West Inc.[1]	5550 SW. Macadam Ave. Suite 300 Portland, OR 97201	Plants and quarries	Baker.
Diatomtie:			
Eagle-Picher Industries Inc.	Graham Blvd. Vale, OR 97918	Surface mine and plant	Harney and Malheur.
Oil-Dri Production Co.	Box 191 Christmas Valley, OR 97638	do.	Lake.
Lime:			
Amalgamated Sugar Co.	Box 1766 Nyssa, OR 97913	Plant	Malheur.
Ash Grove Cement West Inc.	5550 SW. Macadam Ave. Suite 300 Portland, OR 97201	do.	Multnomah.
Perlite (expanded):			
Supreme Perlite Co.	4600 North Suttle Rd. Portland, OR 97217	do.	Do.
Pumice:			
Cascade Pumice Co.	Box 1087 Bend, OR 97701	Pit	Deschutes.
Central Oregon Pumice	5 NW. Greenwood Ave. Bend, OR 97701	Pit	Do.
Sand and gravel (construction):			
Cascade Aggregate	5975 E. Marginal Way South Seattle, WA 98111	Pit	Columbia.
Lone Star Northwest Aggregates	3510 SW. Bond St. Portland, OR 97201	Pits	Clackamas and Multnomah.
Morse Brothers Inc.	Box 251 Tangent, OR 97389	do.	Linn and Marion.
Talc (soapstone):			
Steatite of Southern Oregon Inc.	2891 Elk Lane Grants Pass, OR 97527	Surface mine and mill	Jackson.
Titanium:			
Oregon Metallurgical Corp.	Box 580 Albany, OR 97321	Smelter	Linn.
Zeolite:			
Teague Mineral Products Co.[2]	Box 35-C, Rt. 2 Adrian, OR 97901	Surface mine and plant	Malheur.
Zirconium:			
Teledyne Wah Chang Albany[3]	1600 NE. Old Salem Rd. Albany, OR 97321	Plant	Do.

[1] Also clays, pumicite, and crushed stone.
[2] Also bentonite.
[3] Also columbium, hafnium, tantalum, and vanadium.

THE MINERAL INDUSTRY OF PENNSYLVANIA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Pennsylvania Bureau of Topographic and Geologic Survey, Department of Environmental Resources, for collecting information on all nonfuel minerals.

By L. J. Prosser, Jr.,[1] and S. W. Berkheiser, Jr.[2]

The value of nonfuel mineral production in Pennsylvania in 1988 exceeded $1 billion for the second consecutive year. The value of $1,042 million was the highest ever reported for the State and showed an increase of $26 million compared with that of 1987.

Pennsylvania, historically noted as a center for coal and steel production, has become the Nation's top crushed stone producer. In 1988, Pennsylvania became the first State to produce more than 100 million short tons of crushed stone. In the last 2 years, about 202 million tons of crushed stone has been produced in the State.

TRENDS AND DEVELOPMENTS

Pennsylvania has moved to the forefront as one of the Nation's leading producers of industrial minerals. Traditionally, the State's minerals industry was dominated by coal and steel production. Indigenous resources, waterway and rail transportation systems, and stable market conditions provided Pennsylvania with the competitive advantages necessary to lead the Nation in output of coal and steel. From the turn of the century until the late 1970's, coal and steel fueled the State's economy by providing employment for hundreds of thousands of workers through mining and metal manufacturing.

During the 1980's, the State's steel and coal industries continued to decline. Increased international competition, followed by declining oil prices, forced cutbacks and closures at mines and mills throughout the State. Initially, the decline was considered temporary or part of the economic cycle with steel and coal the last to rebound. However, conditions improved only slightly for steel in 1988, and coal production remained at the 60-million-ton-per-year level. In part because of environmental concerns, a return to high production levels of previous decades was considered unlikely as the 1990's approached.

While the coal and steel industries were declining, the State's crushed stone industry was expanding. Demand by the construction industry for aggregate resulted in record-setting production of crushed stone in Pennsylvania in each of the past 2 years. Output of 97.2 million short tons in 1987 and 104.6 million tons in 1988 was the highest ever reported for a single State in the Nation.

In 1988, the State continued in the third year of a $11.7 billion highway improvement and construction program. According to a study by The Road Information Program, that work has generated 26,774 jobs annually: 12,412 in construction; 4,017 in retail trade; 4,017 in the service sector; 2,740

TABLE 1

NONFUEL MINERAL PRODUCTION IN PENNSYLVANIA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	391	$26,683	397	$30,464	391	$28,713
Portland	do.	6,290	324,187	6,325	334,709	6,309	329,634
Clays[2]	short tons	1,233,791	5,061	1,206,121	4,751	1,375,836	5,843
Gem stones		NA	5	NA	5	NA	5
Lime	thousand short tons	1,417	81,234	1,574	93,430	1,641	91,214
Peat	do.	19	532	18	513	21	736
Sand and gravel:							
Construction	do.	15,373	68,880	e14,800	e72,900	19,826	91,966
Industrial	do.	688	10,091	W	W	W	W
Stone:							
Crushed	do.	e63,700	e317,100	97,213	458,676	e104,600	e470,700
Dimension	short tons	e72,352	e8,100	60,118	10,177	e59,022	e9,584
Combined value of clays (kaolin), mica (scrap), tripoli and values indicated by symbol W		XX	1,185	XX	r10,872	XX	14,098
Total		**XX**	**843,058**	**XX**	**1,016,497**	**XX**	**1,042,493**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

in manufacturing; and 3,588 in other industries.[3]

EMPLOYMENT

A comparison with 1983 data showed the decline in employment in mining and primary metals resulted from lower output of coal and steel. Mining employed 42,000 workers in 1983, but only 30,000 in 1988. Similarly, employment in primary metals has dropped from 123,000 to 92,000 workers. In contrast, construction industry employment has increased by nearly 55% from 153,000 in 1983 to 236,000 in 1988.[4]

LEGISLATION AND GOVERNMENT PROGRAMS

The Pennsylvania General Assembly enacted House bill 1852 creating a State "superfund" program requiring generators of hazardous waste to be taxed for transportation, storage, and disposal of those wastes. The law was expected to generate $30 million annually for cleanup of waste sites. Pennsylvania also enacted legislation requiring a mandatory recycling program under House bill 528. Communities with populations of more than 10,000 were required to begin curbside collection programs within 2 years for three of the following items: clear glass; colored glass; aluminum, steel, and bimetal cans; high-grade office paper; newsprint; corrugated paper; and plastics. Both of these measures were expected to have a greater impact on the minerals manufacturing sector than on the mining industry.

The Ad Hoc Subcommittee on Coal, formed through House Resolution 55, approved a report addressing conditions in the State's coal industry. Coal production has declined in Pennsylvania from 89 million short tons in 1979 to 65 million tons in 1988. The report included the following recommendations: creating a State Department of Energy to promote use of Pennsylvania coal; providing tax credits for purchase of Pennsylvania-mined coal; encouraging research and development; and requiring State-owned, -related, or -supported facilities to use coal.

The Federal Highway Administration approved the use of about 400,000 tons of fly ash as fill in construction of a portion of an interstate highway north of Pittsburgh. Fly ash, a byproduct of coal burning powerplants, has been used as a concrete additive in about 40 States, but had never before been used in such large quantities in interstate highway construction.[5]

The Pennsylvania Bureau of Topographic and Geologic Survey was the primary State agency involved in mineral resource investigations. During the year, the Survey continued studies on identifying sources of high-purity carbonates because it anticipated increased demand for limestone used in sulfur removal and acid water neutralization. Other ongoing investigations were for potential mica, talc, silica, and carbonates in the Piedmont physiographic province of the State for use in industrial applications as mineral fillers. Coal resource mapping projects for illustration of crop lines, mined-out areas, and structure controls were continued in Clearfield, Greene, Elk, Indiana, Jefferson, and Washington Counties.

A reconnaissance study by the Pennsylvania Survey for precious metals in the southeastern part of the State identified several conceptual targets and some pan-concentrate anomalies. Followup bedrock sampling in volcanic terrain and layered igneous complexes continued. Another study in York County identified palladium and gold anomalies. The U.S. Geological Survey verified a palladium-bismuth antimonide in the area.[6] This investigation continued in cooperation with the Pennsylvania Survey, which reported gold values up to 0.26 ounce per ton from early Mesozoic contact skarns.[7]

The U.S. Bureau of Mines Pittsburgh Research Center continued research programs directed at improving health, safety, and productivity in the mining industries and conserving environmental resources. Mine-scale research was conducted under controlled conditions at facilities including the Experimental Mine, the Safety Research Coal Mine, the Mine Equipment Test Facility, the Wire Rope Laboratory, and the Lake Lynn Laboratory.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

In 1988, 4 of the 12 nonfuel minerals produced in Pennsylvania accounted for 95% of the total value as given in table 1. Output of crushed stone and portland cement accounted for 45% and 32% of the State's value, respectively. Construction sand and gravel and lime each contributed 9%. Output increased for sand and gravel by 34%, crushed stone by 8%, and lime by 4%; portland cement output declined slightly.

Output levels of these four commodities in 1988 were indicative of continued strong demand by the construction industry. Crushed stone production was the highest ever recorded in Pennsylvania, sand and gravel output was the highest since 1979, and lime was the highest since 1981. Although portland cement output declined slightly, the production of about 6.3 million short tons in 1988 exceeded 6.2 million tons for the third consecutive year. This continued level of production had not occurred since the 1977–79 period. Not only the mineral commodities were in demand; but so were the pits, quarries, and mines, as indicated by the transactions that occurred during the year and detailed in the following commodity section.

Cement.—Two of the twelve active cement plants in the State were sold

during the year. Scancem Industries Inc. of Norway purchased Allentown Portland Cement Co. in Evansville for $63.5 million in an acquisition initiated late in 1987 and completed in January of 1988.[8] The plant had an annual capacity of 830,000 short tons. Lone Star Industries Inc. and Moore McCormack Cement Inc. (subsequently acquired by Southdown Inc.) formed a joint venture involving the Lone Star plants at Pittsburgh, PA, and Superior, OH, (inactive) and the Moore McCormack subsidiary Kosmos Cement Co. in Kosmosdale, KY. The plants had a combined annual capacity in excess of 1 million short tons. Also during the year, an offer was made for Keystone Cement Co. in Bath and Giant Cement Co. in Harleyville, SC, both subsidiaries of Giant Group Ltd. The offer of $110 million by Environmental Treatment and Technologies Corp. of Ohio was lowered and subsequently rejected by Giant Group.

Pennsylvania ranked third nationally in output of portland cement and contributed 9% of U.S. output.

TABLE 2

PENNSYLVANIA: LIME SOLD OR USED BY PRODUCERS, BY USE

Use	1987		1988	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Agriculture	35,541	$1,811	17,876	$1,010
Acid water neutralization	15,914	1,022	80,534	4,595
Paper and pulp	W	W	31,025	1,483
Steel, basic oxygen	W	W	490,873	24,555
Steel, electric	132,503	6,057	213,556	10,152
Sewage treatment	90,211	5,062	74,348	4,284
Water purification	45,830	2,624	33,338	19,853
Other[1]	1,254,015	76,854	699,588	25,282
Total	**1,574,014**	**93,430**	**1,641,138**	**91,214**

W Withheld to avoid disclosing company proprietary data; included with "Other."

[1] Includes glass (1988), industrial solid waste, ladle desulfurization, open hearth steel, ore concentration, other chemical and industrial, other metallurgy, paint, petroleum refining, refractory, road stabilization, sand-lime brick, silica brick, sugar refining, sulfur removal, tanning, wire drawing; and uses indicated by symbol W.

Lime.—One of the nine active lime plants in Pennsylvania was sold in 1988. Glenn O. Hawbaker Inc. purchased the operation of Marblehead Lime Co. in Pleasant Gap, Centre County, for $5.6 million and renamed it Centre Lime & Stone Co. Inc.[9]

In 1988, Pennsylvania ranked third nationally in lime output, producing about 1.6 million short tons. About 45% of the lime produced, about 700,000 tons, was used by the steel industry. In 1978, 60% of the lime production in Pennsylvania, or 1.3 million tons of lime, was consumed by the steel industry. Because of worldwide excess capacity in the steel industry, a significant increase in lime production in Pennsylvania for that use did not occur. However, use of lime for environmental control applications was increasing and was expected to continue to increase, particularly if Federal clean air legislation requires scrubbers at coal-burning electric utility plants.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1987. Data for odd-numbered years are based on annual company estimates.

Pioneer Concrete Services Ltd. of Australia purchased one of the State's leading sand and gravel producers, Davison Sand & Gravel Co., for an estimated $50 million.[10] The sale included four plants, dredging operations, and a towboat and barge company.

Reflecting continued strong demand from the construction industry, sand and gravel production increased to 19.8 million short tons in 1988, the highest output since 1979. Sand and gravel was produced in 37 of Pennsylvania's 67 counties. Westmoreland, Bucks, Luzerne, Armstrong, and Beaver were the leading producing counties in order of descending output. Statewide, 106 companies operated 151 pits.

Pennsylvania sand and gravel production statistics are compiled by geographical districts. Table 4 presents end-use data for sand and gravel in the four Pennsylvania districts that are outlined in the centerfold map. A comparison of district data in 1988 with that of 1986 showed a significant increase in production in district 4. That district, which includes 19 counties in the southeastern part of the State, also reported the lowest county unemployment rates in the State, indicative of the sustained economic growth in that area. A total of 11 counties in district 4 had unemployment rates of less than 3.7%, which was 1.0% below the State average and 1.6% below the U.S. average.[11]

District 4 was also the leading area for crushed stone production and accounted for about 70% of the State's output in 1987. Low unemployment often reflects strong economic growth. Sometimes overlooked is the relationship between economic growth and mineral production, particularly for industrial minerals. The availability of sand and gravel and crushed stone in Pennsylvania has spurred and facilitated economic development in building and highway construction projects.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-

TABLE 3

PENNSYLVANIA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	4,672	$25,608	$5.48
Plaster and gunite sands	351	2,081	5.93
Concrete products (blocks, bricks, pipe, decorative, etc.)	442	2,237	5.06
Asphaltic concrete aggregates and other bituminous mixtures	2,550	12,287	4.82
Road base and coverings[1]	3,101	13,048	4.21
Fill	788	1,753	2.22
Snow and ice control	252	1,148	4.56
Other[2]	2,223	5,619	2.53
Unspecified:[3]			
Actual	3,793	22,718	5.99
Estimated	1,654	5,466	3.30
Total or average	**19,826**	**[4]91,966**	**4.64**

[1] Includes road and other stabilization (cement).
[2] Includes roofing granules.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data do not add to total shown because of independent rounding.

numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

Crushed.—A major acquisition in the crushed stone industry in 1988 was the purchase of Pittsburgh-based Koppers Co. by Beazer PLC, of the United Kingdom. Beazer acquired 80 stone quarries and 24 sand and gravel operations in a $1.8 billion transaction. The sale included Kopper's subsidiary, the General Crushed Stone Co., which operated eight quarries in Pennsylvania. Beazer named its new operations Beazer Materials & Services Inc. (BM&S). Also during the year, BM&S, through its subsidiary, HRI Inc. (Herbert R. Imbt Inc.), purchased Columbia Asphalt Corp. in Columbia County. The sale included 344 acres of land, 3 asphalt plants, a sandstone quarry, and a sand and gravel operation for about $6 million.[12] Another United Kingdom firm, Scottish Heritable Trust PLC, purchased about 28% of the outstand-

TABLE 4

PENNSYLVANIA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	570	2,191	523	3,023	986	6,408	2,593	13,986
Plaster and gunite sands	—	—	34	226	—	—	317	1,856
Concrete products (blocks, bricks, etc.)	178	617	70	408	149	1,005	46	207
Asphaltic concrete aggregates and other bituminous mixtures	524	2,167	763	3,809	772	5,109	490	1,203
Road base and coverings[1]	1,235	4,037	706	2,787	340	1,507	821	4,717
Fill	208	577	455	785	112	W	12	W
Snow and ice control	123	427	51	262	48	W	30	W
Other miscellaneous[2]	286	1,118	71	210	1,566	3,151	300	1,989
Other unspecified[3]	769	2,952	1,989	9,196	2,340	15,140	348	896
Total[4]	**3,892**	**14,087**	**4,664**	**20,705**	**6,313**	**32,321**	**4,957**	**24,854**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (cement).
[2] Includes sand and gravel for roofing granules.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data may not add to totals shown because of independent rounding.

ing shares of the Rangaire Corp.[13] Rangaire, Pennsylvania's seventh leading crushed stone producer, operated the Corson Quarry and lime plant in Montgomery County.

As Pennsylvania's crushed stone industry produced record tonnages in 1987 and 1988 of 97.2 million tons and 104.6 million tons, respectively, the opening and expansion of quarries became a controversial and emotional issue in many towns and communities. Generally, citizens claimed that developments in the stone industry would cause noise, dust, and traffic to increase, thus degrading the quality of life and potentially lowering the value of their homes and property. A quarry controversy in West Rockhill Township, Montgomery County, illustrated how extreme opposition can be to the opening of a new quarry. A citizens group has fought the proposed quarry at Naceville since 1969 and was expected to continue opposition, having budgeted $60,000 for legal costs in 1989.

Township officials continued to challenge air, water, and mining permits approved by the Pennsylvania Department of Environmental Resources for operation of a quarry by Magnatti Construction Co. However, it may be 1990 before the township's case may be heard because the State's ruling authority, the Environmental Hearing Board, had a backlog of 1,100 cases.[14]

Other Industrial Minerals.—The mineral commodities discussed below collectively accounted for about 5% of the value of Pennsylvania's nonfuel mineral production as given in table 1.

Masonry cement was produced at 11 plants in Pennsylvania in 1988. Output of nearly 400,000 short tons ranked the State third nationally in production and accounted for 11% of the U.S. total. Demand for common clay and shale, used in the manufacture of brick, resulted in the third consecutive year of output of more than 1.2 million short tons. Production of fire clay increased significantly as demand by the steel industry for refractory brick showed improvement. Output of kaolin more than tripled as uses for environmental applications expanded. Scrap mica was mined near Fairfield, Adams County, and sold primarily as filler. About 21,000 short tons of peat was mined by eight companies with most of the production from Lackawanna and Monroe Counties. Industrial sand, used primarily for manufacture of glass containers, was mined in Huntingdon County. A small quantity of industrial sand was also produced in Allegheny County and used in castings. Bluestone, slate, sandstone, and diabase were quarried for dimension stone. Dimension slate was produced in only five States, with Pennsylvania leading the Nation in output. Increasing quantities of diabase were shipped to Elberton, GA, for finishing as monuments. Tripoli or rottenstone was produced by one company in Northumberland County and sold for use as a mild abrasive for polishing compounds and as filler.

Mineral commodities processed in Pennsylvania included those that were imported, shipped from domestic sources, or manufactured into higher value end products. Commodities surveyed by the Bureau of Mines were synthetic graphite, iodine, expanded perlite, sulfur (recovered), sulfuric acid, and exfoliated vermiculite. The combined value of these commodities was about $75 million.

Metals

No metals were mined in Pennsylvania. Metals discussed in the section were processed from materials received from both foreign and domestic sources. Production and value data for these metals are not included in table 1.

Beryllium.—NGK Metals Corp., a subsidiary of NGK Insulators Ltd., announced a 2-year, $15 million plant capacity expansion program. NGK of Japan purchased the plant in Reading from the Cabot Corp. in 1986 and continued production of beryllium-copper alloys. Beryllium copper was used in the manufacture of electronic components for appliances and other consumer products.

Iron and Steel.—Steel production increased 18% in 1988 to 13.7 million short tons but was less than one-half the output of 28.2 million short tons reported in 1979. Pig iron shipments were not reported to the Bureau of Mines in 1988, because several of the Nation's major producers decided against responding to the Bureau survey. However, for the last 6 years, steel production and pig iron shipments in Pennsylvania have been reported at about a 2-to-1 ratio. Based on that ratio, pig iron shipments in 1988 were estimated at 6.9 million tons, an increase of 1.8 million tons compared with the 1987 total.

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[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA.

[2] Economic geologist, Pennsylvania Bureau of Topographic and Geologic Survey, Department of Environmental Resources, Harrisburg, PA.

[3] Constructioneer. Highway Spending Would Create Jobs, Increase Tax Revenues. South Edition, Aug. 15, 1988, p. 93.

[4] Pennsylvania Business Survey. College of Business Administration, the Pennsylvania State University, University Park, PA, Feb. 1984 and Feb. 1989, pp. 4.

[5] Constructioneer. Trumbull Corporation Uses 300,000 Yards of Fly Ash. Dec. 5, 1988, p. 15.

[6] Gottfried, D., and A. J. Froelich. Variations of Palladium and Platinum Contents and Ratios in Selected Early Mesozoic Thokiltic Rock Associations in the Eastern United States, ed. by A. J. Froelich and G. R. Robinson, Jr. Studies of the Early Mesozoic Basins of the Eastern United States, U.S. Geol. Surv. Bull. 1776, 1988, pp. 332-340.

[7] Smith, R. C., II, S. W. Berkheiser, Jr., and D. T. Holt. Locations and Analyses at Selected Early Mesozoic Copper Occurrences in Pennsylvania, ed. by A. J. Froelich and G. R. Robinson, Jr. Studies of the Early Mesozoic Basins of the Eastern United States, U.S. Geol. Surv. Bull. 1776, 1988, pp. 320-331.

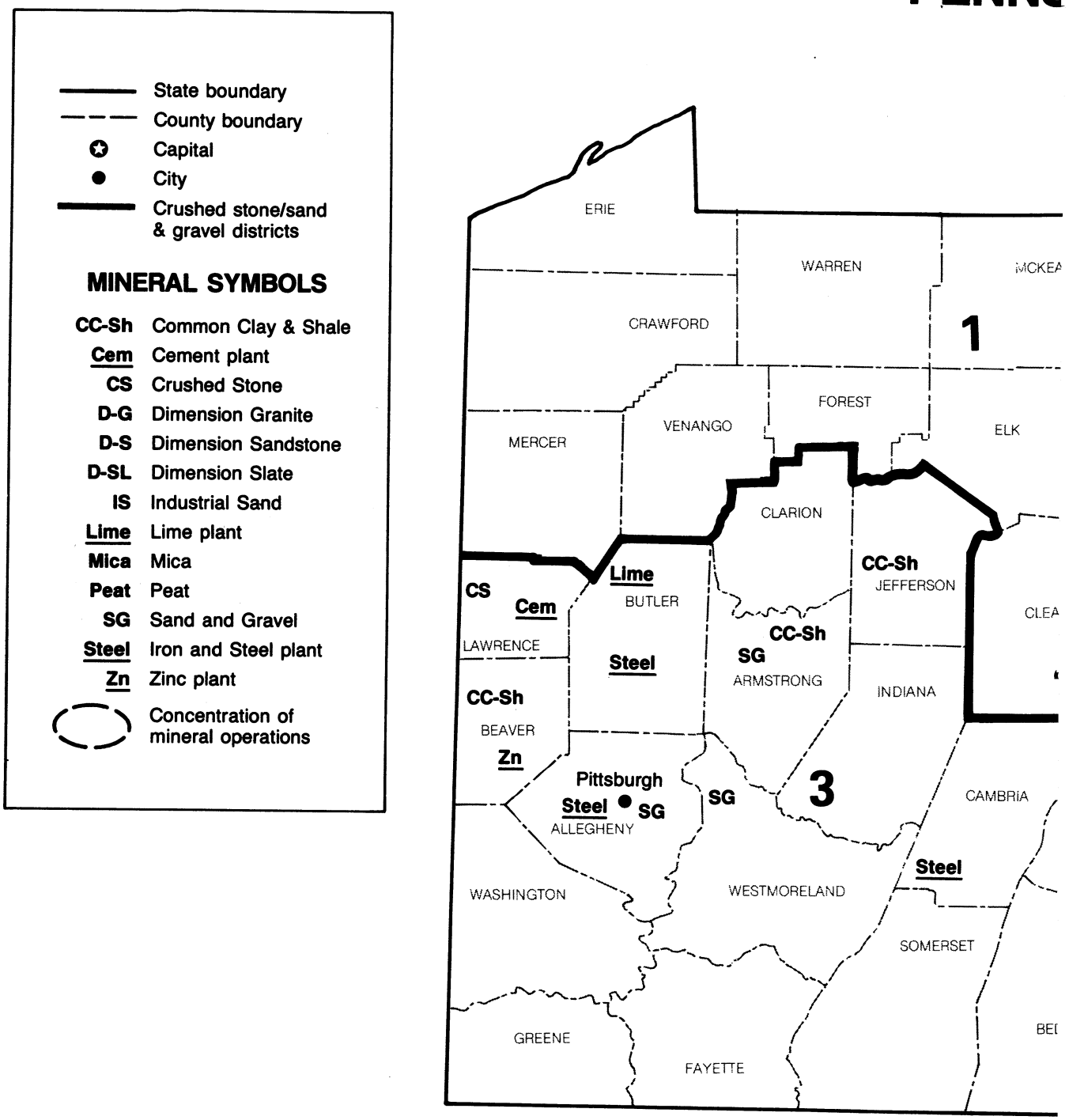
[8] Rock Products. Scancem Acquires Allentown Cement. Jan. 1988, p. 9.

[9] Centre (PA.) Daily News. Lime Plant Sold for $5.6 Million. Jan. 28, 1988, p. 1.

[10] Rock Products. Australians Plan To Acquire Davison Sand & Gravel Co. Apr. 1988, p. 7.

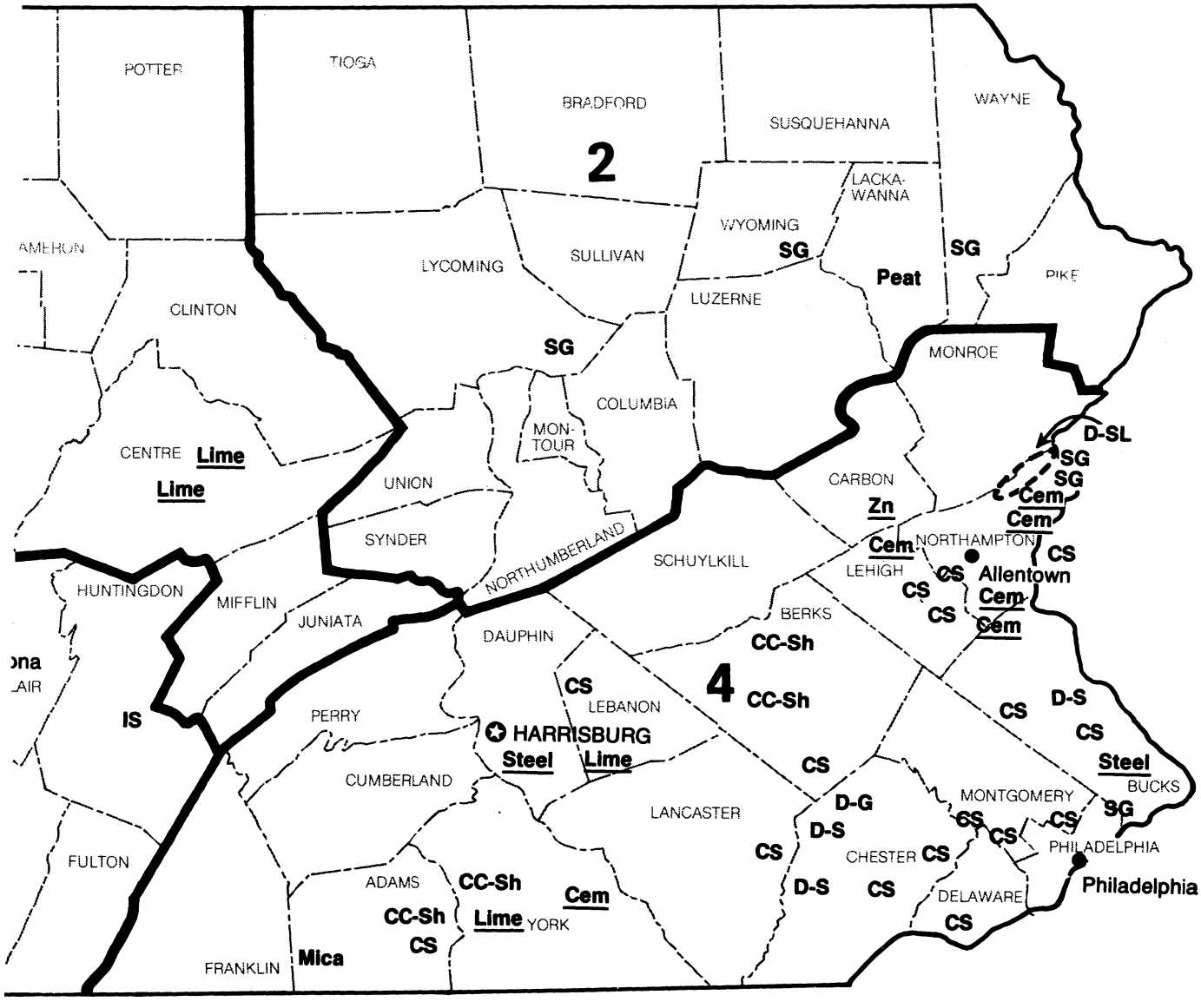
[11] Pennsylvania's Labor Force, Dec. 1988 Data.

PENNS



Principal Mineral-Producing Localities

VANIA


POTTER
TIOGA
BRADFORD
2
SUSQUEHANNA
WAYNE
LACKA-
WANNA
WYOMING
SG
SG
Peat
SG
PIKE
LUZERNE
LYCOMING
SULLIVAN
CLINTON
SG
MONROE
COLUMBIA
MON-
TOUR
D-SL
SG
SG
Cem
Cem
CENTRE Lime
Lime
UNION
CARBON
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SYNDER
NORTHUMBERLAND
SCHUYLKILL
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NORTHAMPTON
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LEHIGH
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Allentown
CS
Cem
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Cem
HUNTINGDON
MIFFLIN
JUNIATA
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LEBANON
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CS
Steel
BUCKS
CUMBERLAND
LANCASTER
D-G
MONTGOMERY
SG
D-S
CS
CS
CS
CS
PHILADELPHIA
CHESTER CS
FULTON
ADAMS
CC-Sh
Cem
D-S
CS
DELAWARE
Philadelphia
CC-Sh
Lime
YORK
CS
CS
FRANKLIN
Mica

Table 5. Pennsylvania Counties Ranked by Rate of Unemployment. Dec. 1988, p. 6.

[12]Press Enterprise (Bloomsburg, PA). British Giant Buys Regional Quarry Firm. Jan. 4, 1989, p. 1.

[13]Rangaire Corp. Special Report to Stockholders, Box 177, Cleburne, TX 76031, Aug. 1988, p. 1

[14]The Times Herald (Norristown, PA). West Rockhill Will Continue Quarry Fight. Dec. 28, 1988, p. 1.

TABLE 5

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Allentown Portland Cement Co.	Box 199 Blandon, PA 19510	Plant and quarry	Berks.
Coplay Cement Co.	Drawer 32 Nazareth, PA 18084	Plant and quarries	Lehigh and Northampton.
General Portland Inc.	5160 Main St. Whitehall, PA 18052	Plant	Lehigh.
Hercules Cement Co.	Center St. Stockerton, PA 18083	Plant and quarry	Northampton.
Lone Star Industries Inc.	Wood and Prospect St. Box 270 Nazareth, PA 18064	Plant	Do.
Clays and shale:			
L. D. Baumgardner Coal Co. Inc.	Box 104, R.D. 3 Phillipsburg, PA 16866	Pit	Clearfield.
Glen-Gery Corp.	Box 1542 Reading, PA 19603	Pits and plant	Adams, Berks, York.
Medusa Corp.	Box 5668 Cleveland, OH 44101	Pit	Lawrence.
Lime:			
J. E. Baker Co.	320 N. Baker Rd. York, PA 17404	Plant and quarry	York.
Bellefonte Lime Co. Inc.	Box 448, N. Thomas St. Bellefonte, PA 16823	Plant and quarries	Do.
Broyhill & Associates Inc.[1]	R.D. 1 Annville, PA 17003	Plants and quarries	Adams and Lebanon.
Centre Lime & Stone Co. Inc.	Box 130 Pleasant Gap, PA 16823	Plant and quarry	Centre.
Mercer Lime & Stone Co.	525 William Penn Pl. Pittsburgh, PA 15219	Plant	Butler.
Peat:			
Gouldsboro Wayne Peat Co.	Box 68 Gouldsboro, PA 18424	Bog	Lackawanna.
Hyponex Corp.	2013 S. Anthony Blvd. Fort Wayne, IN 46803	Bog and plant	Monroe.
Sand and gravel:			
Construction:			
Davison Sand & Gravel Co.	3d Ave. and 4th St. New Kensington, PA 15068	Dredge and pits	Armstrong and Westmoreland.
Dravo Corp.	4800 Grand Ave. Pittsburgh, PA 15222	Dredge, pit, plant	Allegheny and Beaver.
Glacial Sand & Gravel Co.	Box 1022 Kittanning, PA 16201	do.	Armstrong.
Stabler Co. Inc.[1]	Box 3188 Wescoville, PA 18106	Pits and plants	Bradford and Northampton.
Warner Co.	699 Bristol Pike Morrisville, PA 19067	Pit and plant	Bucks.
Wyoming Sand & Stone Co.	R.D. 1 Falls, PA 18615	do.	Wyoming.

See footnote at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Industrial:			
McCrady Inc.	Box 11566 Pittsburgh, PA 16238	Quarries and plant	Allegheny.
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	do.	Huntingdon.
Stone:			
Crushed:			
Beazer Materials & Service Inc.	436 7th Ave. Pittsburgh, PA 15219	do.	Berks, Bucks, Chester, Clinton, Columbia, Dauphin, Delaware, Lancaster, Montour, Tioga, York.
New Enterprise Stone & Lime Co. Inc.	R.D. 3 New Enterprise, PA 16664	do.	Adams, Bedford, Blair, Cumberland, Franklin, Huntingdon, Lancaster, Somerset.
Dimension:			
A. Dally & Sons Inc.	Railroad Ave., Box 27 Pen Argyl, PA 18072	Quarries and mills	Northampton.
Delaware Quarries	Rt. 22 Lumberville, PA 18933	Quarry	Bucks.
Pennsylvania Granite Corp.	Box 510 St. Peters, PA 19470	do.	Chester.

[1] Also stone.

THE MINERAL INDUSTRY OF PUERTO RICO, NORTHERN MARIANAS, ISLAND POSSESSIONS, AND TRUST TERRITORY

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Department of Natural Resources, Commonwealth of Puerto Rico, for collecting information on all nonfuel minerals.

By Doss H. White, Jr.,[1] Ivette E. Torres,[2] and Ramon M. Alonso[3]

THE COMMONWEALTH OF PUERTO RICO

In 1988, the value of Puerto Rico's nonfuel mineral commodities (excluding construction sand and gravel) produced by the extractive mineral industry was $167 million. The value was an increase of $15 million over that of 1987 and was a record high for the Commonwealth's mineral industry. More than 90% of Puerto Rico's mineral production was used by the island's construction industry. A profitable year for construction means increased sales for the mineral producers, and 1988 was a good year for the Commonwealth construction firms.

Trends and Developments

Much of the extractive mineral tonnage produced in Puerto Rico—cement, clay, lime, salt, sand and gravel, and stone (both crushed and dimension)—provided the basic raw materials for the island's construction companies. Although the construction industry's share of Puerto Rico's gross domestic product (GDP) plummeted from 22.3% in 1972 to 9.6% in 1987, construction remains an important segment of the Commonwealth's economy.

The effect of the 12% GDP decrease on the mineral industry may be gauged by stone and cement output. In 1972, the Commonwealth produced 13.5 million short tons of stone and 1.9 million short tons of cement. In 1988, 1.4 million tons of stone and 9.4 million tons of cement were produced, a decrease of 30% and 26%, respectively.

In 1987, the last year for which employment figures are available, the construction industry employed about 41,000 workers, almost 5% of the island's total work force. In the 1970's, private investments fueled the major portion of the island's construction activity. However, in the 1980's, public sector construction such as roads, bridges, and prisons accounted for almost 60% of the construction spending, indicating the reliance of the construction and construction minerals industry on public funding.

Despite the decline in private sector construction as compared to the public sector, the 3 years of 1986 through 1988 witnessed the decade's highest number of housing starts, which buoyed the demand for construction mineral commodities. During these 3 years, the output of cement increased 45% and output of crushed stone increased 70%.

Unfortunately, construction was hampered by a shortage of engineers and skilled laborers, and construction activity was limited partially by a building endorsement system that required some projects to obtain the approval of more than 20 Commonwealth agencies. In addition, a continuing moratorium by the U.S. Environmental Protection Agency (EPA) on home sewer hookups stalled or canceled several projects.

Contractors were concerned over a possible aggregate shortage toward yearend. Bad weather, equipment problems, and "excessive government red tape for getting and renewing licenses" affected output. Commonwealth officials stated that producers were not fully exploiting deposits and were exporting more stone than in previous years.

One of the island's two cement producers began work to convert its facility from wet to dry processing.

During the year, American Metal Climax (AMAX) sold the Commonwealth 720 acres of land in the Utuado-Adjuntas area of Central Puerto Rico. The purchase price, almost $750,000, included detailed geologic information of the area. The acreage was almost all of AMAX's holdings in the area. In the 1970's, AMAX and Kennecott Copper Co. planned to develop a joint open pit mining and processing complex to re-

TABLE 1

NONFUEL MINERAL PRODUCTION IN PUERTO RICO[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	W	W	1,296	$106,185	1,397	$113,966
Clays	short tons	110,997	$223	148,029	318	163,382	365
Lime	thousand short tons	24	3,291	25	3,558	25	3,802
Salt	do.	40	880	40	900	40	900
Sand and gravel (industrial)	do.	31	624	67	W	31	624
Stone (crushed)	do.	e5,400	e26,000	8,480	41,299	9,350	47,400
Total[2]		**XX**	**31,018**	**XX**	**152,260**	**XX**	**167,057**

e Estimated. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Total does not include value of items not available or withheld.

cover copper, gold, and silver. Local opposition and falling copper prices canceled the plans. Reserve estimates, released in 1981, indicated 1.2 million ounces of recoverable gold and 2.9 billion pounds of copper in the Utuado-Adjuntas-Lares area.

Sun Oil Co. completed a $45 million expansion of its Yabucoa oil refinery. In 1988, Sun provided 50% of Puerto Rico's energy needs, including one-third of the energy requirements of the Puerto Rico Electric Power Authority.

Exploration Activities

Cominco American Resources Inc. obtained exploration permits for gold in four areas totaling about 200 square kilometers. The areas included Cerro Avispa, Bermeja-Lajas and Cabo Rojo, Barranquitas, and San German, the latter including the old Minillas mine.[4]

Regulatory Issues

Officials of the General Electric Wiring Devices (GEWD) Company met with EPA officials to determine methods for mercury removal from a contaminated area north of Ponce near Juana Diaz. During the 12-year period between 1957 and 1969, defective mercury light switches were discarded in the area, resulting in 5,500 cubic yards of contaminated soil and 500,000 gallons of contaminated water.

Barceloneta was the site of a 1982 toxic spill by the Upjohn Manufacturing Co. (UMC). UMC has been cleaning the underground contamination for several years with the cost expected to reach some $12 million.

EPA officials noted that the GEWD and UMC projects were the most serious of Puerto Rico's eight designated Superfund waste sites because nearby potable water supplies were threatened.

Legislation and Government Programs

No legislation that was enacted during 1988 had a direct effect on the island's mineral industry.

During the year, the Puerto Rican Geological Survey was involved in several projects. A principal activity was the study of landslide susceptibility in the Corozal, Naranjito, San Sebastian, and Penuelas areas. This study was part of a cooperative landslide assessment project with the U.S. Geological Survey.

A study by the Puerto Rico Association of Engineers and Surveyors on the Puerto Rico Highway Authority's (PRHA) $875 million, 5-year plan suggested that the work proposed in the plan could be compressed into 3 years. The study also noted PRHA's "excessive bureaucracy and low salaries."[5] If the study suggestions are adopted, they could strain the island's crushed stone industry's ability to supply the required raw materials.

The U.S. Geological Survey and the British Institute of Ocean Sciences mapped areas of the sea floor in the Exclusive Economic Zone, including seabed resources within 200 nautical miles of the U.S. coastlines.

Review by Nonfuel Mineral Commodities

Industrial Minerals.—Historically, industrial mineral production has dominated Puerto Rico's mineral industry. The construction mineral commodities—cement, sand and gravel, and stone—comprised approximately 98% of the island's mineral value.

Cement.—Puerto Rico's cement industry consisted of two firms, Puerto Rican Cement Co. in Ponce and San Juan Cement Co. west of San Juan. The two companies produced 1.4 million short tons of cement valued at $114 million, an increase of 101,000 short tons and $7.8 million over 1987 production.

Imports of foreign cement have been a problem for the two Puerto Rico cement producers for several years. Imports grew from 23,000 sacks in 1982 to 1.7 million sacks 4 years later. However, as of October 1988, imported shipments declined to under 700,000 sacks annually.

The fight against imports from Tunisia, Spain, Central and South America, the Caribbean, and Morocco was waged on two fronts. First, the island's cement companies improved the quality of their product, and second, a law was passed requiring the Commonwealth Government to purchase locally manufactured cement for all public work projects.[6]

Puerto Rican Cement began design work on converting from wet- to dry-process manufacturing. The conversion was to increase the capacity of the plant's No. 6 kiln from 600,000 to 1 million short tons per year. The completion date was scheduled for the early 1990's.[7]

During the year, the Board of Directors of Puerto Rican Cement ratified separate compensation agreements with 19 company executives in a continuing effort to thwart hostile takeover attempts. Each agreement specified severance pay to be given to an executive who is laid off or forced to resign as a result of a takeover.[8]

San Juan Cement continued its program of energy conservation to lower costs. San Juan Cement converted to coal in 1983, cutting energy costs from $12 million to $5.5 million. The company experimented with burning graphite dust from the Union Carbide Corp. plant at Yabucoa and, in 1988, was burning organic-based pharmaceutical waste, which accounts for approximately 5% of the fuel requirements.[6]

Clays.—Common clay was mined by both cement producers for use in clinker manufacture.

Graphite (Synthetic).—Union Carbide Corp. continued to operate a synthetic graphite electrode plant at Yabucoa. Raw material (petroleum coke) was obtained from Union Carbide's plant at Penuelas, and pitch was obtained from the mainland. The raw

materials were mixed, extruded, and shaped into green forms that were carbonized to drive off volatiles. After this process, the shaped materials were graphitized.

Because of economics, the company announced in 1987 that the Yabucoa plant would be closed by yearend, and the company's plant in Tennessee would handle the markets supplied by the Puerto Rican facility. However, late 1987 and 1988 orders were higher than projected, and the plant remained open throughout the year. The fate of the plant remains in doubt.

Lime.—Puerto Rican Cement produced chemical-grade lime at a plant near Ponce for markets in Puerto Rico and the Virgin Islands. Principal markets were for water purification and construction.

Salt.—Cabo Rojo Enterprises operated a solar saltworks on the island's southwest coast using seawater as the raw material. A second company produced salt obtained from seawater evaporation at an operation near La Parguera. Markets included pharmaceutical and petrochemical producers, tuna packers, sugar mills, and curing and tanning plants.

Sand and Gravel.—Many construction sand and gravel producers in Puerto Rico did not respond to the Bureau of Mines questionnaires, and figures are therefore not available for this commodity.

Construction.—U.S. Mine Safety and Health Administration records indicated that, in 1988, 42 firms produced either sand or gravel. Several crushed stone firms produced a sand-sized material as a coproduct of stone crushing.

Industrial.—One company mined sand under contract with Owens-Illinois de Puerto Rico. Owens-Illinois beneficiated the sand to glass grade for feed for a bottle manufacturing facility near Vega Alta. After mining, the sand was washed, dried, and sized, then trucked to the bottle plant where iron minerals were removed by magnetic separation before melting. The company also purchased scrap glass which was ground to supplement the sand feed. The Vega Alta plant supplied approximately 65% of Puerto Rico's glass container demand.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—In 1988, the production of 9,350 tons of stone was valued at $47.4 million. This amount was a 10% increase in output over 1987 levels.

In September, Caribbean Business reported that a shortage of crushed stone hampered construction projects. The article mentioned "outmoded technology and faulty equipment" as two problems slowing production.

Productora de Agregados Inc., a major producer with 24% of the island's output, closed for 51 days in the fourth quarter to repair equipment and "do some overdue" maintenance work at a cost of approximately $3 million.

A second producer, Master Aggregate, invested almost $3 million in a new quarry near Isabela.

Caribbean Business reported that concrete producers rationed aggregate. Caribe Inc. reported that one of its five plants had no sand and its overall concrete output was down 30% because of the aggregate problem. Aggregate prices increased 20% in 1988.[9]

Dimension.—Although no companies reported production to the Bureau of Mines, riprap and jetty stone were produced. Seasonal storms and strong currents along the north shore of the island dictate the use of large rubble for breakwater and jetty construction. The U.S. Army Corps of Engineers is the largest consumer of rubble in Puerto Rico.

THE COMMONWEALTH OF THE NORTHERN MARIANAS

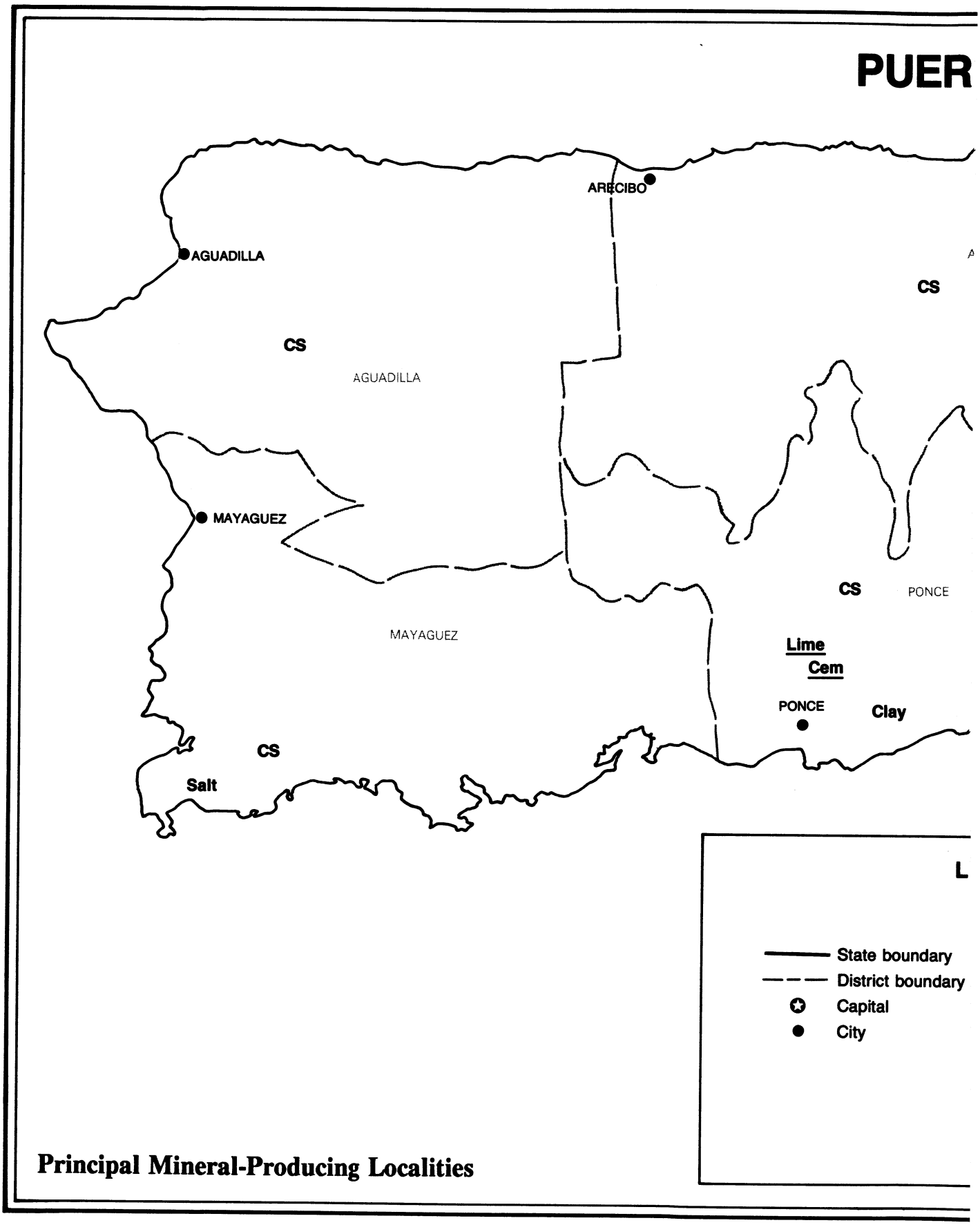
The Northern Marianas Commonwealth consists of 16 islands covering 184 square miles in the Pacific Ocean. Saipan (the capital), Tinian, and Rota are three of the main islands. The Northern Marianas became a United States Commonwealth in the late 1970's.

Trends and Developments

In 1988, the Commonwealth experienced a construction boom, which resulted in a strong demand for crushed stone. Much of the stone was produced from a quarry developed by the U.S. Navy to build Arnold Field during the latter days of World War II. Other quarries have been developed to supply the booming economy. All of the cement used in the Commonwealth construction projects was imported. There has been no report of nonconstruction mineral commodities produced, though manganese, phosphate, and sulfur were produced or noted prior to World War II.

CARIBBEAN ISLAND POSSESSIONS

The United States possessions in the Caribbean, excluding Puerto Rico, consist of the U.S. Virgin Islands; Navassa Island south of Guantanamo, Cuba; the Swan and Corn Islands off the Honduran and Nicaraguan coasts; and the Quita Sueno Banks, Roncador Banks, Serrana, and the Serranilla Banks approximately 250 miles east of the Central American coast. The U.S. Virgin Islands were the only Caribbean possession re-



Principal Mineral-Producing Localities

RICO

D

MINERAL SYMBOLS

Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Lime	Lime plant
Salt	Salt
St	Stone

porting mineral production.

St. Croix, St. John, St. Thomas, and 62 smaller islands compose the U.S. Virgin Islands in the West Indies, approximately 1,000 miles south of Miami and 40 to 60 miles east of Puerto Rico. Production of construction sand and crushed traprock was reported from St. Croix and St. Thomas.

Trends and Developments

Plans to construct four new hotels, three on St. Thomas and one on St. Croix, were welcomed by the island's construction mineral commodity producers. Two major projects scheduled for the two islands in 1989 will provide markets for aggregate and sand output after the hotels are completed: (1) work on a new terminal for the Cyril E. King Airport on St. Thomas and (2) beginning in 1989, the 3,600-foot extension of the runway at St. Croix's Alexander Hamilton Airport.

Review by Nonfuel Mineral Commodities

***Industrial Minerals.*—Sand and Gravel.**—Devcon International Corp. produced manufactured sand from its crushing operations at the Brookman Quarry on St. Thomas. The quarry was operated by Control Concrete Products Inc., a Devcon subsidiary. Approximately 30% of St. Thomas' annual sand requirements was imported from Barbuda, an island 40 miles north of Antigua.

On St. Croix, manufactured sand was produced by the Devcon subsidiary, Caribbean Materials Supply Co. Inc., at the Springfield quarry near Groveplace. Another Devcon subsidiary, Mark 21, imported sand from Barbuda to St. Croix.

Stone.—Devcon also produced crushed stone through subsidiary operations at the Brookman Quarry on St. Thomas and the Springfield Quarry on St. Croix. St. Croix stone was exported to several other Caribbean islands. St. Croix Stone and Sand Co. operated the Robes Hill Quarry on St. Croix. Approximately 15% of the stone used on St. Thomas was imported by Turnbull, Malone, and Turnbull. The company also imported a limited tonnage of sand.

Other Industrial Minerals.—Mark 21 operated a cement storage facility on St. Thomas. Cement was imported from Colombia and Venezuela.

PACIFIC ISLAND POSSESSIONS

Several islands in the mid-Pacific area were acquired by the United States during the 1800–1900 time period for mining (guano), harbors, coaling stations, or seaplane fueling points. These include American Samoa (1900), Baker (1839), Canton and Enderburg (a 1939 joint treaty with Great Britain for administration of both islands), Guam (1898), Howland (1934), Jarvis (1934), Johnston (1858), Kingmen Reef (1922), Midway (1967), Palmyra (1898), and Wake (1898). American Samoa and Guam were the only two islands reporting mineral production. Both are underlain by volcanic rock, limestone, and coral, and mineral production was limited to construction materials—crushed stone and sand. Cement was imported.

TRUST TERRITORY OF THE PACIFIC ISLANDS

The Marshall Islands, the Eastern and Western Caroline Islands, and the Northern Mariana Islands are collectively termed Micronesia. Following World War II, the islands were placed under the newly formed trusteeship system with the United States as the administrator. Four political "districts" were established: (1) Northern Mariana Islands, (2) Marshall Islands, (3) Federated States of Micronesia, and (4) the Republic of Palau.

The Northern Marianas became a U.S. Commonwealth in the 1970's. The Marshall Islands and the Federated States of Micronesia have become free States.

The Republic of Palau is the only remaining component in the Trust Territory. Phosphate was mined on Angura in the Republic until 1955.

More recently, the U.S. Geological Survey identified epithermal gold mineralization on the southeastern part of Babelthip, the largest of Palau's 200 islands.[10] During 1988, several companies investigated the Republic's precious metals potential.

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[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL.

[2] Program Specialist, Minerals Information, Washington, DC.

[3] Director, Puerto Rico Geol. Survey.

[4] Mining Journal (London). Hispaniola Update. July 14, 1989, p. 22.

[5] Caribbean Business. Study Says Highway Construction Could be Stepped Up. Jan. 26, 1989.

[6] ——. San Juan Cement Exhibitor at PREXPO '88. Nov. 17, 1988.

[7] Pit & Quarry. Puerto Rican Cement to Convert to Dry Process. Aug. 1988, p. 148.

[8] Caribbean Business. P.R. Cement Agreements Discourage Hostile Takeover. Dec. 8, 1988.

[9] ——. Aggregate Shortage May Delay Construction Projects. Sept. 20, 1988.

[10] Malk, Rois. Epithermal Gold System, Republic of Palau. U.S. Geol. Surv. Open File Report 85-600, 1985, 6 pp.

THE MINERAL INDUSTRY OF RHODE ISLAND

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Rhode Island Department of Environmental Management for collecting information on all nonfuel minerals.

By Donald K. Harrison[1]

The value of nonfuel mineral production in 1988 was $17.2 million, a $1.5 million decrease from the 1987 value. The primary reason for the decrease was the drop in sales of construction sand and gravel, the State's second leading mineral commodity. Crushed stone accounted for the majority of the rest of the State's production. A small amount of industrial sand was also mined. Although there were fewer than 200 persons employed by the mining industry, wages generated during the year amounted to $4.7 million. Employment in the mineral-dependent construction industry was slightly under 20,000 persons with wages of nearly $450 million.

TRENDS AND DEVELOPMENTS

According to F. W. Dodge Co., a division of McGraw-Hill Inc., the total value of construction contract awards was down 5.8% during the first 11 months of 1988. Although nonresidential contracts were up nearly 8% from 1987 levels, in 1988 decreases of 1% and 32% were reported for residential and public works and utilities contracts, respectively. Since demand for mineral aggregates is almost totally dependent on construction activity, there is usually a correlation between aggregate output and construction contract awards. According to estimated data, crushed stone production rose slightly in 1988. Construction sand and gravel figures, which were obtained from company canvasses, decreased 33% in volume and 28% in value compared to 1987 levels. The average unit price for construction sand and gravel also rose from $4.03 in 1987 to $4.23 in 1988.

The East Providence Zoning Board of Review turned down a request by the Highland America Corp. to store imported raw gypsum outdoors at the proposed gypsum wallboard plant in the town. In 1987, the company had received Zoning Board permission to build the plant, but at the time, the Board mandated that the gypsum be stored indoors. According to Highland America, subsequent test borings of the proposed indoor storage site showed oil-contaminated soil; rather than excavate the contaminated soil to build the plant, the company sought permission to store the gypsum outside. No decision was announced by Highland America as to whether or not the company would go ahead with the entire project.

Korf KG, Baden-Baden, West Germany, reached an agreement in early August to purchase Rhode Island Forging Steel Co. in East Providence as a raw materials source for another of Korf's operations, Connecticut Steel Corp. In addition, Korf will install the first energy optimizing furnace in North America at the East Providence Plant. Korf will also install a reconditioned billet caster at the plant.

The world's only occurrence of cumberlandite, the State rock of Rhode Island, was threatened with being buried by fill for a housing development. This unique deposit of titaniferous magnetite at Iron Mine Hill was used as an iron ore to make cannons during the Revolutionary War. Historical societies in the State joined with conservation, environmental, and geological groups to pressure the State and town into purchasing the site for posterity.

TABLE 1

NONFUEL MINERAL PRODUCTION IN RHODE ISLAND[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	W	NA	$1	NA	$1
Sand and gravel:							
Construction	thousand short tons	2,269	$8,252	e2,700	e10,900	1,853	7,847
Industrial	do.	22	143	W	W	W	W
Stone (crushed)	do.	e[2]1,000	e[2]5,700	1,228	7,797	e1,500	e9,400
Combined value of other industrial minerals and values indicated by symbol W		XX	101	XX	(3)	XX	(3)
Total		**XX**	**14,196**	**XX**	**[4]18,698**	**XX**	**[4]17,248**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Excludes crushed miscellaneous stone; value included with "Combined value" data.
[3] Value excluded to avoid disclosing company proprietary data.
[4] Partial total, excludes values that must be concealed to avoid disclosing company proprietary data.

LEGISLATION AND GOVERNMENT PROGRAMS

The Rhode Island Office of State Planning, a division of the Department of Administration, began developing criteria for siting solid and hazardous waste facilities. Following review by the State Planning Council, these criteria needed to be ratified by the General Assembly during its 1989 session. The Division then expected to inventory existing facilities and identify areas not suitable for new or expanded facilities. The Rhode Island Office of State Planning also continued updating and reviewing the State's land use plan titled "Land Use 2010." The study addressed topics such as air quality, water resources, acid rain, energy resources, topography, geology, and minerals.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

Construction sand and gravel was the State's second leading mineral commodity in terms of value, accounting for 46% of the value of all minerals produced in the State. Output amounted to nearly 1.9 million short tons of construction sand and gravel valued at $7.8 million. In 1988, 10 companies mined construction sand and gravel from 11 operations in all of the State's counties. Leading counties in order of output were Kent, Washington, and Providence. Construction sand and gravel was used for concrete aggregates, asphaltic concrete aggregates, road base and coverings, and fill.

In 1988, more than a dozen sand and gravel operations in various parts of the State were involved in legal disputes with zoning boards or complaining citizens concerning blasting, expansion, haulage regulations, dust, and noise. In one such case, Palisades Ltd., a sand and gravel operator in South Kingston, sued the town for $125,000 after South Kingston closed down the company's gravel pit in April. The town zoning board upheld an earlier ruling by the town building inspector that the pit did not comply with local zoning ordinances. Palisades argued that the gravel pit was legal because the zoning board approved a gravel pit adjacent to the contested site in 1979.

Industrial.—Holliston Sand Co. Inc., Providence County, was the only industrial sand producer in the State. Most of the sand was used for filtration, blasting, golf course sand, and molding and core.

Stone (Crushed).—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Estimates of the crushed stone produced in the State totaled 1.5 million short tons valued at $9.4 million, a 22% increase in quantity and a 21% increase in value over prior levels. In 1987, four companies operated four quarries in Providence County and one in Newport County. Traprock (basalt), limestone, and granite were the three types of rock quarried. Most of the stone was used for bituminous aggregate, filter stone, surface treatment, and riprap.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA.

TABLE 2

RHODE ISLAND: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	390	$2,700	$6.92
Plaster and gunite sands	W	W	8.14
Asphaltic concrete aggregates and other bituminous mixtures	W	W	8.50
Road base and coverings	W	W	3.91
Fill	W	W	2.06
Snow and ice control	20	125	6.25
Other	376	2,374	6.31
Unspecified: [1]			
Actual	474	837	1.77
Estimated	593	1,812	3.06
Total or average	**1,853**	**7,848**	**4.24**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
A. Cardi Construction Co. Inc.	451 Arnold Rd. Coventry, RI 02816	Pits and plant	Kent.
Holliston Sand Co.[1]	Box 393 Slatersville, RI 02876	Pit and plant	Providence.
River Sand & Gravel Co. Inc.	101 Ferris St. Pawtucket, RI 02861	Pit	Kent.
South County Sand & Gravel Co.	North Rd. Peace Dale, RI 02878	Pit and plant	Washington.
TASCA Sand & Gravel Co.	Log Rd. Smithfield, RI 02917	Pit	Providence.
Stone:			
The Conklin Limestone Co.	RFD 1 Lincoln, RI 02865	Quarry	Do.
Forte Bros. Inc.	14 Whipple St. Berkley, RI 02864	do.	Do.
J. H. Lynch & Sons Inc.[2]	825 Mendon Rd. Cumberland, RI 02864	do.	Do.
Peckham Brothers Co. Inc.	Box 193 Newport, RI 02840	do.	Newport.
Tilcon Inc.	875 Phoenix Ave. Cranston, RI 02920	do.	Providence.

[1] Also industrial sand.
[2] Also sand and gravel.

RHODE ISLAND

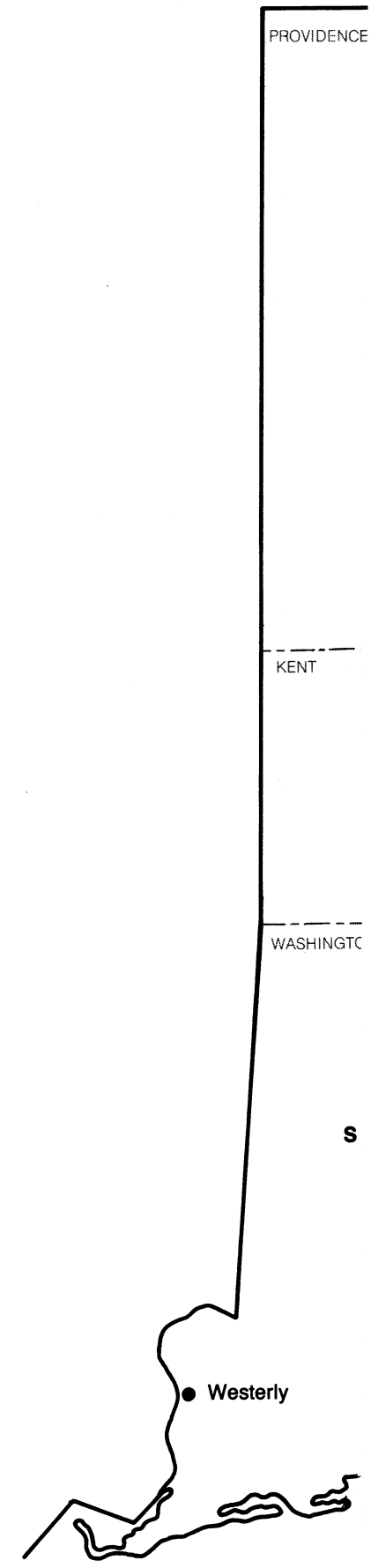
LEGEND

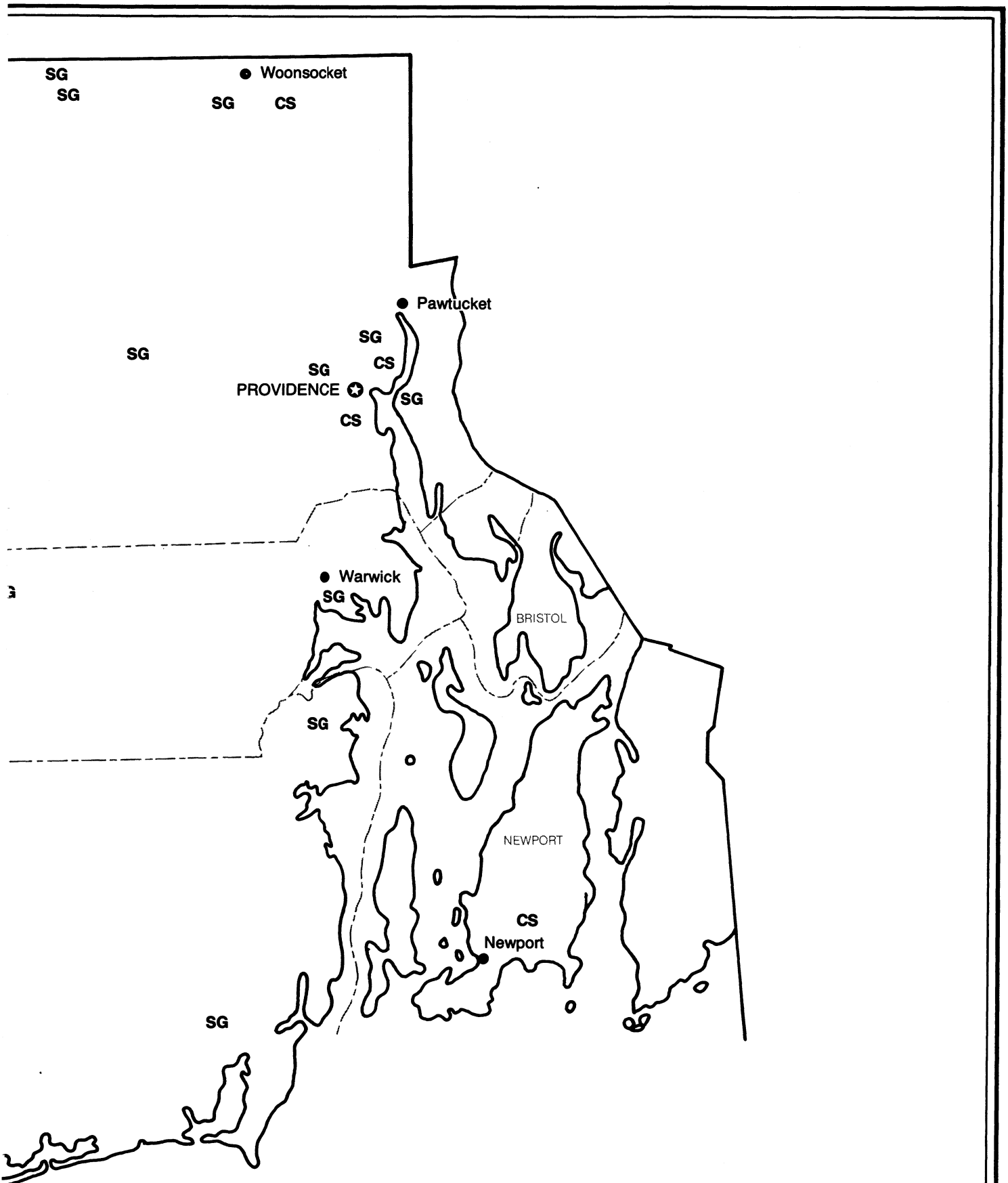
- State boundary
- County boundary
- Capital
- City

MINERAL SYMBOLS

- **CS** Crushed Stone
- **SG** Sand and Gravel

Principal Mineral-Producing Localities

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Woonsocket
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Pawtucket
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PROVIDENCE
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CS
Warwick
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BRISTOL
SG
NEWPORT
CS
Newport
SG

THE MINERAL INDUSTRY OF SOUTH CAROLINA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the South Carolina Geological Survey, State Division of Research and Statistical Services, for collecting information on all nonfuel minerals.

By Doss H. White, Jr.,[1] and Norman K. Olson[2]

In 1988, South Carolina's mineral industry produced mineral commodities valued at $358 million, an increase of approximately 5% over that of 1987. The State led the Nation in the production of vermiculite, ranked second in kaolin output, and was among the top 10 States in the production of ferroalloys and masonry cement. South Carolina ranked 27th nationally in total mineral production.

TRENDS AND DEVELOPMENTS

For six consecutive years the value of South Carolina's mineral output has increased. This rise was due primarily to the continued demand for construction mineral commodities, cement, crushed stone, and sand and gravel, which historically accounted for more than 75% of the State's mineral value. In the 1980's, the value of portland cement increased almost 59%, from $75 million in 1980 to $119 million in 1988. Crushed stone value more than doubled from $50 million in 1980 to the estimated $106 million in 1988. Construction sand and gravel production increased from $13 million in 1980 to $24 million in 1988.

Although industrial mineral commodities have been the cornerstone of South Carolina's mineral economy, development in the metals sector eclipsed industrial mineral activity in 1988. During the year, Ridgeway Mining Co., a BP Minerals America and Galactic Resources Ltd. joint venture, reached a settlement with an environmental group and the State that allowed Ridgeway to begin work on its gold mining complex. The Ridgeway mine-mill complex was located approximately 20 miles north of Columbia and was the third gold producer in South Carolina. Westmont Mining Inc. and its wholly-owned subsidiary, Brewer Gold Co., the State's second gold producer, announced the discovery of several new gold deposits in Lancaster County.

BP Minerals and an Australian firm, Gwalia, U.S.A. Ltd., completed an exploration program at the Barite Hill property. The program, conducted under a joint venture agreement, identified 1.43 million metric tons of gold ore averaging 0.043 ounce per ton. Gwalia later purchased BP's share of the property.

In the industrial minerals sector, Santee Cement Co. purchased a cement import terminal in coastal South Carolina. Cyprus Minerals Co. sold its clay division to Hecla Mining Co. Included were mines, mills, and resources in Aiken County, South Carolina. Mineral Mining Corp., the State's only sericite producer, was purchased by a local businessman.

TABLE 1

NONFUEL MINERAL PRODUCTION IN SOUTH CAROLINA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	2,306	$109,529	2,567	$117,878	2,533	$118,670
Clays	short tons	[2]1,986,253	[2]37,980	[2]2,193,540	[2]38,244	2,058,927	40,541
Gem stones		NA	10	NA	10	NA	10
Manganiferous ore	short tons	14,320	W	W	W	W	W
Sand and gravel:							
Construction	thousand short tons	7,200	19,783	e7,500	e19,500	7,529	20,751
Industrial	do.	800	14,081	844	15,188	859	15,271
Stone:							
Crushed	do.	e18,200	e76,700	[3]24,278	[3]105,387	e[3]23,500	e[3]105,800
Dimension	short tons	e7,550	e533	2,319	312	e353	e31
Combined value of cement (masonry), clays (fuller's earth, 1986–87), gold, mica (scrap), peat, silver, stone (crushed shell, 1987–88), vermiculite, and values indicated by the symbol W		XX	37,273	XX	44,806	XX	56,728
Total		**XX**	**295,889**	**XX**	**341,325**	**XX**	**357,802**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

[3] Excludes certain stones; kind and value included with "Combined value" data.

REGULATORY ISSUES

Ridgeway Mining Co. announced that it would compensate the South Carolina Wildlife and Marine Resources Department for the death of 56 sea gulls that landed in a tailings pond containing spent cyanide liquid from the gold-leaching vats.

A former fuller's earth mine was the center of a hazardous waste disposal controversy. The abandoned mine had been used as a repository for containers of hazardous waste under State permit. Opponents to the operation feared that the site, located above the Tuscaloosa aquifer, would pollute the water supply of a large part of South Carolina. The opponents wanted the dump closed immediately. The State Department of Health and Environmental Control (DHEC) worked on State-wide standards for landfills. The drafting of the standards was expected to take at least 1 year.

LEGISLATION AND GOVERNMENT PROGRAMS

In January, a group of bills (House bills 3163, 3410, and 3413 and Senate bill 850) was introduced into the South Carolina General Assembly to regulate the State's mining industry in general and the gold producers specifically. The bills all died in committee.

If enacted, the bills would have required all South Carolina mines to prepare an environmental impact statement on their operation. Mining permits would be good for only 4 years as opposed to the current 10-year period. DHEC would replace the Land Resources Conservation Commission as the primary regulatory agency.

The bills would have provided for a tax of 10% of the average price of gold per ounce on the London Exchange for the prior year on Ridgeway Mining Co.'s production. Tax proceeds would have been used to create a "Palmetto Environmental Fund" to solve environmental problems resulting from mining. Gold-mining firms would have been prohibited from processing ore from any mine outside a 12-mile radius of the processing facility. The State would have been required to prepare a full environmental study when a mining operation used "potentially dangerous materials."[3]

The South Carolina Geological Survey, a branch of the Division of Research and Statistical Service, continued as the lead agency in the investigation and dissemination of geologic and mineral resource information. During the year, the Geologic Mapping Section continued mapping in the upper Coastal Plain. The Mineral Resources Section continued to assist established and potential industry as well as individuals with information on the State's mineral resources.

Several government programs announced during the year were of interest to the metals sector of the minerals industry. The University of South Carolina (USC) was one of three universities chosen by the Federal Government to help small- and medium-size metals companies to improve output. The USC effort would "emphasize a multidisciplinary approach, working with all facets of the metals industry to improve their productivity." One area of work would focus on "automated manufacturing techniques . . . (to) automate materials-handling equipment to move parts, tools, and raw materials from one work station to another and a variety of industrial robots to tend machine tools."[4]

Westinghouse Electric Corp. was awarded a $6.7 billion contract to operate the Department of Energy's Savannah River plant for 5½ years. The South Carolina facility (now called Savannah River Site) produced plutonium and tritium for nuclear weapons.[5]

The U.S. Senate appropriated $3.5 million for a strategic materials research facility for North Charleston. The facility, composed of a consortium development of the South Carolina Research Authority, MacAlloy Corp., Clemson University, the Massachusetts Institute of Technology, and a private company, would develop the use of a plasma arc smelter to produce high-purity ferrochromium for defense and industrial purposes. MacAlloy Corp. in North Charleston is the Nation's only producer of high-purity ferrochromium.[6]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

During 1988, nine industrial minerals were mined in South Carolina. These minerals comprised approximately 95% of the State's extractive mineral value. Industrial minerals were produced by 223 companies operating 476 surface mines.

Cement.—South Carolina's cement industry produced 2.5 million short tons of portland cement valued at $118.7 million. Both production and value were close to 1987 figures. The industry accounted for more than 30% of the State's total mineral value. Masonry cement output and value decreased compared with 1987 totals.

The State's cement industry consisted of three companies: Giant Portland Cement Co. and Gifford-Hill Cement Co. of South Carolina in Harleyville and Santee Cement Co. in Holly Hill. The industry operated six wet- and one dry-process kilns with an annual clinker capacity of 2,380,000 short tons. All three plants were coal-fired. Portland Types I and II cement were produced by all three companies, and masonry cement was manufactured by Giant and Santee.

All three producers mined a Tertiary marl and local clay for raw materials. Gypsum was imported from Canada

and the Caribbean; iron materials were obtained from southeastern suppliers.

In May, Santee, a wholly-owned subsidiary of Dundee Cements, which is owned by the Swiss cement company Holderbrok, acquired the cement import terminal recently constructed by Delta Cement Corp. The acquisition was an extension of Santee's marketing area.[7]

Clays.—The State's 1988 clay output of 2 million short tons was valued at $40.5 million, accounting for 11% of the State's total mineral value. South Carolina's clay sector was buoyed by the demand for kaolin fillers and extenders, the strong showing of the construction industry, and the requirements for brick and structural clay products.

Common Clay.—Mining of common clay and phyllite accounted for approximately 20% of the State's total clay production. Fourteen companies produced brick-grade clay-phyllite from 18 mines in 13 counties. Most of the clay was used in brick manufacturing.

Kaolin.—Kaolin production accounted for 39% of the State's clay output, and kaolin was produced from an area extending from south-central South Carolina to east-central Georgia. Industrial kaolin production was reported by five companies operating eight surface mines in Aiken County. Kaolin for brick manufacturing was mined by 6 companies operating 10 mines in 10 counties. All kaolin production was from surface mines; trucks and/or pipelines transported the raw clay to the processing facilities. Industrial kaolin processing methods included both wet and dry beneficiation. Wet-processed kaolin was used as a paper coating, in inks and in high-gloss paints, and for similar applications. Dry-processed kaolin was used as a paper filler, in ceramics and fiberglass, and by several other industries.

Cyprus Minerals clay division sold its Aiken County kaolin properties to Hecla Mining Co. Cyprus produced both hard and soft kaolins used in ceramics and in rubber building products.

Mica.—Sericite, a fine-grained variety of mica, was mined by Mineral Mining Corp. (Minco) from a deposit adjacent to the Haile Gold Mine west of Kershaw in Lancaster County. Both production and value decreased slightly, compared with 1987 figures.

Crude sericite was trucked several miles to the Minco grinding and bagging plant northeast of Kershaw. United States and Canadian paint industries were the principal customers, with additional sales to wall and roofing paper and electrical equipment manufacturers.

In December, Minco's company president purchased the firm for approximately $4 million. In 1988, Minco employed approximately 30 workers.[8]

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1987. Data for odd numbered years are based on annual company estimates.

South Carolina construction sand and gravel statistics are compiled by geographical districts. Table 3 presents end-use data for the State's three districts.

Construction sand and gravel production was more than 7 million short tons valued at almost $21 million. Both production and value increased compared with 1987 data, as demand for construction mineral raw materials continued.

Sand for construction was produced by 37 companies operating 48 mines in 22 counties. Approximately 53% of the construction sand production came from District 2, followed by District 3

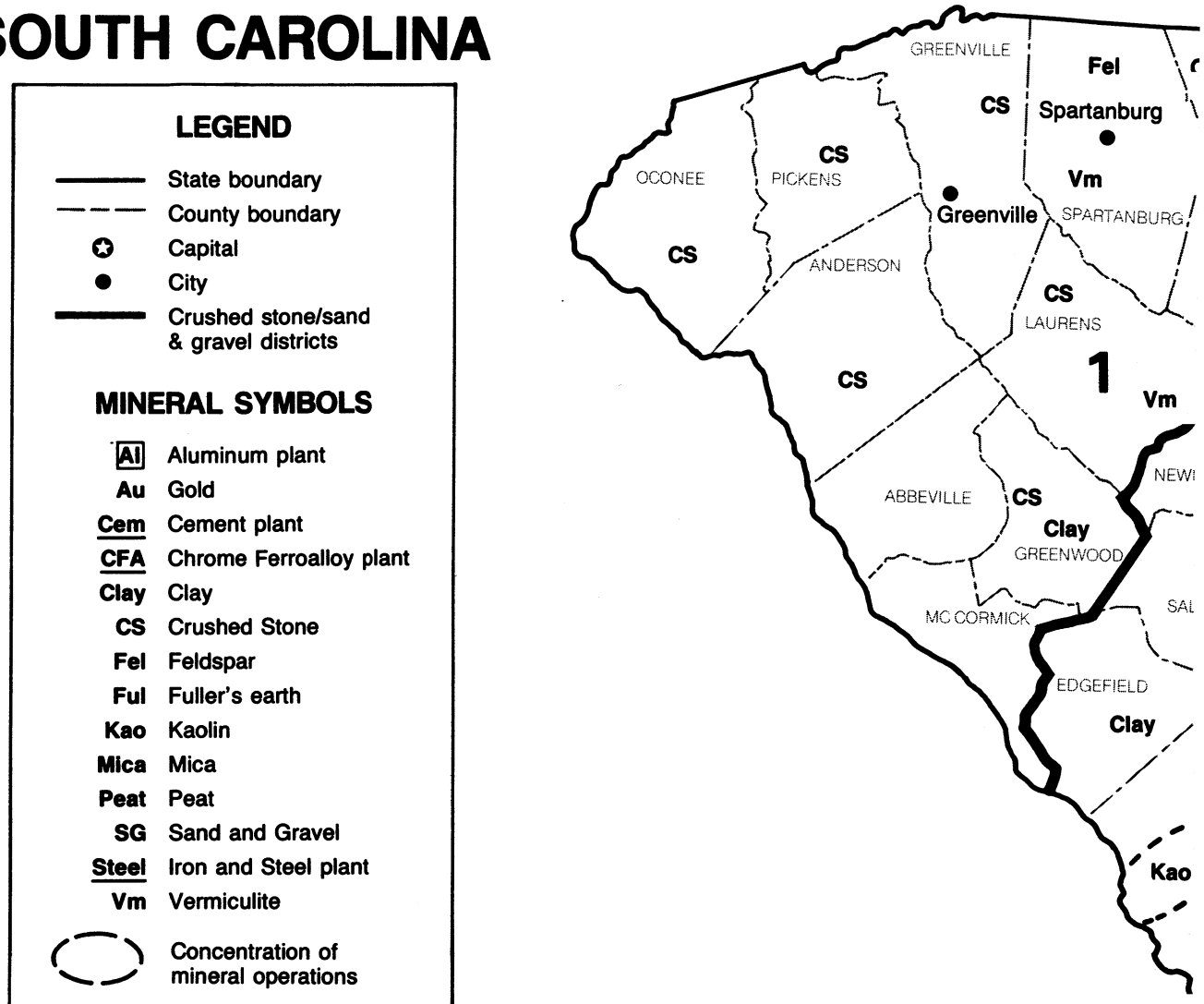
TABLE 2

SOUTH CAROLINA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	4,182	$12,751	$3.05
Plaster and gunite sands	390	935	2.40
Concrete products (blocks, bricks, pipe, decorative, etc.)	330	779	2.36
Asphaltic concrete aggregates and other bituminous mixtures	637	1,502	2.36
Road base and coverings	413	2,065	5.00
Fill	664	966	1.45
Snow and ice control	W	W	3.40
Railroad ballast	W	W	1.00
Other[1]	27	98	3.62
Unspecified:[2]			
Actual	750	1,446	1.92
Estimated	137	210	1.53
Total[3] or average	**7,529**	**20,751**	**2.76**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes roofing granules.
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

SOUTH CAROLINA



LEGEND

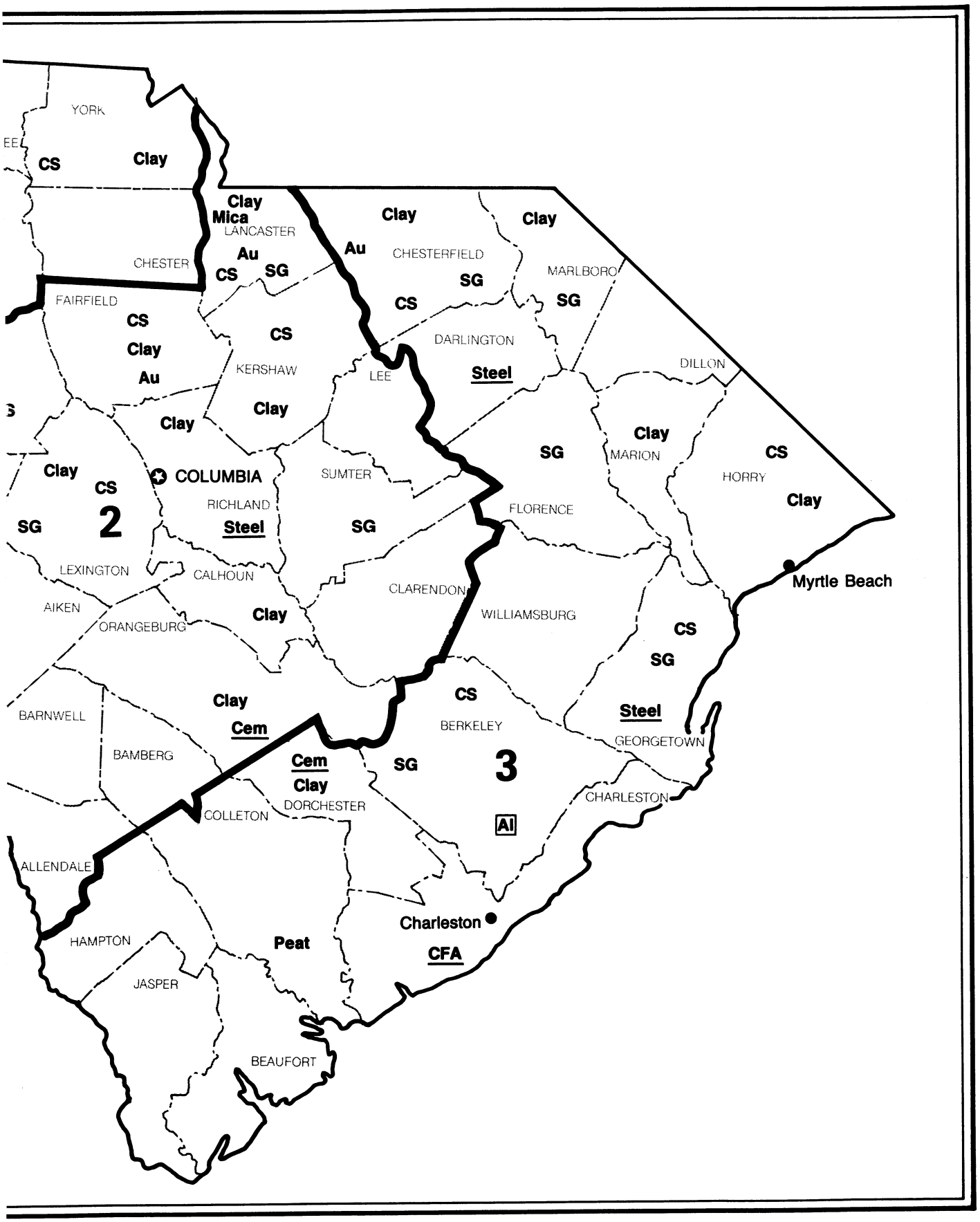
- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Al	Aluminum plant
Au	Gold
Cem	Cement plant
CFA	Chrome Ferroalloy plant
Clay	Clay
CS	Crushed Stone
Fel	Feldspar
Ful	Fuller's earth
Kao	Kaolin
Mica	Mica
Peat	Peat
SG	Sand and Gravel
Steel	Iron and Steel plant
Vm	Vermiculite

Concentration of mineral operations

Principal Mineral-Producing Localities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DARLINGTON
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HORRY
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Myrtle Beach
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AIKEN
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Clay
WILLIAMSBURG
CS
SG
Clay
Cem
CS
BERKELEY
Steel
BARNWELL
BAMBERG
Cem
Clay
SG
3
GEORGETOWN
DORCHESTER
CHARLESTON
COLLETON
Al
ALLENDALE
Charleston
HAMPTON
Peat
CFA
JASPER
BEAUFORT

TABLE 3

SOUTH CAROLINA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	63	192	3,013	8,388	1,826	5,885
Asphaltic concrete aggregates and road base and coverings[2]	138	378	901	1,731	675	2,425
Snow and ice control	W	W	—	—	—	—
Railroad ballast	W	W	—	—	—	—
Other miscellaneous[3]	5	17	20	77	1	3
Other unspecified[4]	74	82	68	122	746	1,453
Total[5]	**280**	**670**	**4,001**	**10,317**	**3,248**	**9,765**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for plaster and gunite sands.
[2] Includes sand and gravel for fill.
[3] Includes sand and gravel for roofing and granules.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

(43%) and District 1 (4%). Principal end uses reported to the Bureau of Mines were concrete aggregates, asphalt concrete, and fill.

Industrial.—Industrial sand output of 859,000 short tons valued at $15.3 million increased slightly over that reported in 1987. The industry was composed of six companies operating mines in Lexington, Kershaw, and Cherokee Counties. The glass and fiberglass industries were the principal customers for the industrial sand produced by the State's industrial sand producers.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

Crushed.—In 1988, the Bureau of Mines estimated that the crushed stone industry produced more than 23 million short tons valued at nearly $106 million. Stone sales accounted for nearly 30% of the State's total mineral value. As with other construction mineral commodities, the construction of new dwellings and commercial buildings, coupled with infrastructure maintenance, accounted for the continued strong demand for stone.

Dimension.—Six companies operated granite quarries in Kershaw, Lancaster, and Newberry Counties in the north-central part of the State. Quarried blocks were finished both in-State and at Elberton, GA facilities. The Newberry County operation exported rough stone to Japan.

Vermiculite.—Among the three States that produced vermiculite in 1988, South Carolina ranked first, although both production and sales decreased slightly compared with 1987 figures.

Three vermiculite-producing companies operated in two counties. During the year, Enoree Minerals Corp. began production in Spartanburg County near the community of Enoree.

Other Industrial Minerals.—Industrial minerals shipped into the State for processing or manufacturing into a variety of higher value products or recovered in-State as coproducts of other industrial processes included ball clay-kaolin-gypsum, colemanite-ulexite, feldspar-silica, graphite (synthetic), mica, and slag.

Colemanite and ulexite, calcium borate minerals mined in Turkey, were imported through the Port of Charleston and shipped by rail to Industrial Minerals Inc. at Kings Creek in Cherokee County. The minerals were ground to specifications and then shipped to fiberglass plants in South and North Carolina.

Ball clay mined in Tennessee and Kentucky and high-plastic kaolin mined in Florida were shipped to the Kohler Company in Spartanburg and slurried to manufacture a variety of whiteware bathroom fixtures. Gypsum was purchased to construct molds used to manufacture the whiteware shapes. A feldspar-silica concentrate was ground by Spartan Minerals Corp., a Lithium Corp. of America subsidiary, at a plant at Pacolet. The concentrate was produced during lithium ore beneficiation at Cherryville, NC. Principal markets were glass and whiteware manufacturers.

Synthetic graphite shapes were produced by Union Carbide Corp. at Greenville and by Airco Carbon South Carolina Works, a BOC division in Ridgeville. The 1-million-pound annual capacity Greenville plant produced graphite-epoxy composites while the Ridgeville facility produced electrodes 60 to 110 inches long in four diameters for electric arc furnaces. Electrode sales were to most U.S. minimills and to approximately 12 foreign countries.

A mica concentrate was dry ground by Spartan Minerals for use in joint compound manufacturing. The concentrate was recovered at Lithco's North Carolina operation. South Carolina slag produced as a waste product of metal manufacture was marketed as an industrial mineral by two segments of the metals sector. Steel slag from the State's three steel mills was marketed for aggregate applications, and slag from MacAlloy Corp.'s ferroalloy plant in Charleston was sold for aggregate purposes, as a refractory material, and for roofing shingle applications.

Metals

Gold, silver, and manganiferous ore were the only metals mined in-State and the only three whose values appear on table 1. However, several other metals were produced from scrap, refinery products (alumina), ore concentrates, and ores. Their sales added a significant amount to South Carolina's economy.

Gold.—Piedmont Mining Co., the initial gold producer in South Carolina's "new" gold rush, began production at the old Haile mine near Kershaw in April 1985. Piedmont was the first 20th century mining firm in South Carolina to use cyanide heap leaching to recover gold. In 1988, Piedmont began an exploration program on 2,000 acres; the company spent about $150,000 on a geophysical program and drilled approximately 200 "sample holes." Several gold-bearing areas reportedly were noted.

Piedmont's 20-day leach cycle recovered approximately 80% of the gold value in the ore, and, in 1988, the Haile Mine produced 11,738 troy ounces of gold and 6,998 troy ounces of silver.[9]

The State's second "1980's" gold producer, the Brewer Mine in Chesterfield County, was operated by the Brewer Gold Co., a wholly-owned subsidiary of Westmont Mining Inc. of Denver, CO. Brewer Gold Co. owns 1,900 acres, which includes the Brewer ore body. The first ore from the Brewer mine was crushed on June 30, 1987, and the first gold was poured on August 8, 1987. Like the Haile Mine, the Brewer Mine is a cyanide-heap-leach operation.

Following open pit mining, the ore was reduced by a two-stage crushing operation followed by agglomeration. A radial stacker was used to build 35-foot-high leach piles of crushed, agglomerated ore. After leaching, gold was recovered from the pregnant solution by carbon adsorption followed by pressure stripping and electrowinning-replate. Initial leach recoveries were 75%. The Brewer Mine produced 8,900 troy ounces of gold during the initial 6 months of operation in 1987.[10] Gold production for 1988 was projected at 40,000 troy ounces, which exceeded the original planning.[11]

During the year the parent company, Westmont Mining Inc., announced the discovery of several new ore bodies in Lancaster County.[12] These deposits are located at sites having historic gold production.

South Carolina's third gold producer, Ridgeway Mining Co., cleared all legal hurdles on its twin-pit mining complex in the first quarter of 1988 and poured its first gold in December. The company was owned by BP Minerals America (52%) and Galactic Resources Ltd. (48%).

The process at Ridgeway used vat leaching rather than the heap leaching used at the Haile and Brewer operations. After mining at Ridgeway, the ore was ground; mixed with a water, lime, and sodium cyanide solution; and leached for 27 hours in a 10-tank leaching system. The gold was dissolved and bonded to granulated carbon added during the final leaching step; the gold-carbon fraction was screened from the spent leach solution and gold was chemically separated from the carbon and plated electrically on steelwool. The gold was then back-plated on stainless steel plates, scraped from the plates, and melted into dore bars. Spent ore slurry was pumped to an impervious double-lined 270-acre tailings pond.

Manganiferous Ore.—Zones in the Battle Mountain Schist with relatively high manganese content, 5% to 15%, were mined by companies in Cherokee County. The manganiferous material from the Battleground Schist was ground, bagged, and sold as a coloring agent to brick manufacturers in North and South Carolina.

Silver.—Coproduct silver was recovered during the refining of gold bullion produced at the Haile, Brewer, and Ridgeway Mines. Silver content of the bullion averaged about 30%.

Other Metals.—Alumina, the intermediate product between bauxite and aluminum, was imported from Australia by Alumax Inc. at Mt. Holly. The 181,000-metric-ton-per-year facility operated two potlines and produced billets, ingots, and slabs. The Mt. Holly direct reduction smelter ranked 10th of the 23 U.S. aluminum plants in total annual capacity.

AT&T Nassau Metals Corp. operated a copper recycling facility at Gaston. The facility, which produced rod and wire, contained a scrap handling and upgrading section, a secondary smelter, an electrolytic refinery, and a continuous cast wire plant.

MacAlloy Corp., the Nation's principal producer of ferrochrome, converted imported chrome ore into ferrochrome at a plant in Charleston. During the

year, Congress funded a ferrochrome Strategic Materials Research Facility. The facility, a consortium development of the South Carolina Research Authority, MacAlloy Corp., Clemson University, Massachusetts Institute of Technology, and A. D. Little Co., would "develop . . . a plasma arc smelter to produce high-grade ferrochromium for defense and industrial purposes." Work began in late 1988.[13]

A germanium compound was used to manufacture fiber optic cables at a Pirelli Cable Corp. plant near Lexington. Palladium, platinum, rhodium, and ruthenium were used to produce a variety of catalysts at an Engelhard Corp. plant near Seneca. The catalysts were used by the automobile, chemical, film, and petroleum industries. M & T Chemicals Inc. at Andrews imported zircon concentrate from Australia and Florida for feed for a custom grinding plant. The ground zircon was used by the ceramics, foundry, wall tile, and whiteware industries.

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[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL.

[2] State geologist, South Carolina Geological Survey, Columbia, SC.

[3] Columbus State. Precious Metal Mining Bill Proposes Hefty Taxes in South Carolina. Jan. 7, 1988.

[4] American Metals Market. Three R and D Centers Picked By U.S. to Aid Manufacturing Firms. Dec. 23, 1988.

[5] Pittsburgh Post Gazette. Westinghouse Wins Major Federal Nuclear Contract. Sept. 19, 1988.

[6] Charleston News and Courier. Planned North Charleston Research Facility Gets $3.5 Million Senate Appropriation. June 22, 1988.

[7] Rock Products. Santee Acquires Delta Cement. June 1988, p. 7.

[8] Lancaster News. $4 Million Paid for Mining Firm. Jan. 6, 1989.

[9] Charlotte Business Journal. Piedmont Mining Co. Seeks to Raise 11.3 Million. May 8, 1989, p. 7.

[10] Pay Dirt. Brewer Gold Produces 8,900 Ounces of Gold in 1987. Feb. 1988, p. 10b.

[11] Progressive Journal. Brewer Gold Mine Producing More Than Expected. Dec. 31, 1988.

[12] ———. Brewer Gold Co. Finds Sites in Lancaster County Promising. May 17, 1988.

[13] Charleston Evening Post. Ferrochromium Facility Planned in North Charleston, July 22, 1988

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum (smelters)			
Alumax Inc.	Box 1000 Goose Creek, SC 29445	Plant	Berkeley.
Cement:			
Giant Portland Cement Co.	Box 218 Harleyville, SC 29448	do.	Dorchester.
Gifford-Hill Cement Co. of South Carolina	Box 326 Harleyville, SC 29448	do.	Do.
Santee Cement Co.	Box 698 Holly Hill SC 29059	do.	Orangeburg.
Clays:			
Common clay and shale:			
Gifford-Hill & Co. Inc.	Box 326 Harleyville, SC 29448	Mines and plant	Dorchester.
Palmetto Brick Co.[1]	Box 430 Cheraw, SC 29520	do.	Chesterfield and Marlboro.
Richtex Corp.[1]	Box 3307 Columbia, SC 29230	do.	Lexington and Richland.
Santee Portland Cement Co.	Box 698 Holly Hill, SC 29059	do.	Orangeburg.
Southern Brick Co.	Box 208 Ninety Six, SC 29666	do.	Greenwood, Newberry, Saluda.
Kaolin:			
Cyprus Industrial Minerals Co.	7000 South Yosemite St. Englewood, CO 80155	do.	Aiken.
W.R. Grace & Co., a subsidiary of National Kaolin Products Co.	Box 276 Aiken, SC 29802	do.	Do.
J.M. Huber Corp.	Rt. 4 Huber Macon, GA 31298	do.	Do.
Richtex Corp.	Box 3307 Columbia, SC 29230	do.	Lexington and Richland.
Colemanite:			
Industrial Minerals Inc.	Box 459 York, SC 29745	Plant	York.
Feldspar:			
Spartan Minerals Corp., a subsidiary of Lithium Corp. of America	Box 520 Pacolet, SC 29372	do.	Spartanburg.
Manganiferous ore:			
Ashe Brick Co.	Van Wyck, SC 29744	Mine and plant	Do.
Broad River Brick Co., a division of Borden Clay Products Co.	Box 368 Pleasant Garden, NC 27313	do.	Do.
Fletcher Brick Co., a division of Moland-Drysdale Corp.	Box 2150 Hendersonville, NC 28739	do.	Do.
Mica (sericite):			
Mineral Mining Corp.	Box 458 Kershaw, SC 29067	do.	Lancaster.
Sand and gravel:			
Becker Sand and Gravel Co. Inc.	Box 848 Cheraw, SC 29520	Pits and plants	Dorchester, Florence, Marlboro, Sumter.

See footnote at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued			
Brewer Sand Co. Inc.	Box 267, Rt. 2 Lancaster, SC 29720	Pit and plant	Lancaster.
Palmetto Sand Co.	Box 1893 Summerville, SC 29483	do.	Dorchester and Orangeburgh.
Stone (1987):			
Granite:			
Crushed:			
Lone Star Industries Inc.	515 West Greens Rd. Houston, TX 77067	Quarries and plant	Fairfield, Greenwood, Richland.
Martin Marietta Aggregates	Box 30013 Raleigh, NC 27612	do.	Fairfield, Lexington, Richland, York.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	do.	Greenville, Laurens, Pickens, Spartanburg.
Dimension:			
Granite Panelwall Co., a division of Florida Crushed Stone Co.	Box 898 Elberton, GA 30635	Quarry	Kershaw.
Matthews International Corp.	Box 606 Kershaw, SC 29067	do.	Do.
Limestone (crushed):			
Martin Marietta Aggregates	Box 30013 Raleigh, NC 27612	Quarry and plant	Berkeley and Georgetown.
Southern Aggregates Co.	Box 4510 Augusta, GA 30907	do.	Berkeley.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	do.	Cherokee.
Marl (crushed):			
Giant Portland & Masonry Cement Co.	Box 218 Harleyville, SC 29448	Pit	Dorchester.
Gifford-Hill & Co. Inc.	Box 326 Harleyville, SC 29448	Pit	Do.
Santee Portland Cement Co.	Box 698 Holly Hill, SC 29059	Pit	Orangeburg.
Vermiculite:			
Carolina Vermiculite Co. Inc.	Box 98 Woodruff, SC 29388	Mines and plant	Spartanburg.
W. R. Grace & Co.	Rt. 1 Enoree, SC 29335	do.	Laurens.
Patterson Vermiculite Co.	Rt. 1 Enoree, SC 29335	do.	Do.

[1] Also kaolin.

THE MINERAL INDUSTRY OF SOUTH DAKOTA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the South Dakota Geological Survey for collecting information on all nonfuel minerals.

By Leon E. Esparza[1]

In 1988, the value of South Dakota's nonfuel mineral production was about $285.7 million, an increase of 9% compared with the 1987 value. South Dakota ranked 33d nationally in the value of nonfuel mineral production, accounting for about 1% of the U.S. total. This marked the third consecutive year of significant increases in value. The growth, as in recent years, was attributed to increased production and attendant value of gold mined in Lawrence County. Gold, the State's leading commodity, accounted for 69% of the total value of nonfuel minerals produced in the State in 1988, followed by portland cement and crushed stone.

Precious metals exploration activity mirrored the growth in production. Twenty-three permits were issued to 14 companies for nonfuel minerals exploration in Butte, Custer, Lawrence, Meade, and Pennington Counties. All but one of these permits specified gold and silver as the target commodities. Six new life-of-mine permits were issued by the State, three of which were for pegmatite minerals and three for precious metals.

Minerals used in construction accounted for about 30% of the nonfuel mineral production value. In 1988, the value of nonresidential construction permits increased by more than 20% when compared with the 1987 value; the number of private and public residential units authorized increased by about 2.5%.[2] The value of State road contract awards dropped by nearly 3%, to $116 million.[3] According to the South Dakota Department of Labor, mining employment totaled about 2,760 jobs in 1988, a slight increase over 1987.

Mineral taxes in South Dakota are levied only on gold and silver production. Collections for the fiscal year ending June 30, 1988, totaled slightly more than $7.1 million, up about 58% from the previous fiscal year, according to the South Dakota Department of Revenue.

TRENDS AND DEVELOPMENTS

South Dakota voters rejected two antimining initiatives on November 8. The initiatives originally had been proposed by various local environmental groups; funding and support from local and national environmental groups spurred the drive. The first initiative called for large-scale open pit metal mines to be reclaimed to approximately their original contours upon completion of mining. The second initiative would have increased State severance taxes on sales of gold produced by open pit methods. Tax revenues were to be earmarked for a minesite cleanup fund, an unreclaimed lands fund, and regulation of the industry. There was industry-wide concern that if the South Dakota initiatives had passed, open pit sodium cyanide heap-leach operations in other States would become targets for similar actions.

TABLE 1

NONFUEL MINERAL PRODUCTION IN SOUTH DAKOTA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	4	W	4	W	4	W
Portland	do.	635	W	519	W	490	W
Clays[2]	short tons	118,718	$375	W	W	W	W
Gem stones		NA	100	NA	$100	NA	$100
Gold (recoverable content of ores, etc.)	troy ounces	W	W	W	W	449,514	197,026
Gypsum	thousand short tons	31	268	W	W	W	W
Sand and gravel (construction)	do.	9,713	19,853	e9,600	e19,100	7,929	18,681
Silver (recoverable content of ores, etc.)	troy ounces	W	W	W	W	84,398	552
Stone:							
Crushed	thousand short tons	e3,600	e12,600	5,070	18,515	e5,500	e20,600
Dimension	short tons	e54,934	e18,399	50,718	18,209	e43,297	e16,472
Combined value of beryllium concentrates (1986–87), clays (bentonite 1986, common 1987–88), iron ore (1988), lime, mica (scrap), and values indicated by symbol W		XX	181,291	XX	206,968	XX	32,288
Total		**XX**	**232,886**	**XX**	**262,892**	**XX**	**285,719**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kinds and values included with "Combined value" data.

REGULATORY ISSUES

The State Board of Minerals and Environment issued six life-of-mine permits in 1988. Two of these were issued to Bond Gold-Richmond Hill Inc. (formerly known as St. Joe Gold Corp.) and to The Golden Reward Mining Co. for new gold mining operations in Lawrence County. The other four permits went to operations in Custer County. These included one small, underground gold mine west of Custer held by Rhyolite Inc. of Gillette, WY, and three pegmatite minerals mining projects operated by two Custer-based companies. Mining Claims Management Co. operated one of these projects and North American Accounts Inc. operated the other two.

In November, a circuit court judge ruled that Consolidated Management Corp. (CMC) was illegally storing 285,000 short tons of incinerated sewage ash and that steps must taken to dispose of the ash. CMC had planned to construct a processing plant using "proprietary reactor technology" to extract gold and other products from the ash. The Metropolitan Waste Control Commission of St. Paul, MN, had paid CMC $9 million to haul the ash to a site near Edgemont, SD, beginning in 1986. CMC had claimed that the ash would be processed into fertilizer, paving materials, and $60 million worth of gold, and that the operation would create 300 new jobs. At yearend, the South Dakota Department of Water and Natural Resources was considering plans to spend at least part of CMC's $1.25 million bond on burying the ash.

EXPLORATION ACTIVITIES

Gold exploration in the Black Hills during 1988 escalated from the already feverish pace of the 2 previous years. Twenty-four exploration permits were issued to 13 companies. All but one of these permits were for gold; the other was for pegmatite minerals exploration by one company. Over the past 10 years, 145 State exploration permits identifying precious metals as a target have been held by 44 different companies. Most of this activity was in Lawrence County. In 1988, a total of 13,979 test holes was permitted for drilling.[4] Also permitted were 353 bulk sample pits, 3,800 small test pits, 21 trenches, and 69 miles of access roads. Sample targets included Precambrian iron formations, Cambrian Deadwood Formation, Mississippian Pahasapa (Madison) Limestone, Tertiary igneous intrusives, Quaternary alluvial placer deposits, and mine tailings.

Companies conducting minerals exploration included Beau Val Nevada Inc., Bond Gold-Richmond Hill Inc., Brohm Mining Corp., Compass Resources Ltd. (d.b.a. Oakmont Resources Inc.), Goldstake Explorations (SD) Inc., Homestake Mining Co., Minerva Exploration Inc., St. Joe Richmond Hill Inc., Mining Claims Management Co., Noranda Exploration Inc., Tera Mining Co., The Golden Reward Mining Co., and Wharf Resources (U.S.A.) Inc.

In addition to gold exploration near or adjacent to active or proposed mines, several old mining districts were explored. Beau Val drilled claims in the Keystone Mining District near Keystone, in the shadow of Mt. Rushmore. Exploration activity increased in the area around Rochford, about 15 miles south of Lead. Noranda received exploration permits for an area near Castle Peak, and Compass acquired permits for an area around Irish Gulch. Mining Claims Management Co. received permits to explore for pegmatite minerals east of Custer.

LEGISLATION AND GOVERNMENT PROGRAMS

Public debate continued on the Sioux Nation Black Hills Act, U.S. Senate bill 705 and House bill 1506, also known as the Bradley Bill. The bill's intent was to return 1.3 million acres, including almost all Federal land in western South Dakota, to the Sioux Indian Nation. At yearend, the bill was held in committee.

A new State law was implemented that gave counties with severed precious metals part of the minerals severance tax paid to the State. The law provided an allocation of 20% of the minerals severance tax paid by mining companies that began operations after January 1, 1981. Revenues would be used to fund road and school projects and other needs created by mining activities. A new law empowered the State Board of Minerals and Environment to amend fees, transfer mining permits, and amend the timetable for public hearings on mining applications. Also enacted was a State law exempting collection of State retail sales tax on sales of South Dakota-minted bullion pieces.

An allotment grant of $138,000 from the U.S. Bureau of Mines was received by the Mining and Mineral Resources Research Institute at the South Dakota School of Mines and Technology in Rapid City, under provisions of Public Law 98–409. The purpose of the institute is to coordinate and administer training and research in mining, mineral resources, minerals development, and mineral processing. Ten graduate fellowships were supported by the allotment grant. Projects undertaken included one on the origin of Tertiary age ore-forming fluids in the northern Black Hills. This study determined that an important factor in exploration for epithermal gold deposits similar to those in the Northern Black Hills is the recognition and characterization of intrusive rocks as sources of the fluids and gold.

Another study addressed the physical and economic feasibility of highwall reduction of surface mines in the Black Hills. Various pit slope angles ranging from 35° to 70° were used to evaluate three pit plans. Another study sought to develop a ground water flow model for the Pahasapa aquifer near Terry Peak in

the northern Black Hills. A study was begun to characterize rocks of the Cambrian Deadwood Formation by shear strength and surface roughness of rock joints using fractal geometry.

The Mining and Mineral Resources Research Institute also provided technical assistance to the South Dakota Department of Water and Natural Resources in reviewing gold mine permit applications and other technical issues related to mining in South Dakota. For example, the technical content of The Golden Reward Mining Co. permit application was reviewed; the review included an on-site inspection of planned mine areas and submission of written comments. An on-site inspection of construction progress was made of the Brohm Mining Corp. Gilt Edge Mine. Associates of the institute also conducted a stability assessment of an area proposed by Homestake Mining Co. for a waste dump near the Homestake Mine.

In 1988, the Employer's Investment in South Dakota's Future, an investment fund created by the State legislature, provided $71,800 to research a high-temperature chlorination process to recover gold from scrap. Matching funds of $8,400 were provided by the Chlor-Pure Corp. of Rapid City. The study was done by the Center for Innovation, Technology, and Enterprise at the South Dakota School of Mines and Technology. The research indicated that gold scrap from Black Hills jewelry manufacturing can be easily refined using chlorine gas, and that gold, arsenic, and mercury can be removed from Whitewood Creek mine tailings by the same method.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Beryllium.—Pacer Corp. has historically reported production of beryllium as a coproduct of feldspar mining by its contract miners. Beryllium, feldspar, and mica occur in pegmatite deposits in the vicinity of Custer. In 1988, no beryllium production was reported because of a dearth of beryl associated with pegmatites mined during the year. This development, however, is not expected to be trend setting.

Gold and Silver.—The State ranked third of 14 States in gold production and hosted the second largest gold mine in the United States. Gold production in 1988 totaled almost 450,000 troy ounces valued at nearly $200 million, up significantly from 1987 production. Gold accounted for about 69% of the State's total nonfuel mineral production value. Silver, produced as a coproduct of gold mining, also posted production and value increases. Precious metals production increased because of increased efficiency, new heap-leach pads coming on-line, and one new mine beginning production. All of the active, major gold operations were located in the northern Black Hills of Lawrence County.

Homestake Mining Co. was the State's largest gold producer. According to the Homestake 1988 annual report, gold production from the Homestake and Open Cut Mines at Lead totaled nearly 390,200 ounces, a 20% increase over 1987 output. Gold metal yields from the Homestake and the Open Cut were 343,987 and 46,175 ounces, respectively. Production was at its highest level since 1972. Improved mine scheduling, higher grade ore blocks, and strict grade control led to a 17% increase in the grade of underground ore to 0.187 ounce of gold per ton. Overall grade of ore milled increased 15% to 0.168 ounce per ton. Unit costs at the Open Cut were decreased through higher ore production and slightly reduced waste stripping. Total tons of milled ore increased 5% owing to a new gravity separation circuit that was installed in 1987. Its first full year of operation was completed in 1988.

Ore reserves at the Homestake Mine were nearly 18.6 million short tons at 0.218 ounce of gold per ton. Ore reserves at the Open Cut totaled about 6.6 million tons at 0.120 ounce per ton. Total gold reserves were about 4.8 million troy ounces. Exploration for new reserves at the Open Cut and in deep levels of the Homestake essentially replaced gold produced in 1988. Average full production costs declined to $314 per ounce of gold in 1988, a decrease of $33 per ounce from costs reported in 1987. Homestake also produced silver as a coproduct of gold mining.

Construction of a $6 million ventilation cooling system on the 6,950-foot level of the underground mine was completed and commissioned. This project was expected to reduce ambient temperatures in the lower portions of the mine and thus increase productivity.

Construction of a 50-foot lift on the Grizzly Gulch tailings dam was begun, with an expected cost of about $17 million. Completion of the 350-foot-high dam in 1989 was expected to add 11 years of storage capacity. The addition will raise the dam's total capacity by 9,300 acre feet, to a total of about 21,000 acre feet. This was the second of three planned lift expansions. The original 250-foot-high zoned earth- and rock-filled dam, completed in 1977, was designed to accommodate three additional raises. The first raise was completed in 1982.

Wharf Resources (U.S.A.) Inc.'s operations at its Foley Ridge project were expanded in 1988. The open pit and sodium cyanide heap-leach operation is located north of Terry Peak in Lawrence County. Heap leach methods extract precious metals from ore by spraying a diluted solution of sodium cyanide over crushed rock heaped on an impervious pad; the metal dissolved by the solution is then recovered. At midyear, construction on a major expansion to increase ore treatment capacity from 1.3 million tons to 2.3 million tons per year was begun. Wharf estimated that $7.2 million would be

spent for a new crushing circuit and an addition to the gold treatment plant. At yearend, the gold plant expansion was essentially complete and construction completion on the crushing plant was expected in early 1989. In late summer, construction on a fourth heap-leach pad was completed. Gold production for the year was 59,500 ounces, an increase of 29% over that of 1987.[5] Total ore production was about 1.5 million tons at an average grade of 0.046 ounce of gold per ton. The increase was attributed to mild winter weather, enhanced performance of the winter heap-leach system, more efficient leach pad spraying methods, and improved gold recovery from the more finely crushed ore placed on the pads in 1987, which resulted in faster leach rates. Cash operating costs in 1988 were $178 per ounce of gold, a decrease of 6% from 1987 costs. Gold reserves totaled about 904,000 ounces, down almost 7% from those reported in 1987. Average cash cost of sales per ounce of gold was $183, down about 3% from that reported in 1987. Wharf also recovered silver as a coproduct. In early November, the boards of directors for Dickenson Mines Ltd. and Wharf Resources Ltd. decided, due to market conditions, to postpone indefinitely the proposed arrangement announced in late July, under which shares of Dickenson and the common shares of Wharf were to be exchanged for shares of a new company, Dickenson Mines, Inc.

Brohm Mining Corp., a wholly owned subsidiary of MinVen Gold Corp., poured the first doré button on October 6 from its Gilt Edge operation, 5 miles southeast of Lead. MinVen was formed in early August by the amalgamation of Brohm Resources Inc. and MFC Mining Finance Corp. Construction on the $17.5 million open pit mine, sodium cyanide heap-leach pads, and Merrill-Crowe recovery plant began in late March. Annual gold production was expected to be 45,000 ounces of gold. In 1988, ore production totaled about 548,000 tons, grading 0.035 ounce of gold per ton and yielding 6,666 ounces of gold and 8,072 ounces of silver.[6] Cash operating costs were estimated to be $240 per ounce of gold.[7] Brohm began a 2-year, $11.8 million development program to increase ore reserves at the Gilt Edge and to evaluate the feasibility of a major project expansion. In 1988, $3.6 million was spent on 160,000 feet of development drilling. Drilling results brought total proven and probable ore reserves to about 54 million tons, grading 0.041 ounce of gold per ton and containing about 2.2 million ounces of gold.[8] Based on these results and metallurgical tests, MinVen commissioned Bechtel Engineering Inc. of San Francisco to conduct an engineering study for a 6.0-million-ton-per-year mining and milling facility at Gilt Edge. A preliminary estimate of the capital cost for the expansion was $100 million. This estimate included $18 million for mining equipment, $62 million for a gravity separation and cyanide leaching mill, and $20 million for a tailings dam. The expanded project would produce about 200,000 ounces of gold per year beginning in mid-1992.[9]

At yearend, Brohm awaited approval from the South Dakota Department of Water and Natural Resources to resume production following repair of a leak in a cell in the heap-leach pad's primary liner. Brohm uses an on-off load, heap-leach system. The system was shut down in late October when a leak occurred along cold seams where the liner changed from asphalt to high-density polyethylene. Solutions did not escape the secondary liner; they were pumped to storage ponds that are part of a state-of-the-art leak collection recovery system. Total cost of the repairs was estimated to be about $120,000.[10] In March, the State Board of Minerals and Environment granted Brohm an amendment to its mining permit. The amendment allowed Brohm 65 additional acres for a heap-leach pad site and an enlargement of proposed open pits at the current operation.

Bond Gold-Richmond Hill Inc., a wholly owned subsidiary of Bond International Gold Inc. and formerly known as St. Joe Gold Corp., began mine and plant construction on its Richmond Hill project in early spring. The $11 million open pit mine and sodium cyanide heap-leach operation received its mining permit in late January from the State Board of Minerals and Environment. The mining permit is for the Richmond Hill area about 5 miles northwest of Lead and includes the Richmond Hill and Turnaround deposits. The project was expected to have a mine life of about 10 years. Ore reserves were reported to be 3.9 million tons, grading 0.053 ounce of gold per ton. Gold metal reserves were stated to be 357,000 ounces.[11] Gold recovery was expected to be about 78% using carbon absorption. Annual production was expected to be 43,000 ounces, with operating costs at about $200 per ounce.[12] Gold production, which began in December, totaled about 1,000 ounces for 1988.[13]

Bond Gold's ore body is hosted within an elongated Tertiary breccia pipe and stockwork fractures emplaced in Precambrian metamorphic rocks. Part of the deposit is reportedly underlain by an as yet unevaluated auriferous sulfide zone.

The Golden Reward Mining Co. began operations at its Golden Reward Mine in July. The company is a joint venture with equal shares held by Coin Lake Gold Mines, Moruya Gold Mines of North America Inc., and MinVen Gold Corp., which acquired its interest in late December from the Denver-based Ventures Trident Limited Partnership. Construction began on the open pit mine, sodium cyanide heap-leach pads, and Merrill-Crowe recovery plant. Upon completion, total capital cost, excluding working capital, was anticipated to be $35.3 million.[14] Production was expected by the third quarter of 1989. The 772-acre project area had company-reported proven and

probable ore reserves of 18.8 million tons, containing 824,000 ounces of gold and about 3.77 million ounces of silver at a cutoff grade of 0.0175 ounce of gold per ton.[15] Annual ore production of 2.0 million tons, yielding 60,000 ounces of gold, was expected over a 6-year mine life. Gold recovery was expected to be 70%.

The Golden Reward Mine plan indicated reclamation concurrent with the mining of seven pits to be mined, in turn, to depths ranging from about 100 to 300 feet, and to be backfilled when feasible. Ore is to be crushed in a 10,000-ton-per-day mill, then loaded by conveyor and mobile stacker onto the leach pad. A mobile side bucket reclaimer and conveyor system will offload spent ore. The use of the conveyor and mobile stacker reclaimer system was to be a first for gold heap-leach operations. The intent was to keep heavy equipment off the heaps, which would protect the impermeable leach pad liners from punctures and subsequent leaking. Operating costs, including royalties and severance taxes, were expected to average $204 per ounce over the mine life.[16]

As an investment and goodwill gesture, the company bought $1.2 million worth of stock in the Black Hills Chairlift Co., which operates the Terry Peak ski facility, the largest in the central United States. The mine operation is adjacent to, and highly visible from, the ski facilities. Golden Reward previously bought land on part of the mountain, in part for the mine site and in part as an investment. Money from the stock purchase was used for a new lodge and snowmaking equipment.

The Whitewood Creek joint venture involving Whitewood Development Corp. and Goldstake Explorations (SD) Inc. was formed in October. The venture was to be managed by Whitewood Development Corp., a wholly owned subsidiary of Homestake Mining Co. Goldstake is a wholly owned subsidiary of Goldstake Explorations Inc., Toronto, Canada. Each of the partners had equal shares. Goldstake's previous partner, Strawberry Hill Mining Co., received a 20% interest of Goldstake's share in the venture. The partners evaluated relict mine tailings along an 18-mile stretch of Whitewood Creek, from its confluence with the Belle Fourche River southward to an area just north of the town of Whitewood. The area includes parts of Butte, Meade, and Lawrence Counties. The tailings occur at the surface and have a weighted average thickness of 4.8 feet. The material was carried downstream from mines and stamp mills that operated in the northern Black Hills from 1876 to the early 1900's. According to the Whitewood joint venture, the area has over 10.4 million tons of tailings, containing over 500,000 ounces of gold. The area is listed as a U.S. Environmental Protection Agency (EPA) Superfund site eligible for remediation under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The tailings reportedly contain an average of 2,500 parts per million (ppm) total arsenic, primarily in an iron arsenate form with trace amounts of cadmium and mercury. An environmental baseline assessment and economic feasibility study for a potential mining project were underway at yearend. An initial decision by the EPA on proposed optional remedies under CERCLA guidelines was anticipated by November 1989 and expected to become final in the early part of 1990.

Minerva Exploration Inc., a subsidiary of Naneco Resources Ltd. of Calgary, Alberta, unsuccessfully sought a water permit for its proposed Johnson Gulch surface gold mine west of Lead. In December, the South Dakota Water Management Board, in an unprecedented action, ordered Minerva to provide detailed plans for the operation before granting the permit. The Board indicated that it would reconsider the application in March 1989 if Minerva completed its final mine plan. Historically, the board had been required only to decide on water availability, impacts on other users, and whether the proposed use was in the public interest; review of detailed mine and reclamation plans had been a responsibility of the South Dakota Department of Water and Natural Resources.

Minerva had sought to drill three wells, each about 1,000 feet deep, to supply the mine and mill with water at a maximum pump rate of 150 gallons per minute. According to Naneco, the deposit had ore reserves, at a cutoff grade of 0.010 ounce of gold per ton, of about 6.5 million tons, with an average grade of 0.04 ounce of gold per ton for a metal content of 260,000 ounces.[17] The ore occurs in flat-lying silicified limestone breccia that averages 16 feet in thickness at depths from 0 to about 45 feet. Naneco indicated an annual production rate of 1 million tons for up to 10 years. Construction of the surface mine and vat leach recovery plant was expected to cost $12 million. The mine site would be near the rim of Spearfish Canyon, a scenic area popular with local citizens and tourists.

Rhyolite Inc. received a life-of-mine permit for its D&R Claim No. 3 from the South Dakota Department of Water and Natural Resources in late April for a proposed small underground gold operation. The permit application indicated a planned mine life of 10 years with an annual production rate of up to 5,000 tons. At yearend, development had not begun.

Iron Ore.—Pete Lien & Sons Inc. entered a 5-year contract with the South Dakota Cement Commission to produce a small amount of iron ore for use in cement manufacturing. According to the contract bid specification delivery schedule, the bidder was to provide the equivalent of 8,000 tons of elemental iron each year for 5 consecutive years beginning in 1988. Iron ore was surface mined from a small deposit near Nemo.

Industrial Minerals

Cement.—In 1988, sales and attendant value of the State's second leading commodity, portland cement, fell for

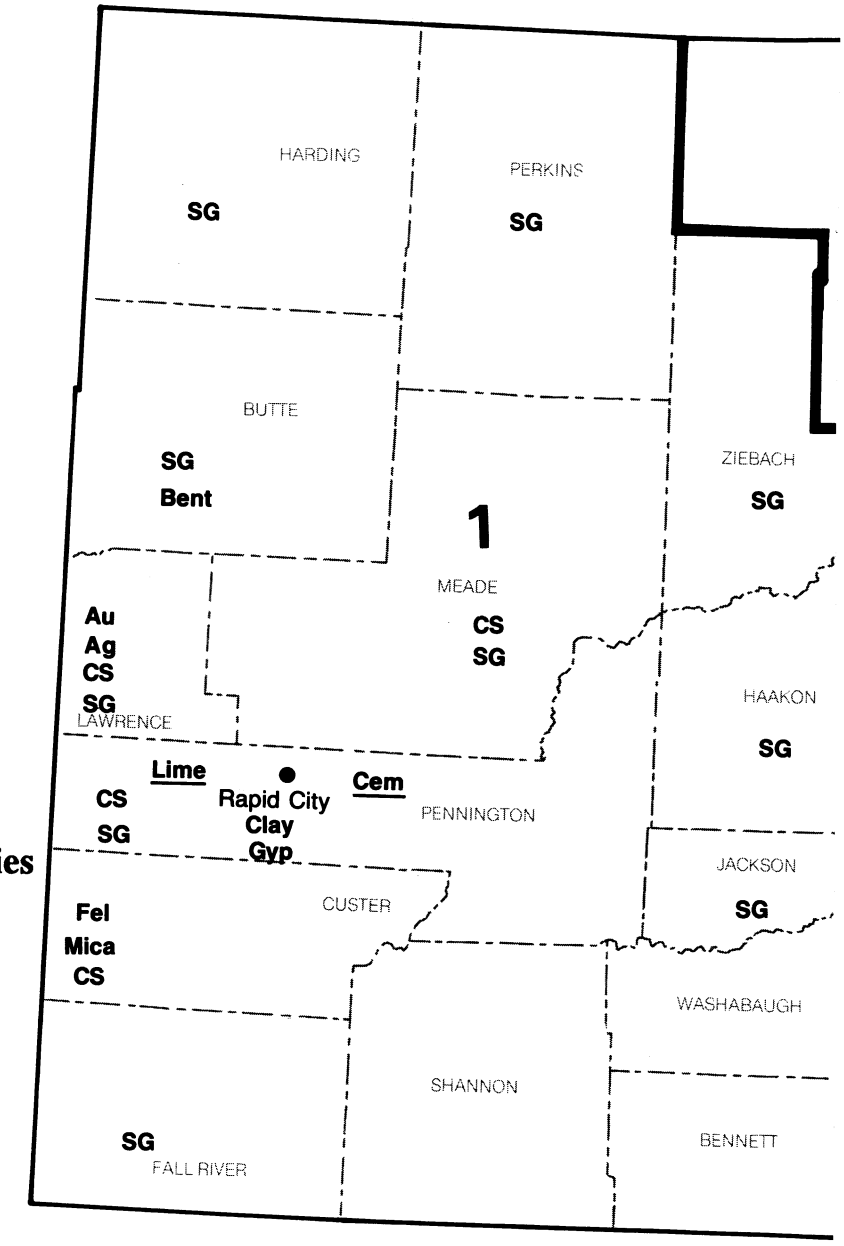
SOUTH

LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

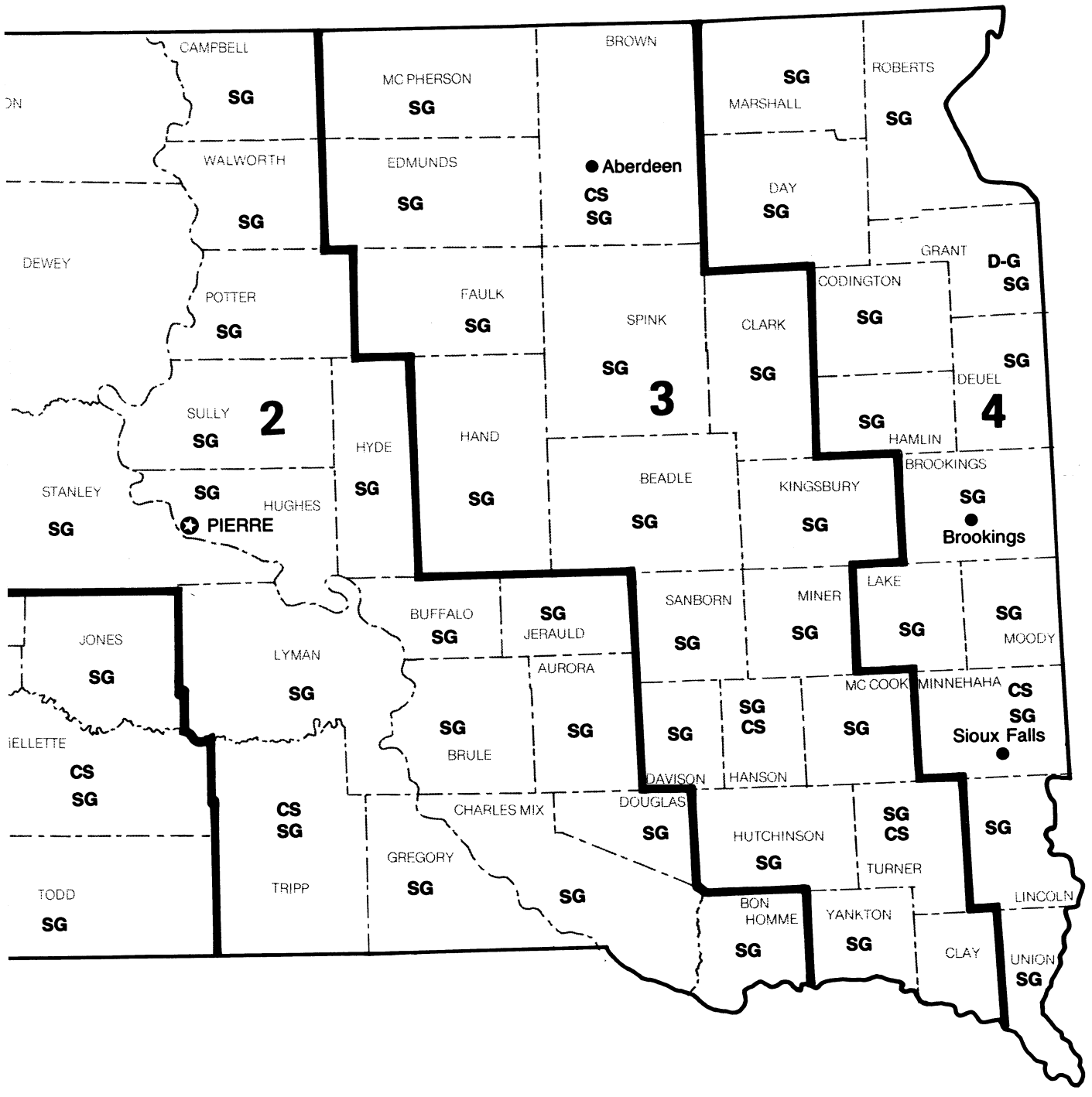
MINERAL SYMBOLS

Ag	Silver
Au	Gold
Bent	Bentonite
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-G	Dimension Granite
Fel	Feldspar
Gyp	Gypsum
Lime	Lime plant
Mica	Mica
SG	Sand and Gravel



Principal Mineral-Producing Localities

AKOTA


CAMPBELL
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BROWN
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MARSHALL
ROBERTS
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WALWORTH
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EDMUNDS
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Aberdeen
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DAY
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DEWEY
POTTER
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FAULK
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SPINK
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CLARK
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CODINGTON
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SULLY
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HAND
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KINGSBURY
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HAMLIN
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BROOKINGS
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Brookings
STANLEY
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HUGHES
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PIERRE
BUFFALO
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JERAULD
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MC COOK
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Sioux Falls
IELLETTE
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CHARLES MIX
DAVISON
HANSON
DOUGLAS
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HUTCHINSON
SG
SG
CS
TURNER
SG
GREGORY
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TRIPP
SG
TODD
SG
BON HOMME
SG
YANKTON
SG
CLAY
LINCOLN
UNION
SG

the third consecutive year. The 6% decline was mostly because of reduced sales to ready-mixed concrete operations, which experienced decreased sales in some marketing regions, in part because of reduced road construction or building construction. Masonry cement sales and attendant value fell nearly 8% in 1988, resuming the declines reported in 4 of the previous 5 years. Total clinker sales in 1988 were 588,000 short tons.[18] About 54% of the finished portland cement was sold to ready-mixed concrete companies, 22% to highway contractors, 8% to other contractors, and 16% to various other consumers. The State's only cement plant, at Rapid City, is owned by the State of South Dakota and governed by a seven-person commission, appointed by the Governor. A high percentage of the plant's earnings is remitted to the State's general fund each year. The plant employed about 230 people and operated around the clock all year. The plant uses both the wet- and dry-kiln processes and has a clinker production capacity of 965,000 tons. The finished product is marketed under the name Dakotah Brand in South Dakota, in six adjacent States, and in Colorado.

In 1988, $1.8 million was appropriated for various capital improvements for the plant. One improvement was designed to control fugitive dust from cement loading onto railroad cars, at a cost of at least $400,000.

Feldspar and Mica.—Feldspar and mica were mined from numerous pegmatite deposits in the vicinity of Custer by miners under contract with Pacer Corp. of Custer, SD. In 1988, feldspar production and value increased about 42% as compared with 1987 figures. In the same period, scrap mica production and value increased about 7% and 10%, respectively. Based on quantity produced, South Dakota ranked sixth of six feldspar-producing States and second of seven mica-producing States. Feldspar is used as a flux in glass and ceramics manufacturing. Mica is used in manufacturing gypsum wallboard, cement, paint, roofing materials, rubber products, and as an oil-well drilling mud additive.

Not included in the Bureau of Mines production totals was output from Mining Claims Management Co. (MCMC) and North American Accounts Inc. (NAAI). NAAI produced small amounts of pegmatite deposits from its Sheryl and Whale claims near Custer. Scrap mica reportedly was shipped to Franklin Minerals Corp., Hartwell, GA. Ore was processed by NAAI at its 12-ton-per-day mill. The mill's jaw crushers, roll crushers, and single and double deck screens reduced the mica to a +⅛-inch size, averaging about 4% biotite, which was removed using magnetic separation.[19]

MCMC had limited production from its Arcade and Scott pegmatite mines in Custer County. Total production was less than 100 tons of hand-cobbed specimen-grade beryl, feldspar, mica, and rose quartz. Production was sold to collectors. In December, MCMC was sold to Good Faith Mining Co. of Custer at an undisclosed price. However, the former management of MCMC retained the Arcade Mine and reported plans to continue and eventually expand operations for commercial-grade feldspar[20] and rose quartz for applications ranging from landscape material to gem stones.

Gem Stones.—The value of gem stones collected during 1988 was estimated to have remained the same as that of 1987 and represented material collected by rockhounds, mineral collectors, and other hobbyists. Gem stones common to the State include various euhedral, coarse-grained, and cryptocrystalline varieties of quartz, including rose quartz and numerous multicolored varieties of agate, chalcedony, jasper, and petrified wood. Gem stones commonly associated with metamorphic rocks in the Black Hills area or nearby placer deposits are staurolite and garnet, includ-

TABLE 2

SOUTH DAKOTA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	804	$2,874	$3.57
Plaster and gunite sands	W	W	4.67
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	3.25
Asphaltic concrete aggregates and other bituminous mixtures	524	2,024	3.86
Road base and coverings[1]	2,823	5,867	2.08
Fill	191	219	1.15
Snow and ice control	9	17	1.89
Other	118	367	3.11
Unspecified:[2]			
Actual	1,556	3,753	2.41
Estimated	1,904	3,561	1.87
Total or average	**7,929**	**[3]18,681**	**2.36**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes road and other stabilization (cement and lime).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data do not add to total shown because of independent rounding.

TABLE 3

SOUTH DAKOTA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	297	1,256	114	382	235	715	168	560
Asphaltic concrete aggregates and other bituminous mixtures	112	870	37	77	227	665	148	412
Road base and coverings[2]	490	1,156	869	1,910	629	1,282	835	1,518
Fill	([3])	([3])	W	W	W	W	144	151
Snow and ice control	—	—	W	W	W	W	8	15
Other miscellaneous	42	99	21	54	70	209	23	36
Other unspecified[4]	174	253	1,003	1,302	492	1,756	1,791	4,003
Total[5]	**1,115**	**3,635**	**2,044**	**3,726**	**1,652**	**4,626**	**3,117**	**6,695**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for plaster and gunite sands.
[2] Includes sand and gravel for road and other stabilization (cement and lime).
[3] Less than 1/2 unit.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

ing almandite, andradite, grossularite, pyrope, and spessartite.

***Sand and Gravel* (Construction).**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987. South Dakota construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data for the State's four districts.

Construction sand and gravel was the State's fourth leading nonfuel mineral commodity. In 1988, production declined 17% in quantity and 2% in value. Leading counties were Codington, Corson, and Minnehaha.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—Crushed stone production and value were estimated to have increased 8% and 11%, respectively, in 1988.

Dimension.—South Dakota ranked 10th of 35 States in dimension stone production. Grant County hosted five granite dimension stone operations, all east of Milbank, in 1988. Production was mostly of the variety locally referred to as mahogany granite, a burgundy- and black-colored, coarsely crystallined granite that crops out or lies near the surface. Cut and polished slabs or rough-cut slabs were hauled by truck to finishing plants, then shipped to various domestic and international markets. Large volumes were sold to Japan and Italy for use as building stone veneers. Another large use is in manufacturing monuments. Part of Cold Spring Granite Co.'s South Dakota production was used in manufacturing granite floor tile at its Cold Spring, MN, plant. At yearend, Dakota Granite Co. was finalizing plans to begin manufacturing granite floor tile at its Milbank plant by mid-1989.

Other Industrial Minerals.—Common clay and shale increased in production and value about 23% and 38%, respectively, during 1988. Crude gypsum production, used by the Cement Commission plant at Rapid City in the manufacture of cement, decreased almost 3%, and value increased nearly 19%. Output and value of hydrated lime and quicklime increased 27% and 22%, respectively. High-purity, highly refined natural quartz for use in the manufacture of semiconductors and specialty glass was produced by MinTech Corp. of Custer.

[1] State Mineral Officer, Bureau of Mines, Minneapolis, MN.

[2] U.S. Department of Commerce, Bureau of the Census. Private communication, 1989; available upon re-

quest from L.E. Esparza, BuMines, Minneapolis, MN.

[3]Highway and Heavy Construction. Market Update: On the Road Again. V. 130, No. 6, June 1987, p. 36.

———. Highways: New State Revenue Cushions Falling General Aid. V. 131, No. 6, June 1988, p. 34.

[4]Mining Engineering. State Activities 1988—South Dakota. V. 41, No. 5, May 1989, pp. 316–317.

[5]Wharf Resources Ltd. (Toronto, Canada). 1988 Annual Report to Stockholders. 20 pp.

[6]MinVen Gold Corp. (Denver, CO). 1988 Annual Report to Stockholders. 40 pp.

[7]Western Mining Activity Report. V. 2, No. 11, Nov. 1988, p. 4.

[8]Work cited in footnote 6.

[9]Ibid.

[10]Ibid.

[11]Engineering and Mining Journal. Richmond Hill Gold Mine Opens. V. 190, No. 1, Jan. 1989, p. 13.

[12]Work cited in footnote 11.

[13]Bond International Gold Inc. (Denver, CO). Second Quarter Report, Dec. 31, 1988, 12 pp.

[14]Work cited in footnote 6.

[15]The Mining Record. Final License Received For Golden Reward Mining Project. V. 99, No. 28, July 13, 1988, p. 5.

[16]Work cited in footnote 6.

[17]Naneco Resources Ltd. Private communication, 1989; available upon request from L. E. Esparza, BuMines, Minneapolis, MN.

[18]The Rapid City Journal. Cement Plant OKs $487,000 for Two Projects. July 22, 1989, p. A8.

[19]Stratton, Vernon (North American Accounts Inc.). Private communications, 1989; available upon request from L. E. Esparza, BuMines, Minneapolis, MN.

[20]Ventling, Larry (Mining Claims Management Co.). Private communications, 1989; available upon request from L. E. Esparza, BuMines, Minneapolis, MN.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
South Dakota Cement Commission	Box 360 Rapid City, SD 57709	Plant	Pennington.
Clays:			
South Dakota Cement Commission	Box 360 Rapid City, SD 57709	Open pit mine	Do.
Feldspar:			
Pacer Corp.	Box 912 Custer, SD 57730	Open pit mines and dry-grinding plant	Custer.
Gold:			
Bond Gold-Richmond Hill Inc., a subsidiary of Bond International Gold Inc.[1]	601 West Main St. Lead, SD 57754	Open pit and leach pads under development	Lawrence.
Brohm Mining Corp., a division of MinVen Gold Corp.[1]	Box 485 Deadwood, SD 57732	Open pit and leach pads	Do.
Golden Reward Mining Co.	Box 888 Lead, SD 57754	Open pit and leach pads under development	Do.
Homestake Mining Co.[1]	Box 875 Lead, SD 57754	Underground mine and open pit, cyanidation mill, gravity separation, refinery	Do.
Wharf Resources (U.S.A.) Inc.	Box 897 Lead, SD 57754	Open pit and leach pads	Do.
Gypsum:			
South Dakota Cement Commission	Box 360 Rapid City, SD 57709	Open pit mine	Pennington.
Iron ore:			
Pete Lien & Sons Inc.	Box 440 Rapid City, SD 57709	do.	Lawrence.
Lime:			
Pete Lien & Sons Inc.	Box 440 Rapid City, SD 57709	Plant	Pennington.
Mica:			
Pacer Corp.	Box 912 Custer, SD 57730	Mine and dry-grinding plant	Custer.
Sand and gravel (construction):			
Bob Bak Construction Co.	Box 256 White River, SD 57579	Pits and plant	Corson.
Birdsall Sand & Gravel Co.	Box 767 Rapid City, SD 57709	Pits and plants	Fall River, Pennington, Sully.
Brownlee Construction Co.	Route 3 Watertown, SD 57201	do.	Codington.
Tom Luke Construction Co.	Box 169 Kimball, SD 57355	do.	Brule and Sanborn.
Bernard Mahrer Construction Inc.	Main Street Rutland, ND 58067	do.	Marshall.

See footnote at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone (1987):			
Crushed:			
Limestone:			
Pete Lien & Sons Inc.	Box 440 Rapid City, SD 57709	Quarries and plants	Custer and Pennington.
Northwestern Engineering Co. (Hills Materials Co.)	Box 2320 Rapid City, SD 57709	do.	Pennington.
South Dakota Cement Commission	Box 360 Rapid City, SD 57709	Quarry and plant	Do.
Sandstone-quartzite:			
Concrete Materials Co.	Box 809 Sioux Falls, SD 57101	do.	Minnehaha.
L. G. Everist Inc.	Box 829 Sioux Falls, SD 57101	do.	Do.
Spencer Quarries Inc.	Box 25 Spencer, SD 57374	do.	Hanson.
Dimension:			
Granite:			
Cold Spring Granite Co.	202 South 3d Ave. Cold Spring, MN 56320	Quarries and plant	Grant.
Dakota Granite Co.	Box 1351 Milbank, SD 57252	do.	Do.

[1] Also silver.

THE MINERAL INDUSTRY OF TENNESSEE

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Tennessee Division of Geology for collecting information on all nonfuel minerals.

By Doss H. White, Jr.,[1] Ray Gilbert,[2] and Gregory Upham[2]

The value of nonfuel mineral production in Tennessee in 1988 was $585.6 million, a $57.8 million increase over that of 1987 and a new State record. The State ranked 17th nationally in total nonfuel mineral output. Tennessee again led the Nation in the output of ball clay and zinc. The five leading nonfuel mineral commodities mined in Tennessee, in terms of value, were crushed stone, zinc, portland cement, gem stones, and clays. The State's fuel mineral value was $212.6 million.

TRENDS AND DEVELOPMENTS

For many years the construction mineral commodities—clay, sand and gravel, and stone—have accounted for over one-half of the State's mineral value; they continued to do so in 1988. The resurgence of zinc production and sales, which began in 1986, continued with zinc sales accounting for approximately 27% of Tennessee's mineral value.

During 1988, Cyprus Industrial Minerals signed a letter of intent to sell its ball clay operation in northwestern Tennessee to Hecla Mining Corp. A new industrial sand company began operations in eastern Tennessee, and a chemical company perfected a process to remove elemental phosphorus from sludge generated by electric furnace processing of phosphate rock.

In 1987, the 144-year-old mining history of the Tennessee copper basin came to a close when the Tennessee Chemical Company closed the Cherokee mine and mill. During the early years of mining, the basin's hills were denuded for fuel for the copper roasters; later, sulfur fumes from the roasters destroyed the remaining vegetation. Without a cover, the hills soon eroded into a "bad lands" type of topography. Over the past several years, revegetation efforts by mining companies and the Tennessee Valley Authority have recovered much of the scarred landscape. However, further reclamation efforts are strongly opposed by many basin residents "who view (reclamation) as a threat to the area's unique heritage and landscape."[3]

Within a year of the closure of the Cherokee mine and mill, which eliminated almost 900 positions, the community of Copperhill, the hub of Polk County's defunct mining industry, filed for bankruptcy with more than $300,000 in debts. In 1979, Copperhill had contracted with a sister community, McCaysville, GA, to purchase water; in return, Copperhill provided sewer service for the Georgia community. (Copperhill no longer needed the extra water following the demise of mining.) The Georgia community had been paying Copperhill about $36,000 per year for the sewer service but began withholding payment because of the water dispute. McCaysville claimed that Copperhill owed $255,000 in back water payments.[4]

TABLE 1

NONFUEL MINERAL PRODUCTION IN TENNESSEE[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	short tons	1,164,290	$25,228	1,260,873	$25,480	1,285,002	$27,696
Phosphate rock	metric tons	1,231,000	21,191	W	W	W	W
Sand and gravel:							
Construction	thousand short tons	7,360	24,592	e7,900	e28,900	6,836	23,343
Industrial	do.	488	5,523	W	W	W	W
Stone:							
Crushed	do.	e[3]40,700	e[3]175,600	51,406	227,263	e52,200	e235,000
Dimension	short tons	e5,598	e1,553	3,360	573	e3,942	e567
Zinc	metric tons	102,118	85,550	115,699	106,926	119,954	159,201
Combined value of barite, cement, clays (bentonite 1988, fuller's earth), copper, gem stones, lead (1987–88), lime, pyrites (1986–87), silver, stone (crushed granite 1986), and values indicated by symbol W		XX	136,610	XX	138,670	XX	139,842
Total		**XX**	**475,847**	**XX**	**527,812**	**XX**	**585,649**

e Estimated. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Excludes certain clays; kind and value included with "Combined value" data.
[3] Excludes certain stones; kind and value included with "Combined value" data.

A 1-month strike by workers at the Tennessee Chemical Co.'s Copperhill plant ended as workers returned to work under a 6-month contract extension. A feasibility team was examining the possibility of an employee stock ownership plan, which would allow the approximately 420 workers to buy out the current stock owners. "The plan could range from as little as 10% ownership to 100% ownership . . ." and would create more of a ". . . trusting atmosphere between workers and management."[5]

Fuel mineral production fell for all three fuel commodities: coal, oil, and natural gas. Coal production declined 3% to 6.5 million tons valued at $174 million. Oil production declined 14,000 barrels to 600,000 barrels valued at $8.4 million, and natural gas output fell 0.6 billion cubic feet to 2.1 billion cubic feet. Natural gas value from the State's 802 producing wells was $3 million.

ENVIRONMENT

Early in 1988, E.I. du Pont de Nemours & Co. Inc. began drilling a multimillion dollar, 8,500-foot hole in Humphries County in western Tennessee. A continuous 4-inch-diameter core was being recovered; the hole was scheduled to bottom approximately 300 feet into the crystalline basement complex. Ground water samples were to be collected and analyzed for about 40 major constituents and trace inorganic constituents. Selected water samples from different horizons were to be sent to laboratories in the United States and Europe for age determinations. An electric log suite from surface to hole bottom was scheduled to be run. The project was initiated by Du Pont as part of an agreement with the U.S. Environmental Protection Agency (EPA). The company had submitted applications for permits under Underground Injection Control regulations, and EPA reviews considered some of the data submitted by Du Pont to be inconclusive with respect to underground sources of drinking water. To resolve the issue and obtain more precise data, the company agreed to drill the hole.[6]

LEGISLATION AND GOVERNMENT PROGRAMS

Early in 1988, Claiborne County, following the lead of other counties in the State, adopted a 15 cents per ton severance tax on all minerals mined in the county. State law dictated that mineral tax funds be used for construction and maintenance of county roads.

Williamson County adopted a countywide zoning plan, which included the establishment of mining districts. Local phosphate mining companies were concerned over the zoning of reserve areas not scheduled for mining for several years in the future. Under the plan, active mines would be phased out after a 5-year period.

The Tennessee Geological Survey (TGS) officially operated as the Division of Geology of the Tennessee Department of Conservation and also functioned as staff for the State Oil and Gas Board. During 1988, TGS's program of geologic mapping at the 1:24,000 scale was slowed to a virtual halt by preemption of staff time for work on Tennessee's bid for the Department of Energy's massive Superconducting Super Collider project. This work finally came to a conclusion when the project was awarded to Texas, although Tennessee finished respectably in the final group under consideration. Nevertheless, only 8 quadrangles were published during the year, and 13 mapping projects were in progress at various times during the year, mostly out of TGS's East Tennessee regional office in Knoxville.

More than 2,500 active and inactive mine, prospect, and outcrop locations for several of Tennessee's mineral commodities have been recorded. These records have been given to the Mineral Resources Data System of the U.S. Geological Survey in exchange for their Tennessee records. Eventually, every documented Tennessee mineral commodity location will be computerized in a format designed to generate usable maps and tables.

The State purchased the 16.4-acre site of the former Burra Burra copper mine in the southeastern Tennessee Copper Basin for approximately $230,000 to preserve the historic complex. The Burra Burra, named after an Australian mine, opened around 1900 and produced copper until 1958. The mine complex was placed on the National Register of Historic Places in 1973.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Barite.—Tennessee was one of two States in the eastern United States and five States nationwide with barite production. Barite, a natural barium sulfate, was used principally in the manufacture of barium chemicals and in drilling mud used by the petroleum industry. Tennessee's barite output was produced by the A.J. Smith Co., which operated a surface mine in the historic Sweetwater District in Loudon County. Barite was recovered from weathered residuum overlying the Knox Group composed of Cambro-Ordovician limestones and dolomites. Barite concentrates were shipped out-of-State for processing. Output increased 33% over that reported in 1987.

Cement.—Tennessee, with two cement plants, was one of six cement-producing States in the seven-State southeastern region. Both plants were in eastern Tennessee, and both produced masonry and portland cement. In 1988, the output of portland cement increased 5%; masonry cement pro-

duction fell 9%.

Dixie Cement Co. Inc. in Knoxville operated a 2-kiln, 550,000-short-ton-per-year clinker capacity, dry-process facility. Signal Mountain Cement Co. in Chattanooga operated a 2-kiln, 450,000-short-ton-per-year clinker capacity, wet-process plant.

Clays.—The State ranked 12th nationally in total clay production. In individual clay type output, Tennessee ranked 1st of the 5 States producing ball clay, 3d of the 9 States producing fuller's earth, and 19th of the 43 States with common clay and shale production. In 1988, clay production accounted for approximately 5% of the State's mineral value.

Tennessee's clay industry consisted of 8 companies operating 18 mines in 5 eastern and 4 western counties. The value of ball clay output ranked first, followed by that of fuller's earth.

Ball clay production was concentrated in northwestern Tennessee in Carroll, Gibson, Henry, and Weakley Counties. Production of 721,000 short tons valued at $26 million increased 29,000 short tons over that reported in 1987. The strong demand for new housing buoyed the demand for ball clay, and primary sales were to the sanitary ware and tile industries.

Common clay and shales were produced in five counties in eastern Tennessee and one county in the western part of the State. Eastern Tennessee production was reported from Anderson, Knox, Sullivan, Washington, and Hamilton Counties. Two companies operated six mines in these five east Tennessee counties. Despite the continuing demand for brick, cement, clay pipe, and other clay products, common clay output fell 5,000 short tons below that reported in 1987.

Lowe's Inc. mined a montmorillonite fuller's earth from pits in Henry County. The clay was marketed as an industrial and pet waste absorbent and as an insecticide and fungicide carrier. Production increased 5% over that reported in 1987, primarily due to the increase in demand for pet waste absorbents.

Lime.—Tennessee ranked 15th out of 34 lime-producing States. The State's lime industry consisted, as in past years, of Tenn-Luttrell Lime Co., a subsidiary of Penn-Virginia Corp., and Bowater Southern Paper Corp. The former operated a limestone mine and an 800-short-ton-per-day, coal-fired lime plant, while the latter produced lime as a byproduct of the papermaking process. Production increased slightly as the demand for lime by the paper, steel, and water purification industries rose.

Phosphate Rock.—The State continued to rank third among the six phosphate-producing States. Phosphate-rock-bearing residual clays, weathered from Ordovician limestones, were mined by Occidental Chemical Corp. and Stauffer Chemical Co. In 1988, surface mines were operated in Giles, Hickman, Maury, and Williamson Counties. The phosphate rock concentrate was feed for plants in Columbia and Mt. Pleasant, which converted the phosphate rock to elemental phosphorus used in the manufacture of a variety of chemical products. Production increased 5% over that of 1987, reflecting the continued growth of the Nation's economy and the demand for industrial chemicals.

During the year, which marked the centennial of phosphate mining in south-central Tennessee, Occidental Chemical Corp. announced it had developed a process for the recovery of elemental phosphorus from furnace sludge, a byproduct of phosphorous manufacture. Research efforts began in 1985 and became fully operational on a pilot plant scale in the fourth quarter of 1987. The new process was to recover the furnace sludge-phosphorus which, in past years, had been discharged into settling or tailings ponds. Rates in excess of 90% were reported for recovery of phosphorus from the ponds. If added to conventional phosphorus production, these recovery rates would increase a plant's output by 10%. The company planned to eliminate the tailings and reclaim the ponds after the phosphorus has been recovered.[7]

The Williamson County planning commission and two phosphate companies, Stauffer Chemical Co. and Monsanto Co. (a former producer), reached an agreement concerning the county's new "growth management plan." In the proposed zoning map, mining was listed as a conditional use in some zoning categories. In suburban zone areas, mining was forbidden. The phosphate companies were concerned also about the plan to require mining in some areas to cease after 5 years.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1987. Data for odd numbered years are based on annual company estimates.

Tennessee construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data for the State's three districts.

Tennessee's 46 reporting producers of sand and gravel produced 6.8 million tons worth $23.3 million. This amount was a 1.1-million-short-ton decrease and was $5.6 million below the value estimated for the industry in 1987. Sand and gravel sales accounted for almost 4% of the State's mineral value.

Forty companies produced construction sand and gravel from 48 pits in 25 counties. Tennessee's producers reported that principal sales were for concrete aggregate (26%) and road base and cover (25%).

Industrial.—Production of industrial sand and gravel was reported by four companies with operations in Campbell, Carroll, Hawkins, and Henry Counties.

In March, Short Mountain Silica Co. (SMS) began operations in Hawkins

TABLE 2

TENNESSEE: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	1,756	$6,131	$4.49
Plaster and gunite sands	65	342	5.26
Concrete products (blocks, bricks, pipe, decorative, etc.)	227	664	2.93
Asphaltic concrete aggregates and other bituminous mixtures	701	3,436	4.90
Road base and coverings	1,723	3,643	2.11
Fill	72	207	2.88
Snow and ice control	W	W	8.50
Railroad ballast	W	W	4.00
Other	194	1,192	6.14
Unspecified: [1]			
Actual	1,503	5,418	3.60
Estimated	595	2,310	3.88
Total or average	**6,836**	**23,343**	**3.41**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.

County. The company mined sandstone on Short Mountain and trucked the broken stone to a processing plant at the base of the mountain, where it was crushed, washed, sized, dried, and stored. The company's major customer was AFG Industries, which was also located in Hawkins County. Future SMS plans included the production of silica flour used in the electronics industry.[8]

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

Tennessee's 1988 stone production (crushed and dimension) was estimated to be 56.1 million short tons valued at $235.6 million, which was 40% of the State's 1988 mineral value. In 1987, the last year of a full 12-month stone canvass, 74 companies operated 135 quarries.

TABLE 3

TENNESSEE: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	1,128	2,853	W	W	W	W
Plaster and gunite sands	16	32	49	310	—	—
Concrete products (blocks, bricks, etc.)	118	314	W	W	W	W
Asphaltic concrete aggregates and other bituminous mixtures	435	1,184	W	W	W	W
Road base and coverings	1,307	2,257	332	1,124	85	261
Fill	W	W	W	W	—	—
Snow and ice control	—	—	W	W	W	W
Railroad ballast	W	W	—	—	—	—
Other miscellaneous	153	500	1,089	6,579	26	201
Other unspecified [1]	1,291	4,554	429	1,130	379	2,044
Total [2]	**4,448**	**11,693**	**1,898**	**9,144**	**490**	**2,506**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[2] Data may not add to totals shown because of independent rounding.

Crushed.—Crushed stone sales accounted for over 99% of the State's total stone production. Limestone and dolomite were the only stone types produced. In 1987, Tennessee's crushed stone industry consisted of 69 companies operating 129 quarries. The estimated 1988 production exceeded that reported in 1987 by 800,000 short tons. The increase was due, in part, to the continued strong showing of the construction industry in Tennessee and other southeastern States. Principal sales reported by the stone industry in 1987 included graded road base (15%), bituminous aggregate (15%), crusher run fill (13%), concrete aggregates (9%), and agricultural limestone (2%).

Dimension.—The State's dimension stone industry in 1987 was composed of five companies operating five quarries in the eastern part of the State. Principal rock types marketed were sandstone and quartzite from the Crab Orchard area on the Cumberland Plateau in Cumberland County and marble (Holston Limestone) from eastern Tennessee in Blount and Grainger Counties. The three sandstone-quartzite producers reported sales of (1) irregular-shaped stone, (2) cut and veneer stone, and (3) flagging. The two marble producers reported sales of (1) rough blocks, (2) irregular-shaped stone, (3) rough monument stone, and (4) sawed blocks and flagging.

Other Industrial Minerals.—Several industrial minerals were shipped into Tennessee and manufactured into a higher-value product. The value of these minerals is not included in the value data for nonfuel production in Tennessee.

In 1988, two companies operated three plants in Carter, Maury, and Montgomery Counties to produce electric furnace electrodes and high-modulus graphite fibers. Both the electrodes and fibers were manufactured from petroleum coke and coal tar pitch. One company produced organolithium compounds at a plant in New Johnsonville. Lithium carbonate and lithium metal used in the manufacturing process were obtained from other company operations in Nevada and North Carolina. Fused magnesia was produced at a plant in Greeneville. Three refractory grades and several grades of electrical magnesia were produced. Perlite obtained from New Mexico was expanded by a Nashville firm. The horticultural, construction, and filter industries provided the primary markets. The same plant that produced fused magnesia produced fused silica. The silica was used in the manufacture of silica nozzles, shrouds, and other refractory products. Vermiculite, obtained from South Carolina, was exfoliated at the Nashville plant. Principal sales were to the insulation market.

W.R. Grace & Co.'s fixed-nitrogen production facility at Woodstock was purchased by Western Branch Holding Co. The Woodstock facility can produce 400,000 short tons of urea annually.

Metals

With the closing of Tennessee's last pyrite-copper mine and mill complex on July 31, 1987, zinc became the only metal mined in the State. Several metal products were produced from foreign ores and concentrates and scrap. However, their values are not included in the mineral value noted in table 1.

Zinc.—In 1988, Tennessee accounted for 49% of the Nation's zinc output. Output increased 4,200 metric tons over the tonnage reported in 1987. The higher output was due to a continued rise in the worldwide price for zinc. As in past years, seven mines were operated in eastern and central Tennessee by three companies: ASARCO Incorporated, Jersey Miniere Zinc Co., and USX Corp. In eastern Tennessee, Asarco operated four mines and two mills, while USX operated a single mine and mill. In central Tennessee, Jersey Miniere operated two mines and a mill. Jersey Miniere also operated an electrolytic zinc refinery in Clarksville, northwest of Nashville. The company's two mines in central Tennessee's Smith County supplied approximately one-half of the concentrate used at the Clarksville refinery.

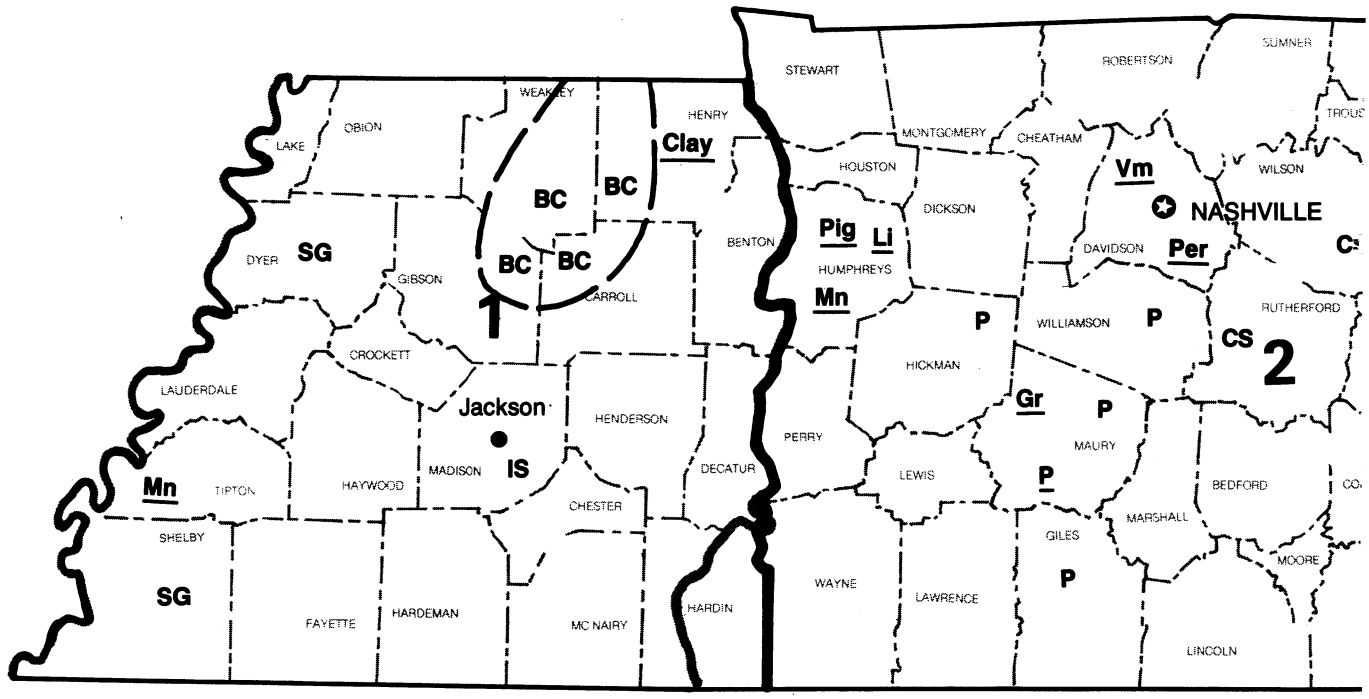
Asarco purchased the Beaver Creek and Jefferson City mines from Inspiration Resources Corp. The Beaver Creek mine was purchased in March and restarted in May, and ore was processed at Asarco's Young mill. The Asarco annual report stated that the company milled 2.7 million tons of ore to produce 67,850 tons of zinc concentrate. This output was an increase of 2,800 tons of concentrate over that produced in 1987.

In October, 320 Asarco miners returned to work following a 4-day strike resulting from a contract misunderstanding. A new contract was signed that excluded cost of living allowances and provided for hourly wage hikes and salary increases based on grade level over the following 3 years. At yearend, the weighted average wage was $8.93 per hour, with insurance and other benefits adding an additional amount.

Tennessee was the site of the world's largest zinc products manufacturing plant. Ball Corp.'s Zinc Products Division operated a 300,000-square-foot plant at Greeneville in northeastern Tennessee. The facility produced penny blanks, zinc battery cans, and rolled strip zinc used in several industrial applications. In 1988, the company made approximately 9 billion penny blanks for the U.S. Government.[9]

Horsehead Resources Development Co. Inc. purchased the operating assets of Reserve Carbon Inc. in Rockwood and planned to spend several million dollars to renovate and update the facility to recycle hazardous inorganic materials. Zinc, lead, and cadmium recovery was planned during the waste recycling steps; the waste was primarily dust from electric arc furnaces. An iron-rich material remaining after recycling was to be used in road construction, in cement, and as a sand substitute for icy roads.[10]

TENI



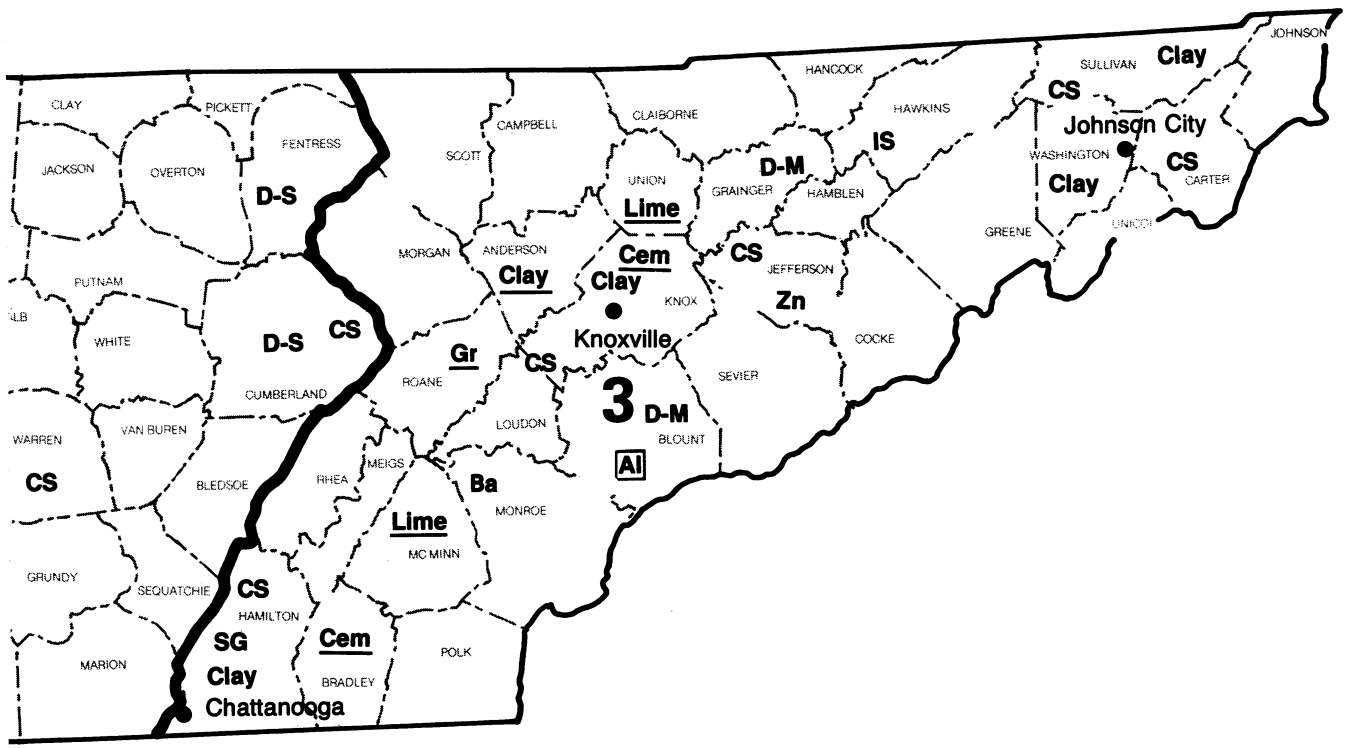
State boundary
County boundary
Capital
City
Waterway
Crushed stone/sand & gravel districts

MINERA

Al	Alumi
Ba	Barite
BC	Ball C
Cem	Ceme
Clay	Clay
CS	Crush
D-M	Dimer
D-S	Dimer
Gr	Graph
IS	Indust
Li	Lithiur

Principal Mine

SSEE



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MBOLS

Lime	Lime plant
Mn	Manganese Dioxide plant
P	Phosphate rock
P	Phosphorous plant
Per	Perlite plant
SG	Sand and Gravel
TiPig	Titanium Dioxide pigment plant
Vm	Vermiculite plant
Zn	Zinc
Zn	Zinc smelter
⬭	Concentration of mineral operations

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roducing Localities

Other Metals.—The Aluminum Company of America (ALCOA) operated a 200,000-metric-ton-per-year smelter at the city of Alcoa. During the year ALCOA and Coastal Products and Chemicals, Houston, formed a partnership to produce and market liquid sodium aluminate. A new plant to manufacture the sodium aluminate was to be constructed in Tennessee.[11]

Ferroalloys (ferrophosphorus) were produced by Stauffer Chemicals Co. and Occidental Petroleum Corp. at plants in Columbia and Mt. Pleasant. Jersey Miniere Zinc Co. recovered germanium and cadmium residues at the Clarksville zinc refinery and shipped the residues to Belgium for processing. Lead was recovered from scrap by General Smelting & Refinery Co., College Grove; Refined Metals Corp., Memphis; and Ross Metals Inc., Rossville. Manganese dioxide was produced by electrolytic methods at a Chemetals plant at New Johnsonville. The material was sold to alkaline battery manufacturers. Monazite mined in Australia was used to produce rare-earth catalysts and compounds at a W.R. Grace plant in Chattanooga.

Tennessee's steel industry consisted of Florida Steel Corp. with plants in Jackson and Knoxville. In 1988, Florida Steel constructed its first electric-arc furnace dust processing facility at the Jackson minimill. Zinc metal was to be recovered from the dust.

A steel billet and bar mill in Harriman, closed since 1981, was scheduled to be reopened by a group of local investors. The former Tennessee Forging Steel Co. plant was scheduled to be "melting and rolling by the end of the first quarter (1989) under the new name Tennessee Valley Steel Corp."[12]

Titanium dioxide pigments were produced by Du Pont at a 228,000-ton-per-year capacity plant, the world's largest, near New Johnsonville.

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[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL.

[2] Geologist, Tennessee Division of Geology, Nashville, TN.

[3] Franklin Review-Appeal. Basin's Raw, Red Hills Show Mining History. Nov. 11, 1988.

[4] Madisonville Democrat Observer. Copperhill Bankrupt Debts Total $300,000. Mar. 29, 1988.

[5] Cleveland Daily Banner. Workers Ownership Studied for Copperhill Industrial Firm. Apr. 20, 1988.

[6] Tennessee Division of Geology News Letter. The DuPont Deep Well in Humphries County, TN. V. 2, No. 2, July 1989.

[7] Industrial Minerals. Occidental Phosphorus Recovery. July 1988, p. 13.

[8] Kingsport Times-News. Short Mountain Silica Gold Dust in Hawkins. June 27, 1988.

[9] Greeneville Sun. World's Largest Zinc Mill Rolls Out Three Major Product Lines. May 27, 1988.

[10] Kingston News. Horsehead to Bring 120 Jobs. Jan. 6, 1989.

[11] Pittsburgh Press. ALCOA Forms Partnership. Feb. 8, 1988.

[12] American Metal Market. Investors Set to Reopen Tennessee Forging Mill. Sept. 9, 1988.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum smelters:			
Aluminum Co. of America	Box 158 Alcoa, TN 37701	Plant	Blount.
Consolidated Aluminum Corp.	1102 Richmond St. Jackson, TN 38301	do.	Humphreys.
Barite:			
A.J. Smith Co.	Route 3 Sweetwater, TN 37874	Open pit mine	Loudon.
Cement:			
Dixie Cement Co. Inc., a subsidiary of Moore McCormack Cement Inc.[1 2]	Box 14009 Knoxville, TN 37914	Plant	Knox.
Signal Mountain Cement Co.	1300 American National Bank Bldg. Chattanooga, TN 37402	do.	Hamilton.
Clays:			
Cyprus Industrial Minerals Co.	Box 111 Gleason, TN 38229	Pits and plants	Carroll and Weakley.
General Shale Products Corp.	Box 3547 CRS Johnson City, TN 37601	do.	Anderson, Hamilton, Knox, Sullivan, Washington.
Kentucky-Tennessee Clay Co.	Box 449 Mayfield, KY 42066	do.	Carroll, Gibson, Henry, Weakley.
Lowe's Inc.	Box 819 Paris, TN 38242	do.	Henry.
Old Hickory Clay Co.	Box 188 Gleason, TN 38229	do.	Henry and Weakley.
H.G. Spinks Clay Co. Inc.	Box 820 Paris, TN 38229	do.	Carroll, Henry, Weakley.
Copper:			
Tennessee Chemical Co.[3]	Copperhill, TN 37317	Underground mines, surface mine, plant	Polk.
Graphite (synthetic):			
Great Lakes Carbon Corp.	Box 1301 Rockwood, TN 37643	Plant	Roane.
Union Carbide Corp.	Box 513 Columbia, TN 38401	do.	Maury.
Lime:			
Bowater Southern Paper Corp.	Calhoun, TN 37309	do.	McMinn.
Tenn-Luttrell Lime Co.	Box 69 Luttrell, TN 37779	do.	Union.
Perlite (expanded):			
Chemrock Corp.	Osage St. Nashville, TN 37208	do.	Davidson.
Phosphate rock:			
Occidental Chemical Corp.[4]	Box 591 Columbia, TN 38401	do.	Do.
Stauffer Chemical Co.[4]	Box 89 Mount Pleasant, TN 38474	do.	Do.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Memphis Stone and Gravel Co.	Box 1683 Memphis, TN 38101	Pits	Shelby.
Rogers Group Inc.[2]	Box 25250 Nashville, TN 37202	do.	Madison, Roane, Tipton.
Standard Construction Co. Inc.	Box 38289 Germantown, TN 38138	Pit	Shelby.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	Pits	Hamilton.
Stone (1987):			
Limestone:			
American Limestone Co.	180 Maiden Lane New York, NY 10038	Quarries	Jefferson, Knox, Sullivan.
Hoover Inc.	Box 17346 Nashville, TN 37217	do.	Bedford, Hamilton, Rutherford, Warren.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	do.	Do.
Marble:			
John J. Craig Co.	Box 9300 Knoxville, TN 37920	Quarry	Blount.
Imperial Black Marble Corp.	8013 Chesterfield Dr. Knoxville, TN 37919	do.	Grainger.
Sandstone:			
Ross L. Brown Cut Stone Co. Inc.	Box 398 Crab Orchard, TN 37723	do.	Cumberland.
Crab Orchard Stone Co. Inc.	Drawer J Crossville, TN 38555	do.	Do.
Crossville Limestone Co. Inc.	Box 485 Crossville, TN 38555	do.	Do.
Mountain Stone Co.	Box 246 Jamestown, TN 38556	do.	Fentress.
Vermiculite (exfoliated):			
W. R. Grace and Co.	4061 Powell Ave. Nashville, TN 37204	Plant	Davidson.
Zinc:			
ASARCO Incorporated[2]	Mascot, TN 37806	Underground mines and plant	Jefferson and Knox.
Inspiration Resources Corp.	Box 32 Jefferson City, TN 37760	Underground mine and plant	Jefferson.
Jersey Miniere Zinc Co.	Elmwood, TN 38560	Underground mines, plant, smelter	Smith.
USX Corp.[2]	Jefferson City, TN 37760	Underground mine	Jefferson.

[1] Also clays.
[2] Also stone.
[3] Also pyrites, silver, and zinc.
[4] Also ferroalloys.

THE MINERAL INDUSTRY OF TEXAS

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Bureau of Economic Geology, The University of Texas at Austin, for collecting information on all nonfuel minerals.

By Jane P. Ohl,[1] L. Edwin Garner,[2] and Mary W. McBride[2]

Total value of nonfuel minerals produced in Texas in 1988 was nearly $1.5 billion, slightly higher than the 1987 value. The State fell to fifth rank in the Nation, having been as high as second in 1985 and 1986. The value of the State's nonfuel mineral output accounted for nearly 5% of the national total. In 1988, Texas produced 20 nonfuel minerals, 18 of which were industrial minerals and 2 of which were metals (iron, in the form of low-grade limonite-siderite, and magnesium metal).

TRENDS AND DEVELOPMENTS

While the Texas economy overall continued to recover after the drastic collapse of oil prices in 1986, individual sectors of the economy such as mining, construction, finance, and real estate were still struggling to rebound. More than 95% of mining activities in Texas are related to oil and gas extraction.[3]

The demand for industrial minerals such as sand and gravel and crushed stone depended strongly on the construction and real estate sectors, and reduced activities in those sectors controlled the output of industrial minerals. In 1987–88, the combined values of sand and gravel and crushed stone were approximately $898 million, or 12% lower than in 1985–86.

The value of highway construction work in Texas was expected to be as high as $1.9 billion in 1988 and to continue at that level for the next several years.[4]

EMPLOYMENT

Although unemployment throughout the State has been on the decline since the 1986 high of about 9%, unemployment in 1988 averaged 7.5%, nearly two percentage points higher than the national average.

EXPLORATION ACTIVITIES

Cyprus Sierra Blanca Inc. continued to evaluate and develop the Sierra Blanca beryllium project in Hudspeth County.[5]

LEGISLATION AND GOVERNMENT PROGRAMS

Winning over six other finalist States, Texas was awarded the scientific world's largest project, the $4.4 billion particle accelerator, the Superconducting Super Collider. The U.S. Department of Energy and the State of Texas now look to international cooperation for funding the project, which is to be built in Ellis County, south of Dallas. Construction of the underground, 53-mile-long oval collider will require large quantities of industrial and metallic materials and hundreds of workers. Nearly 16,000 acres of land will be required and 425 landowners will be affected.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Calcium Carbonate.—The Calcium Carbonate Division of J. M. Huber Corp., Edison, NJ, planned to construct a new calcium carbonate plant at Nolanville in 1989. Calcium carbonate has been used as a pigment substitute for kaolin clay in paper products.

Cement.—Portland cement production was down to its lowest level in 19 years: 7.0 million short tons in 1988, compared with a low of 6.2 million tons in 1970 and a high of 10.4 million tons in 1984. The decline in production has been attributed to an increase of cement and clinker imports, particularly from Mexico, and the downturn of the State's economy that began in 1986 with oil industry, real estate, and construction slowdowns.

The Bureau of Mines compiles Texas cement data in northern and southern divisions. In 1988, the northern division had eight plants. In the southern division, a plant in Bexar County was closed at the end of 1987, reducing the number of cement plants in the southern division to six. Yet the six southern division plants continued to produce more than the eight in the northern division: 3,561,000 short tons compared to 3,202,000. Capacity continued to be underutilized by 30% (southern division) compared to 47% (northern division).

The total value of portland cement output fell 47.6% between 1984 and 1988; nevertheless, Texas ranked 2d of 39 portland-cement-producing States. The price of oil-well cement sold in 1988 averaged $55.60 per ton, up 13% from the 1987 average and 2% higher than that of 1986. The average price of all types of portland cement (including that for the oil industry) was $41.75, down from $43.73 in 1987. Masonry cement output and value declined about 21% and 4%, respectively. The average value of masonry cement was $79.41 per short ton.

Twelve firms operated the 15 cement plants in Texas, with 12 wet-process and 11 dry-process kilns.

Raw materials consumed were 8.6 million short tons of limestone, cement rock, and chalk; 1.7 million tons of marl, clay, and shale; 330,400 tons of sand; 303,200 tons of gypsum; and lesser amounts of anhydrite, fly ash, iron ore, and various resins and chemicals. In addition, nearly 1 million tons of clinker was used, the majority (65%) of which was of domestic origin, a slight reversal of the recent trend to import clinker (52% in 1987) from Mexico and other foreign sources.

TABLE 1

NONFUEL MINERAL PRODUCTION IN TEXAS[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	209	$15,790	172	$11,283	136	$10,800
Portland	do.	8,883	412,697	7,318	319,996	7,000	292,256
Clays[2]	short tons	2,514,546	11,724	r3,315,424	r14,825	2,992,166	17,468
Gem stones		NA	297	NA	345	NA	340
Gypsum	thousand short tons	2,131	14,982	1,874	14,254	1,943	15,790
Lime	do.	1,173	62,670	1,140	59,027	1,192	55,935
Salt	do.	8,520	62,996	7,810	60,857	7,802	62,925
Sand and gravel:							
Construction	do.	59,562	209,855	e48,200	e178,600	50,370	171,167
Industrial	do.	1,302	18,274	1,509	22,843	1,631	26,645
Stone:							
Crushed	do.	e84,200	e301,500	84,347	276,477	e82,000	e271,300
Dimension	short tons	e49,457	e15,407	75,426	10,030	e66,354	e8,310
Sulfur (Frasch)	thousand metric tons	2,506	W	2,152	W	2,622	W
Talc	short tons	282,744	6,456	255,039	4,380	260,950	4,466
Combined value of asphalt (native, 1986), clays (ball clay, fuller's earth 1986–87, kaolin), fluorspar (1986), helium (crude and Grade-A), iron ore, magnesium compounds, magnesium metal, sodium sulfate (natural), and values indicated by symbol W		XX	579,340	XX	r457,814	XX	531,416
Total		**XX**	**1,711,988**	**XX**	**1,430,731**	**XX**	**1,468,818**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Excludes certain clays; kinds and values included with "Combined value" data.

Finished portland cement was sold to ready-mixed concrete companies (63% of shipments), concrete product manufacturers, contractors, highway contractors, building materials dealers, and government agencies. Almost 80% of finished cement was sent directly from the plant to the ultimate consumer, mostly in bulk by truck.

Several cement plants, including the Gifford-Hill & Co. and Texas Industries Inc. (TXI) plants at Midlothian, were burning nontraditional, waste-derived inexpensive fuels, enabling continued production at profitable levels.

Clays.—Texas clay output was down nearly 10% from the 1987 level, but total value rose 18%. Seven types of clay—ball clay, bentonite (nonswelling and swelling), common clay and shale, fire clay, fuller's earth, and kaolin—were produced in 26 of the 254 Texas counties. Clay-producing firms included the following companies: A. P. Green Industries Inc., a subsidiary of USG Corp., which produced fire clay from Cherokee and Wood Counties; Balcones Minerals Corp., producing fuller's earth from Fayette County; Milwhite Co. Inc., producing nonswelling bentonite from Fayette County; and Southern Clay Products Inc., producing ball clay and nonswelling and swelling bentonite from Gonzales County. Kaolin was produced from Limestone County, and 86% (2.5 million short tons) of the total common clay and shale production (2.9 million tons) was extracted from pits in Bastrop, Cherokee, Denton, Eastland, Ellis, Fort Bend, Guadalupe, Henderson, Navarro, Palo Pinto, and Smith Counties. Common clay and shale were used principally in brick and cement manufacture.

By midyear, Southern Clay Products Subsidiary, part of E.C.C. America Inc., completed a major expansion of its "organoclay" production facility at Gonzales.[6] The multimillion-dollar expansion, started at yearend 1987, was expected to increase capacity of existing rheological additive products and provide capabilities for producing new, improved products.

U.S. Silica Co. of Texas began using a U.S. Bureau of Mines-developed de-

watering technique in its Kosse plant, Limestone County, to reclaim kaolin that had formerly been wasted as a marketable product. The new process allowed the company to increase the solid content of waste slurries to more than 35%, which then could be dispersed and calcined to a high brightness standard. Kaolin recovered by this process was marketed principally for paper coating and filling uses.

Gypsum.—Texas was the fourth-ranking of 21 crude gypsum-producing States, accounting for 12% of the tonnage mined in 1988. Mined gypsum output was up slightly, and its average value rose $0.52 to $8.13 per short ton. With seven calcining plants, Texas was the second-ranking of 28 States in calcined gypsum output, although tonnage and value declined 16% and 19%, respectively, from figures for 1987. Byproduct gypsum production was up 85%, but total tonnage was much smaller than that of natural crude gypsum output. Texas Utilities Co. sold byproduct gypsum from its powerplant at Tatum, Rusk County, exclusively for feed to Windsor Gypsum Co.'s plant.

Helium.—Crude and Grade-A helium were produced at plants in Hansford and Moore Counties. Total output and value of crude helium were up 14%; Grade-A helium output and value were up 26%. Major uses of helium were cryogenics, welding, and pressurizing and purging.

Lime.—Output of lime at the State's seven plants increased slightly (5%), but average value per short ton fell from $51.78 in 1987 to $46.95 in 1988. Output at most plants was sold as either quicklime or hydrated lime. Holly Sugar Corp. in Deaf Smith County used only its own quicklime to process sugar and did not produce hydrated lime. USG Corp. completed the transfer of its Texas lime operation at New Braunfels, Comal County, to its spun-off subsidiary, A. P. Green Industries Inc.

Magnesium Compounds.—Production and value of magnesium compounds from seawater were unchanged from the preceding year.

Perlite.—Six firms reported expanding perlite at plants in Bexar, Comal, Dallas, Harris, and Nolan Counties. The average value of expanded perlite was $263.81 per short ton. Perlite was used as fillers, as a filter aid, and for horticultural aggregates.

Potash.—AMAX Potash Corp. took over the operation of the potash processing plant in Dumas, Moore County. The plant processed potash from New Mexico mines.

Salt.—Texas output accounted for one-fifth of the Nation's salt. The average value rose $0.37 to $8.07 per short ton.

Sand and Gravel.—**Construction.**—Construction sand and gravel produc-

TABLE 2

TEXAS: LIME SOLD OR USED BY PRODUCERS, BY USE

Use	1987		1988	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Road stabilization	W	W	576,396	$28,883
Other[1]	1,079,731	$55,900	615,614	27,052
Total	**1,079,731**	**55,900**	**1,192,010**	**55,935**

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1] Includes acid water neutralization, agriculture, aluminum and bauxite, glass, Mason's lime, open hearth steel, (1987), ore concentration (1987), other chemical and industrial uses, paper and pulp, sewage treatment, sugar refining, tanning, and uses indicated by symbol W.

TABLE 3

TEXAS: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	22,963	$78,531	$3.42
Plaster and gunite sands	228	1,183	5.19
Concrete products (blocks, bricks, pipe, decorative, etc.)	327	1,460	4.46
Asphaltic concrete aggregates and other bituminous mixtures	2,787	11,268	4.04
Road base and coverings[1]	3,426	13,198	3.85
Fill	2,448	4,818	1.97
Other[2]	407	1,530	3.76
Unspecified:[3]			
Actual	5,514	23,863	4.33
Estimated	12,270	35,317	2.88
Total or average	**50,370**	**[4]171,167**	**3.40**

[1] Includes road and other stabilization (cement and lime).
[2] Includes roofing granules.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data do not add to total shown because of independent rounding.

tion is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

Texas construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 4 presents end-use data for this commodity in the nine Texas districts.

Texas ranked third nationally in the tonnage of construction sand and gravel produced in 1988. The average value per short ton decreased $0.40 from that of 1987 and was the same as the national average, $3.30.

Industrial.—Nine firms operated 15 industrial sand pits in 11 counties. Production was up from 1987 levels and more than one-third of it came from McCulloch County. Unit value, by use, of industrial sand ranged from $9.43 per short ton for chemicals to $27.30 for filtration. Among its other uses, in decreasing order of unit value, industrial sand was used in silica flour, hydraulic fracturing, sandblasting, ground fillers, golf course sand, roofing granules, flat glass, containers, unground fiberglass, molding and core, pottery porcelain, and traction sand. The average unit value for all uses was $16.34. More than 86% of industrial sand output was transported by truck; the remainder was moved by rail or not transported.

Sodium Sulfate.—In 1988, output fell slightly and the average value per short ton fell more than 20%. Ozark-Mahoning Co. produced sodium sulfate at its Seagraves plant from brines that underlie playa lakes in the Texas

TABLE 4

TEXAS: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	536	2,839	496	1,925	208	812
Asphaltic concrete aggregates and road base and coverings[2]	1,277	6,572	W	W	739	3,169
Other miscellaneous[3]	162	419	44	262	—	—
Other unspecified[4]	1,749	7,160	21	66	562	2,585
Total[5]	**3,725**	**16,990**	**560**	**2,253**	**1,509**	**6,565**
	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	411	2,641	7,582	28,143	52	210
Asphaltic concrete aggregates and road base and coverings[2]	40	206	2,079	5,993	150	547
Other miscellaneous[3]	2	10	7	24	—	—
Other unspecified[4]	149	665	4,592	15,838	605	2,290
Total[5]	**602**	**3,522**	**14,261**	**49,998**	**808**	**3,047**
	District 7		District 8		District 9	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	1,811	6,915	11,469	33,426	952	4,264
Asphaltic concrete aggregates and road base and coverings[2]	1,470	4,872	2,771	7,385	W	W
Other miscellaneous[3]	—	—	236	1,077	93	278
Other unspecified[4]	6,468	21,072	3,576	9,306	62	197
Total[5]	**9,748**	**32,860**	**18,051**	**51,194**	**1,106**	**4,740**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for plaster and gunite sands.
[2] Includes sand and gravel for road and other stabilization (cement and lime) and fill.
[3] Includes sand and gravel for roofing granules.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

Panhandle; the firm's Brownfield plant, temporarily closed since 1987, did not report production in 1988.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—Crushed stone output and value were estimated to have decreased slightly from figures reported for 1987. Texas ranked third in the Nation as a crushed stone producer, down from its usual first or second place. Continuing the trend for foreign takeover of Texas mineral production, Lafarge Corp. (Canada) acquired East Texas Stone Co. in Freestone County.

Dimension.—Output of dimension stone decreased significantly, 12%, and the value fell 17%. Through the U.S. Bureau of Mines-funded Texas Mining and Mineral Resources Research Institute, the Texas Bureau of Economic Geology conducted a Texas Dimension Stone Industry study. A report was to be completed in 1989.

Several small producers of flagstone, ledgestone, and dimension stone were expanding production in response to their customers' preference for natural, rather than manufactured, construction materials.

Sulfur.—**Frasch.**—Pennzoil Sulphur Co., a division of Pennzoil Co., and Texasgulf Chemicals Co., a division of Texasgulf Inc. (in turn a subsidiary of Elf Aquitaine Inc.), operated Frasch sulfur mines in Culberson, Pecos, and Wharton Counties. The State's Frasch sulfur production rose nearly 9%, and sales and total value increased 22% and 15%, respectively. Prices for Frasch sulfur in the final quarter of 1988 had risen by $6 to $138 per long ton f.o.b. Tampa, FL.

Recovered Elemental.—Elemental sulfur was recovered during petroleum refining at plants in 26 counties. The six top-ranking counties were Harris, Nueces, Galveston, Jefferson, Van Zandt, and Henderson; all produced more than 100,000 metric tons of sulfur. Elemental sulfur, produced as a byproduct of petroleum processing, is not included in table 1; its value in Texas, the leading State in production of recovered sulfur, was greater than $137 million.

Byproduct sulfuric acid (100% basis), recovered from copper refineries in Texas, increased nearly 10%, and total value tripled.

Talc.—Texas talc production ranked third highest among 10 producing States; output and total value rose slightly, and price per short ton was down $0.06 to $17.12. Five mines were operated in Hudspeth County and a sixth mine in Culberson County.

Vermiculite (Exfoliated).—W. R. Grace & Co. exfoliated vermiculite from out-of-State sources at its plants in San Antonio and Dallas, and Vermiculite Products Inc., at its plant in Houston. Total output was down 9% from the preceding year. The product was used for concrete and plaster aggregates, fireproofing, loose fill and block insulations, and soil conditioners.

Metals

Although no metals are mined in Texas, the State has several refineries and smelters that process aluminum, antimony, copper, gold, magnesium, silver, tin, and, in the past, lead and zinc.

Aluminum.—Primary aluminum production in Texas was estimated to have risen nearly 57% while total value more than doubled. The year was a good one for most U.S. aluminum makers, buoyed by high prices and a worldwide shortage of products. Prices were up from $0.40 per pound 2 years earlier to about $1.20 in July 1988, generating record profits for some of the major producers.

Copper.—ASARCO Incorporated reported in its 1988 annual report that its blister copper capacity at the El Paso smelter was 115,000 short tons; production in 1988 was 99,900 tons, an insignificant change from 1987 and 1986. Sulfuric acid also was produced at the smelter. Its lead department operations, however, were suspended indefinitely in August 1985. At its Amarillo electrolytic copper refinery, the firm produced copper, gold, palladium, platinum, selenium, silver, and tellurium. Production in 1988 at Amarillo amounted to 446,200 short tons of copper, 399,700 troy ounces of gold, and 35.7 million troy ounces of silver. Capacity at Amarillo was 456,000 tons of blister copper, 600,000 troy ounces of gold, and 60 million troy ounces of silver.

Mitsubishi Metal Corp., Tokyo, Japan, planned to invest $230 million in the construction of a 150,000-metric-ton-per-year copper smelter at Texas City, near Houston. The smelter will be supplied with copper ores from Chile and other South American countries and use the continuous copper smelting process developed at Mitsubishi Metal's Naoshima copper plant in Japan. This process also is used by Falconbridge Ltd. at Kidd Creek, Ontario, Canada. Contingent upon receipt of the required permits, the smelter was expected to be operational by the end of 1991.

Iron and Steel.—Production and value of iron ore increased significantly from 1987 figures, up about one-fifth.

Lone Star Technologies Inc. posted nearly $25 million in losses in 1988 and thus launched a program to liquidate its supply of steel slabs to raise cash. Low demand for oil country tubular goods was the stated cause for the program. The firm's main steel operation was near Lone Star, Morris County. In April, Lone Star asked the Department of Commerce for special permission to exceed foreign quotas by buying 203,500 tons of steel slabs over-

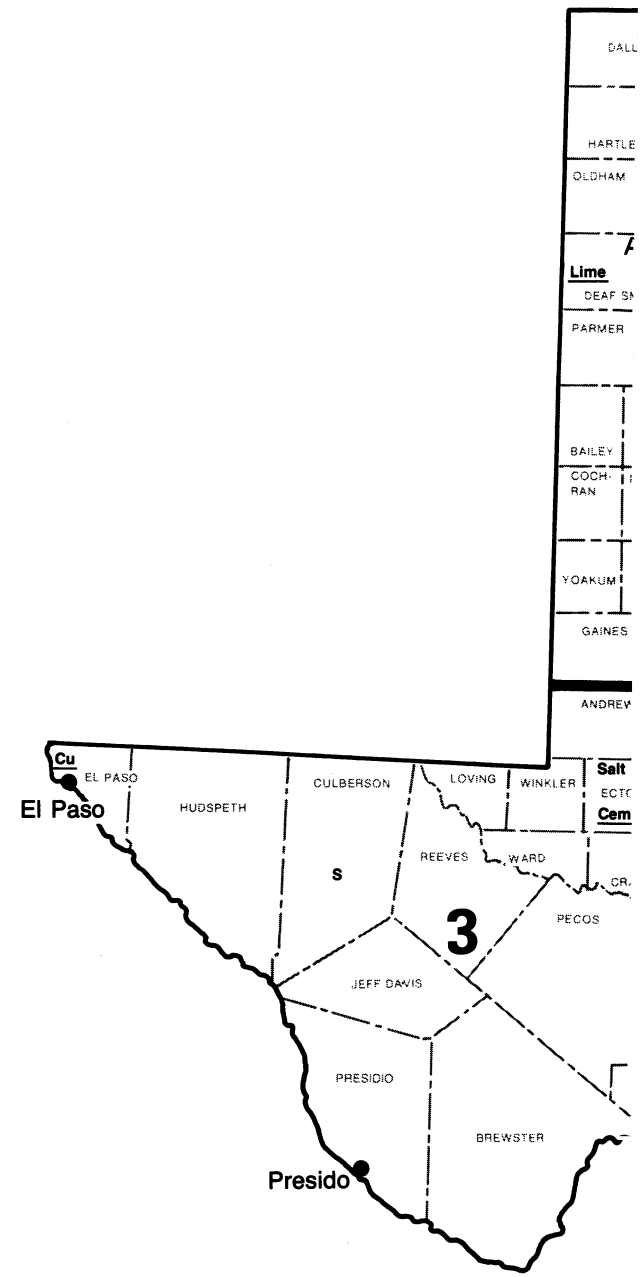
TEXAS

LEGEND

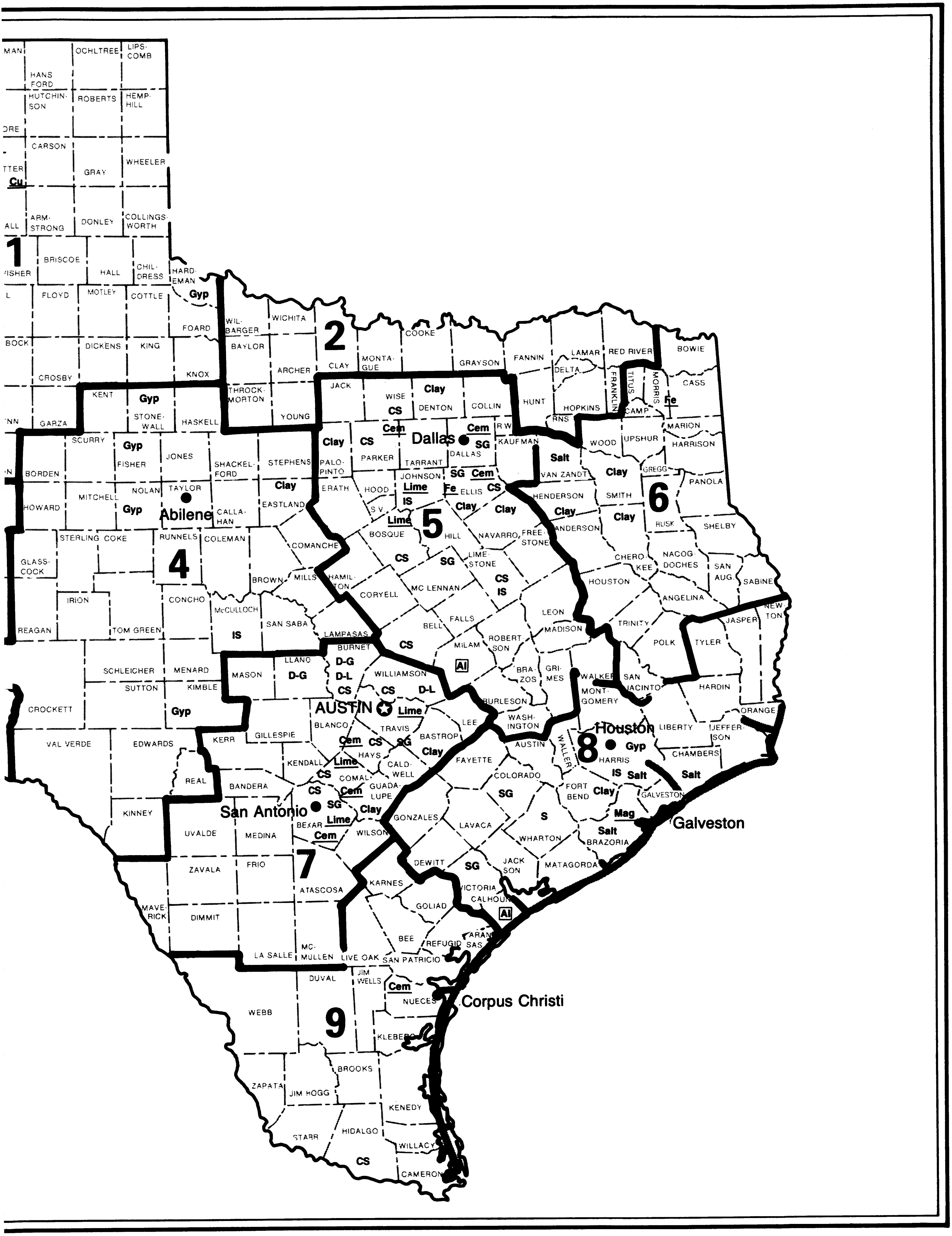
- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Al	Aluminum plant
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper plant
D-G	Dimension Granite
D-L	Dimension Limestone
Fe	Iron ore and/or scrap steel plant
Gyp	Gypsum
IS	Industrial Sand
Lime	Lime plant
Mag	Magnesium metal from seawater
S	Sulfur
Salt	Salt
SG	Sand and Gravel



Principal Mineral-Producing Localities



OCHLTREE
LIPSCOMB
HANSFORD
HUTCHINSON
ROBERTS
HEMPHILL
CARSON
GRAY
WHEELER
Cu
ARMSTRONG
DONLEY
COLLINGSWORTH
1
BRISCOE
HALL
CHILDRESS
HARDEMAN
Gyp
FLOYD
MOTLEY
COTTLE
FOARD
WILBARGER
WICHITA
2
COOKE
BOCK
DICKENS
KING
BAYLOR
MONTAGUE
GRAYSON
FANNIN
LAMAR
RED RIVER
BOWIE
CROSBY
KNOX
ARCHER
CLAY
DELTA
CASS
KENT
Gyp
THROCKMORTON
JACK
WISE
Clay
DENTON
COLLIN
HUNT
FRANKLIN
TITUS
MORRIS
Fe
GARZA
STONEWALL
HASKELL
YOUNG
CS
HOPKINS
CAMP
SCURRY
Gyp
JONES
Cem
Dallas
Cem
RW
WOOD
UPSHUR
MARION
FISHER
SHACKELFORD
STEPHENS
Clay
CS
SG
KAUFMAN
HARRISON
BORDEN
PALO PINTO
PARKER
TARRANT
DALLAS
Salt
GREGG
NOLAN
TAYLOR
Clay
JOHNSON
SG
Cem
VAN ZANDT
Clay
MITCHELL
Abilene
EASTLAND
ERATH
HOOD
Lime
Fe
ELLIS
CS
HENDERSON
SMITH
6
PANOLA
HOWARD
Gyp
CALLAHAN
IS
Clay
Clay
Clay
Lime
5
Clay
RUSK
SHELBY
STERLING
COKE
RUNNELS
COLEMAN
COMANCHE
BOSQUE
HILL
NAVARRO
FREESTONE
ANDERSON
GLASSCOCK
4
CS
SG
LIMESTONE
CHEROKEE
NACOGDOCHES
SAN AUGUSTINE
SABINE
BROWN
MILLS
HAMILTON
CORYELL
MC LENNAN
CS
IS
HOUSTON
IRION
CONCHO
McCULLOCH
ANGELINA
NEWTON
LEON
JASPER
REAGAN
TOM GREEN
SAN SABA
IS
LAMPASAS
BELL
FALLS
MADISON
TRINITY
POLK
TYLER
BURNET
CS
ROBERTSON
MILAM
Al
SCHLEICHER
MENARD
MASON
LLANO
D-G
D-G
D-L
WILLIAMSON
BRAZOS
GRIMES
WALKER
SAN JACINTO
HARDIN
SUTTON
KIMBLE
CS
CS
D-L
MONTGOMERY
CROCKETT
Gyp
AUSTIN
Lime
BURLESON
ORANGE
BLANCO
TRAVIS
LEE
WASHINGTON
Houston
LIBERTY
JEFFERSON
VAL VERDE
EDWARDS
KERR
GILLESPIE
Cem
CS
SG
BASTROP
AUSTIN
8
Gyp
CHAMBERS
HAYS
Clay
WALLER
HARRIS
KENDALL
Lime
CALDWELL
FAYETTE
IS
Salt
Salt
REAL
CS
COMAL
COLORADO
BANDERA
GUADALUPE
Cem
SG
FORT BEND
Clay
GALVESTON
San Antonio
SG
Clay
S
Mag
KINNEY
BEXAR
Lime
GONZALES
LAVACA
Galveston
UVALDE
MEDINA
Cem
WILSON
WHARTON
Salt
BRAZORIA
7
DEWITT
SG
JACKSON
MATAGORDA
ZAVALA
FRIO
KARNES
ATASCOSA
VICTORIA
CALHOUN
GOLIAD
Al
MAVERICK
DIMMIT
BEE
REFUGIO
ARANSAS
LA SALLE
MC MULLEN
LIVE OAK
SAN PATRICIO
DUVAL
JIM WELLS
Cem
NUECES
Corpus Christi
WEBB
9
KLEBERG
BROOKS
ZAPATA
JIM HOGG
KENEDY
STARR
HIDALGO
WILLACY
CS
CAMERON

seas during the third quarter. The request included 46,000 tons of steel whose purchase had been previously denied when Commerce approved a request for 180,000 tons in offshore purchases during the first one-half of the year. The 46,000 tons was denied because USX Corp., Pittsburgh, PA, had indicated it could supply the company with that much. Lone Star rejected the USX offer.

LTV Corp., the Nation's second-largest steelmaker to be in bankruptcy proceedings in 1988, announced in October that it would sell its steel bar division—a move that resulted in a substantial charge against the company's third-quarter earnings. The division's 5,400 workers had produced about 1.2 million tons of steel annually. The division was one of the Nation's leading producers of high-quality carbon and alloy steel bars. LTV decided to concentrate its resources in flat-rolled and tubular products as it reorganized under chapter 11 of the Bankruptcy Code. LTV Steel Co. and LTV Steel Bar divisions are located in Dallas.

USX permanently closed its Texas Works in Baytown, Harris County, on May 1, ending a year-long speculation over whether the mill might be reactivated to meet strong demand for the steel plant. The plant included electric furnaces, a 1.2-million-short-ton-per-year plate mill, and a large-diameter welded pipe mill. The plant was shut in July 1986 during a strike and failed to reopen after ratification of a new contract ended the strike in January 1987.

Commercial Metals Co. (CMC Steel Group), Dallas, owned three minimills with combined shipping capacity of nearly 800,000 short tons. The firm, also the owner of SMI-Texas, Seguin, where the main product was reinforcing bar, planned to install a no-twist rolling mill as part of plant modernization at Seguin.[7]

In Ellis County, the Midlothian mill of Chaparral Steel Co., a subsidiary of TXI, doubled its annual capacity to 1.2 million tons of steel and was exporting steel made from recycling scrap. TXI acquired Chaparral to complement its cement and concrete businesses, and the subsidiary has succeeded in becoming a steel exporter, shipping to Europe and Canada.

Steel slag output in the State was significantly reduced (37%) from 1987 levels.

Magnesium Metal.—Dow Chemical Co. announced plans to increase the operating level of its Freeport primary magnesium plant to 100% of its 96,000-short-ton-per-year capacity by midyear. Low inventories and increased demand prompted the production increase.

Refinery production of magnesium metal rose 12% and total value rose 21%. Average price per pound increased $0.20 to $1.50.

Rare-Earth Elements.—The Rhone-Poulenc Inc. processing plant at Freeport processes a rare-earth hydroxide shipped from France. In France, the firm extracts the phosphate portion from monazite (an ore mineral containing rare earths and thorium) of worldwide origin, converts the monazite to the rare-earth hydroxide, and ships it to Freeport. There, the light group of rare-earth elements (those with atomic numbers 58 through 64) are processed by solvent extraction. The remaining product contains minor impurities and a small amount of heavy rare-earth elements (atomic numbers 64 through 71). This product is returned to France for final processing to recover those heavier rare earths. Rare earths have many uses, including high-technology applications that produce synthetic crystals used in lasers.

Selenium.—Primary selenium metal output, a byproduct of electrolytic copper refining at Amarillo and El Paso, increased about 8%. Domestic demand for selenium continued high. World demand exceeded production, and the average domestic price rose during the first quarter of 1988 to about $11 per pound, continuing the upward trend begun in 1987. However, the price fell to an average of $9.30 per pound at yearend. Selenium metal is used in electronics (42%), pigments and chemicals, glass manufacturing, agriculture, metallurgy, and other areas.

Tin.—Proler International planned to build a new detinning plant to separate tin from steel in tin cans. The facility, on the Houston Ship Channel, was expected to be brought on-stream early in 1989.

Zinc.—Asarco's 104,000-metric-ton-per-year zinc plant at Corpus Christi, formerly on standby status, was converted into a hazardous waste treatment and recycling facility. The plant is operated by Encycle Inc., a subsidiary of Asarco.

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[1] State Mineral Officer, Bureau of Mines, Denver, CO.

[2] Research associate, Bureau of Economic Geology, The University of Texas at Austin, TX.

[3] Texas Business Review. The Texas Economy: Manufacturing Is The Key To Recovery. June 1989, p. 1.

[4] The Kiplinger Texas Letter. Highway Construction Work in Texas. V. 8, No. 1, Jan. 8, 1988, p. 4.

[5] Cyprus Sierra Blanca Inc., Englewood, CO. Beryllium Project. June 1988. 10 pp.

[6] Industrial Minerals (London). Southern Clay Expands Organoclay Production. No. 247, Apr. 1988, p. 23.

[7] American Metal Market. CMC Zeroing In On Steel Market. V. 96, No. 74, Apr. 15, 1988, p. 4.

TABLE 5

TEXAS: PRIMARY SMELTERS, REFINERIES, AND REDUCTION PLANTS

Product, company, and plant	Location (county)	Material treated
Aluminum:		
Aluminum Co. of America:		
Point Comfort	Calhoun	Bauxite.
Rockdale (reduction)	Milam	Alumina.
Reynolds Metals Co.:		
Sherwin plant (alumina)	San Patricio	Do.
Antimony:		
ASARCO Incorporated:		
El Paso smelter	El Paso	Ore.
Cadmium:		
ASARCO Incorporated:		
El Paso smelter	do.	Ore.
Copper:		
ASARCO Incorporated:		
Amarillo refinery[1]	Potter	Blister and anode.
El Paso smelter	El Paso	Ore and concentrates.
Phelps Dodge Refining Corp.:		
Nichols refinery[2]	do.	Blister and anode.
Magnesium:		
The Dow Chemical Co.:		
Freeport plant, electrolytic	Brazoria	Seawater.
Tin:		
TinTex Corp.:		
Texas City smelter	Galveston	Ore and concentrates.

[1] Asarco's Amarillo refinery also produced gold, nickel sulfate, palladium, platinum, selenium, silver, and tellurium.
[2] Phelps Dodge's El Paso (Nichols) refinery also produced copper sulfate, gold, palladium, platinum, selenium, silver, and tellurium.

TABLE 6

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Alamo Cement Co.	Box 34807 San Antonio, TX 78233	Quarry and plant	Bexar.
Centex Cement Corp.	4600 Republic Bank Tower Dallas, TX 75201	Quarries and plant	Hays and Nueces.
Gifford-Hill & Co. Inc.[1]	Box 520 Midlothian, TX 76065	Quarry and plant	Ellis.
Lafarge Corp.[2]	3333 Fort Worth Ave. Dallas, TX 75211	Quarries and plant	Comal, Dallas, Tarrant.
Southwestern Portland Cement Co.[3]	Box 1547 Odessa, TX 79760	do.	Ector, El Paso, Potter.
Texas Industries Inc.[4]	8100 Carpenter Freeway Dallas, TX 75247	do.	Comal and Ellis.
Clay and shale:			
Acme Brick Co., a division of Justin Industries Inc.	Box 886 Denton, TX 76202	Pits and plants	Denton, Guadalupe, Nacogdoches, Parker, Van Zandt, Wise.
Featherlite Building Products Corp.	Box 141 Ranger, TX 76470	Pit and plant	Eastland.
Wolff Inc.	Box 34870 San Antonio, TX 78265	do.	Guadalupe.
Gypsum:			
Domtar Gypsum Inc. Co.	Box 720 Sweetwater, TX 79556	Quarry and calcining plant	Nolan.
Georgia-Pacific Corp.	133 Peachtree St, N.E. Atlanta, GA 30303	do.	Hardeman.
National Gypsum Co., Gold Bond Div.	2001 Rexford Rd. Charlotte, NC 28211	Quarries and calcining plants	Fisher, Kimble, Stonewall.
Standard Gypsum Co.	Box 667 McQueeny, TX 78123	do.	Gillespie and Guadalupe.
USG Corp. (parent of United States Gypsum Co.)	101 South Wacker Dr. Chicago, IL 60606	Quarry and calcining plant	Harris and Nolan.
Lime:			
APG Lime Corp.	Route 6, Box 662 New Braunfels, TX 78132-5011	Plant	Comal.
Austin White Lime Co.	Box 9556 Austin, TX 78766	Quarry and plant	Bosque and Travis.
Chemical Lime Co.	Box 427 Clifton, TX 76634	Plant	Bosque.
Holly Sugar Corp.	Drawer 1778 Hereford, TX 79045	do.	Deaf Smith.
Redland Worth Corp.	Route 2, Box 222 San Antonio, TX 78229	Quarry and plant	Bexar.
Round Rock Lime Co., a subsidiary of Dravo Lime Co.	Box 38 Blum, TX 76627	Plant	Hill.
Texas Lime Co., a subsidiary of Rangaire Corp.	Box 851 Cleburne, TX 70631	Quarry and plant	Johnson.

See footnotes at end of table.

TABLE 6—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Salt:			
The Dow Chemical Co.[5]	2020 Dow Center Midland, MI 48640	Brine	Brazoria.
Morton Thiokol Inc.	110 North Wacker Dr. Chicago, IL 60606	Underground mine and brine	Van Zandt.
Occidental Chemical Corp.	Box 809050 Dallas, TX 75380	Underground mine	Chambers.
Texas Brine Corp.	2000 West Loop South Houston, TX 77027	Brine	Harris, Jefferson, Matagorda.
Sand and gravel:			
Construction:			
C. H. Beazer Holdings PLG, parent of Gifford-Hill & Co. Inc.	Box 1369 Waco, TX 76703	Plants	Brazos, Dallas, Ellis, McLennan.
Capital Aggregates Inc.	Box 33240 San Antonio, TX 78265	Stationary plants	Bexar, Pecos, Reeves, Travis, Val Verde.
Centex Materials Inc.	Drawer 928 Buda, TX 78610	Pits and plants	Hays, Johnson, Travis.
The Fordyce Co.	Box 1981 San Antonio, TX 78297	do.	Hidalgo, Victoria.
Ideal Basic Industries Inc.	Rt. 1, Box 139 Garwood, TX 77442	do.	Colorado and Fayette.
Pioneer Concrete of Texas	2537 South Gessner, Suite 102 Houston, TX 77063	Plants	Colorado, Kaufman, Liberty, Montgomery.
Texas Industries Inc.	Box 400 Arlington, TX 76010	do.	Ellis, Parker, Travis, Wise.
Industrial:			
Oglebay Norton Co., Texas Mining Co.	2104 East Randol Mill Rd. Suite 101 Arlington, TX 76011	Pits and plant	McCulloch.
UNIMIN Corp.	50 Locust Ave. New Canaan, CT 06840	Plant	Johnson.
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	Pits and plants	Limestone, Live Oak, McCulloch.
Sodium sulfate (natural):			
Ozark-Mahoning Co.	1870 South Boulder Tulsa, OK 74119	do.	Gaines and Terry.
Stone:			
Redland Worth Corp.	Route 2, Box 222 San Antonio, TX 78229	Plants and quarries	Bexar, Limestone, San Patricio.
Texas Crushed Stone Co.	Box 1000 Georgetown, TX 78626	Plant and quarry	Williamson.
Vulcan Materials Co.[6]	Box 13010 San Antonio, TX 78213	Plants and quarries	Bexar, Brown, Grayson, Parker, Taylor, Uvalde, Williamson, Wise.
Sulfur:			
Byproduct:			
Amoco Production Co. (Standard Oil Co., Indiana)	Box 591 Tulsa, OK 74102	Secondary recovery	Andrews, Ector, Galveston, Hockley, Van Zandt, Wood.

See footnotes at end of table.

TABLE 6—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Chevron U.S.A. Inc.	575 Market St. San Francisco, CA 94105	Secondary recovery	Crane, El Paso, Hopkins, Jefferson, Karnes.
Exxon Chemical Americas	Box 77253-3272 Houston, TX 77079	do.	Atascosa, Crane, Harris.
Phillips Petroleum Co.	Bartlesville, OK 74003	do.	Andrews, Brazoria, Crane, Hopkins, Hutchinson.
Smackover Shell Ltd.	Route. 2, Box 152 Eustace, TX 75124	do.	Henderson.
Texaco Producing Inc.	Box 8 Scroggins, TX 75480	do.	Franklin, Freestone, Jefferson.
Native:			
Pennzoil Sulphur Co.	1906 First City National Bank Houston, TX 77002	Frasch mine	Culberson.
Texasgulf Chemicals Co., a subsidiary of Elf Aquitaine Inc.	Glenwood at Glen Eden Box 30321 Raleigh, NC 27622-0321	do.	Wharton.
Talc:			
Clark Minerals Inc.	1000 Coolidge St. South Plainfield, NJ 07080	Pits and plant	Hudspeth.
Dal Briar Corp. (Dal-Tile)	Box 17130 Dallas, TX 75217	Pits	Do.
The Milwhite Inc.	Box 15038 Houston, TX 77020	Mine and plant	Culberson.
Southern Clay Products Inc.[7]	Box 44 Gonzales, TX 78629	Pit and plant	Hudspeth.
Vermiculite (exfoliated):			
W. R. Grace & Co.	2651 Manila Rd. Dallas, TX 75200	Exfoliating plants	Bexar and Dallas.
Vermiculite Products Inc.	Box 7327 Houston, TX 77008	Exfoliating plant	Harris.

[1] Also clays, Ellis County; sand and gravel, Brazos, Dallas, Ellis, and McLennan Counties; and crushed stone, Comal, Cooke, Ellis, Limestone, Walker, and Wise Counties.
[2] Also clays, Dallas County; sand and gravel, Dallas, Johnson, Tarrant, and Wise Counties; and stone, Dallas, Tarrant, and Wise Counties.
[3] Also clays, Potter County.
[4] Also clays, Ellis, Fort Bend, Guadalupe, Henderson, Navarro, and Van Zandt Counties; sand and gravel, Dallas, Ellis, Parker, Travis, and Wise Counties; and crushed stone, Comal, Ellis, Jack, and Wise Counties.
[5] Also magnesium compounds and magnesium chloride for magnesium metal, Brazoria County.
[6] Also industrial sand, McCulloch County.
[7] Also clays, Gonzales County.

THE MINERAL INDUSTRY OF UTAH

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Utah Geological and Mineral Survey for collecting information on all nonfuel minerals.

By Michael N. Greeley[1] and Robert W. Gloyn[2]

The value of nonfuel mineral production in 1988 increased 45% over 1987 levels, reaching a record high of more than $1 billion. Home to a diversified mineral industry, Utah ranked 11th nationally in the value of its nonfuel mineral production. Toward yearend, the Utah Mining Association, whose members achieved the record production, began arrangements to celebrate the association's 75th anniversary in 1990.

Metals accounted for approximately four-fifths of the mineral value, with copper, gold, and magnesium as the principal components. Other commodities important to the State, some of which posted impressive gains in 1988, included beryllium, gilsonite, iron, portland cement, phosphate, potash, sand and gravel, salt, and silver.

TRENDS AND DEVELOPMENTS

The substantial rise in the value of nonfuel mineral production was due in part to high prices for copper and gold and, more importantly, to increased output of these metals at the recently reopened Bingham Canyon Mine located southwest of Salt Lake City. This operation was the State's principal producer of copper and byproduct gold, molybdenum, and silver.

Another factor that strengthened Utah's mineral industry was the dramatic comeback of iron and steel and of mineral production in general centered around the Great Salt Lake. In late 1987, operations were resumed at the integrated steel mill in Provo, bringing 1,600 employees back to work, and steel capacity was expanded at the minimill in Plymouth. Both facilities operated close to full capacity during 1988.

Repairs to mineral production facilities adjacent to the Great Salt Lake, which were damaged by lake waters in floods occurring in 1984 and 1986, were essentially completed in 1988. This renovation enabled lakeside producers to resume normal production of magnesium chloride, magnesium metal, and

TABLE 1

NONFUEL MINERAL PRODUCTION IN UTAH[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Beryllium concentrates	short tons	6,533	$7	6,062	$6	5,851	$6
Cement (portland)	thousand short tons	1,014	58,431	935	50,565	772	39,664
Clays[2]	short tons	304,547	2,048	315,154	1,959	340,156	2,469
Gem stones		NA	96	NA	105	NA	370
Gypsum	thousand short tons	284	2,478	W	W	W	W
Lime	do.	232	13,079	562	17,894	365	17,252
Salt	do.	1,112	31,830	1,108	34,264	1,006	35,294
Sand and gravel:							
Construction	do.	16,452	39,763	e21,000	e56,700	17,843	49,796
Industrial	do.	6	123	6	11	3	60
Stone:							
Crushed	do.	e4,500	e14,100	7,989	23,606	e7,300	e20,600
Dimension	short tons	W	W	2,004	93	e2,004	e93
Vermiculite	do.	W	153	—	—	—	—
Combined value of asphalt (native, 1986), cement (masonry), copper, gold, iron ore, magnesium compounds, magnesium metal, mercury, molybdenum (1987–88), phosphate rock, potassium salts, silver, sodium sulfate (natural, 1986 and 1988), stone (dimension, 1986), vanadium, and values indicated by symbol W		XX	212,330	XX	514,661	XX	849,243
Total		**XX**	**374,438**	**XX**	**699,864**	**XX**	**1,014,847**

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

sodium chloride.

The total value of construction in the State declined more than 21%. The decrease reflected substantial drops in both residential and nonresidential construction activity. Accompanying this decline was a major downturn in demand for the group of commodities that provide raw materials for the construction industry. Included in this group were cement, gypsum, lime, sand and gravel, and crushed stone.

EXPLORATION ACTIVITIES

Prospectors and mine developers continued to show an increased interest in the precious-metal potential of Utah. Claim staking, particularly in the western part of the State, was heavy. Much of the exploration was concentrated around old mining districts, but a significant percentage took place outside of known districts and established trends.

Records maintained by the U.S. Bureau of Land Management ranked Utah fourth in the Nation in the number of active claims for all commodities. According to the Utah Division of Oil, Gas, and Mining, 55 applications to drill and perform other exploration activities in the State were submitted to the agency in 1988.

EMPLOYMENT

According to the Utah Department of Employment Security, the State employed an average of 8,612 workers in its mining industry during 1988. This figure, which represents an increase of almost 8% over industry employment in 1987, included employees in the fuels sector.

The mining industry of Utah provided total income to its workers of $276 million.[3] Average wages paid on a monthly basis to individual miners rose more than 4% from those of 1987 to $2,820.

REGULATORY ISSUES

During 1988, the Utah Mining Association formed a committee to address environmental concerns that impact the mineral industry. The committee prepared technical comments that were considered by the State in developing proposed ground water regulations.

LEGISLATION AND GOVERNMENT PROGRAMS

In House bill 183, the Utah State Legislature changed the basis and rate of severance tax on metalliferous minerals. This legislation, which is retroactive to January 1, 1988, set a new rate of 2.4% of the taxable value of all metals or metalliferous minerals sold. It also established a standard deduction of $50,000 in gross value for each mine.

In the area of surface mine reclamation and safety, House bill 85 prescribed procedures for the adoption of rules more stringent than Federal regulations. The Board of the Division of Oil, Gas, and Mining was given the authority to apply stricter standards when there is evidence that Federal regulations are inadequate. The legislation also created a trust fund for the reclamation of abandoned mines.

The Trust Land Management Act (House bill 273) created a new Board and Division of State Lands and Forestry. Effective July 1, 1988, this agency was designated a division of the Utah Department of Natural Resources and charged with the management of State trust lands and mineral estates. In other legislation, House bill 99 changed the name of the State College of Mines and Mineral Industries at the University of Utah to the College of Mines and Earth Sciences.

In addition to operating the Salt Lake City Research Center, the U.S. Bureau of Mines supervised the administration of the Utah Mining and Mineral Resources Research Institute and the Comminution Generic Center. The Institute and the Generic Center were housed at the University of Utah and administered by faculty members of the College of Mines and Earth Sciences. Total grant money awarded by the Bureau to both units in 1988 exceeded $800,000. Affiliated research on sampling and control of mine dust at the University was granted approximately $65,000 by the Bureau.

During the year, the Bureau issued seven open-file reports addressing mineral land assessments in Utah. These reports summarized mineral evaluations of wilderness study areas under the jurisdiction of the U.S. Bureau of Land Management.

The Utah Geological and Mineral Survey (UGMS) continued its program of funding outside geologic projects designed to encourage economic development of Utah's resources. During the 1988 fiscal year, approximately $110,000 that was generated from State mineral leases and Federal rebates was allocated to fund 12 projects.

The UGMS published several papers and maps on mineral deposits in Utah, completed a study on the Keg Mountain district, and finished a statewide investigation of zeolites. The latter study documented approximately 175 zeolite occurrences with detailed site descriptions of the larger deposits. In addition, the agency also completed a computerized data base of the State's mineral resources comprised of more than 11,000 occurrences. This information is to be presented as a series of 1:250,000-scale maps with accompanying text that will cover the entire State.

The Utah Division of Oil, Gas, and Mining, a regulatory agency, continued its program of reclamation of abandoned mine sites. Reclamation projects are financed through a Federal tax paid by coal operators in the State. The agency also initiated development of an educational workbook for schoolchildren. The book will discuss mining in Utah, its history, and the dangers of abandoned mines.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Beryllium.—Utah continued to lead the Nation as the principal domestic source of beryllium. During 1988, more than 99% of the beryllium mined and recovered in the United States was derived from ores owned and/or processed by Brush Wellman Inc. This company's extraction plant in Delta in Millard County is the only facility of its type in the free world. Most of the ore treated at the plant was mined from bertrandite-bearing tuffs controlled by the company at Spor Mountain in Juab County.

Copper.—In 1988, the third largest domestic producer of copper was the State of Utah. Virtually all Utah's production was credited to the Bingham Canyon open pit mine in Salt Lake County. This pit, which measures one-half-mile deep, is the deepest man-made excavation in the world.

According to British Petroleum Co.'s (BP) 1988 annual report on Form 20–F, the Bingham Canyon mine increased its copper production more than 39% over that of 1987 to 212,000 short tons. The value of this copper represented nearly 50% of all nonfuel mineral value in the State.

Having completed a 33-month modernization program in the fall of 1988, BP Minerals America (a BP subsidiary) announced that Bingham Canyon would be among the lowest cost copper producers worldwide. It is estimated that at full capacity, the completely integrated operation from mine to refinery will produce 200,000 short tons of refined copper, 300,000 ounces of gold, 2.3 million ounces of silver, and 12 million pounds of molybdenum per year.

The modernization has increased the scale of the facilities that transport and process the copper ore. The result is less maintenance, fewer employees, and improved metal recoveries. Today, the work force of approximately 1,800 reflects a reduction to about one-fourth its size a decade earlier.

Gallium and Germanium.—The world's first primary producer of gallium and germanium, Utah's Apex Mine in Washington County was closed throughout 1988. Hecla Mining Co. obtained an option to purchase the mine from the St. George Mining Co. in July.

Gold.—Utah ranked fourth in the United States in the production of gold. Because of the relatively high 1988 average price of approximately $438 per troy ounce, the value of gold production represented about 18% of the total value of nonfuel mineral production in the State.

Most of Utah's recovery of gold was as a byproduct, most of which was derived from copper ore mined at Bingham Canyon. The 1988 Form 20–F submitted by BP stated that 291,000 ounces of gold was extracted from the mine, approximately 46% more than the previous year.

Another source of byproduct gold in the State in 1988 was the Trixie Mine owned by Sunshine Mining Co. in Utah County. This property supplied a silica-rich fluxing ore to the BP smelter. The company's production, as reported on its 1988 Form 10–K, was 6,717 ounces.

In addition to its gold production at Bingham Canyon, BP continued to develop primary gold capacity at the nearby Barney's Canyon Mine. This property, which is scheduled for startup in 1989, is expected to produce about 80,000 ounces annually.

Capital improvements by American Barrick Resources Corp. increased production in 1988 to record levels at its Mercur Mine in Tooele County. Chief among these improvements was the installation of an alkaline, pressure oxidation autoclave facility at a cost of $10 million. Commissioned in February as the first of its type in the United States to treat refractory sulfide ores, the autoclave operated at 20% more than the designed capacity of 750 short tons per day.

For 1988, the Mercur Mine was ranked as the leading producer of primary gold in Utah and 13th in the Nation. During the year, the mine produced 115,390 ounces of gold, according to American Barrick's 1988 annual report.

Gold was recovered using the cyanide leaching process at the Drum Mine in Millard County and from mill tailings near Silver City in Juab County. Toward the end of the year, the Drum Mine was purchased by ASOMA Inc., reportedly for $1 million.[4] Leaching of mill tailings near Silver City was begun in mid-1988 by North Lily Mining Co. The firm reported that its facility was installed for approximately $1.5 million.[5]

During 1988, the Goldstrike Mine in Washington County, another primary gold facility, was under construction by Tenneco Minerals Co. When completed in 1989, the open-pit, heap-leach operation is expected to produce 40,000 ounces of gold per year and a similar amount of silver.

Iron Ore and Steel.—The relatively small, integrated steel facility owned by Geneva Steel Co. completed its first full year of operation since it resumed shipments in October 1987.[6] The plant had been closed in July 1987 by USX Corp., the previous owner, and was purchased the following month by Geneva. The company shipped more than 1 million tons of steel in 1988, 10 to 15 percent of which was exported to Japan. This amount represented the largest percentage of steel production exported to that country from any mill in the United States.

The steel facility located in Utah County received about 27% (551,000 short tons) of its ore feed from Geneva's Comstock Mine and nearby properties in Iron County. The balance of its iron requirement was imported as

iron-ore pellets from Minnesota.

Relying principally on ferrous scrap, Nucor Corporation continued to operate its steel minimill in Box Elder County. This mill, which utilizes electric arc furnaces, had an annual production capacity of about 600,000 short tons of billet in 1988.

Magnesium.—During 1988, Utah continued as one of only three domestic producers of refined magnesium metal. The metal was electrolytically won by AMAX Magnesium Corp. from magnesium chloride bitterns obtained from solar-evaporated brines. Reported production in 1988 was more than 35% higher than 1987 production.

By mid-1988, AMAX Magnesium, a subsidiary of AMAX Inc., completed a new evaporation and precipitation pond system north of Knolls in Tooele County. This system replaced company ponds that were inundated 2 years earlier resulting from a storm on the Great Salt Lake. The new ponds received preconcentrated brines from a large, shallow lake formed from water pumped by the State to lower the dangerously high level of water in the Great Salt Lake. Highly concentrated, magnesium chloride brines were transported from the new ponds through a 41-mile pipeline to the firm's processing plant at Rowley. The reported cost of the new evaporation system was more than $16 million.

On April 8, the company reached agreement with members of the United Steelworkers of America union on a new 3-year labor contract. Under terms of the agreement, workers accepted a wage reduction of 5% and received a share of future cost savings. Toward the end of 1988, AMAX announced plans to sell AMAX Magnesium. The primary and alloy-metal facility has an annual production capacity of 38,000 short tons.

Molybdenum.—The only producer of molybdenum in Utah was the Bingham Canyon Mine in Salt Lake County. Molybdenite concentrates were recovered as a byproduct of the primary production of copper. The sulfide concentrates were roasted and converted to molybdic oxide in the BP Minerals plant at Magma.

Although average prices for molybdenum were up approximately 12% during the year, total production was reduced about 65% from 1987. This reduction was caused presumably by normal start-up problems associated with the newly installed concentration facilities.

Silver.—In 1988, Utah was the fifth largest producer of silver in the United States. As in the previous year, production continued to rise. Silver output increased in the State almost 10% over 1987 production.

The Escalante Mine in Iron County, a primary producer, continued to be among the top 10 silver mines in the country. According to Hecla Mining Co.'s annual report, output from the underground mine was 1,831,172 troy ounces in 1988. Due to exhaustion of the known ore deposit and increased dewatering costs, however, mining operations ceased on December 30.

Hecla announced that the mill would continue to process stockpiled ore amounting to about 500,000 tons over the next 2 years. The Escalante had been in continuous operation since 1981.

Byproduct silver production at the Bingham Canyon Mine in Salt Lake County ranked the mine seventh among all silver producers in the country. BP stated in its 1988 Form 20–F annual report that the mine recovered 2,446,000 ounces, an increase of nearly 37% over production in 1987.

The Trixie Mine shipped 22,611 tons of fluxing ore, which contained 159,973 ounces of byproduct silver, to the BP smelter, according to the 1988 Form 10–K issued by Sunshine Mining Co. The Mercur Mine in Tooele County and the Silver City tailings operation in Juab County also produced byproduct silver.

Other Metals.—During 1988, the Mercur Mine continued production of byproduct mercury. By virtue of this production, Utah was one of only three producers of quicksilver in the United States during the year.

Uranium concentrate production in Utah, including ores from several northern Arizona mines, accounted for about 17% of domestic output. At the end of 1988, two principal producers of uranium had operations in the State: an ion-exchange (IX) plant located adjacent to the Bingham Canyon Mine in Salt Lake County and the underground La Sal Mine in San Juan County. Energy Fuels Nuclear Co. had reopened the IX plant in February 1987. Ore from the La Sal Mine was trucked to the White Mesa Mill at Blanding in San Juan County.

On August 9, Atlas Corp. announced the closing of its uranium mill at Moab in Grand County. The company expected tailings reclamation to require 6 to 7 years at an estimated cost of $6 million. Mining and milling of uranium at the Lisbon Mine in San Juan County was suspended by Rio Algom Mining Corp. during the fall of 1988.

Scandium was recovered as a byproduct of the Energy Fuels facility in Salt Lake County. In 1988, this plant was the only mine producer of scandium in the United States. Various trace metals, including palladium, platinum, selenium, and tellurium, were recovered from anode slimes at the copper refinery owned by BP Minerals America at Magna in Salt Lake County.

Vanadium was recovered as a byproduct of uranium ores shipped to the White Mesa Mill from the La Sal Mine and other Colorado Plateau mines. In 1988, the mill produced 2.286 million pounds of uranium oxide and 1.175 million pounds of vanadium oxide.[7]

At its plant near Ogden in Weber County, Western Zirconium Inc. maintained production of primary zirconium sponge and coproduct hafnium sponge from zircon concentrates imported from Australia.

Industrial Minerals

Cement.—In 1988, production of portland cement continued to decrease as construction activity declined. The drop, which was rather dramatic in Utah, was more than 17% from the previous year. Masonry cement output exhibited little change.

Because of low demand, Lone Star Industries Inc. did not operate its cement plant in Salt Lake City in Salt Lake County. Southwestern Portland Cement Co., a subsidiary of Southdown Inc., announced that in 1989 it would relinquish its lease on the plant in Leamington in Millard County owned by Martin Marietta Corp. The Lone Star plant had a rated capacity of 420,000 tons per year. Southwestern, according to its annual report, shipped 369,000 tons of cement from the Leamington plant in 1988. During the year, Ideal Basic Industries Inc. commenced construction of new cement-grinding and raw-grinding systems at its cement plant at Devil's Slide in Morgan County.

Clays.—The moderate increase in clay production registered during 1988 was attributed primarily to an uptick of about 7% in production of common clay and shale. Mining of bentonite, a component of the total clay production, increased to almost 33,000 short tons or 13% more than 1987 levels. Western Clay Co. produced fuller's earth from its mine near Aurora in Sevier County and sold the clay as a filtering agent for edible oils and wine.

Gypsum.—Gypsum was mined from several open pit mines northeast of Sigurd in Sevier County. Although the 1988 production of crude gypsum remained about the same as that of 1987, the output of calcined gypsum, used primarily in wallboard, decreased more than 26%.

Lime.—During 1988, there was a major downturn in the production of lime. State output decreased slightly more than 35%. A partial reason for the decrease was the cessation of lime production by Utah Marblehead Lime Co. which sold its plant to United States Pollution Controls Inc. (USPCI) in 1987. USPCI converted the facility to burn hazardous materials.

Geneva Steel's lime requirements were met by the company's Keigley Quarry in Utah County. Included in this mine's output of about 500,000 tons per year were shipments of limestone powder for use as a suppressor of coal dust in underground coal mines. BP Minerals also utilized a captive source of lime for its Bingham Canyon operations.

Magnesium Compounds.—Utah's upward trend in production of magnesium chloride brines that began in 1967 was sustained in 1988. Recovery of brines, from collection ditches and a wellfield at the Bonneville Salt Flats in Tooele County and from the eastern portion of the Great Salt Lake in Weber County jumped production more than 30% over 1987 production. Most of this output was sold as feedstock for the production of magnesium metal.

Phosphate Rock.—Production of phosphate rock continued to rise in Utah. Chevron Resources' open pit mining operation near Vernal at Little Brush Creek, in Uintah County, increased output nearly 14% over 1987 production. The phosphate rock was beneficiated at the Little Brush Creek facility and pumped as slurry to the company's fertilizer plant in Rock Springs, WY.

Potash.—In 1988, Utah was the second largest producer of potash in the Nation. A total increase in production of about 42% over the previous year was reported. The average annual price nationwide for all potash products rose about 28%.

During the year, Kaiser Aluminum and Chemical Corp. sold its Kaiser Chemicals plant at the Bonneville Salt Flat to Reilly Tar and Chemical Corp. of Indianapolis, IN. The plant was renamed Reilly-Wendover. The facility's principal potash product has been potassium chloride (sylvite, or muriate of potash).

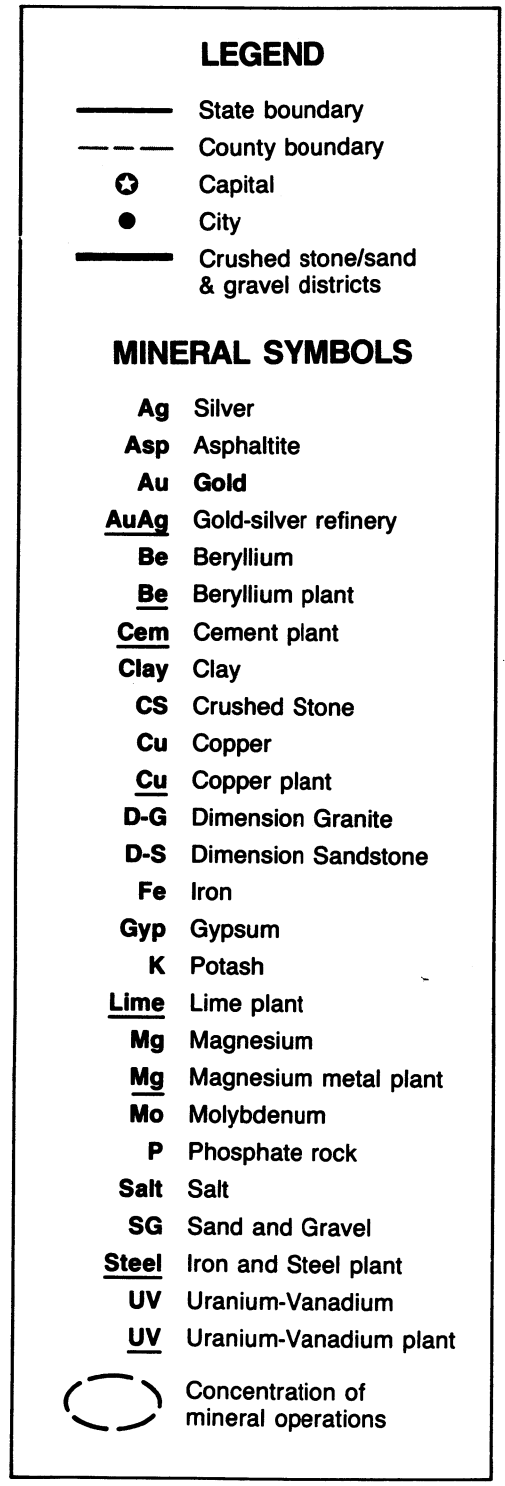
Great Salt Lake Minerals and Chemicals Corp. continued to repair its harvesting facility that had been severely damaged in 1984 by flood waters from the Great Salt Lake. Flooding of the harvesting facility occurred as the result of extremely high levels of water in the lake. Although the firm did not report production in 1988, it did begin concentration of potassium-rich brines in its recently rebuilt solar evaporation ponds.

In the eastern part of the State, near Moab in Grand County, newly formed Moab Salt Inc. produced potassium chloride and byproduct salt by solution mining and solar evaporation. The establishment of Moab Salt was initiated by an agreement between Texasgulf Inc. and Carey Salt Inc. to operate the existing Texasgulf plant and market the salt product through Carey. Elf Aquitaine Inc., Texasgulf's parent company, stated in its annual report that potash production in 1988 was 118,000 short tons, up 25% from 1987 levels.

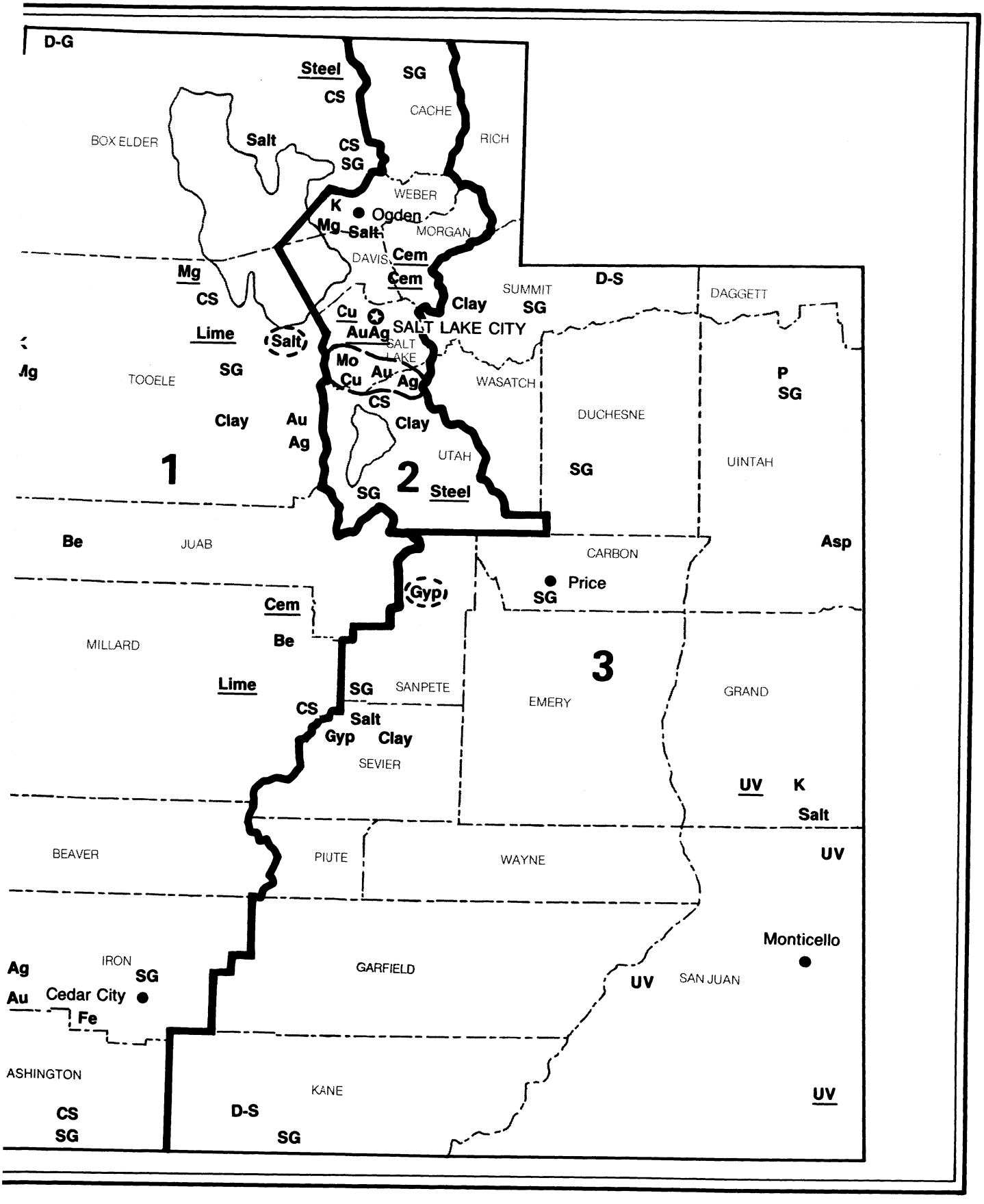
Salt.—Utah ranked seventh in the Nation in the production of salt in 1988. The State registered an output decline of approximately 9% from 1987, while the value of its production increased about 3%. Salt production in Utah was hampered by continued dilution of brines caused by the unusually high influx of fresh water in the Great Salt Lake.

During the year, eight Utah firms produced salt. In some operations, salt was recovered as a primary product; in others, it was recovered as a byproduct or coproduct. With the exception of rock salt mined at the American Orsa pit at Redmond in Sevier County, salt was precipitated from solution in solar evaporation ponds. The solutions came

UTAH



Principal Mineral-Producing Localities


D-G
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CARBON
Asp
Price
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Cem
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MILLARD
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SANPETE
EMERY
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BEAVER
PIUTE
WAYNE
UV
Monticello
Ag
IRON
SG
GARFIELD
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primarily from the surface brines of the Great Salt Lake, but substantial production came from subsurface brines of the Great Salt Lake Desert and the Paradox Basin. Salt produced as a byproduct of Moab Salt's potash operation in Grand County was marketed by the firm's affiliate, Carey Salt.

The Crystal Peak Minerals Co., a subsidiary of the W.D. Haden Co., began construction of facilities to produce salt in Sevier Dry Lake southwest of Delta (Millard County). In 1987 and 1988, the company built dikes and segmented a portion of the southern end of the dry lake and began laying salt floors in their evaporation ponds.

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

Utah construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data for the State's three districts.

Compared to the estimated production in 1987, Utah's production in 1988 fell approximately 15%. District 2 sand and gravel mines, encompassing the population centers of Ogden, Provo, and Salt Lake City, produced approximately 52% of the total output in the State.

Industrial.—Utah's sole producer of industrial sand was Salt Lake Valley Sand and Gravel Co. Mined from the Nash pit in Salt Lake County, the commodity was sold for molding and core for metal casting and for sandblasting.

Sodium Sulfate.—During 1988, sodium sulfate was crystallized from brines taken from the Great Salt Lake and held in solar evaporation ponds. This extraction system is operated by Great Salt Lake Minerals and Chemicals Co. in Weber County. Although the company had produced sodium sulfate in previous years, no production was reported in 1987.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—Utah's production of crushed stone in 1988 dropped an estimated 9% from actual production reported in 1987.

Dimension.—Aragonite in Tooele County and quartz schist in Box Elder County were mined intermittently during the year as dimension stone.

Other Industrial Minerals.—AMAX Magnesium recovered chlorine as a byproduct at its Rowley facility. Two companies continued production of gilsonite, a hydrocarbon, from underground mines in Uintah County. The commodity was marketed as an additive for drilling muds and a variety of other nonfuel applications.

Synthetic graphite was produced for use in composite materials developed and manufactured by Hercules Inc. at its plant near Salt Lake City. As in prior years, perlite was shipped in from out of the State to be expanded at the plant owned by Pax Co. in Salt Lake County.

A relatively small amount of sulfur was recovered at the petroleum refinery owned by Chevron Oil Co. in Salt Lake County. As a byproduct of smelting copper ore, BP Minerals America produced sulfuric acid at its Magna facility. For 1988, acid production exceeded 1987 output by more than 120%.

Intermountain Products Inc. continued to produce exfoliated vermiculite at its plant in Salt Lake County. Crude vermiculite was purchased from out-of-State sources. A small amount of zeolite was mined in 1988 for sampling and testing purposes in Cache County.

TABLE 2

UTAH: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	2,692	$8,570	$3.18
Plaster and gunite sands	65	244	3.94
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	2.93
Asphaltic concrete aggregates and other bituminous mixtures	1,851	6,654	3.59
Road base and coverings	3,037	7,782	2.56
Fill	931	1,480	1.59
Snow and ice control	28	42	1.50
Railroad ballast	W	W	2.41
Other	3,639	12,626	3.46
Unspecified:[1]			
Actual	1,642	4,209	2.56
Estimated	3,961	8,190	2.06
Total or average	**17,843**	**[2]49,796**	**2.79**

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1] Includes production reported without a breakdown by end use, and estimates for nonrespondents.
[2] Data do not add to total shown because of independent rounding.

[1] State Mineral Officer, U.S. Bureau of Mines, Tucson, AZ.

[2] Senior Geologist, Utah Geological and Mineral Survey, Salt Lake City, UT.

[3] Utah Mining Association. The Utah Mining Industry. Mar. 1989, 6 pp.

[4] Rocky Mountain News. Oct. 19, 1988.

[5] Salt Lake Tribune. July 3, 1988.

[6] Rolando, J. Geneva Steels Itself for Modernization. Salt Lake Tribune, Aug. 20, 1989.

[7] Private communication, September 15, 1989, available upon request from Umetco Minerals Corp., Blanding, UT.

TABLE 3

UTAH: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	428	1,188	2,227	7,054	195	852
Asphaltic concrete aggregates and other bituminous mixtures	179	490	1,331	4,003	341	2,160
Road base and coverings	148	349	1,338	3,222	1,551	4,212
Fill	129	290	693	1,009	110	181
Snow and ice control	14	22	—	—	13	20
Railroad ballast	—	—	W	W	—	—
Other miscellaneous	—	—	62	357	3,480	11,988
Other unspecified[2]	1,351	2,867	3,595	7,937	657	1,594
Total[3]	**2,249**	**5,206**	**9,247**	**23,583**	**6,346**	**21,007**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."

[1] Includes sand and gravel for plaster and gunite sands.

[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.

[3] Data may not add to totals shown because of independent rounding.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Asphaltite:			
American Gilsonite Co., a subsidiary of Chevron Corp.	Kennecott Bldg., Suite 1150 Salt Lake City, UT 84133	Underground mines and plant	Uintah.
Ziegler Chemical and Mineral Corp.	363 East Main Vernal, UT 84078	do.	Do.
Beryllium:			
Brush Wellman Inc.	67 West 2950 South Salt Lake City, UT 84115	Open pit mines and plant	Juab and Millard.
Cement:			
Ideal Basic Industries Inc., Cement Div.[1]	Box 8789 Denver, CO 80201	Quarries and plant	Morgan.
Portland Cement Co. of Utah, a division of Lone Star Industries Inc.[1]	Box 90765 Houston, TX 77290	do.	Salt Lake and Tooele.
Southwestern Portland Cement Co., a subsidiary of Southdown Inc.[1 2]	Box 21158 Salt Lake City, UT 84121	do.	Millard.
Clays:			
Interpace Corp., Structural Div.	736 West Harrisville Rd. Box 447 Ogden, UT 84402	Open pit mines and plant	Utah.
Interstate Brick Co., subsidiary of Mountain Fuel Co.	9780 South 5200 West West Jordan, UT 84084	do.	Box Elder, Tooele, Utah.
Utelite Corp.	Box 387 Coalville, UT 84017	Open pit mine and plant	Summit.
Western Clay Co.[1]	Box 1067 Aurora, UT 84620	Open pit mines	Sevier.
Copper:			
BP Minerals America Inc.[3]	10 East South Temple Box 11248 Salt Lake City, UT 84147	Open pit mine, mills, smelter, refinery.	Salt Lake.
Gold:			
Barrick Mercur Gold Mines Inc., a subsidiary of American Barrick Resources Corp.[4]	Box 838 Tooele, UT 84074	Open pit mine, mill, carbon-in-pulp plant	Tooele.
Jumbo Mining Co., a subsidiary of ASOMA, Inc.	Box 999 Delta, UT 84624	Heap leach	Millard.
North Lily Mining Co.[5]	Box 759 Moss Beach, CA 94038	do.	Jaub.
Gypsum:			
Georgia-Pacific Corp.	Box 80 Sigurd, UT 84657	Open pit mine and plant	Sevier.
United States Gypsum Co., a subsidiary of USG Corp.	Box 120 Sigurd, UT 84657	do.	Do.
Iron and Steel:			
Geneva Steel of Utah	Box 2500 Provo, UT 84603	Mines and plant	Iron and Utah.
Nucor Steel Div., Nucor Corp.	Box 100 Plymouth, UT 84330	Plant	Box Elder.
Lime:			
Chemstar Inc.[1]	Box 537 Grantsville, UT 84029	Open pit mine and plant	Tooele.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Continental Lime Inc., a subsidiary of Steel Bros. Canada Ltd.	Box 266 Delta, UT 84624	Quarry and plant	Millard.
Materials Energy Research and Recovery Corp., a subsidiary of United States Pollution Controls Inc. (formerly Utah Marblehead Lime Co.)[1]	Box 596 Grantsville, UT 84029	Open pit mine and plant	Tooele.
Magnesium:			
AMAX Magnesium Corp., a subsidiary of AMAX Inc.[6 7]	238 North 2200 West Salt Lake City, UT 84116	Plant and solar evaporation ponds	Do.
Phosphate Rock:			
Chevron Resources Co., a subsidiary of Chevron Corp.	Manilla Star Route Vernal, UT 84078	Open pit mine and plant	Uintah.
Potassium Salts:			
Great Salt Lake Minerals and Chemicals Corp., a division of Gulf Resources and Chemicals Corp.[8]	765 North 10500 West Little Mountain Box 1190 Ogden, UT 84402	Plant, concentrator, solar evaporation ponds	Weber.
Moab Salt Inc., a division of Texasgulf, Inc., a subsidiary of Societe Nationale Elf Aquitaine[7]	Box 1208 Moab, UT 84532	Solution mine, solar evaporation, concentrator, plant	Grand.
Reilly Tar and Chemicals Corp., Reilly Wendover Div. (formerly and Kaiser Chemicals of Kaiser Aluminum and Chemical Corp., Bonneville Ltd. Div.)[7 9]	Box 580 Wendover, UT 84083	do.	Tooele.
Salt:			
American Salt Co.	Box 477 Grantsville, UT 84029	Plant	Do.
Morton Salt Co., a division of Morton-Thiokol Inc.	A.M.F. Box 22054 Salt Lake City, UT 84122	do.	Salt Lake.
Redmond Clay and Salt Co.[2]	370 S. State St. Redmond, UT 84652	Underground mine	Sanpete.
Sol-Aire Salt and Chemical Co., a division of International Salt Co.	1428 Hardy Rd. Lake Point, UT 84074	do.	Tooele.
Sand and gravel (construction):			
Concrete Products Co., a division of Gibbons and Reed Co.[2]	41 West Central Ave. Box 7356 Murray, UT 84107	Pits and plants	Davis, Salt Lake, Summit, Utah, Weber.
Geneva Rock Products Inc.	1565 West 400 North Box 538 Orem, UT 84057	do.	Salt Lake.
Harper Excavating Inc.	4655 West 5415 South Kearns, UT 84118	do.	Do.
Kiewit Western Co.	5900 South 370 West Box 7780 Murray, UT 84107	do.	Do.
LeGrand Johnson Construction	Box 248 Logan, UT 84321	do.	Cache, Jaub, Rich.
Monroc Inc.	1730 North Beck St. Box 537 Salt Lake City, UT 84110	do.	Salt Lake.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Jack B. Parson Co. Inc.	5200 South Washington Blvd. Ogden, UT 84402	do.	Box Elder, Cache, Davis.
Pioneer Sand and Gravel Co.	6000 West 5400 South Kearns, UT 84118	Pits and plant	Salt Lake.
Salt Lake Valley Sand and Gravel Co.[7]	Box E Sandy, UT 84070	do.	Do.
Savage Rock Products	748 West 300 South Salt Lake City, UT 84104	Pits and plants	Davis and Salt Lake.
Silver:			
Hecla Mining Co., Escalante Unit.	Box 308 Enterprise, UT 84725	Underground mine, mill, plant	Iron.
Stone (Crushed):			
Cedarstrom Calcite and Clay Corp.	145 East 5th North Lehi, UT 84045	Quarry	Utah.
Diversified Marketing Services Inc.	Box 1181 Fillmore, UT 84631	Quarry and plant	Millard.
Lava Products Inc.	94 West Tabernacle St. George, UT 84770	do.	Washington.
Lone Pine Quarries Co.	Route 1, Box 120-01 Oakley, ID 83346	Quarries	Box Elder.
Lost Dutchman Construction Co.	Box 718 Lakeside, UT 84074	Quarry	Do.
McFarland and Hullinger	Box 238 Tooele, UT 84074	Quarries	Tooele.
Savage Rock Products	Box 11537 Salt Lake City, UT 84147	do.	Salt Lake.
Southern Pacific Transportation Co.	One Market Place San Francisco, CA 94105	Quarry	Box Elder.
Stone (smelter flux):			
Sunshine Mining Co.[4 10 11]	Box 250 Eureka, UT 84628	Underground mine	Utah.
Uranium/Vanadium:			
Atlas Corp., Atlas Minerals Div.	Box 1207 Moab, UT 84532	Underground mines and mill	Emery, Grand, San Juan.
Energy Fuels Nuclear[11]	1 Tabor Center, #2500 1200 17th St. Denver, CO 80202	Ion-exchange plant	Salt Lake.
Rio Algom Mining Corp.	La Sal Route Moab, UT 84532	Underground mine	San Juan.
Umetco Minerals Corp.	Box 669 Blanding, UT 84511	Underground mines, ore-buying station, research, laboratory	Emery, Garfield, San Juan.

[1] Also stone.
[2] Also clays.
[3] Also gold, molybdenum, and silver.
[4] Also silver and mercury.
[5] Also silver.
[6] Also chlorine.
[7] Also salt.
[8] Also magnesium compounds, salt, and sodium sulfate.
[9] Also magnesium compounds.
[10] Also gold.
[11] Also scandium.

THE MINERAL INDUSTRY OF VERMONT

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Office of the State Geologist, Agency of Environmental Conservation, for collecting information on all nonfuel minerals.

By Donald K. Harrison[1] and Charles A. Ratté[2]

The value of nonfuel mineral production in 1988 was $76.9 million, a $3.5 million increase over the 1987 value. The increase was largely attributed to a greater demand for construction sand and gravel, which rose 29% in volume and 62% in value compared to 1987 estimated numbers. Leading mineral commodities produced, in descending order of value, were dimension stone, crushed stone, sand and gravel, talc, and asbestos. Nationally, the State ranked second of 11 States that produced talc. It ranked third in quantity in dimension stone output, but first in value. Vermont was one of only two States that produced asbestos, the other being California.

TRENDS AND DEVELOPMENTS

Vermont was the only State in the six-State New England region that posted a gain in residential building contracts in 1988. Although the entire New England region reported a net loss of 18% in the number of residential building permits authorized, building permits in Vermont increased 17% in the same period. The value of nonresidential building permits in Vermont also increased substantially (67%) in 1988. The only other New England States to report gains were New Hampshire (68%) and Massachusetts (1%). Since demand for mineral aggregates is almost totally dependent on construction activity, there is usually a correlation between aggregate output and construction contracts awarded. Although output of crushed and dimension stone remained essentially the same as 1987, output and value of construction sand and gravel increased 29% and 62%, respectively.

REGULATORY ISSUES

During 1988, acid rain was clearly viewed as the most critical environmental problem facing Vermont. In December, Vermont, eight other States, and the National Audubon Society filed suit against the Environmental Protection Agency (EPA) for its failure to take actions to limit U.S. air pollution sources causing acid rain in Canada. The suit was filed in response to EPA's refusal to act on a petition filed in April, in which Vermont, eight other States, and three environmental groups called upon the agency to regulate acid rain as an international air pollution problem pursuant to Section 115 of the Federal Clean Air Act. The State contends that the harmful effects of acid rain in Canada are exactly the same as those encountered in Vermont.

Solid waste and toxic waste disposal were also concerns in Vermont. During the year, tighter regulations were established for solid waste disposal sites and underground hazardous-waste storage tanks. Despite the State's reputation for a clean environment, at least 80 hazardous waste sites containing toxic chemicals were identified. Two of the sites have been added to the Federal Superfund list of toxic waste sites, and six others were being studied for the Federal program.[3]

LEGISLATION AND GOVERNMENT PROGRAMS

During the 1988 legislative session, two bills were introduced into the Vermont House that would have directly affected mineral resource extraction. House bills 583 and 593 would have eased restrictions on mining operations (especially aggregate producers) by ex-

TABLE 1

NONFUEL MINERAL PRODUCTION IN VERMONT[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	W	NA	$10	NA	$10
Sand and gravel (construction)	thousand short tons	4,834	$11,226	e4,700	e10,800	6,047	17,478
Stone:							
Crushed	do.	e1,600	e7,600	[2]2,159	[2]20,400	e[2]2,000	e[2]18,000
Dimension	short tons	e104,610	e27,075	103,923	30,074	e105,000	e30,500
Combined value of asbestos, stone (crushed granite 1987–88), talc, pyrophyllite, and values indicated by symbol W		XX	9,310	XX	r12,160	XX	10,957
Total		**XX**	**55,211**	**XX**	**73,444**	**XX**	**76,945**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain stones; kinds and values included with "Combined value" data.

empting them from certain taxes and regulatory statutes. However, both bills died in the House Natural Resources and Energy Committee.

In December, the New Hampshire-Vermont Chapter of the Soil and Water Conservation Society sponsored a conference in Rutland on sand and gravel extraction. The conference included speakers on environmental concerns, regional and town planning, and site planning and reclamation. Participants were from the construction, mineral extraction, and engineering industries; Federal, State, and town governments; regional and town planning groups; and private groups and organizations.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Asbestos.—The Vermont Asbestos Group (VAG) Inc. produced chrysotile asbestos at an open pit mine and operated a dry-processing mill at Lowell, Orleans County. In 1988, shipments of asbestos remained relatively unchanged from 1987 levels. The asbestos was sold primarily for manufacturing clutches, brake components, and diaphragms for chlorine production.

In late June, VAG announced that it was reducing its working hours at the mine because of declining sales. The mine's 75 employees began working 40 hours per week, down from the 50 per week they had been working since the mining season began in April. In 1988, the mine operated only 6 months. In the 1970's, the mine operated 24 hours per day, 6 days per week.[4] Recent adverse publicity on asbestos-related health risks and a proposed EPA ban on asbestos products have severely curtailed demand for the product.

In August, VAG announced plans to apply for permits to open an asbestos landfill at the Lowell Mine site to serve the East Coast. The company stated that the landfill could accommodate asbestos collected in abatement programs to remove the material from buildings. In 1988, more than 90% of the asbestos from Vermont's abatement program was disposed of outside the State.[5]

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

Construction sand and gravel was the third leading mineral commodity produced in terms of value, slightly below crushed stone. In 1988, production and value rose 29% and 62%, respectively, over 1987 estimated figures. A total of 61 companies mined construction sand and gravel from 77 operations in all the State's counties. Leading counties in descending order of output were Chittenden, Rutland, and Lamoille. Main uses were for road base and coverings, concrete aggregates, and fill.

Near yearend, the H.A. Manosh Corp., Morrisville, agreed to pay a $30,000 penalty for operating a gravel pit in violation of Act 250 and State water pollution laws. The agreement was an out-of-court settlement reached between the Attorney General and Manosh. The Attorney General had sued the firm in April 1987 for extracting large amounts of sand and gravel from the Duhamel Gravel Pit without a permit under Act 250, the State's main development control law. In addition to the $30,000 paid to the State, Manosh was forced to set aside $20,000 that will be forfeited if the company violates State laws in the next 5 years.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter

TABLE 2

VERMONT: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	642	$2,891	$4.50
Plaster and gunite sands	W	W	2.50
Concrete products (blocks, bricks, pipe, decorative, etc.)	92	413	4.49
Asphaltic concrete aggregates and other bituminous mixtures	358	1,706	4.77
Road base and coverings	1,960	5,527	2.82
Fill	323	498	1.54
Snow and ice control	247	577	2.34
Railroad ballast	W	W	5.00
Other	448	1,530	3.42
Unspecified:[1]			
Actual	305	591	1.94
Estimated	1,672	3,746	2.24
Total or average	**6,047**	**[2]17,479**	**2.89**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[2] Data do not add to total shown because of independent rounding.

contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—Crushed stone was the State's second leading commodity produced, accounting for nearly a quarter of the State's mineral value. Limestone was the primary rock quarried, followed by granite and marble. Major uses were for bituminous concrete, fill, and road base aggregates.

Dimension.—Dimension stone, the State's leading mineral commodity in terms of value, accounted for nearly 40% of the State's value. Nationally, the State ranked third in output but first in value. Types of rocks quarried, in descending order of output, were granite, slate, and marble.

In February, fire destroyed three granite businesses in Barre. The three firms affected were Nativi & Son Inc., Tosi Custom Sandblast, and Apex Memorial Co. Property damages from the fire were estimated to be $500,000. All three businesses were temporarily operating in other facilities until deciding whether to rebuild on the gutted sites or permanently locate elsewhere.

Talc.—Nationally, Vermont ranked second in talc production after Montana. Both production and value rose slightly in 1988. Primary uses for the talc were as a filler-extender in cosmetics, building materials, and plastics.

Cyprus Industrial Minerals Inc. completed its acquisition of Vermont Talc Co. Included in the acquisition were Vermont Talc's reserves, a mine near Troy, a flotation mill near Johnson, and a mine and mill near Chester. The Troy-Johnson facilities produced pharmaceutical-grade talc and other fine-grade products used in paper, plastics, and paints.

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[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA.

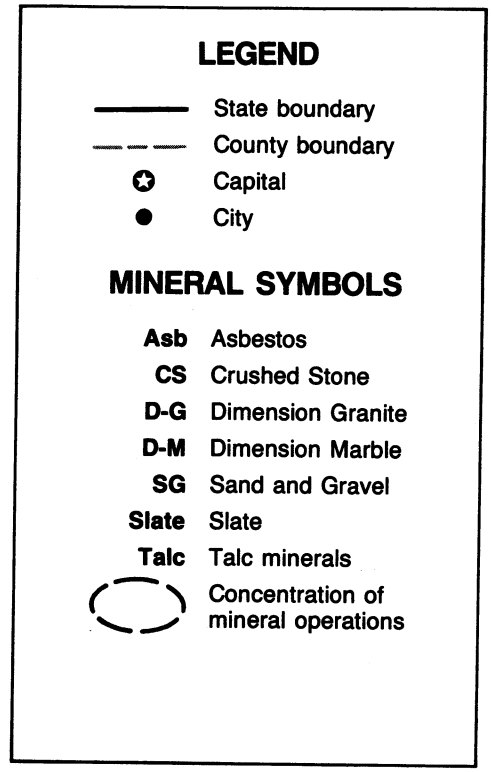
[2] State geologist, Agency of Environmental Conservation, Waterbury, VT.

[3] Vermont Business. The Evils Which Lurk Beneath Our Feet. June 1988, pp. 8–10.

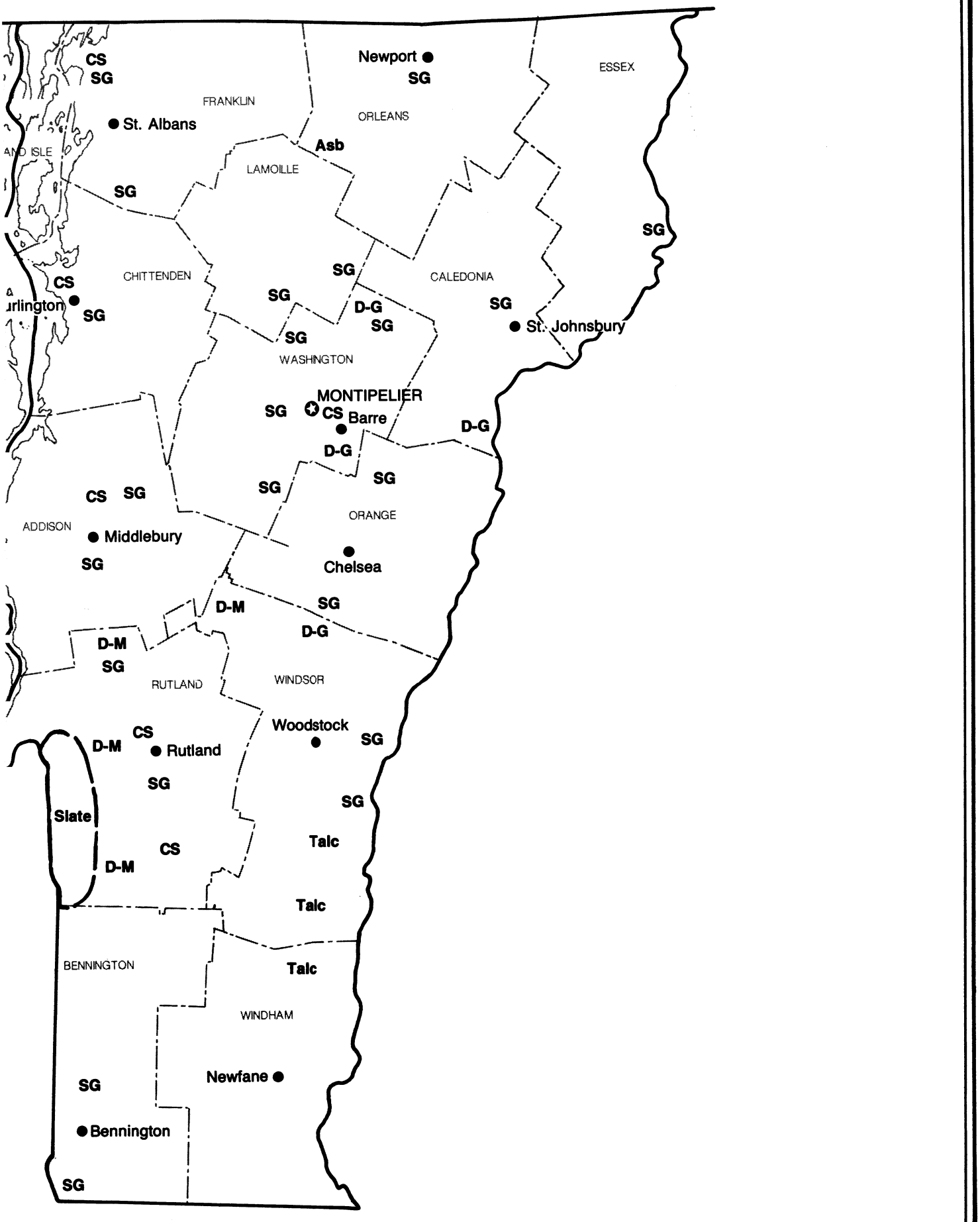
[4] The Chronicle (Barton, VT). Hours Cut At Lowell Mine. July 6, 1988.

[5] The Burlington Free Press (VT). Asbestos Landfill Planned. Aug. 12, 1988.

VERMONT



Principal Mineral-Producing Localities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St. Johnsbury
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WASHINGTON
MONTIPELIER
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ORANGE
ADDISON
Middlebury
Chelsea
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Woodstock
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Rutland
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Slate
Talc
CS
D-M
Talc
BENNINGTON
Talc
WINDHAM
Newfane
SG
Bennington
SG

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Asbestos:			
Vermont Asbestos Group Inc.	Box 54B Morrisville, VT 05661	Pit	Orleans.
Sand and gravel (construction):			
Ormand Bushey & Sons Inc.	Box 183 Fairfax, VT 05454	Pits	Chittenden and Franklin.
Calkins Sand & Gravel Inc.	Box 82 Lyndonville, VT 05851	Pits and plant	Caledonia and Orleans.
Joseph P. Carrara & Sons Inc.	Route 116 Middlebury, VT 05753	Pits	Addison and Rutland.
William E. Daily Inc.	Route 1, Box 51 Shaftsbury, VT 05262	do.	Bennington.
Hinesburg Sand & Gravel Co.	Box 200 Hinesburg, VT 05461	do.	Chittenden.
Frank W. Whitcomb Construction Corp.	Box 429 Bellows Falls, VT 05101	Pit and plant	Rutland.
Stone:			
Crushed:			
Cooley Asphalt Paving Corp.	Box 542 Barre, VT 05641	Quarry	Washington.
Pike Industries Inc.	Route 3, Box 91 Tilton, NH 03276	do.	Caledonia.
Frank W. Whitcomb Construction Corp.	Box 429 Bellows Falls, VT 05101	Quarries	Chittenden.
White Pigment Corp.	Florence, VT 05744	do.	Addison and Rutland.
Dimension:			
OMYA Inc.	61 Main St. Proctor, VT 05765	Quarry and plant	Rutland and Windsor.
Rock of Ages Corp., a subsidiary of John Swenson Granite, Co. Inc.	Box 482 Barre, VT 05641	Quarries	Washington and Windsor.
John Swenson Granite Co. Inc.	North State St. Concord, NH 03301	Quarry	Washington.
Talc:			
Vermont Talc Co., a subsidiary of OMYA Inc.	Route 11, Box 117 Chester, VT 05143	Mine and mill	Windham.
Windsor Minerals Inc.	Box 680 Windsor, VT 05089	Mines and mills	Windsor.

THE MINERAL INDUSTRY OF VIRGINIA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Virginia Division of Mineral Resources for collecting information on all nonfuel minerals.

By L. J. Prosser, Jr.,[1] and Palmer C. Sweet[2]

The 1988 value of nonfuel mineral production in Virginia was about $495 million, the highest in State history. The value of nonfuel mineral production and the output of crushed stone, Virginia's leading mineral commodity, increased in each of the past 6 years. Nationally, the State ranked 20th in the value of nonfuel mineral production and 4th in crushed stone output.

EXPLORATION ACTIVITIES

In 1988, strong interest in titanium mineralization developed as the result of investigations in parts of Dinwiddie and Sussex Counties. Initial work in the area, which was published early in the year by the Virginia Division of Mineral Resources, spurred exploration activity by the mining industry.[3] The mineralized area was owned by local residents and was used primarily for farming.

Mild interest in gold and uranium deposits in Virginia also resurfaced during the year. Two proposals to mine gold in western Goochland County were announced early in the year by Southern Piedmont Mining Corp. and by Goldridge Ltd. However, no development or subsequent activity occurred during the year. The Marline Uranium Corp. discovered an estimated 30 million pounds of uranium oxide (U_3O_8) ore with an average grade of 4 pounds per ton of ore in Pittsylvania County in 1982. Despite the passage of legislation in the early 1980's banning uranium mining in the State, the company wanted to develop a uranium deposit in Southside, Virginia. That law would have to be rescinded before mining could occur.

EMPLOYMENT

The Virginia Department of Mines, Minerals, and Energy, Division of Mineral Mining, reported 2,935 plant workers and 1,859 quarry workers were employed in the nonfuels mining industry in 1988. Compared with 1987, employment of plant workers dropped by 115 while the number of quarry workers increased by 186. Overall, in 1988, the limestone industry employed the most workers with a total of 988 employees. The Division also reported that about 500 nonfuel mining operations were active in the State in 1988.

LEGISLATION AND GOVERNMENT PROGRAMS

Longwall mining and subsidence became an issue in the General Assembly in 1988. Virginia ranked seventh nationally in coal production, mining about 46.4 million short tons. About one-third of the coal output came from the 13 longwall mines operated in the State, all of which were in Buchanan, Dickenson, and Wise Counties. Although no legislation was introduced, a report on longwall mining in Virginia was prepared, examining its effect on mine safety, the coal industry, the economy, water supplies, tax income for localities, wildlife, and tourism.[4]

The Virginia Division of Mineral Resources was involved in several metallic, energy, and industrial mineral projects during 1988. The Division completed reports on the following subjects: large andalusite crystals in Campbell County; precious metal mines, prospects, and occurrences; plume agate mines; Rockbridge County gold occurrences; Albemarle County mineral occurrences; and the history of the Richmond coal basin. The Division also continued work on several coal resource and evaluation reports and on the mapping of 7.5-minute quadrangles in the southwest Virginia coal fields. Other studies nearing completion included those on travertine-marl deposits, tantalum-niobium resources, nonbauxitic aluminum resources, and the first report on a Statewide carbonate study.

United Coal Co. Research Corp. (UCC) began production of a coal-based liquid fuel at a plant in Bristol in June. UCC opened a $2.5 million research and development center that included the production plant. The plant had the capacity to produce about 35,000 gallons of fuel per day. The fuel was tested initially as a replacement for diesel fuel in locomotives, but was also expected to be usable in automobiles. Both the State and Federal governments provided funding for the research.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Crushed stone accounted for about $327 million or two-thirds of Virginia's total value of nonfuel mineral production. The combined output of lime and construction sand and gravel represented about 16% of the total State value. Although these three commodities accounted for more than 80% of Virginia's nonfuel mineral value, a wide range of other industrial minerals were also mined. Common clays, fuller's earth, dimension stone, cement, iron oxide pigments, and industrial sand were among the minerals produced in the State. Virginia remained the only State producing kyanite and a feldspar marketed as "Virginia aplite." It was one of only three States that mined crude vermiculite. Mineral manufacturing operations, including processing lithium, magnetite, manganese, perlite, and sulfur, also contributed to the State's economy.

Cement.—Tarmac PLC, a construction company in the United Kingdom, acquired the remaining 40% interest in Lone Star Industries Inc.'s operations in Virginia and two other southeastern States. Lone Star was the State's leading cement producer. Tarmac had purchased the other 60% of the operations in 1987.

TABLE 1

NONFUEL MINERAL PRODUCTION IN VIRGINIA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	899,977	$7,700	[2]1,174,442	[2]$6,291	[2]1,113,459	[2]$6,614
Gem stones		NA	20	NA	20	NA	20
Lime	thousand short tons	624	27,362	699	29,435	741	33,875
Sand and gravel (construction)	do.	11,670	46,488	[e]12,100	[e]43,400	12,551	42,573
Stone:							
Crushed	do.	[e]52,000	[e]224,700	60,376	295,903	[e]66,000	[e]326,700
Dimension	short tons	[e]9,542	[e]3,128	9,077	2,720	[e]10,000	[e]2,900
Combined value of aplite, cement, clay (fuller's earth, 1987–88), gypsum, iron oxide pigments (crude), kyanite, sand and gravel (industrial), soapstone (1987–88), vermiculite		XX	83,639	XX	83,673	XX	81,830
Total		**XX**	**393,037**	**XX**	**461,442**	**XX**	**494,512**

[e]Estimated. NA Not available. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" data.

Clays.—General Shale Products Corp., the State's leading common clay producer, purchased Webster Brick Co. Inc. With the acquisition, General Shale mined clay in Botetourt, Orange, Rockbridge, and Smyth Counties. Statewide in 1988, 9 companies mined common clay at 14 pits in 12 counties. One company mined fuller's earth in King and Queen County.

Lime.—USG Corp. transferred its Kimballton Mine and lime plant operations in Giles County to a new subsidiary, APG Lime Corp. Four other companies also manufactured lime in Virginia.

TABLE 2

VIRGINIA: LIME SOLD OR USED BY PRODUCERS, BY USE

Use	1987		1988	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Acid water neutralization	W	W	81,044	$3,898
Paper and pulp	W	W	W	W
Steel, basic oxygen	98,493	$4,206	90,905	4,241
Steel, electric	49,574	2,153	33,336	1,546
Other[1]	550,441	13,101	535,463	24,190
Total	**698,508**	**15,254**	**740,748**	**29,977**

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes agriculture, alkalies, ladle desulfurization, mason's lime, ore concentration, other chemical and industrial, precipitated calcium carbonate, road stabilization, sewage treatment, water purification, and uses indicated by symbol W.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1987. Data for odd-numbered years are based on annual company estimates.

Virginia construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data for the State's three districts.

Production of 12.6 million short tons of construction sand and gravel was the highest in Virginia since 1974. Demand for sand and gravel paralleled conditions in the construction industry. During the last period of strong building growth and expansion, from 1977 through 1979, Virginia produced an average of 11.2 million tons of sand and gravel per year. From 1980 through 1983, when high interest rates adversely affected the construction industry, annual production averaged 7.4 million tons. From 1985 through 1988, sand and gravel production averaged 11.6 million tons per year, reflecting lower interest rates along with increased funding for road construction and maintenance.

Soapstone.—The New Alberene Stone Co. Inc. began an $8 million modernization program to increase its production capacity sixfold. The operation,

owned by the Tuli Kivi Group of Finland, reopened the soapstone quarry in 1987. Much of the firm's production was exported to Europe for use as heating element panels in stoves; soapstone blocks were also marketed worldwide for use in residential and commercial buildings.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for even-numbered years are based on annual company estimates.

During the year, W.W. Boxley Co., one of the State's leading crushed stone producers, purchased 2 quarries, giving the firm 10 stone operations in Virginia. W.W. Boxley acquired the Dominion Stone Plant Inc. and the Stuarts Draft Sand & Gravel Co., which it placed under its subsidiary, the Blue Ridge Stone Corp. Luck Stone Corp., another of the State's leading stone producers, opened a $10 million traprock quarry operation in Bealeton. Crushed stone from the quarry, which is within 45 miles of the Arlington-Washington, DC, market, was sold for use in road construction, septic tank fields, and concrete block and pipe. Frederick County granted a conditional use permit in March to Seal Corp. to open a quarry in the Ridgeley sandstone, near Star Tannery southwest of Winchester.

However, expansion and opening of quarries in 1988 were opposed in some areas. Amherst County again turned down a proposed granite quarry by Lawhorne Brothers Inc. The company had previously been turned down for a

TABLE 3

VIRGINIA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	3,938	$18,406	$4.67
Plaster and gunite sands	222	1,412	6.36
Concrete products (blocks, bricks, pipe, decorative, etc.)	303	1,171	3.86
Asphaltic concrete aggregates and other bituminous mixtures	993	3,718	3.74
Road base and coverings	498	1,571	3.15
Fill	2,476	4,915	1.99
Snow and ice control	72	246	3.42
Other[1]	205	853	4.16
Unspecified:[2]			
Actual	2,699	7,070	2.62
Estimated	1,145	3,213	2.81
Total or average	**12,551**	**[3]42,573**	**3.39**

[1] Includes roofing granules.
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data do not add to total shown because of independent rounding.

TABLE 4

VIRGINIA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates and concrete products[1]	184	1,109	15	85	4,264	19,795
Asphaltic concrete aggregates and road base and coverings[2]	288	1,753	72	203	3,607	8,248
Snow and ice control	—	—	13	41	59	205
Other miscellaneous[3]	—	—	1	2	205	851
Other unspecified[4]	261	1,091	47	114	3,535	9,078
Total[5]	**734**	**3,953**	**148**	**445**	**11,670**	**38,175**

[1] Includes sand and gravel for plaster and gunite sands.
[2] Includes sand and gravel for fill.
[3] Includes sand and gravel for roofing granules.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

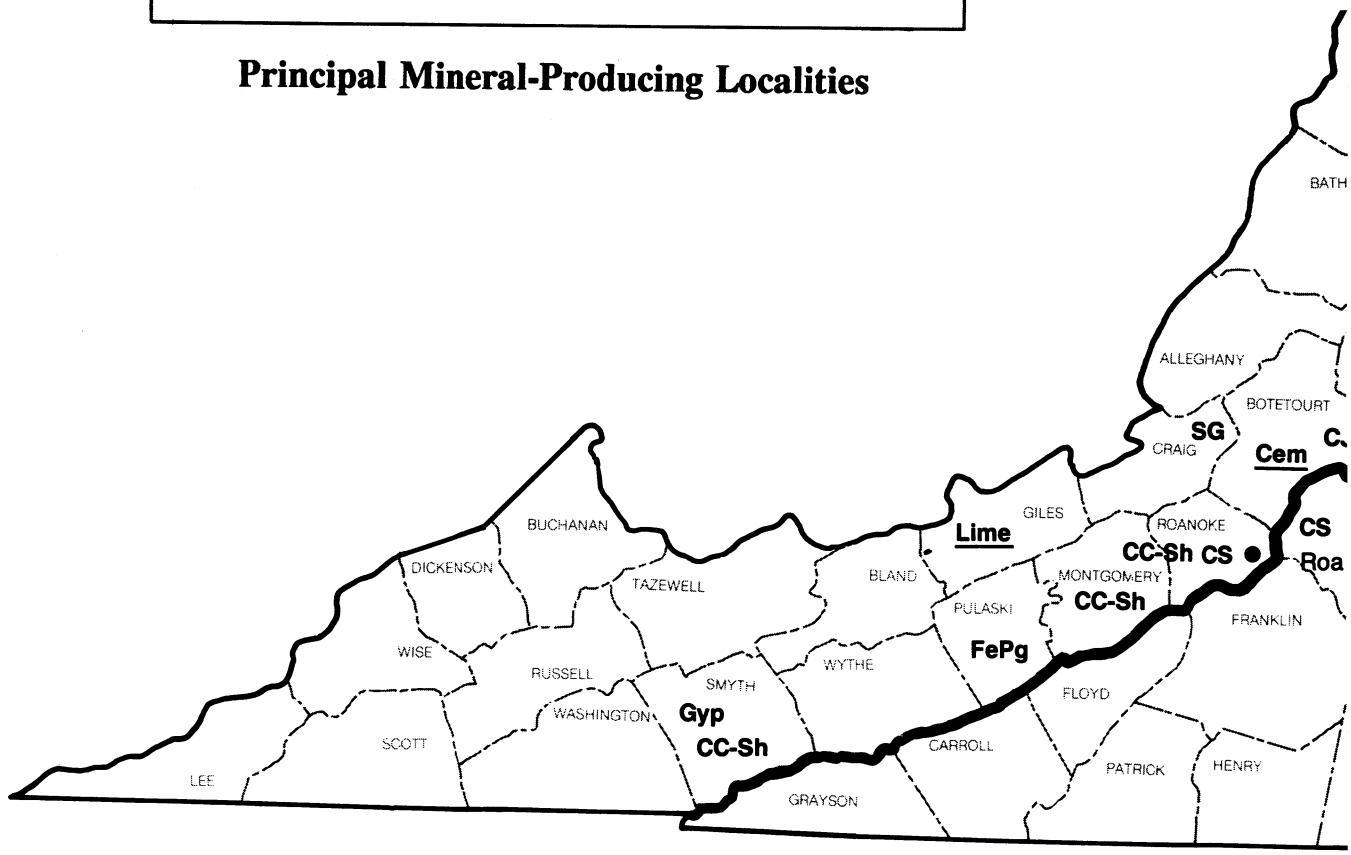
LEGEND

State boundary
County boundary
Capital
City
Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Cem Cement plant
CC-Sh Common Clay & Shale
CS Crushed Stone
D-G Dimension Granite
D-SL Dimension Slate
D-SP Dimension Soapstone
Fel Feldspar
FePg Iron Oxide pigments
Ful Fuller's earth
Gyp Gypsum
IS Industrial Sand
Ky Kyanite
Lime Lime plant
SG Sand and Gravel
Vm Vermiculite
Concentration of mineral operations

Principal Mineral-Producing Localities



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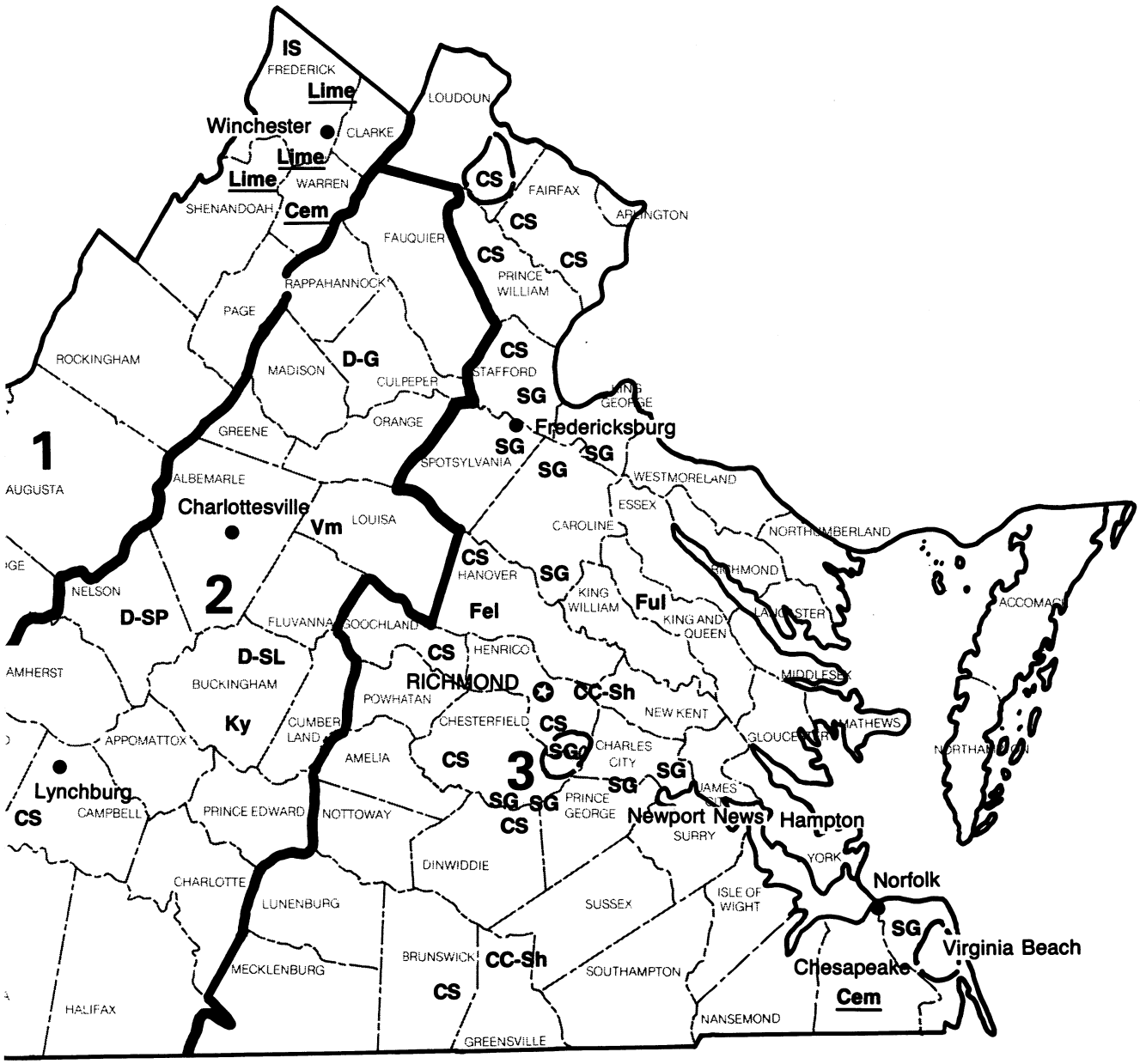
IS
FREDERICK
Lime
Winchester
CLARKE
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Lime
WARREN
SHENANDOAH
Cem
LOUDOUN
CS
FAIRFAX
ARLINGTON
CS
FAUQUIER
CS
CS
PRINCE WILLIAM
RAPPAHANNOCK
PAGE
ROCKINGHAM
MADISON
D-G
CULPEPER
CS
STAFFORD
SG
KING GEORGE
Fredericksburg
ORANGE
GREENE
SG
SG
SPOTSYLVANIA
SG
WESTMORELAND
1
AUGUSTA
ALBEMARLE
Charlottesville
Vm
LOUISA
ESSEX
CAROLINE
NORTHUMBERLAND
CS
HANOVER
SG
RICHMOND
NELSON
2
KING WILLIAM
Ful
KING AND QUEEN
LANCASTER
ACCOMACK
D-SP
FLUVANNA
GOOCHLAND
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D-SL
CS
HENRICO
AMHERST
BUCKINGHAM
RICHMOND
CC-Sh
MIDDLESEX
POWHATAN
NEW KENT
Ky
CUMBER LAND
CHESTERFIELD
CS
MATHEWS
APPOMATTOX
SG
CHARLES CITY
GLOUCESTER
NORTHAMPTON
AMELIA
CS
3
SG
JAMES CITY
Lynchburg
CS
CAMPBELL
PRINCE EDWARD
NOTTOWAY
SG
SG
PRINCE GEORGE
Newport News
Hampton
CS
SURRY
YORK
DINWIDDIE
Norfolk
CHARLOTTE
LUNENBURG
SUSSEX
ISLE OF WIGHT
SG
Virginia Beach
BRUNSWICK
CC-Sh
MECKLENBURG
SOUTHAMPTON
Chesapeake
CS
Cem
HALIFAX
NANSEMOND
GREENSVILLE

special zoning exception. Major objections to the quarry were potential water contamination, truck traffic, and blasting damage. MoRock Corp. was denied its land-use rezoning request for which it applied in the early part of the year. The Louisa County Planning Commission recommended that the county board of supervisors deny the request. Solite, a division of Oldover Corp., filed an application in Fluvanna County in November to rezone a tract of land in Fork Union from agricultural to industrial general. Plans to seek rezoning and then a special-use permit to open a rock quarry were postponed until 1989.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA.

[2] Head geologist, Economic Geology Section, Virginia Division of Mineral Resources.

[3] Berquist, C. R., Jr. Minerals in High-Level Gravel Deposits Along the Fall Zone of Virginia. VA Minerals, v. 33, No. 4, 1987, pp. 37-39.

[4] The Coalfield Progress (Norton, VA). General Assembly Group Begins Study of Longwall Mining. July 14, 1988, pp. 1 and 12.

TABLE 5

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aplite:			
The Feldspar Corp.	Rt. 1, Box 305 Montpelier, VA 23192	Quarry and plant	Hanover.
Cement:			
Lone Star Lafarge Inc.	Box 5128 Chesapeake, VA 23320	Plant	Chesapeake (city).
Riverton Corp.[1]	Box 4004 Front Royal, VA 22630	Quarry and plant	Warren.
Tarmac PLC[2]	Box 27 Cloverdale, VA 24077	do.	Botetourt.
Clays:			
Brick & Tile Corp.	Box 45 Lawrenceville, VA 23868	Pits and plant	Brunswick and Greensville.
General Shale Products Corp.	Box 3547 Johnson City, TN 37601	Pits and plants	Botetourt, Orange, Rockbridge, Smyth.
Old Virginia Brick Co. Inc.	Box 508 Salem, VA 24153	Pit and plant	Montgomery and Roanoke.
Gypsum:			
USG Corp.	Box 4686 Norfolk, VA 23523	Plant	Norfolk (city).
Do.	Rt. 1 Saltville, VA 24370	Mine and plant	Smyth, Saltville, Washington.
Iron oxide pigments (crude):			
Hoover Color Corp.	Box 218 Hiwassee, VA 24347	do.	Pulaski.
Kyanite:			
Kyanite Mining Corp.	Dillwyn, VA 23936	Mines and plant Plant	Buckingham. Prince Edward.
Lime:			
APG Lime Corp.	Star Rt. 635 Ripplemead, VA 24145	Underground mine and plant	Giles.
Chemstone Corp.	Rt. 629, Box 71 Strasburg, VA 22657	Quarry and plant	Shenandoah.
Sand and gravel:			
Culpeper Stone Co. Inc.	Box 1318 Culpeper, VA 22701	Pit and plant	Stafford.
Isle of Wright	Box 216 Carrollton, VA 23314	Pits and plants	Isle of Wright.
Solite Corp.	Box 27211 Richmond, VA 23230	Pit and plant	King George.
Tarmac-Lone Star Inc.	Box 420 Norfolk, VA 23501	Pits and plants	Charles City, Chesterfield, Henrico, Prince George.
Soapstone:			
New Alberene Stone Co.	Box 300 Schuyler, VA 22969	Pit and plant	Nelson.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone:			
W. W. Boxley Co.	Box 13527 Roanoke, VA 24034	Quarries	Amherst, Augusta, Campbell, Bland, Botetourt, Henry, Richmond (city), Tazewell.
Luck Stone Corp.	Box 29682 Richmond, VA 23229	do.	Albemarle, Augusta, Fairfax, Fauquier, Goochland, Greene, Halifax, Loudoun, Nottoway, Richmond, Rockingham.
Vulcan Materials Co., Mideast Div.	Box 7 Knoxville, TN 37901	do.	Fauquier, Goochland, Stafford.
Vermiculite:			
Virginia Vermiculite Ltd.	Box 70 Louisa, VA 23093	Mine and plant	Louisa.

[1] Masonry cement only; also produces lime and limestone.
[2] Also stone.

THE MINERAL INDUSTRY OF WASHINGTON

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Washington Division of Geology and Earth Resources for collecting information on all nonfuel minerals.

By W. L. Rice[1] and Nancy L. Joseph[2]

Nonfuel mineral production value in Washington rose to $459.3 million in 1988, an increase of about 5% over that of 1987. There were substantial increases in the production value of gold, magnesium metal, and silver, offset by a significant drop in portland cement production value and a lesser reduction in the production value of crushed stone. Magnesium metal again was the leading commodity in terms of value, followed by gold, construction sand and gravel, crushed stone, and cement. The metallic minerals—gold, magnesium, and silver—accounted for nearly 49% of the State's nonfuel mineral value in 1988. In comparison, the industrial minerals—chiefly cement, clays, diatomite, lime, olivine, sand and gravel, and stone—were responsible for nearly 55% of the mineral value in 1987, 56% in 1986, 89% in 1985, and 95% in 1984.

Washington ranked 22d in the Nation in the value of nonfuel minerals produced, down from the 21st ranking in 1987.

TRENDS AND DEVELOPMENTS

The upward progression in State gold production, begun in 1985, continued through 1988. New discoveries and gold mine development work started in 1988 should continue to bolster this trend for the foreseeable future, as long as metals prices remain at or near 1988 levels.

The State's aluminum industry achieved an almost total recovery from the depressed state prevalent in the mid-1980's. Each of the seven aluminum reduction plants operated during the year, and all but two had achieved rated capacity by yearend. A conservation-modernization incentive program offered by the Bonneville Power Administration (BPA) was accepted by all companies that operated aluminum smelters in the State.

Base metal mining, once a significant part of the State's mineral producing industry, began to revive in 1988 after a 12-year hiatus. A major zinc-lead mine was optioned, with plans to reopen in 1989, and exploration was ongoing on several base-precious metal properties in northeastern Washington.

EMPLOYMENT

The State's mining industry employment increased by 10% over that of 1987. According to the State of Washington Employment Security Department, mining and quarrying employment rose to about 3,300 workers, 300 more than the total recorded in 1987. Continued recovery in the aluminum-smelting sector of the State's primary metals industry led to a rise in employment to 8,700 workers by yearend, up from 7,400 employed in 1987.

TABLE 1

NONFUEL MINERAL PRODUCTION IN WASHINGTON[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	6	$530	W	W	W	W
Portland	do.	1,212	59,091	1,282	$63,600	979	$48,233
Clays	short tons	252,145	1,560	415,593	2,356	415,487	2,235
Gem stones		NA	200	NA	200	NA	200
Peat	thousand short tons	W	W	7	191	5	142
Sand and gravel:							
Construction	do.	26,342	76,387	e25,300	e78,900	31,170	94,402
Industrial	do.	W	W	294	5,186	W	W
Stone:							
Crushed	do.	e9,000	e34,100	14,754	49,618	e13,900	e48,700
Dimension	short tons	e1,223	e69	297	42	e697	e60
Combined value of calcium chloride (natural), copper (1987), diatomite, gold, gypsum, lime, magnesium metal, olivine, silver, and values indicated by symbol W		XX	204,688	XX	r238,341	XX	265,362
Total		**XX**	**376,625**	**XX**	**438,434**	**XX**	**459,334**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

REGULATORY ISSUES

International Titanium Inc. (ITI) secured approval from the State Department of Ecology to truck 4,000 cubic yards of titanium processing waste to the Hanford nuclear reservation of the U.S. Department of Energy for disposal. The material, called "washed condenser waste," resulted from titanium sponge production at ITI's Moses Lake plant in Grant County. The operation was permanently closed in 1987. The waste contained low levels of radioactivity and chromium, which, under State law, was classified as dangerous waste that could not be disposed of by burial at the titanium plant site.

ASARCO Incorporated (operator of the now-closed Tacoma copper smelter in Pierce County), Kennecott Corp., and Atlantic Richfield Co. were asked to pay environmental cleanup bills exceeding $7 million in a suit filed in a U.S. district court. The suit, filed by Louisiana Pacific Corp. under the Superfund law, sought payment for removal of smelter slag allegedly contaminating the timber company's log-sorting yard with arsenic and other toxic metals. The smelter sold the slag for ballast in local log-sorting yards, where grinding action from heavy equipment tires, plus acid from the logs, reportedly caused the slag to break down and release arsenic, copper, lead, and zinc into a nearby creek.

In midyear, Asarco submitted plans that covered an environmental cleanup of the Tacoma smelter site to the Federal Environmental Protection Agency (EPA). A 572-foot-high smokestack would have to be razed, the smelter buildings torn down, and about 80 acres of contaminated ground treated to neutralize contained toxic metals. Negotiations were started with Asarco to pay for the cleanup, which reportedly could cost several million dollars. The cost of cleanup for Puget Sound sediments adjacent to the smelter site was estimated at about $30 million.

The EPA initiated a remedial investigation and feasibility study of a Superfund site at the abandoned Silver Mountain Mine near Loomis, Okanogan County. In the early 1980's, Precious Metals Extraction Ltd. ran a small cyanide heap-leach operation in an attempt to extract gold and silver from mine waste left over from earlier underground operations. The company abandoned the apparently unsuccessful operation in 1982 without cleaning up the site. In September, the U.S. Bureau of Mines Western Field Operations Center at Spokane was contracted by EPA to do remedial investigation work, which began in late October.

EXPLORATION ACTIVITIES

The level of exploration in Washington rose again in 1988. According to the Washington Division of Geology and Earth Resources, 62 companies explored for metals in 1988; with few exceptions, exploration was for precious-metal deposits. An estimated minimum of $13 million was spent for metals exploration in the State, compared with at least $3.5 million reported in 1987. The U.S. Bureau of Land Management (BLM) reported that mining claim locations on Federal lands were up from previous years; by yearend, an estimated 18,500 active claims were on record.

Ferry County led the State in terms of exploration activity. Twenty-three companies worked in the Republic Graben area, and the number of mining claims located in the county had more than doubled in the past 2 years to a total of about 3,000 claims. Hecla Mining Co. expanded its exploration program in the Republic area, where the company controls more than 5 square miles. Drilling was concentrated in the Golden Eagle area in 1988. Hecla also signed two 35-year exploration leases with Ferry County, covering county-owned lands in the town of Republic.

The Crown Resources Corp.-Sutton Resources Ltd.-Texas Star Resources Corp. joint venture completed a 23-hole delineation drilling program at the South Penn property, which was reported to have open pit potential. The joint venture also completed more than 2,700 feet of drilling at the Seattle-Flag Hill gold property. The Crown Resources-Gold Texas Resources Ltd. joint venture conducted geologic mapping, geochemical surveys, and reconnaissance drilling at the Queen Elizabeth property, searching for an epithermal quartz vein.

Asarco completed geologic mapping, soil geochemistry, an induced-polarization (IP) survey, and 1,500 feet of core drilling at the Curlew project. U.S. Borax & Chemical Corp. drilled on the adjoining Wheaton Ranch property. N.A. Degerstrom Inc., in joint venture with Inland Gold and Silver Corp. and Pegasus Gold Corp., continued exploration on the Leland property, west of the developing Overlook Mine of Echo Bay Mines Ltd.

U.S. Borax did more than 2,000 feet of core drilling at the Lone Star copper-gold property straddling the international boundary between Washington and Canada, and optioned the Empire Creek property north of Republic from Kettle River Resources Ltd. Cyprus Minerals Co. drilled in the Lone Star Creek area east of Danville, and Newmont Exploration Ltd. explored for precious metals and located a claim block on the South Fork of O'Brien Creek. Other companies that explored for gold in Ferry County included Antilles Resources Ltd. and Boise Cascade Corp.

Exploration increased in Okanogan County as the companies seeking precious metals moved west from Ferry County into areas with similar geology. The Crown Resources-Gold Texas Resources joint venture discovered significant mineralization at Buckhorn Mountain in the Meyers Creek District. The companies drilled 13 holes in a gold-bearing skarn and reported promising mineralization in 4 of the 5 areas tested. The joint venture also drilled at the Ida

Mine and did geological and geophysical exploration for gold in the Toroda Creek graben. The Westmont Mining Inc.-Crown Resources joint venture conducted geologic mapping, soil and rock sampling, and drilling to 3,000 feet at the Bodie Mine in the Toroda Creek graben.

Several companies explored for precious metals west of the Okanogan River. The Newhawk Gold Mines Ltd.-Reliant Resources Ltd.-Nord Resources Corp. joint venture explored the Smith Canyon property; ECM Inc. explored at the Alder gold-silver-copper mine near Twisp; and Quintana Minerals Corp. continued to explore at the American Flag property near Mazama. Say Energy Inc. and OWC Inc., holders of large claim blocks in the southwestern part of Okanogan County, explored those claims for gold, silver, and copper. L.F. Baum and Assoc. continued to explore at the Turtle Lake property for sedimentary rock-hosted deposits containing precious metals and copper.

In Stevens County, the Boise Cascade Corp.-Pathfinder Gold Co. joint venture continued to drill for gold and silver at the First Thought Mine and to explore on the McNally-Freedom claims. Boise Cascade also continued to explore at the Fifteenmile Creek gold-bearing massive sulfide property and explored for metals in other corporate lands in the county.

Vanhorn and Watson Mining Co. explored at the Copper Penny and Gold Nugget properties; Chewelah Eagle Mining Co. continued to explore for base metals and silver on claims near Chewelah Mountain; and Leadpoint Consolidated Metals explored at its lead-silver properties in the Northport District.

In Chelan County, Montana de Oro Inc. removed overburden, opened old mine adits, and drove 300 feet of new drifts at its gold property in the Blewett District. Raven Hill Mining Co. conducted geological exploration and sampling on lode and placer deposits in the Chiwaukum graben, and Welcome Nugget Mines explored placer claims on the upper Wenatchee and Little Wenatchee Rivers.

In King County, Weyerhaeuser Co. completed a third season of drilling and mapping at the White River property, seeking gold and copper. Cannon Minerals explored for gold-bearing vein deposits near North Bend and for precious metals at its White River property.

Elsewhere in the State, Raven Hill Mining Co. explored for base and precious metals at the Peacock claims in Pend Oreille County.

LEGISLATION AND GOVERNMENT PROGRAMS

The Federal Office of Surface Mining (OSM) continued with a program to locate and close abandoned underground coal-mine openings and subsidence areas in heavily populated parts of King County. A seismic survey, followed by core drilling and geologic map preparation, was done in 1988 in the Coal Creek area near Bellevue. This work enabled OSM to determine areas where openings occurred or where subsidence might occur. About 35 old coal-mine openings had been plugged in King County's Cougar Mountain Park alone; an additional 21 openings in the park and elsewhere in the county were closed during the year.

The Confederated Tribes of the Colville Indian Reservation continued its program to assess the potential for economic mineral deposits on tribal lands. Activities consisted of reconnaissance examination of selected areas and detailed examinations of several prospects, including mapping, contract mine work, and diamond drilling.

Total revenue from prospecting, mining, and quarrying on State lands was $399,695 for the fiscal year ending June 30, 1988. This figure included payments on approximately 300 mineral leases and contracts. Revenue from prospecting increased, while revenue from sand and gravel operations decreased approximately 16% from that of 1987.

The Mining and Mineral Resources Institute of the University of Washington, Seattle, received an allotment of $138,000 from the U.S. Bureau of Mines in 1988. The institute had received a total of $1,512,185 since inception of the Mineral Institute program in 1978.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Calcium Chloride.—Tahoma Chemical Co. Inc. in Steilacoom produced natural calcium chloride. Occidental Chemical Corp. in Tacoma manufactured synthetic calcium chloride using hydrochloric acid and limestone barged in from British Columbia, Canada.

Cement.—The State's portland cement production dropped substantially, by about 24% in both quantity and value from that of 1987. This drop occurred despite an expanding economy in the populous Puget Sound region of northwestern Washington, with consequent prosperity in the public and private construction sectors. A significant increase in the use of lower cost imported cement, and the yearlong use of one plant to process imported clinker, were largely responsible for the decrease. About 85% of the cement used in Washington in 1988 was imported. Portland cement was produced by Ideal Basic Industries Inc. in King County, by Lehigh Portland Cement Co. in Pend Oreille County, and by Tilbury Cement Co. in Whatcom County.

Tilbury Cement, of Delta, British Columbia, Canada, ground clinker imported from Canada at its plant in Bellingham. Puget Sound cement-producing operations used limestone barged in from British Columbia; Lehigh processed limestone mined in-State.

In late 1988, Lafarge Corp., a prominent French cement manufacturer, agreed to purchase Lehigh's Metaline Falls operations for approximately $12 million. The acquisition included terminals in Pasco and Spokane, WA, and Missoula, MT. Lafarge also began work on a 6,000-ton cement terminal in Seattle. It received cement by barge from Lafarge's plant in Richmond, British Columbia.

Lone Star Industries and Onoda Cement Co. of Japan formed a $120 million joint venture to produce and sell concrete in the Pacific Northwest. Lone Star properties included five cement terminals in Washington and rock quarries throughout the northwest.

In midyear, Ciment Quebec Inc. of Quebec, Canada, proposed construction of an $85 million cement plant to be sited north of Ellisforde, Okanogan County. The proposed plant would use limestone mined on White Rock Mountain and a 5.5-mile conveyor belt would be used to transport the product to the plant. Between 200 and 250 jobs would be created in an area with 18% unemployment.

The bulk of Washington's cement production was general-use, moderate-heat Types I and II gray portland cement, with lesser amounts of high-early-strength Type II and high-sulfate-resistant Type V; oil well and pozzolanic cements also were produced. Portland cement was used by ready-mixed concrete companies (80%), other contractors (7%), concrete products manufacturers (5%), building material dealers (4%), miscellaneous customers, highway contractors, and government agencies (4%).

Individual cement plants used a mix of natural gas, fuel oil, and bituminous and anthracite coal for fuel; electricity was also purchased for energy. Raw materials consumed were anhydrite, cement rock, clay, fly ash, gypsum, iron ore, limestone, pyrite, quartz, sand, and slag.

Clays.—Clay production in 1988 decreased slightly in quantity and by about 5% in value from that of 1987. Clay was produced by 6 companies from 10 deposits in 5 counties. Nearly 82% of the State's production came from Clallam and King Counties; fire clay was produced from two pits in King County. The bulk of total production was used for common brick, face brick, or in portland cement; the remainder was consumed in flue linings, structural tile, and fire brick manufacture.

Basic Resources Corp. conducted geologic mapping, sampling, and drilling at its Rock Top nonswelling bentonite property in Grant County. The clay was reportedly suitable for absorbents, drilling muds, and filters.

Diatomite.—Washington's diatomite production increased by about 4% in quantity but only slightly in value over that of 1987. The Inorganic Specialties Div. of Witco Chemical Corp., the State's sole producer, mined diatomite from two pits and processed the material at its plant in Quincy, Grant County. Witco applied for permits to develop a new diatomite surface mine in the Frenchman Hills to replace a pit that was depleted and closed by yearend.

Gypsum.—The level of crude gypsum production in the State was only half that of 1987, and value dropped nearly 66%. Crude gypsum was mined by Agro Minerals Inc. from the only gypsum mine in Washington near Tonasket, Okanogan County. Agro Minerals has mined gypsite from small saline lake bottoms since 1948; the dried and sized product is used as a soil conditioner. Calcined gypsum was produced by James Hardie Gypsum in Seattle and by Domtar Gypsum America Inc. at Tacoma.

Lime.—Lime production increased about 4% in quantity and by nearly 3% in value from that of 1987. Quicklime was produced by Northwest Alloys at Addy, Stevens County, while Continental Lime Inc. produced quicklime and hydrated lime at its Tacoma plant.

Olivine.—Washington ranked second in the Nation for olivine production, which increased slightly in both quantity and value over that of 1987. Applied Industrial Minerals Corp. (AIMCOR) milled stockpiled ore. The company closed its Twin Sisters Mine in Skagit County and reclaimed the property. In August, AIMCOR reached an agreement with Olivine Corp., the only other State producer, to purchase raw material from the Olivine Corp. mine for processing at the AIMCOR plant.

Olivine Corp. mined and milled olivine from the Swen Larsen quarry in Whatcom County. The company pioneered development of a waste incinerator using olivine for modular liner slabs.

Peat.—The quantity of Washington's peat production decreased by about 29% and value dropped nearly 26% from that of 1987. Three companies reported production of sold-in-bulk peat.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1987. Data for odd-numbered years are based on annual company estimates.

The State's 1988 construction sand and gravel production increased about 23% in tonnage and nearly 20% in value from that estimated for 1987. Continued prosperity in the private sector construction industry, and the construction of several large-scale Puget Sound region governmental projects kept construction sand and gravel production at a high level. Of 39 counties, 31 reported production. Clark, King, Pierce, and Snohomish were major producing counties. Major uses were for concrete aggregate (24%), asphaltic concrete aggregates (24%), fill (21%), and road base and coverings (15%). About 39% of the State's construction

sand and gravel was transported by truck, and 12% was moved by waterways. The remaining percentage was transported by railroad or by other means or was processed into end-use products on-site.

Washington construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 3 presents end-use data for the State's three districts.

Industrial.—Industrial sand and gravel production rose by 3% in tonnage but only slightly in value from that of 1987. Production was reported from two operations in King and Stevens Counties; primary uses were for glass containers (34%), flat-glass manufacture (15%), cement manufacture (12%), fiberglass (10%), and sandblasting (10%).

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; this chapter contains estimates for 1986 and 1988 and actual data for 1987. Data for

TABLE 2

WASHINGTON: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	7,354	$27,159	$3.69
Plaster and gunite sands	140	617	4.41
Concrete products (blocks, bricks, pipe, decorative, etc.)	W	W	4.01
Asphaltic concrete aggregates and other bituminous mixtures	2,598	9,894	3.81
Road base and coverings[1]	4,813	17,090	3.55
Fill	6,679	13,904	2.08
Snow and ice control	183	494	2.70
Railroad ballast	71	224	3.15
Other	493	1,704	3.46
Unspecified:[2]			
Actual	4,755	13,250	2.79
Estimated	4,085	10,067	2.46
Total[3] or average	**31,170**	**94,402**	**3.03**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes road and other stabilization (cement and lime).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to total shown because of independent rounding.

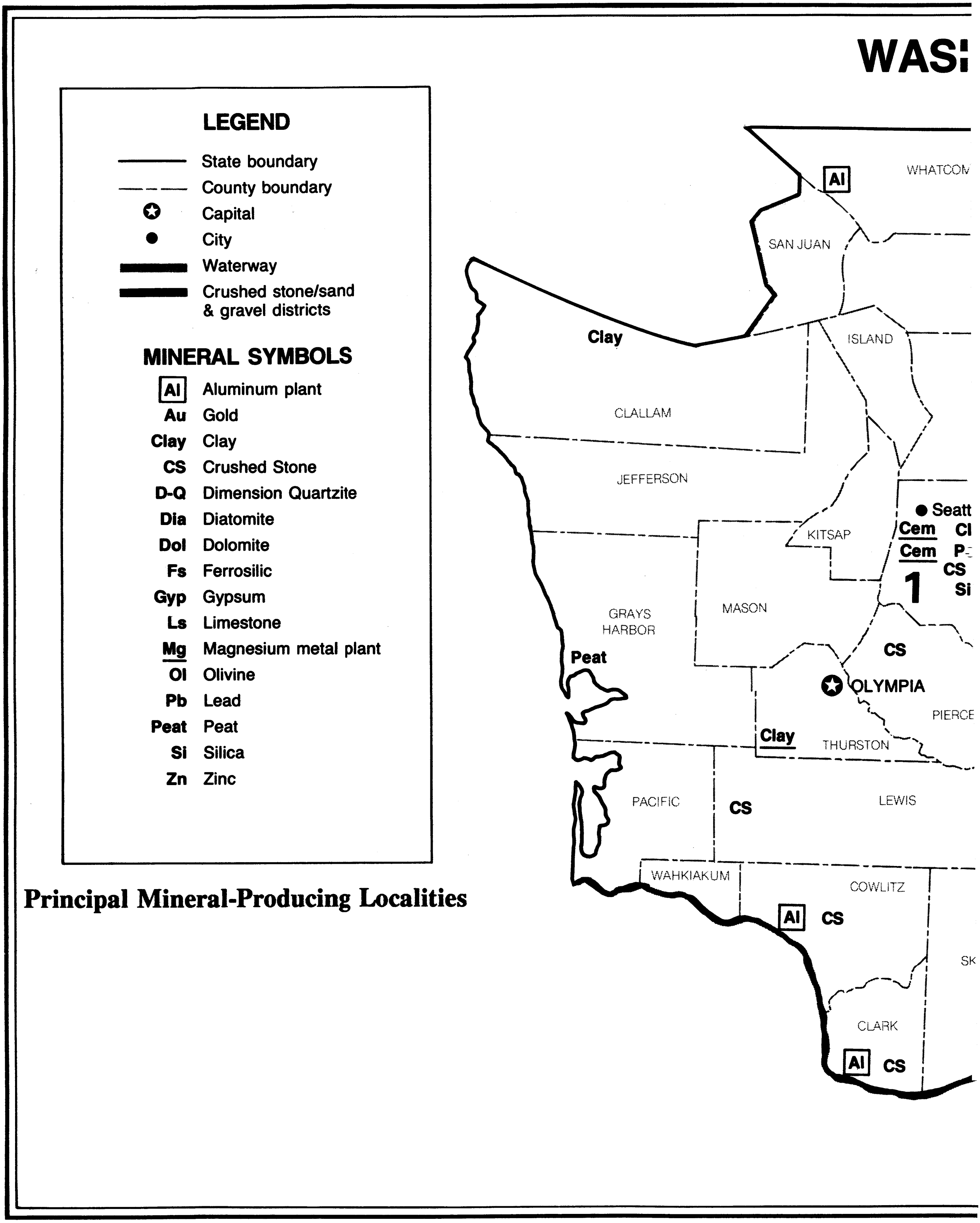
TABLE 3

WASHINGTON: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

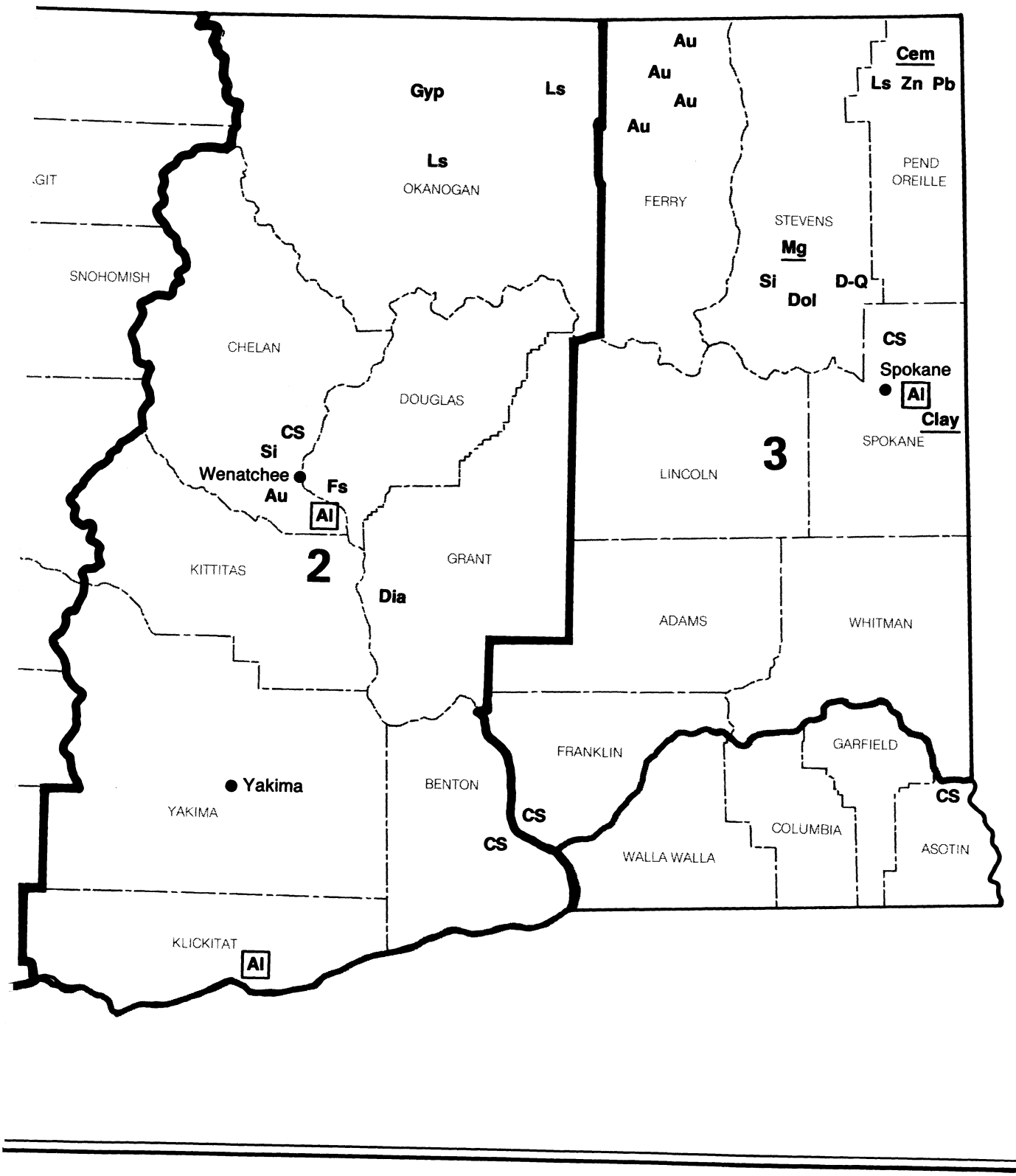
Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	5,998	21,960	650	2,082	706	3,116
Plaster and gunite sands	W	W	5	18	W	W
Concrete products (blocks, bricks, etc.)	W	W	W	W	W	W
Asphaltic concrete aggregates and other bituminous mixtures	1,511	6,372	522	1,671	565	1,851
Road base and coverings[1]	2,996	11,754	961	2,639	856	2,698
Fill	6,530	13,378	95	289	54	238
Snow and ice control	31	66	61	185	91	243
Railroad ballast	W	W	W	W	—	—
Other miscellaneous	322	1,196	74	208	303	1,122
Other unspecified[2]	7,439	18,773	447	1,438	954	3,106
Total	**24,827**	**73,499**	**[3]2,814**	**8,530**	**3,529**	**12,374**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (cement and lime).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data do not add to total shown because of independent rounding.



Principal Mineral-Producing Localities

GTON


Gyp
Ls
Ls
OKANOGAN
Au
Au
Au
Au
FERRY
Cem
Ls Zn Pb
PEND
OREILLE
STEVENS
Mg
Si
D-Q
Dol
GIT
SNOHOMISH
CHELAN
DOUGLAS
CS
Si
Wenatchee
Au
Fs
Al
2
KITTITAS
GRANT
Dia
LINCOLN
3
CS
Spokane
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Clay
SPOKANE
ADAMS
WHITMAN
FRANKLIN
GARFIELD
Yakima
YAKIMA
BENTON
CS
CS
COLUMBIA
WALLA WALLA
CS
ASOTIN
KLICKITAT
Al

even-numbered years are based on annual company estimates made before yearend.

Crushed stone production in Washington remained at a high level in 1988, although the quantity and value estimated for the year were down slightly from those of 1987.

Columbia River Carbonates operated its quarry at Wauconda, Okanogan County, and produced ground white calcium carbonate at the Woodland plant, Clark County.

Northwest Alloys quarried magnesian dolomite near Addy, Stevens County, for use in its magnesium production plant. Nanone Aggregates Inc. produced dolomite for terrazzo chips, decorative stone, and fillers from several Stevens County quarries. Northport Limestone Co. mined limestone from its Stevens County quarry.

Pacific Calcium Inc. operated its Tonasket quarry in Okanogan County; the limestone was crushed and marketed for poultry grit and for agricultural uses.

Sulfur (Recovered).—The State's sulfur production, recovered as byproduct from petroleum refining in the Puget Sound area, increased by about 12% in tonnage and by nearly 15% in value over that of 1987. Sulfur production was reported by Shell Oil Co. and Texaco Inc. from their Skagit County refineries, and by Atlantic Richfield Co. and BP Oil Co. from refinery operations at Cherry Point and Ferndale in Whatcom County.

Metals

Aluminum.—Aluminum production in Washington increased by nearly 23% in volume and by almost 87% in value over that of 1987. The State again ranked first nationally and was credited with slightly more than 29% of the total domestic aluminum output. The worldwide industry revival that began in 1987 continued throughout 1988. Prices for the metal, about 88 cents per pound in January, rose to approximately $1.29 per pound in June and retreated slightly to about $1.11 per pound by yearend. The average aluminum price for 1988 was $1.12 per pound, up about 53% from that of 1987. The State's seven aluminum smelters, which operated at about 90% of total annual rated ingot capacity in January, finished the year producing at nearly 97% of a total rated capacity of 1,328,000 short tons of aluminum ingot.

Columbia Aluminum Corp. accelerated production at its reduction plant near Goldendale, Klikitat County. It operated as a tolling facility, smelting imported alumina for Norsk Hydro A/S of Norway. The company began 1988 operating the 185,000-ton-per-year smelter at 66% of capacity; in midyear, production increased to 92% of capacity.

Kaiser Aluminum & Chemical Corp. began the year operating its Mead smelter, Spokane County, at about 88% of the 220,000-ton-per-year rated capacity. In April, Kaiser restarted all idle reduction pots, bringing the plant back to full capacity for the first time in 6 years. The smelter last operated all eight of its potlines in January 1982. Escalated prices for energy and depressed metal prices had rolled production back to as few as two potlines in operation, and shutdown of the 1942-vintage facility was contemplated. In October, MAXXAM Group Inc. announced the $708 million purchase of Kaiser Tech Ltd., parent company of Kaiser Aluminum & Chemical Corp.

Vanalco Inc. restarted a potline at the Vancouver smelter, Clark County, bringing production up to 76% of the 121,000-ton-per-year rated capacity. The 50 people hired for the restart brought total employment up to 540, compared with 550 to 600 employees before Aluminum Co. of America (Alcoa) sold the plant in mid-1987.

Arsenic.—Asarco shipped byproduct arsenic trioxide from stock at its terminated Tacoma copper smelter. The quantity of the shipments decreased about 33%, but value increased by nearly 72% over that of 1987. The smelter, permanently closed in 1985, had been the sole domestic processor of high-arsenic copper concentrate.

Gold and Silver.—Washington's gold production, reported from three lode mines in Chelan and Ferry Counties, increased by 9% in quantity and by nearly 7% in value from that of 1987. The State ranked sixth in the Nation in gold production for 1988. Silver, as a byproduct from gold production, was reported from three lode mines; production increased by about 14% in quantity and by nearly 7% in value over that of 1987.

The Asamera Minerals (U.S.) Inc.-Breakwater Resources Ltd. joint ventured Cannon Mine at Wenatchee, Chelan County, again ranked first in gold production in the State, and ranked 12th nationally in 1988. The operation was the second largest underground gold mine in the United States. According to Asamera's annual report, the 1,500-ton-per-day mine produced 151,634 troy ounces of gold and 263,029 troy ounces of silver from 523,764 tons of ore. Average mill-head grade was 0.303 ounce of gold and 0.564 ounce of silver per ton; mill recovery rate averaged 91.79% for gold and 81.88% for silver during the year. Operating costs, including mining, milling, geology, and direct administrative costs, averaged $148.43 per equivalent ounce of gold in 1988, compared with $149.21 in 1987.

More than 43,000 feet of exploration drilling within the Cannon Mine area in 1988 added a total of 351,000 tons of proven and probable reserves to the mine's ore reserve base. Surface and underground drilling at the D-Reef property southeast of the Cannon Mine identified approximately 1.9 million tons of possible open pit ore grading 0.093 ounce of gold per ton. Thirty surface diamond drill holes totaling 52,000 feet were drilled during 1988 in the Wenatchee Heights area, 2 to 3 miles southeast of the Cannon Mine. Explo-

ration in Wenatchee Heights over the past several years had identified three separate mineralized areas along a strike length greater than 12,000 feet.

Hecla's Republic Unit Mine (Knob Hill) at Republic, Ferry County, again was Washington's second-ranked gold producer. Hecla's 1988 annual report cited a record production of 80,301 ounces of gold and 354,073 ounces of silver from 79,210 tons of ore. Recovered ore grade was 1.01 ounces of gold per ton and 4.5 ounces of silver, compared with 0.97 ounce of gold per ton and 4.7 ounces of silver in 1987. Proven and probable ore reserves at the mine increased in 1988 despite high production levels. Reserves at yearend totaled 527,000 tons averaging 0.86 ounce of gold per ton and 4.0 ounces of silver. Additional mineralized material accessible from underground workings totaled 930,421 tons, averaging 0.25 ounce of gold and 1.01 ounces of silver per ton.

Echo Bay Mines Ltd. announced in November that its two Ferry County underground gold mines would begin production in early 1990. Reserves at the Kettle and Overlook properties were estimated at 3.9 million tons grading 0.189 ounce of gold per ton, with deposits not fully delineated. Gold production from the two mines was estimated at 110,000 ounces for the first 2 years, with annual production of 85,000 ounces thereafter at a cost of $200 per ounce. Ore from the mines would be processed at a conventional 1,500- to 2,000-ton-per-day vat cyanidation mill near the Overlook Mine. The $60 million project could employ up to 200 workers.

Steelhead Resources Ltd. continued to explore at the Great Excelsior gold mine near Glacier, Whatcom County. Analysis of geologic and assay data indicated a probable ore reserve of 4.1 million tons grading 0.042 ounce of gold and 2.60 ounces of silver per ton. Sampling done in 1988 examined possible extensions of mineralization to the west and north.

Heap-leach processing continued during part of the year at the Vulcan Mountain Inc. Gold Dike Mine in northern Ferry County.

Magnesium Metal.—Magnesium metal production increased by about 6% in quantity and by nearly 14% in value from that of 1987; the State again ranked second nationally in production of the metal. Northwest Alloys Inc., a wholly owned subsidiary of Alcoa, operated its magnesium metal plant at Addy, Stevens County, at capacity. Most of Northwest Alloys' production was used by parent company Alcoa as an alloying constituent in aluminum. However, some was shipped worldwide to other consumers, including producers that use magnesium to desulfurize steel. The Addy plant produced the metal from locally mined magnesian dolomite, employing a silicothermic process using in-plant manufactured ferrosilicon and aluminum-quartzite flux.

Northwest Alloys sold its process waste sludge to L-Bar Products Inc., which produced fertilizer from the sludge at its plant near Chewelah, Stevens County.

Silicon.—In early September, Silicon Metaltech Inc. completed purchase of the M.A. Hanna Co. silicon plant at Rock Island, Douglas County. The $16 million cost included the plant and quartzite mining operations in British Columbia, Canada. The 17,000-ton-per-year capacity plant produced ferrosilicon for the iron and steel industry and silicon metal for the aluminum industry. The Rock Island plant also produced silica fume, used as a strengthener in concrete products. Under existing labor contracts, all plant employees retained their jobs with the new company.

Union Carbide Corp. operated a polycrystalline silicon plant at Moses Lake, Grant County. The advanced testing and analysis that supported this plant was performed at the Union Carbide facility at Washougal. Production capacity for the Moses Lake plant was estimated at 2,200 tons of high-purity polycrystalline silicon.

Steel.—Washington's steel industry responded to a general increase in demand for the product in 1988. Seattle Steel Inc., the State's largest minimill, shipped 300,000 tons of steel during the year, up from 270,000 tons in 1987. Salmon Bay Steel Corp., the second largest producer, increased production to 220,000 tons, compared with a 150,000 ton output in 1986.

Titanium.—In April, International Titanium Inc. (ITI) sold the remaining equipment at its shuttered titanium sponge plant at Moses Lake, Grant County. The plant, closed since early 1987 owing to a declining titanium sponge market, was sold to China, and reportedly was moved to a site in Shenyang Province, North China. A team of ITI engineers was sent to China for a year to supervise erection of the equipment.

Zinc and Lead.—In late 1988, Resource Finance Corp. (RFC) of Toronto, Ontario, Canada, entered into an option purchase agreement to buy the shut-down Pend Oreille zinc-lead mine at Metaline Falls, Pend Oreille County. RFC was to pay Pintlar Corp., a wholly owned subsidiary of Gulf Resources & Chemical Corp., a total of $1,250,000 for the 13,000-acre property. The Pend Oreille Mine, closed in late 1973, was the largest zinc producer in Washington. RFC immediately began surface drilling to confirm a drill-indicated ore reserve of 3 million tons grading 9.8% zinc and 1.9% lead over an average thickness of 10.8 feet; the ore occurs in the flat-lying Yellowhead ore zone. RFC planned to immediately dewater 400 million gallons from existing mine workings, followed in 1989 by a reserve definition underground drilling effort.

[1] State Mineral Officer, Bureau of Mines, Spokane, WA.

[2] Geologist, Washington Division of Geology and Earth Resources, Spokane, WA.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Aluminum Co. of America	Box 221 Wenatchee, WA 98801	Plant	Chelan.
Columbia Aluminum Co.	Star Rte. 667, Box 46 Goldendale, WA 98620	do.	Klickitat.
Intalco Aluminum Corp	Box 937 Ferndale, WA 98248	do.	Whatcom.
Kaiser Aluminum and Chemical Corp.	Box 6217 Spokane, WA 99207	do.	Spokane.
Do.	3400 Taylor Way Tacoma, WA 98421	do.	Pierce.
Reynolds Metals Co.	Box 999 Longview, WA 98632	do.	Cowlitz.
Vanalco Inc.	Box 120 Vancouver, WA 98660	do.	Clark.
Cement:			
Ash Grove Cement West Inc.	5550 SW. Macadam Ave. Suite 300 Portland, OR 97201	do.	King.
Ideal Basic Industries Inc.	Box 8789 Denver, CO 80201	do.	Do.
Lehigh Portland Cement Co.	718 Hamilton Mall Box 1882 Allentown, PA 18105	do.	Pend Oreille.
Tilbury Cement Co.	Box 37, Marietta Rd. Bellingham, WA 98227	do.	Whatcom.
Clays:			
Ideal Basic Industries Inc.	Box 8789 Denver, CO 80201	Pit	Clallam.
Mutual Materials Co.	Box 2009 Bellevue, WA 98009	Pits and plant	King and Pierce.
Diatomite:			
Inorganic Specialties, a division of Witco Corp.	520 Madison Ave. New York, NY 10072	Mine and plant	Grant.
Gold:			
Asamera Minerals (U.S.) Inc.	2100, 144 4th Ave. SW. Calgary, AB T2P 3N4 Canada	Underground mine and mill.	Chelan.
Hecla Mining Co.[1]	6500 Mineral Dr. Box C-8000 Coeur d'Alene, ID 83814-1931	do.	Ferry.
Lime:			
Continental Lime Inc.	1220 Alexander Ave. Tacoma, WA 98421	Plant	Pierce.
Northwest Alloys Inc.	Box 115 Addy, WA 99101	Mine and plant	Stevens.
Magnesium:			
Northwest Alloys Inc.[2]	Box 138A, Rt. 1 Addy, WA 99101	do.	Do.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Olivine:			
AIMCOR	Box 58 Hamilton, WA 98225	Mine and plant	Skagit.
Peat:			
Chrystel Soils	Ocean City, WA 98569	Bog	Grays Harbor.
Maple Valley Humus	18805 SE. 170th St. Renton, WA 98055	do.	King.
Sand and gravel:			
Construction:			
Central Pre-Mix Concrete Co.	Box 3366 Spokane, WA 99220	Pits	Franklin.
Lone Star Northwest Aggregates	6320 Grandview Dr. W. Tacoma, WA 98467	Pit	Piece.
North Dakota Cement Co.	580 Pear Point Rd. Friday Harbor, WA 98250	do.	San Juan.
Industrial:			
Lane Mountain Silica Co.	Box 236 Valley, WA 99181	Quarry and plant	Stevens.
L-Bar Products Inc.	Box 95 Ravensdale, WA 98051	do.	King.
Stone:			
Dimension:			
Island Frontier Landscape Construction Co.	435 Gibraltar Rd. Anacortes, WA 98211	do.	Skagit.
Mt. Adams Flagstone Co.	4594 Woodworth Rd. Hood River, OR 97041	Quarry	Yakima.

[1] Also silver.
[2] Also industrial sand and stone.

THE MINERAL INDUSTRY OF WEST VIRGINIA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the West Virginia Geological and Economic Survey, for collecting information on all nonfuel minerals.

By L. J. Prosser, Jr.,[1] and Hobart M. King[2]

In 1988, the value of nonfuel mineral production in West Virginia decreased slightly from the previ- year to about $127 million. Output levels of most nonfuel mineral commodities remained about the same as in 1987.

Coal production of about 145 million short tons was at its highest level since 1968. The coal industry remained the most important mineral industry in the State's economy; West Virginia ranked third nationally in coal production in 1988.

The metals manufacturing industries also showed improvement, as indicated by expansions in plant capacity and openings of new operations.

EMPLOYMENT

Despite increased mineral production, employment in mining and mineral-related industries continued to decline in West Virginia. From 37,000 in 1986, coal mining employment has dropped to 30,000 in 1988; overall the mining industry lost 8,000 jobs in 2 years.[3] In 1988, the unemployment rate for West Virginia was 7.4%, about 2% higher than the U.S. rate.

LEGISLATION AND GOVERNMENT PROGRAMS

The West Virginia Geological and Economic Survey (WVG&ES) received a grant from the U.S. Geological Survey to study the effects of geological, environmental, technological, and cultural factors on the availability of coal for mining in the southern part of the State. In 1988, coalbeds in portions of Boone and Kanawha Counties (Sylvester quadrangle) were investigated. Original resources for coalbeds in this area were calculated to be about 1,242 million short tons. About 80 million tons have been mined. Land use, geologic, legal, and technological factors limiting the potential for mining coal disqualified about 67 million tons of the original resource in this area. Another 288 million tons of the coal was less than 28 inches in thickness and, because of economic and technological considerations, was not being mined. Of the original resource, about 807 million tons of coal was considered available for mining.

The WVG&ES published a mineral resources map of the State that identifies areas where coal, limestone, sandstone, oil and gas, and sand and gravel were produced. Also shown are areas with potential for underground limestone mine development, areas underlain by salt deposits in excess of 50 feet in thickness, and areas of sand and gravel deposits along the Ohio River.[4]

West Virginia University completed a study detailing the feasibility of using coal fly ash as a component in manufacturing a lightweight building product. The product, termed autoclaved cellular concrete or ACC, has found wide acceptance in Europe, but has not been produced in the United States. Fly ash is a waste product generated at electric utility plants at a rate of about 1 ton for each 12 tons of coal burned.[5]

West Virginia University also was selected as a National Mined Land Reclamation Center as part of a $1.94 million program sponsored by the U.S. Bureau of Mines and the State. The center's research activities were to focus initially on reclamation of abandoned mines and subsequently on active mines.

The U.S. Bureau of Mines conducted research projects in West Virginia on acid mine drainage, controlled burnout of coal waste banks, coal mine bumps, and subsidence prediction techniques. These projects were aimed at achieving a balance in development of natural resources with protection of the environment. Results of these and other

TABLE 1

NONFUEL MINERAL PRODUCTION IN WEST VIRGINIA[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	214,980	$470	266,037	$565	263,973	$586
Gem stones		NA	1	NA	1	NA	1
Sand and gravel (construction)	thousand short tons	1,501	5,365	e1,000	e3,200	1,653	6,099
Stone (crushed)	do.	e9,800	e37,500	12,458	50,947	e11,600	e47,600
Combined value of cement, lime (1987–88), peat (1987–88), salt, and sand and gravel (industrial)		XX	86,473	XX	89,308	XX	73,169
Total		**XX**	**129,809**	**XX**	**144,021**	**XX**	**127,455**

e Estimated. NA Not available. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Bureau activities were summarized in "U.S. Bureau of Mines Research 88."[6]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Portland cement was the second leading nonfuel mineral commodity produced in West Virginia in terms of value. Capitol Cement Corp. in Martinsburg manufactured portland and masonry cement. Output of these products increased by 6% and 12%, respectively. Capitol Cement, the State's only cement producer, also produced shale and limestone for use in the cement manufacturing process.

Clays.—Continental Brick Co. near Martinsburg operated the State's only brick plant, with an annual capacity of about 65 million brick. The company's primary market area, Washington, DC, is about 75 miles from the plant. Capitol Cement mined shale and clay used in cement manufacture, and Sanders Dummy Co. mined these materials as stemming for explosives.

Lime.—Germany Valley Limestone Co. near Riverton in Pendleton County was West Virginia's only lime producer. The lime was sold for acid mine water neutralization, paper pulp processing, water purification, and sewage treatment.

Salt.—The State's salt industry employed about 1,000 workers at two sites in Marshall County. The salt was used to manufacture chlorine and caustic soda and was marketed to the plastic, pulp and paper, metal fabricating, petroleum refining, and rubber reclaiming industries.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1986 and 1988 and estimates for 1987.

In 1988, six companies operating six pits reported production of 1.7 million short tons of sand and gravel. Most of the output was dredged from the Ohio River. Crushed sandstone quarried east of Elkins was used as a substitute for sand and gravel because of a lack of sand and gravel in that part of the State.

Industrial.—U.S. Silica Co. in Morgan County produced industrial sand. Production data was withheld to avoid disclosing company proprietary data. The primary end use of the sand was in glass manufacture.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Demand by the construction industry from West Virginia and adjacent States resulted in output of an estimated 11.6 million short tons of crushed stone. Although production declined from 1987 levels, the 1988 total was the third highest reported in the last 15 years. Crushed stone accounted for about one-third of the State's total value of nonfuel mineral production.

Metals

Metals discussed in this section were processed from materials received from both foreign and domestic sources; no metals were mined in West Virginia in 1988. Production and value data for these metals, which are not included in table 1, are given if available.

Aluminum.—Late in the year, Kaiser Aluminum & Chemical Corp. announced an agreement to sell its primary aluminum smelter and rolling mill in Ravenswood to Stanwich Partners Inc. The facilities included a 120,000-short-ton-per-year smelter and a 200,000-ton-per-year rolling mill that

TABLE 2

WEST VIRGINIA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	565	$2,147	$3.80
Plaster and gunite sands	46	184	4.00
Concrete products (blocks, bricks, pipe, decorative, etc.)	22	66	3.00
Asphaltic concrete aggregates and other bituminous mixtures	W	W	3.93
Road base and coverings	7	34	4.86
Fill	22	56	2.55
Other	152	602	3.96
Unspecified:[1]			
Actual	819	2,951	3.60
Estimated	20	60	3.00
Total or average	**1,653**	**[2]6,099**	**3.69**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[2] Data do not add to total shown because of independent rounding.

employed about 2,200 workers. In September, because of increased demand and higher prices for aluminum, the company restarted one-half of the capacity of a potline that had been idle since 1981.

Potential Federal legislation to reduce sulfur dioxide emissions could impact the aluminum smelting industry and thus increase the cost of production at Ravenswood, according to a study by the U.S. Bureau of Mines. Smelters in West Virginia and Ohio were expected to experience the highest cost increases, ranging from $.052 to $.077 per pound.[7]

Ferroalloys.—American Alloys Inc. purchased and reopened a ferroalloy plant in Graham previously owned by Foote Mineral Co. Foote had closed that operation in December 1985 because of a decline in demand from the steel industry, combined with a marked increase in foreign imports. The operation was restarted by means of a buyout financing package of $23 million that included a $5 million loan from the State and implementation of an employee stock ownership plan. The plant had an annual capacity of about 65,000 short tons and produced ferrosilicon and miscellaneous silicon alloys.

Iron and Steel.—Three firms produced steel in West Virginia: Weirton Steel Corp. and Wheeling-Pittsburgh Steel Corp., which are both integrated producers, and Steel of West Virginia Inc., a minimill. West Virginia iron and steel production accounted for about 5% of the U.S. output in 1988.

In December, Weirton Steel announced plans for a $115 million modernization program designed to permit the firm to continuously cast 100% of the steel it manufactures. In 1988, about 60% of the steel produced by Weirton was continuously cast, the same as the national average. Weirton shipped 2.7 million tons of steel for sales of $1.4 billion, resulting in a net income of $168 million in 1988, the firm's fifth consecutive profitable year.[8]

In April, Wheeling-Nisshin Inc. began operation of a steel galvanizing plant in Follansbee. The plant, a joint venture between Wheeling-Pittsburgh Steel Corp. and the Japanese steelmaker Nisshin Steel Ltd., had an annual capacity of 250,000 tons.

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[1] State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA.

[2] Economic geologist and head, Economic Minerals and Geologic Hazards Section, West Virginia Geological and Economic Survey, Morgantown, WV.

[3] West Virginia Department of Health and Human Resources, Employment Security Division. Annual Planning Information, Table 5-WV, Nonagricultural Wage and Salary Employment, By Industry. Dec. 1988, 18. pp.

[4] Mineral Resources of West Virginia. WV Geol. and Econ. Survey, Map WV24, compiled by Hobart M. King and D. S. Kirstein.

[5] Devore, P. W., and T. R. Mounkurai. Production of Autoclaved Cellular Concrete Building Products Utilizing Pulverized Fly Ash. WV Program for the Study of Technol. Morgantown, WV. June 1987, 201 pp.

[6] U.S. Bureau of Mines. A Summary of Significant Results in Mineral Technology and Economics. Bu Mines Research 88, 1989, 125 pp.

[7] ———. The Potential Impact of Acid Rain Legislation on the Domestic Aluminum Smelting Industry. BuMines OFR 58-88, 1988, 14 pp.

[8] Weirton Steel Corp. 1988 Annual Report, 24 pp.

WEST VIRGINIA

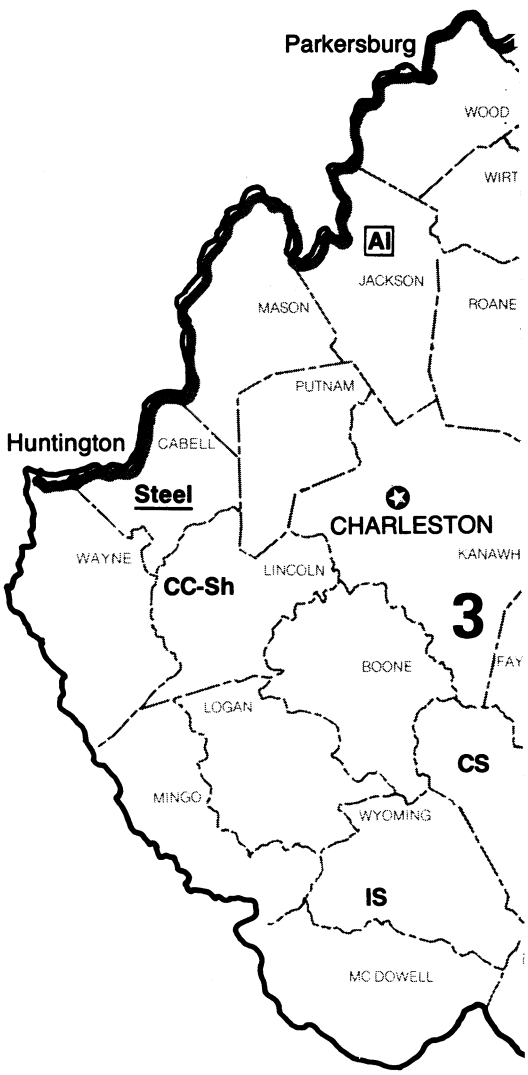
LEGEND

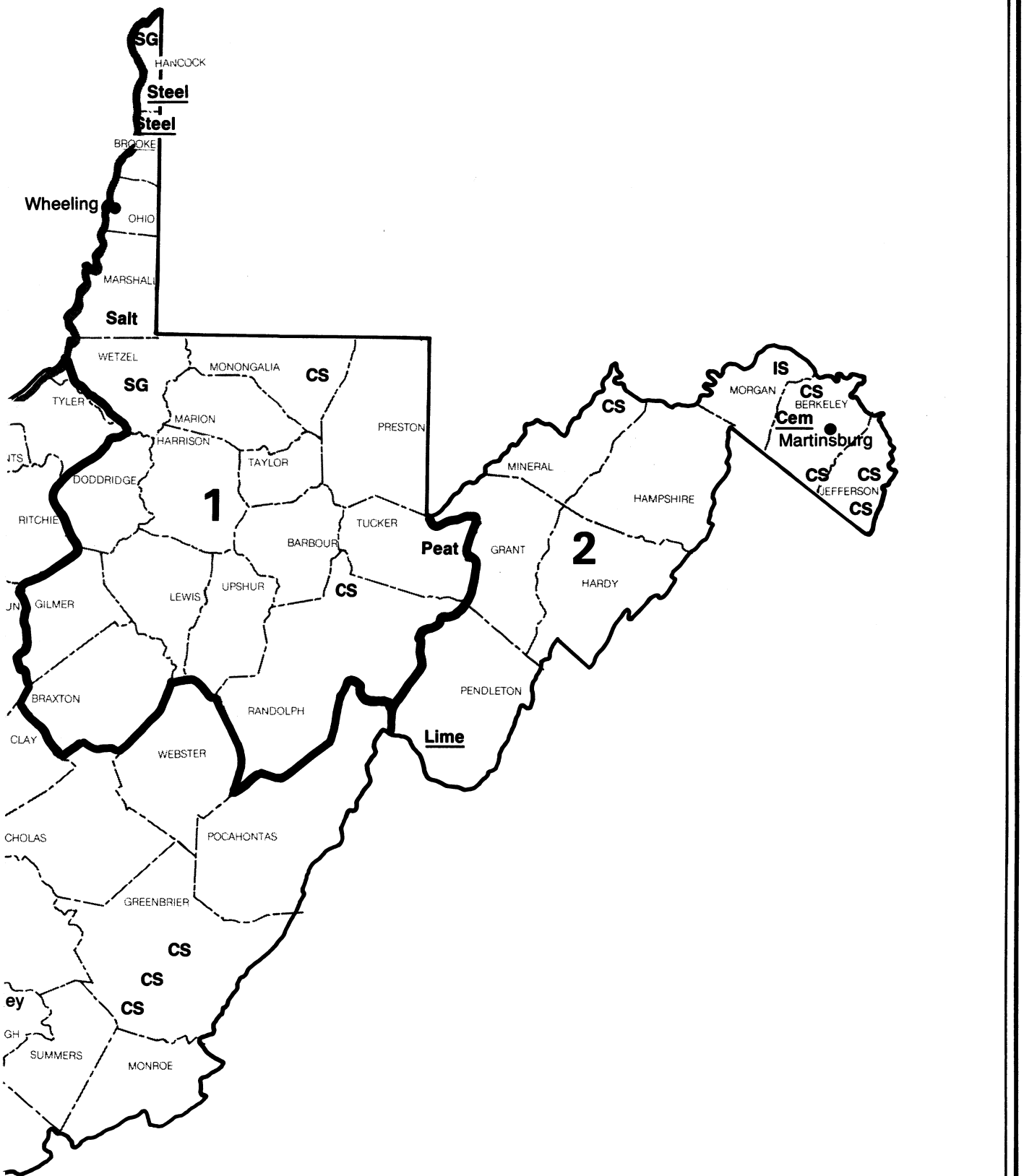
- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Al	Aluminum plant
CC-Sh	Common Clay & Shale
Cem	Cement plant
CS	Crushed Stone
IS	Industrial Sand
Lime	Lime plant
Peat	Peat
Salt	Salt
SG	Sand and Gravel
Steel	Iron and Steel plant

Principal Mineral-Producing Localities




SG
HANCOCK
Steel
Steel
BROOKE
Wheeling
OHIO
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Salt
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MONONGALIA
CS
TYLER
MARION
HARRISON
PRESTON
TAYLOR
DODDRIDGE
1
RITCHIE
TUCKER
BARBOUR
Peat
UPSHUR
CS
LEWIS
GILMER
BRAXTON
CLAY
WEBSTER
RANDOLPH
POCAHONTAS
GREENBRIER
CS
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SUMMERS
MONROE
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GRANT
2
HAMPSHIRE
HARDY
PENDLETON
Lime
IS
MORGAN
CS
BERKELEY
Cem
Martinsburg
CS
CS
JEFFERSON
CS

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Capitol Cement Corp.[1]	Box 885 Martinsburg, WV 25401	Quarry and plant	Berkeley.
Clays:			
Continental Brick Co.	Box 1111 Martinsburg, WV 25401	Pit and plant	Do.
Sanders Dummy Co.	Box 24 Midkiff, WV 25504	Pit	Lincoln.
Lime:			
Germany Valley Limestone Co.	Box 302 Riverton, WV 26814	Quarry and plant	Pendleton.
Salt:			
LCP Chemicals-West Virginia Inc.	Drawer J Moundsville, WV 26041	Brine wells and plant	Marshall.
PPG Industries Inc.	1 Gateway Center Pittsburgh, PA 15222	do.	Do.
Sand and gravel:			
Construction:			
Dravo Corp.	1 Oliver Plaza Pittsburgh, PA 15222	Dredge	Wetzel.
E.T.& S. Inc.	Rt. 1, Box 475-A Gallipolis, WV 25515	Pit and dredge	Mason.
Jesco Corp.	Rt. 2, Box 186-A Letart, WV 25253	Pit	Do.
Standard Aggregates Inc.	1200 Stambaugh Bldg. Youngstown, WV 44501	Plant	Hancock.
Industrial:			
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	Quarry and plant	Morgan.
Stone:			
J. F. Allen Co.	Box 49 Clarksburg, WV 26301	Quarry	Randolph.
Fairfax Sand & Crushed Stone Co.	Box 98 Thomas, WV 26292	Quarries	Grant, Mineral, Randolph, Tucker.
Greer Limestone Co., a division of Greer Steel Co.	Greer Bldg. Morgantown, WV 26505	Mine and quarries	Monongalia and Pendleton.
Millville Quarry Inc.	Box 166 Millville, WV 25432	Quarry	Jefferson.

[1] Also clays and crushed stone.

THE MINERAL INDUSTRY OF WISCONSIN

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Wisconsin Geological and Natural History Survey for collecting information on all nonfuel minerals.

By James J. Hill[1] and Thomas J. Evans[2]

Wisconsin's nonfuel mineral production was valued at $204.9 million in 1988, a gain of nearly 10% over the 1987 value. This was a record year in terms of value, with all commodities registering gains in production except stone used as deburring media. The sole operation producing this commodity was closed in June. In order of value, crushed stone, construction sand and gravel, and lime were the State's leading commodities. Each attained a record high value in 1988, and together they accounted for 89% of the State's total mineral value. Demand for sand and gravel and stone was stimulated by several factors. The number of building permits issued for public and private residential housing exceeded the high level reached in 1987, although high interest rates tempered demand. Outlays for nonresidential construction and State road contract awards increased 11% and 43%, respectively, over those of 1987. Lime sales increased because of demand from the revitalized steel industry. Mineral commodities processed in the State from outside sources included iron oxide pigments, perlite, and vermiculite. Sulfur was recovered as a petroleum refinery byproduct. No metallic minerals were mined in the State in 1988.

TRENDS AND DEVELOPMENTS

Kennecott Minerals Co., a subsidiary of BP America Inc., continued environmental baseline monitoring programs at its Flambeau copper deposit near Ladysmith, Rusk County, in an attempt to bring it into production. Several holes were drilled during 1988 to define ore body characteristics and hydrological conditions. Kennecott successfully sought rule changes from the Department of Natural Resources (DNR) to eliminate a redundant report required for the company's project under the State's mining laws in order to speed up the mine permitting process. The company planned to submit an Environmental Impact Report and mine permit application to the DNR in early 1989, after which a draft environmental impact statement would be issued for public comment. Agreements were also negotiated with the local units of government that had jurisdiction over the proposed mine site (Rusk County, Town of Grant, and City of Ladysmith). The agreement spelled out environmental and monetary guarantees from the company, provided for rezoning the site to an industrial classification, and resulted in a conditional use permit for 40 years.

EMPLOYMENT

Wisconsin's Department of Industry, Labor, and Human Relations reported the State's total civilian labor force as being 2.6 million in 1988, with the State having an average unemployment rate of 4.3%. Mining employment within the State averaged 2,015 persons, nearly 5% higher than in 1987. Mining wages averaged $26,851 annually, up about 5% over the 1987 average.

TABLE 1

NONFUEL MINERAL PRODUCTION IN WISCONSIN[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	$15	NA	$15	NA	$15
Lime	thousand short tons	350	19,715	393	21,733	452	23,986
Peat	do.	9	W	9	r237	11	270
Sand and gravel:							
Construction	do.	24,913	59,325	e23,900	e57,000	25,048	60,080
Industrial	do.	1,194	12,399	1,314	15,168	1,351	15,458
Stone:							
Crushed	do.	e18,700	e57,600	[2]22,757	[2]71,776	e[2]28,500	e[2]98,300
Dimension	short tons	e22,912	e2,878	36,903	3,697	e49,900	e6,200
Combined value of abrasives, cement (masonry 1986–87, portland 1986–87), stone (crushed traprock, 1987–88), and values indicated by symbol W		XX	12,600	XX	r16,846	XX	564
Total		**XX**	**164,532**	**XX**	**186,472**	**XX**	**204,873**

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain stones; kind and value included with "Combined value" data.

EXPLORATION ACTIVITIES

Five companies conducted drilling programs for metallic minerals in 1988, drilling 48 holes that totaled 23,577 feet. Of these, 19 holes were drilled by Kennecott to further evaluate its Flambeau copper deposit in Rusk County, which it was trying to bring into production. Excluding Kennecott's development drilling, most exploration activity centered on Taylor County with 12 holes drilled and Marathon County with 11 holes. Exploration drilling also was conducted in Iron, Lincoln, and Rusk Counties. Most of the State's exploration activity was focused on precious metals. About 7,100 acres were leased for metallic mineral exploration in 1988. The greatest leasehold interests were acquired in Rusk County (4,164 acres), followed by Marathon (1,554 acres), Taylor (950 acres), and Lincoln (470 acres) Counties.

A total of 11,160 acres of Federal lands was under prospecting permits in the Chequamegon National Forest and 760 acres in Nicolet National Forest. Three exploration holes were drilled on Federal lands during the year. No oil and gas leasing activity was reported in 1988. At yearend, more than 431,000 acres were still under lease. Amoco Production Company conducted seismic surveys in Bayfield County during the year.[3]

SHIPPING

Waterborne commerce at the Port of Duluth-Superior totaled 35.6 million metric tons in 1988. This tonnage was a 3% gain over that of 1987. Of this total, the American Iron Ore Association reported that 11.9 million gross tons of taconite pellets originating from the western Mesabi Range in Minnesota were shipped through Burlington Northern Railroad's docks in Superior. This amount was a 6% increase over the 11.2 million tons shipped in 1987. The Superior Midwest Energy Terminal transshipped 10.1 million short tons of Montana coal to electric generating plants on the Great Lakes, compared with 11.2 million tons shipped in 1987. The greatest portion of the coal (8.9 million tons) was shipped to Detroit Edison Co.'s generating facilities in St. Clair, MI. Nearly 1 million tons was shipped to Wisconsin Electric Power Co.'s Presque Isle facility in Michigan's Upper Peninsula.

The Port of Green Bay reported 1.7 million short tons of waterborne commerce in 1988, essentially the same as in 1987. Mineral commodities received at the port included cement, coal, limestone, and salt. Coal made up the largest tonnage coming into the port (938,000 tons), followed by cement (286,000 tons). Nearly 2.6 million short tons of cargo passed through the Port of Milwaukee in 1988, the best year in a decade. Port receipts of selected nonfuel mineral commodities are shown in table 2. Of the receipts, sand had the largest percentage increase (68%). Limestone receipts declined the most (52%).

TABLE 2

PORT OF MILWAUKEE: SELECTED NONFUEL MINERAL COMMODITY IMPORTS[1]

(Short tons)

Commodity	1987	1988
Cement	465,749	488,407
Limestone	20,827	9,982
Pig iron	54,052	44,487
Salt	399,620	591,180
Sand	32,798	55,017
Total	**973,046**	**1,189,073**

[1] Includes Canadian imports and domestic receipts.

Source: 1988 Annual Report, Port of Milwaukee, U.S.A.

LEGISLATION AND GOVERNMENT PROGRAMS

Wisconsin Act 399 of the 1988 Session Laws enabled Kennecott to proceed with development of its Flambeau deposit under favorable terms with local units of government and taxing authorities. The act provided for a one-time $100,000 payment to each county, city, town, village, and Native American community whose boundaries contain at least 15% of a minable metallic ore body on which construction has begun. The payments were to be made from the Mining Investment and Local Impact Fund, which, in turn, is supported by taxes paid by the company or person constructing a mine. The act also allowed for negotiated agreements between a mine operator and local governmental units concerning permits under zoning or land use ordinances. These negotiated agreements allow mining firms to respond to local concerns early in the mine development process and help build local support before State regulatory procedures come into play. Also during the year, two chapters of the Wisconsin Administrative Code that regulate metallic mineral mining and metallic mining wastes were revised by the DNR to allow Kennecott to backfill its proposed open pit mine. This type of action had not been covered in the earlier codes.

Three Wisconsin counties either developed or were in the process of developing mineral extraction ordinances during 1988. In July, the Marathon County Board of Supervisors approved a controversial sand and gravel pit reclamation ordinance, scheduled to become effective on January 1, 1989. After that date, all sand and gravel pit operators in the county were to be required to submit a mining reclamation plan when applying for a mining permit. Reclamation of extraction sites was to be carried out in accordance with specifications contained within

the ordinance. Operatorswere to pay a fee of 4 cents for each cubic yard of material mined to cover the costs of inspections and administration of the ordinance. In December, the county Board of Supervisors decided to delay implementing the ordinance because of numerous objections to its cost. Instead, the Board sent the ordinance back to the county zoning committee for amendments or deletions that were to be acted on in the first quarter of 1989.

In December, the Oneida County Board of Supervisors, through its Forestry and Outdoor Recreation Committee, completed development of a competitive leasing system, which had been under study since 1987, for metallic minerals on county-owned forest lands. The system allowed mining firms to bid for leases on a royalty-type basis with leases awarded to the highest bidder. The county's first lease sale was expected to be held in May 1989. In conjunction with the mineral leasing program, the county board adopted an ordinance that provided for reclamation of nonmetallic mining operations and instituted a permit process for their regulation.

St. Croix County held a public hearing in June on a proposed ordinance to regulate nonmetallic mining operations after several persons living near gravel pits and quarries expressed their frustration concerning the lack of control over truck traffic, blasting, and working hours. The proposed ordinance would have required extraction permits, operation and reclamation plans, buffer zones, and bonding for reclamation purposes and would have limited extraction sites to 20 acres at any one time. No action was taken on the ordinance proposal by yearend.

The Wisconsin Geological and Natural History Survey continued its extensive programs in ground water research, bedrock and surficial mapping, and soil attenuation studies. Ground water quality studies were completed for six counties during 1988. Pleistocene mapping was in progress or completed for eight counties. Other geologic research investigations of the Survey included the sedimentology and genesis of hummocky moraine topography, an update of Pleistocene stratigraphy, glacier-bed conditions in Wisconsin, and the origin and history of glacial Lake Wisconsin. The Survey was instrumental in setting up a competitive leasing program for Oneida County and aided the DNR in reviewing materials for Kennecott's proposed Flambeau copper mine.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Lime.—Wisconsin ranked 13th of 34 States in sales of lime after having ranked 14th in 1987. Four plants, operated by three companies in Brown, Dodge, Fond du Lac, and Manitowoc Counties, produced all of the State's lime. All the plants produced both hydrated lime and quicklime. Production and value reached alltime highs in 1988 —452,000 short tons valued at $24 million—exceeding 1987 figures by 15% and 10%, respectively. Average value per ton dropped for the second consecutive year, about 4% lower than the 1987 value of $55.30 per ton. High volume lime sales were attributed to the revitalization of the steel industry in nearby States. Lime consumption in Wisconsin totaled 115,000 short tons of quicklime and 50,000 tons of hydrated lime in 1988. This was 22,000 tons less of quicklime and 7,000 tons more of hydrated lime than in 1987.

Peat.—Peat sales increased approximately 22% in 1988, to nearly 11,000 short tons. Value of sales was nearly $270,000. Four companies, with operations in Kewaunee and Waukesha Counties, produced all of the State's peat. Four types of

TABLE 3

WISCONSIN: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	7,590	$20,961	$2.76
Plaster and gunite sands	136	556	4.09
Concrete products (blocks, bricks, pipe, decorative, etc.)	359	1,053	2.93
Asphaltic concrete aggregates and other bituminous mixtures	1,046	2,418	2.31
Road base and coverings[1]	5,963	13,265	2.22
Fill	2,414	3,998	1.66
Snow and ice control	223	555	2.49
Railroad ballast	W	W	3.00
Other	220	534	2.43
Unspecified:[2]			
Actual	1,591	3,785	2.38
Estimated	5,504	12,956	2.35
Total[3] or average	**25,048**	**60,080**	**2.40**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes road and other stabilization (cement and lime).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

WISCONSIN

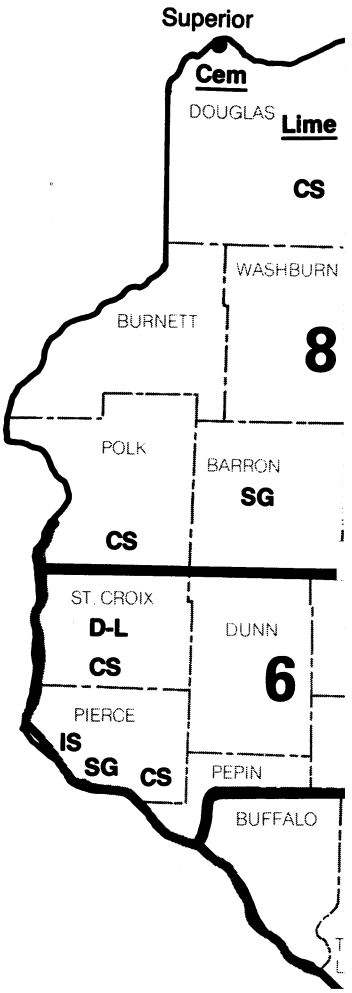
LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Abr	Abrasives
Cem	Cement plant
CS	Crushed Stone
D-G	Dimension Granite
D-L	Dimension Limestone
IS	Industrial Sand
Lime	Lime plant
Peat	Peat
SG	Sand and Gravel

Principal Mineral-Producing Localities



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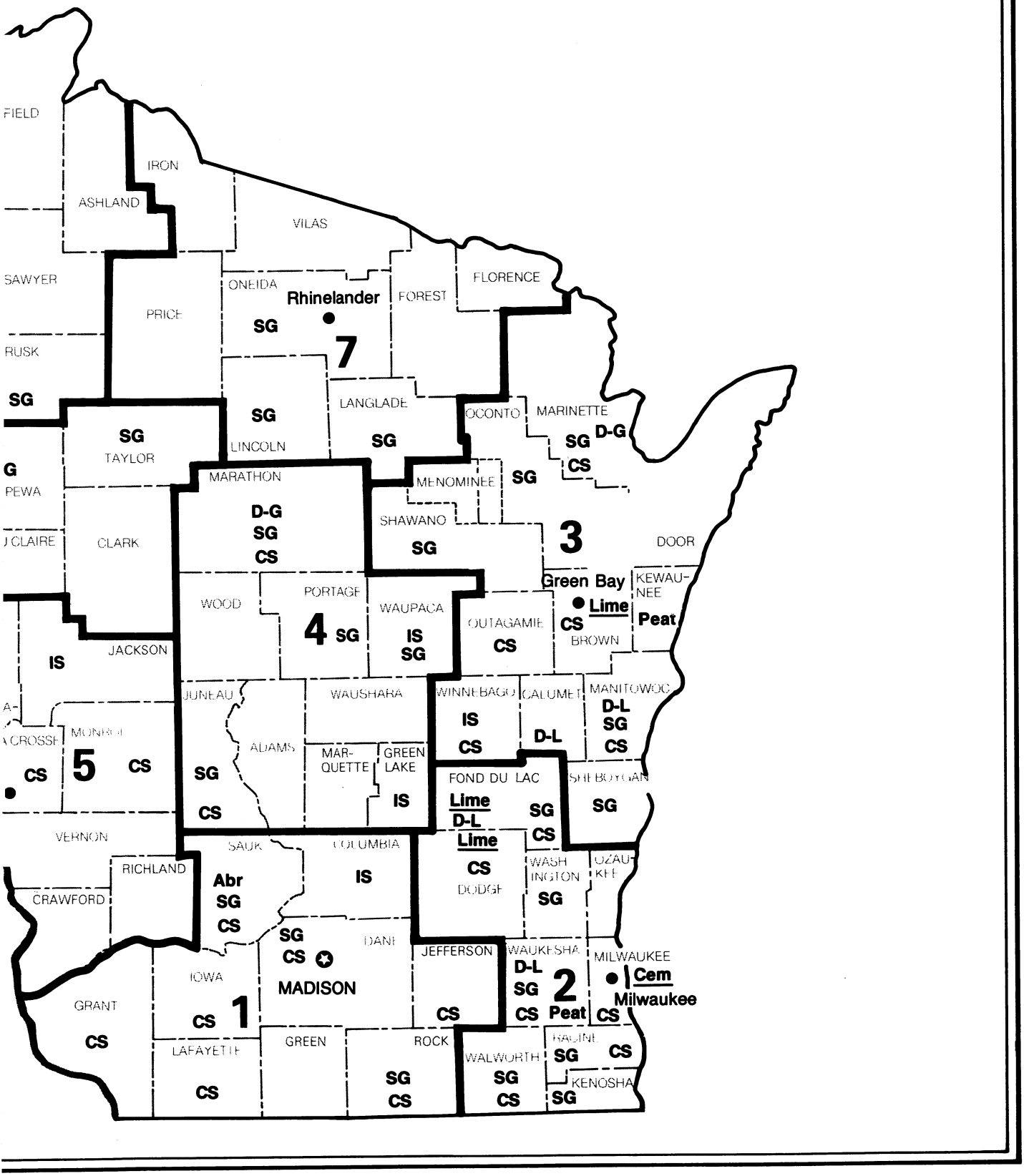
FIELD
IRON
ASHLAND
VILAS
SAWYER
ONEIDA
Rhinelander
FOREST
FLORENCE
PRICE
SG
7
RUSK
SG
SG
LANGLADE
OCONTO
MARINETTE
D-G
SG
TAYLOR
LINCOLN
SG
CS
G
PEWA
MARATHON
MENOMINEE
SG
D-G
SG
CS
SHAWANO
SG
3
DOOR
J CLAIRE
CLARK
Green Bay
KEWAU-
NEE
Lime
Peat
WOOD
PORTAGE
WAUPACA
OUTAGAMIE
CS
BROWN
4 SG
IS
SG
CS
JACKSON
IS
JUNEAU
WAUSHARA
WINNEBAGO
CALUMET
MANITOWOC
D-L
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MONROE
ADAMS
MAR-
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VERNON
SAUK
COLUMBIA
Lime
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JEFFERSON
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MADISON
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Peat
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GRANT
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1
CS
RACINE
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CS
LAFAYETTE
GREEN
ROCK
WALWORTH
SG
CS
SG
CS
KENOSHA
SG

peat were produced: humus, hypnum, reed-sedge, and sphagnum. Most of the State's peat was sold in bulk form for general soil improvement. The second largest quantity was used for seed inoculant. Personnel with the Wisconsin Geological and Natural History Survey completed a U.S. Department of Energy funded investigation of the State's peat resources. Estimates of the State's extensive peat resources were made based on 1,120 samples collected from different physiographic and geomorphic provinces.

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1987. Data for odd-numbered years are based on annual company estimates.

Wisconsin construction sand and gravel statistics are compiled by geographical districts as depicted in the centerfold map. Table 4 presents end-use data for the State's eight districts.

Wisconsin ranked 11th of 50 States in production of construction sand and gravel. Output climbed to 25 million short tons in 1988 and was valued at over $60 million. This output was a 5% increase for both production and value

TABLE 4

WISCONSIN: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT[1]

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	1,437	3,695	3,906	11,423	1,152	2,551	227	663
Plaster and gunite sands	6	22	122	514	W	W	W	W
Concrete products (blocks, bricks, etc.)	134	453	W	W	87	258	—	—
Asphaltic concrete aggregates and other bituminous mixtures	W	127	339	795	248	664	28	57
Road base and coverings[2]	491	1,195	1,799	4,062	1,315	3,132	626	1,392
Fill	284	754	1,873	2,938	70	87	31	37
Snow and ice control	W	W	97	223	41	157	W	W
Railroad ballast	W	W	—	—	—	—	—	—
Other miscellaneous	137	157	176	412	38	96	31	90
Other unspecified[3]	573	1,351	2,063	5,242	1,162	2,275	2,224	5,331
Total[4]	**3,062**	**7,754**	**10,376**	**25,609**	**4,114**	**9,219**	**3,167**	**7,571**
	District 5		District 6		District 7		District 8	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	4	11	417	1,368	331	914	116	335
Plaster and gunite sands	—	—	—	—	—	—	—	—
Concrete products (blocks, bricks, etc.)	—	—	34	85	17	75	W	W
Asphaltic concrete aggregates and other bituminous mixtures	W	3	137	275	122	283	107	214
Road base and coverings[2]	—	—	744	1,497	602	1,205	378	768
Fill	1	W	126	128	23	42	W	W
Snow and ice control	46	69	W	W	9	27	—	—
Railroad ballast	—	—	—	—	—	—	—	—
Other miscellaneous	2	7	17	29	—	—	15	37
Other unspecified[3]	79	226	120	207	435	828	438	1,280
Total[4]	**133**	**317**	**1,596**	**3,589**	**1,539**	**3,375**	**1,053**	**2,633**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."

[1] Excludes 6,927 short tons valued at $13,854 not reported by county.

[2] Includes sand and gravel for road and other stabilization (cement and lime).

[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.

[4] Data may not add to totals shown because of independent rounding.

over 1987 figures and a record high value for production. Output was at its highest level since 1979. Wisconsin had 158 producers with 237 operations at 519 sites. Production occurred in 60 of the State's 72 counties. Waukesha County led the State in production and also had the greatest number of producers.

Industrial.—Wisconsin ranked 7th of 37 States in production of industrial sand. Both output and value had modest increases over 1987 figures. Four companies with eight pits in Columbia, Green Lake, Jackson, Pierce, and Waupaca Counties produced all of the State's industrial sand. Badger Mining Corp. was the State's leading producer with operations in Green Lake and Jackson Counties. About 56% of the State's sales was for foundry use (molding and core). The next largest uses were glass container manufacturing and hydraulic fracturing. Lesser quantities were sold for abrasives (sandblasting), filtration, and traction. Most of the sand was shipped by rail, with lesser quantities by truck.

During 1988, A.F. Gelhar Co. Inc., of Berlin, WI, closed its Winnebago County operation, but continued to produce foundry sands in Green Lake and Waupaca Counties.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Crushed.—Crushed stone production was estimated to have reached 28.5 million short tons, the highest level in State history; value was estimated at $98.3 million, another record high. Average value per ton was estimated at $3.45, about 9% above the 1987 figure.

During 1988, the Chicago and Northwestern Railroad Co. won conditional approval for a 40-acre expansion of its Pink Lady Quarry at Rock Springs, Sauk County. Operated under contract by Martin Marietta Aggregates, the quarry is the railroad's main source of ballast rock in the Midwest.

Dimension.—Wisconsin was estimated to have ranked 8th of 35 States in dimension stone production. Output was estimated at 49,900 short tons valued at $6.2 million.

Other Industrial Minerals.—Baraboo Quartzite Co., the State's sole producer of abrasive stone used as deburring media, ceased production in June. Perlite from out-of-State sources was expanded by Midwest Perlite Co. at its plant in Outagamie County. Both sales and value increased modestly. In descending order of use, sales were for cavity fill insulation, horticultural aggregates, concrete aggregate, and acoustic tile. Sulfur continued to be recovered at Murphy Oil USA Inc.'s refinery at Superior, Douglas County. Production and attendant value decreased 34% and 30%, respectively. Vermiculite mined in other States was exfoliated by Koos Inc. at its Kenosha plant. Sales and value increased 12% and 14%, respectively. Most of the plant's sales were for insulation purposes and filtration.

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[2] Associate professor, Minerals Information, Wisconsin Geological and Natural History Survey, Madison, WI.

[3] Evans, T. J. Selected Developments in Wisconsin's Mineral Industry in 1988. Wis. Geol. and Nat. Hist. Surv. Educational Series 34, 1989, 10 pp.

TABLE 5

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Abrasive stone:			
Baraboo Quartzite Co. Inc.	Box 123 Baraboo, WI 53913	Quarry and plant	Sauk.
Iron oxide pigments (finished):			
DCS Color & Supply Co. Inc.	2011 South Allis St. Milwaukee, WI 53207	Plant	Do.
Lime:			
CLM Corp.	Box 16807 Duluth, MN 55816	do.	Douglas.
Rockwell Lime Co.	4223 Rockwood Rd. Manitowoc, WI 54220	do.	Manitowoc.
Western Lime & Cement Co.	Box 57 West Bend, WI 53095	Plants	Brown and Fond du Lac.
Peat:			
Bogda's Top Soil & Excavating Co.	12600 West Cleveland Ave. New Berlin, WI 53151	Bog and plant	Waukesha.
Certified Peat & Sod Inc.	19000 West Lincoln Ave. New Berlin, WI 53151	do.	Do.
Demilco Inc., Lipha Chemicals Inc.	3101 West Custer Ave. Milwaukee, WI 53209	do.	Do.
Honest to Peat Inc.	North 8548 Hwy. M Algoma, WI 54201	Bog	Kewaunee.
Perlite (expanded):			
Midwest Perlite Co.	4280 Parkway Blvd. Appleton, WI 54915	Plant	Outagamie.
Sand and gravel:			
Construction:			
Janesville Sand & Gravel Co., Lycon Inc.	Box 427 Janesville, WI 53545	Pits and plants	Columbia, Dane, Rock.
Johnson Sand & Gravel Inc.	N8 W 22590 Johnson Dr. Waukesha, WI 53186	Pit and plant	Waukesha.
Mann Bros. Sand & Gravel Inc.	Box 48 Elkhorn, WI 53121	Pits and plants	Dane, Kenosha, Racine, Rock, Walworth, Waukesha, Waushara.
Arthur Overgaard Inc.	Box 87 Elroy, WI 53929	do.	Adams and Juneau.
Tews Co. Inc.	Box 64 Colgate, WI 53017	do.	Racine and Waukesha.
Valley Sand & Gravel Co.	South 63 West 19750 Luchow Dr. Muskego, WI 53150	Pit and plant	Waukesha.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	Pit	Do.
Industrial:			
Badger Mining Corp.	Box 97 Fairwater, WI 53931	Pits and plants	Green Lake and Jackson.
A.F. Gelhar Co. Inc.	Box 209 Berlin, WI 54923	do.	Green Lake and Waupaca.
Treco Sales Inc.	Box 38 Bay City, WI 54723	Underground mine and plant	Pierce.
Unimin Corp.	258 Elm St. New Canaan, CT 06840	Pit and plant	Columbia.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone (1987):			
Crushed:			
Granite:			
Boon Construction Inc.	Route 3, Box 61-H Neillsville, WI 54456	Quarry and plant	Wood.
Kafka Excavating & Granite	101 South Weber Ave. Stratford, WI 54484	Quarries and plant	Marathon.
Roehl Granite Inc.	2200 South Hwy. 107 Mosinee, WI 54445	Quarry and plant	Do.
Limestone and dolomite:			
4X Corp.	Box 509 Neenah, WI 53929	Quarries and plants	Calumet, Fond du Lac, Winnebago.
C.C. Linck Inc.	1226 North Center St. Beaver Dam, WI 53916	do.	Various.
Arthur Overgaard Inc.	Box 87 Elroy, WI 53929	do.	Buffalo, Juneau, La Crosse, Monroe, St. Croix.
Vulcan Materials Co., Midwest Div.	Box 6 Countryside, IL 60525	do.	Milwaukee, Racine, Waukesha, Winnebago.
Sandstone and quartzite:			
Martin Marietta Aggregates, Central Div.	Box 30013 Raleigh, NC 27622	Quarry and plant	Sauk.
Minnesota Mining & Manufacturing Co.	3M Center St. Paul, MN 55101	do.	Marathon.
Traprock (basalt):			
Dresser Traprock Inc.	Box 517 Dresser, WI 54009	do.	Polk.
GAF Chemicals Corp.	Box 630 Pembine, WI 54156	do.	Marinette.
Dimension:			
Granite:			
Anderson Bros. & Johnson Co.	Box 26 Wausau, WI 54401	Quarries and plant	Marathon and Marinette.
Cold Spring Granite Co.	202 South 3d Ave. Cold Spring, MN 56320	Quarry	Marathon.
Lake Wausau Granite Co.	Box 397 Wausau, WI 54401	Quarry and plant	Do.
Limestone and dolomite:			
Buechel Stone Corp.	West 3639 Hwy. H Chilton, WI 53014	Quarries and plant	Calumet and Fond du Lac.
Fond du Lac Stone Co. Inc.	Box 148 Fond du Lac, WI 54935	Quarry and plant	Fond du Lac.
R. & T. Quality Stone Inc.[1]	Box 182 Lannon, WI 53046	do.	Waukesha.
Valders Stone & Marble Inc.	Box 35 Valders, WI 54245	do.	Manitowoc.
Wislanco Stone Co. Inc.	Box 312 Lannon, WI 53046	do.	Waukesha.
Sandstone:			
Klesmith Stone Co.	1633 West River Dr. Stevens Point, WI 54481	Quarry	Wood.
Sulfur (recovered):			
Murphy Oil USA Inc.	Box 2066 Superior, WI 54880	Byproduct sulfur recovery plant.	Douglas.
Vermiculite (exfoliated):			
Koos Inc.	4500 13th Ct. Kenosha, WI 53140	Plant	Kenosha.

[1] Also crushed limestone.

THE MINERAL INDUSTRY OF WYOMING

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Geological Survey of Wyoming for collecting information on all nonfuel minerals.

By Karl Starch,[1] W. Dan Hausel,[2] and R. E. Harris[3]

The value of nonfuel mineral production in Wyoming rose about 10% in 1988 to $709.8 million. A similar percentage increase in the value of natural sodium carbonate-sodium bicarbonate (soda ash) production accounted for most of the change. Soda ash continued to dominate the State's nonfuel mineral production. Bentonite clay, crushed stone, portland cement, and sand and gravel were other commodities produced in the State. No metal production was reported.

In 1988, as in 1987, Wyoming ranked 14th among all States in nonfuel mineral production. The State continued to be the major domestic producer of soda ash (90% of the total) and bentonite clay (nearly 75% of the Nation's supply originated in Wyoming). Wyoming was second among the four States that produced Grade-A helium and second among 26 States that recovered elemental sulfur. According to data provided by the Wyoming State Inspector of Mines, soda ash accounted for more than 70% of the total value of Wyoming's 1988 nonfuel mineral output. Bentonite clay accounted for slightly more than 10%. Trona, which is refined into soda ash, was mined only in Sweetwater County in southwestern Wyoming, and bentonite clay was mined in several counties in northern Wyoming. Minerals provided more than 60% of the State's total assessed value and 70% of State revenue.

TRENDS AND DEVELOPMENTS

The 1988 nonfuel minerals production indicated a continued trend toward recovery from the slump that occurred in the early 1980's when a severe national cutback in steel production led to the closure of Wyoming's two iron ore mines. The decline in oil- and gas-well-drilling cut deeply into bentonite usage, and changes in building construction, automobile design, and the switch to plastic containers decreased demand for soda ash used in glass containers. The 1988 production represented a 129% increase over the 1984 low and was only 8% below the 1981 peak production year. The recovery was due mostly to increased production of soda ash, which was benefiting from a strong U.S. economy, an increase in exports, and substitution of soda ash for caustic soda in some industrial processes. Slightly more than 50% of the soda ash produced in 1988 was used for glass making. Much of the rest of the soda ash was used for water purification and the manufacturing of chemicals, detergents, and pulp and paper. About 26% of the output was exported.

Output of bentonite clay, used extensively in oil- and gas-well-drilling, also increased modestly from its low point in 1986.

Although this report is confined to nonfuel minerals, it should be noted that Wyoming has long been a major source of mineral fuels. In 1988, the State became the Nation's leading coal producer for the first time, with an output of 163.6 million tons. Second ranked Kentucky produced 158.3 million tons. Almost 90% of Wyoming coal production was from the Powder River Basin, one of the Nation's major storehouses of energy fuels. Wyoming had 30 active coal mines, only 2 of which were underground. The Black Thunder Mine in Campbell County was Wyoming's largest coal mine with a 1988 output of almost 25 million tons. Wyoming coal, with its low sulfur content and low price, was marketed in 22 States. Major users of Wyoming coal

TABLE 1

NONFUEL MINERAL PRODUCTION IN WYOMING[1]

Mineral		1986		1987		1988	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	short tons	1,761,635	$51,823	[2]2,127,645	[2]$62,031	[2]2,357,616	[2]$72,174
Gem stones		NA	225	NA	150	NA	150
Lime	thousand short tons	25	1,689	29	1,560	26	1,640
Sand and gravel (construction)	do.	3,377	10,977	e2,600	e9,000	3,413	11,351
Stone (crushed)	do.	e [3]1,700	e [3]5,900	3,171	15,049	e2,500	e11,400
Combined value of beryllium (1986), cement (masonry and portland), clay (common, 1987–88), gypsum, helium (Grade-A), sodium carbonate (natural), and stone (crushed granite, 1986)		XX	484,196	XX	557,265	XX	613,097
Total		**XX**	**554,810**	**XX**	**645,055**	**XX**	**709,812**

e Estimated. NA Not available. XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain clays; kind and value included with "Combined value" data.

[3] Excludes certain stones; kind and value included with "Combined value" figure.

were powerplants in Texas (32 million tons), Wyoming (25 million tons), Kansas (13 million tons), and Oklahoma (13 million tons), along with powerplants in Arkansas, Iowa, and Louisiana. Transportation costs were an impediment to Wyoming's gaining a greater share of the national coal market. A widespread drought, which restricted hydropower, abetted coal production.

Wyoming, once second only to New Mexico in uranium output, had only one surface mine and two solution mining operations active in uranium production in 1988. These mines were kept open just to fill existing contracts. The potential for large-scale production remains, if the market for uranium should recover.

EMPLOYMENT

Employment in mining is more important in Wyoming than in most States. Wyoming Employment Security Commission reports indicated mining employment remained relatively stable through the year at about 17,500 workers, which is about 10% of the total nonfarm wage and salary employment. This number was about 1,500 workers fewer than reported in December 1987. About 4,500 workers were employed in coal mining, 3,000 in trona, 440 in bentonite, 297 in sand and gravel, and 200 in uranium.

Average weekly earnings in mining were $662 in December 1988, up about 2% over December 1987. The U.S. average weekly earning in mining was considerably less at $540. Average hours worked were down slightly while hourly wages were up about 7%, to $15 per hour.

REGULATORY ISSUES

The Wyoming Department of Environmental Quality's Abandoned Mine Land Program to reclaim abandoned bentonite mines continued in northeast Wyoming. The 4-year reclamation project was about 75% complete and, when finished in December 1989, will have reclaimed 214 sites totaling 7,500 acres at a cost of about $39 million. Some of the old mine pits had filled with water and became bog hazards to livestock. The heavy clay and high sodium levels presented a challenge to revegetation. The most successful technique in encouraging new vegetative growth was the use of wood waste from local sawmills as a soil additive. Some of the old mine areas have become beneficial wildlife habitat and recreation areas.

The reclamation of old gold mine sites aroused some history-related concerns, and a committee was formed to investigate the feasibility of legislating an historic mine site preservation act. Landmark Reclamation Co. and MF Ferguson Co. were ahead of schedule in the removal of 1.7 million cubic yards of old uranium-mill tailings from the Wind River Indian Reservation near Riverton to a Gas Hills site 50 miles away, at a cost of $24 million.

EXPLORATION ACTIVITIES

Through continuing assessment work on their properties and mineral exploration work in new areas, operating companies attempted to expand their reserves. Such work was done by Wyoming's five large trona mines and numerous bentonite operations. American Bentonite Co. continued its testing of a bentonite deposit near Poison Spider School southwest of Casper. Exploration continued for construction aggregate, mostly for use in highway construction. Wyoming aggregate producers were also hoping to supply some of the aggregate that was to be required for the new airport at Denver, CO. A large deposit of high-calcium limestone located in the Hartville uplift in Niobrara County was investigated by the Geological Survey of Wyoming for its potential use in sugar beet processing and as high-quality, durable aggregate.

High precious-metal prices encouraged a moderate level of exploration for precious metals, particularly in the South Pass greenstone belt at the southern tip of the Wind River Range, where field exploration studies by the Geological Survey of Wyoming indicated a potential for gold and other metals in shear zones, veins, and placers. A potential for large tonnage, low-grade gold mineralization also has been demonstrated in the area. Schuetz Tool & Die Co. drilled on the eastern edge of the South Pass Granite, and other companies trenched and drilled elsewhere in the district. Platinum, palladium, and gold were exploration targets of four mining companies in the Medicine Bow Mountains of southeastern Wyoming. Claim-staking activity was stimulated by rumors of a large zinc-silver discovery by Broken Hill Mining Co. in the Colorado border area.

In northeastern Wyoming, several companies evaluated large tonnage, low-grade epithermal gold deposits associated with Tertiary alkalic intrusives at Mineral Hill, Black Buttes, and the Bear Lodge Mountains in the northwestern Black Hills. Properties in the Bear Lodge Mountains, a few miles north of the town of Sundance, were explored for low-grade epithermal gold by International Curator Resources Inc. under an option from FMC Gold Co. The more than 30 holes drilled show widespread gold mineralization, with an average grade of 0.021 ounce of gold per ton. The Bear Lodge Mountain area also includes one of the largest low-grade rare earth and thorium deposits in the United States.

In the Bighorn Basin, gold placers were explored north of Cody and east of Winchester. One company continued the exploration and evaluation of iron-titanium-zircon black sands in Hot Springs and Washakie Counties.

The Geological Survey of Wyoming continued its exploration program for

diamond-bearing kimberlite. More than 100 stream-sediment anomalies, which included gold, aquamarine, ruby, and sapphire as well as micro-size diamonds, have been identified to date.

LEGISLATION AND GOVERNMENT PROGRAMS

The Wyoming legislature considered a number of mineral-related bills in its 1988 session. The Governor signed the following bills into law: House bill 317, which repealed the "return on investment" deduction in calculating mineral taxes and was expected to generate an additional $12,825,000 in State revenues in FY 1990; Senate file 54, which required that 10% of Public Law 95-87 monies be placed in the subsidence mitigation account and specified conditions under which abandoned mine reclamation funds could be expended; Senate file 85, which required that all severance tax proceeds in the permanent mineral trust fund in excess of constitutional requirements be diverted to the budget reserve account until June 30, 1990; and Senate file 122, which defined mine rescue teams as an extrahazardous occupation under the State Workers Compensation Act. Enrolled Act No. 36 provided for extensive changes in the reporting frequency, collection, and audit of mineral taxes. The Department of Revenue and Taxation created a Mineral Tax Division to deal with valuation of minerals severed, the collection of taxes based on that value, and the maintenance of appropriate records. The new division was also resonsible for developing the regulations required to implement Enrolled Act No. 36.

The Sweetwater County assessor sought to reverse a county Board of Equalization decision that affected the tax rate of five soda ash producers. The Board granted a 23.7% tax reduction, based on plant obsolescence, that would effectively trim $1.8 million from the $6.6 million tax bill of trona operators for the 1987 tax year.

Wyoming again led the 29 States that received Federal mineral royalty payments under the Mineral Leasing Act. Payment to Wyoming was $163.9 million, 41.2% of the total paid to all States.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Production continued to increase at Wyoming's only cement plant, Mountain Cement Co.'s plant in Laramie. By yearend, Mountain Cement, a subsidiary of Centex Corp., had nearly completed its $20 million plant renovation and conversion from a wet- to a dry-process operation, and the plant approached its annual operating capacity of 500,000 tons. The Laramie plant was expected to employ about 100 people when it reached full capacity. The plant used limestone, shale, and gypsum quarried nearby. Iron additives were derived from tailings of the Iron Mountain magnetite mine 42 miles northeast of Laramie. The plant served customers in Colorado, Nebraska, and Wyoming. Increasing production reflected expanded construction activity, particularly in Colorado's Front Range area.

Clays.—While Wyoming ranked fifth among the 44 States producing all types of clay, it led the Nation in bentonite clay production. Wyoming bentonite is the swelling, sodium type, and when water is added, it increases from 15 to 20 times its dry volume. Bentonite had been one of Wyoming's major exports. Its output has long been tied to the oil and gas industry's drilling activities. The decline in demand from that industry over the past 8 years had changed Wyoming's bentonite industry. Bentonite, which is used as a binder in iron ore pelletizing, also lost a major market when the Nation's steel industry slumped. Peak years for the industry were in the late 1970's and early 1980's, a period of strong oil- and gas-drilling activity as the United States strove to become more energy self-sufficient. In 1981, the State produced 4.8 million tons of bentonite. In 1988, however, the State produced 2.4 million tons of bentonite, up from 2.1 million tons in 1987 and 1.8 million tons in 1986.

In Wyoming, bentonite was mined in the northern part of the State. About two-thirds of the total output originated from Crook County, about 20% from Big Horn County, and the balance from Weston, Johnson, and Natrona Counties.

Although the market for drilling mud was depressed, it still accounted for about 50% of bentonite production. About 20% was used as molding sand binder; 20% for taconite pelletizing; and the remaining 10% for animal feed, ceramics, water softening, chemical manufacturing, laxatives, crayons, paint, insecticides, and medicine uses. Bentonite is advertised as the mineral with 1,000 uses, and it has prospects in environmental use for lining waste ponds and dumps. Producers explored export markets, particularly Japan and Europe, for foundry uses and the development of new products. Black Hills Bentonite began marketing leonardite, a soft, earthy-brown material produced from the weathering of lignite. It was used in drilling fluids, water treatment, and wood stain.

Five companies produced bentonite in Wyoming in 1988. The largest of these were American Colloid Co. and Wyo-Ben Inc., with 40% and 23% of the total output, respectively. These were followed by NL Baroid, a subsidiary of NL Industries Inc.; M-I Drilling Fluids Co.; and Black Hills Bentonite.

Two companies reported production of common clay or shale. The output, however, was a small proportion of the total clay production in the State. Mountain Cement mined common clay

and shale in Albany County for use in cement manufacturing, and Interstate Brick Co. in Uinta County mined common clay for manufacturing building bricks.

Although the bentonite industry continued to produce far below capacity, 1988 production reflected continued improvement over that of 1987 and 1986. Companies continued to develop reserves to improve their operating positions. Black Hills Bentonite, of Casper, and American Bentonite Corp., of Billings, MT, both had mining permits for new areas west of Casper pending before the Wyoming Environmental Quality Council. Wyo-Ben closed its Lucerne bentonite plant in April, citing decreased demand from the iron ore pelletizing industry, better grade reserves elsewhere, and electrical costs at that plant. Eighteen jobs were lost in the closure. The State Inspector of Mines estimated total employment in the bentonite industry in 1988 at 439 workers.

Gem Stones.—An 8-year Geological Survey of Wyoming research project to locate diamond-bearing kimberlite intrusives was unusually successful. More than 1,000 stream-sediment samples were collected over an 800-square-mile region in the search for kimberlite indicator minerals (pyrope garnet, chromian diopside, and picroilmenite). More than 100 anomalies have been identified, mostly in Albany County. An assessment by mining companies of the commercial potential of deposits in the Colorado-Wyoming-State-line area had not led to commercial development. The Geological Survey of Wyoming planned a seminar, to be presented in the spring of 1989, for people interested in looking for diamonds in Wyoming.

Wyoming nephrite, commonly called jade, has been found for many years in both alluvial and lode environments in an east-west belt stretching through the Sweetwater uplift from the southern tip of the Wind River Range to the northern edge of the Laramie Mountains in central Wyoming. This area encompasses southern Fremont and Natrona Counties and bordering segments of Carbon, Converse, and Sweetwater Counties. Although Wyoming jade production was small, it is known worldwide and, in recent years, Chinese artisans have expressed increasing interest as other sources of jade have become less reliable.

Gypsum.—Gypsum production increased moderately in 1988, and partially recouped the 1987 losses. Much of this added output was related to the substantial increase in cement production at Mountain Cement. Gypsum was quarried at three locations. Mountain Cement mined gypsum at Red Mountain, Albany County, for use in cement manufacturing. Georgia-Pacific Corp., at Lovell, Big Horn County, and the Celotex Division of Jim Walter Corp., at Cody, Park County, mined and calcined gypsum to manufacture wallboard for the construction industry.

Helium (Grade-A).—Grade-A helium extraction from natural gas produced in the Riley Ridge gas field in southwestern Wyoming began in 1986. The production value of helium soared in 1987, and Grade-A helium became Wyoming's third most important nonfuel mineral commodity in terms of value. Production and value rose only slightly in 1988. Exxon Co. U.S.A. was the only producer of helium in Wyoming. Wyoming Department of Revenue and Taxation figures indicated nearly $37 million in gross revenue from helium sales by the company in 1987, the most recent year for which figures were available.

Wyoming's Attorney General issued an opinion which stated Wyoming could tax helium production from Federal land unless the Federal Government specifically gave a producer immunity from State taxation.

Lime.—Limestone used for making quicklime was brought into the State from Montana and South Dakota. Western Sugar Co. used the limestone in its sugar beet processing plants in Big Horn County, and Holly Sugar Co. used it in plants in Goshen and Washakie Counties. All lime produced by these companies was used internally.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; this chapter contains actual data for 1986 and 1988 and estimates for 1987. Data for odd-numbered years are based on annual company estimates.

Wyoming construction sand and gravel statistics were compiled by geographical districts as depicted in the centerfold map. Table 3 presents end use data for the State's two districts.

Sand and gravel was produced at 26 sites in 21 counties. Laramie, Johnson, Fremont, and Campbell Counties led in sand and gravel production. Production increased by more than 30% over that of 1987. The State Inspector of Mines estimated about 297 workers in the sand and gravel industry in Wyoming in 1988. Nearly one-third of the sand and gravel produced was not transported, but was used on site. Sand and gravel production was largely a seasonal activity geared to the higher level of construction activity during the warm-weather months.

The Wyoming Supreme Court ruled during the year that gravel was not a mineral. Surface owners could sell gravel for construction without consulting the mineral rights owner. The court held that to be a mineral, a substance had to have characteristics or properties that gave it a special value. Decorative aggregate would be considered a mineral, for example, while common aggregate would not.

Sodium Carbonate.—The world's largest known resource of trona, a natural sodium carbonate-bicarbonate, was in southwestern Wyoming. With five of the Nation's six major trona mines and soda ash processing facilities located within a few miles of Green River, Wyo-

TABLE 2

WYOMING: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 1988, BY MAJOR USE CATEGORY

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregates (including concrete sand)	579	$2,283	$3.94
Plaster and gunite sands	3	12	4.00
Concrete products (blocks, brick, pipe, decorative, etc.)	11	19	1.73
Asphaltic concrete aggregates and other bituminous mixtures	721	2,872	3.98
Road base and coverings[1]	1,255	3,598	2.87
Fill	81	180	2.22
Snow and ice control	30	109	3.63
Railroad ballast	W	W	4.56
Other	134	404	3.01
Unspecified:[2]			
Actual	102	374	3.67
Estimated	496	1,500	3.02
Total or average	**[3]3,413**	**11,351**	**3.33**

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1] Includes road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data do not add to total shown because of independent rounding.

TABLE 3

WYOMING: CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN 1988, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2	
	Quantity	Value	Quantity	Value
Concrete aggregates (including concrete sand)	198	714	381	1,569
Plaster and gunite sands	W	W	W	W
Concrete products (blocks, brick, etc.)	—	—	11	19
Asphaltic concrete aggregates and other bituminous mixtures	268	775	454	2,097
Road base and coverings[1]	571	1,580	684	2,018
Fill	17	52	64	128
Snow and ice control	—	—	30	109
Railroad ballast	—	—	W	W
Other miscellaneous	7	31	130	385
Other unspecified[2]	197	597	401	1,277
Total[3]	**1,259**	**3,749**	**2,154**	**7,602**

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1] Includes sand and gravel for road and other stabilization (cement).
[2] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[3] Data may not add to totals shown because of independent rounding.

ming historically has been the source of about 90% of the Nation's output of natural soda ash. According to the State Inspector of Mines, soda ash comprised 75% or more of the value of Wyoming's total nonfuel mineral production.

Trona production increased by about 20% to a record level in 1988, the third year of increased output. Output had slumped from the 1980 high of 12.2 million tons to the 1982 low of 10.1 million tons and had remained relatively low through 1985, as downsizing of automobiles, a slowdown in building construction, and conversion to plastic containers reduced the demand for glass, the primary use of soda ash.

The 1988 production of 14.9 million tons of trona (about 9 million tons of soda ash), as reported in the annual report of the State Inspector of Mines, was the highest level of production since trona was first mined in the Green River area in 1950. The mines and processing facilities operated at about 97% of capacity by the end of 1988. A stronger U.S. economy, an increase in exports, and a substitution of soda ash for caustic soda in some industrial processes were credited with the record demand for soda ash. About 26% of the soda ash produced was exported. China remained the largest foreign buyer, although its share of total exports declined. Europe, where all soda ash was derived by the inefficient Solvay synthetic process, was seen as a major area for future expansion of U.S. exports. Continued revival of soda ash demand depended upon the number of housing starts, automobile and glass container sales, and its growing use for sodium compounds like caustic soda and sodium cyanide. The State Inspector of Mines estimated that about 3,040 workers were employed in the trona mines and plants in 1988, compared with 4,000 in 1982. These figures, along with the higher level of output, reflected increased productivity.

The Wold Minerals Corp. of Casper actively sought a joint-venture partner to open a trona mine and soda ash

WYOMING

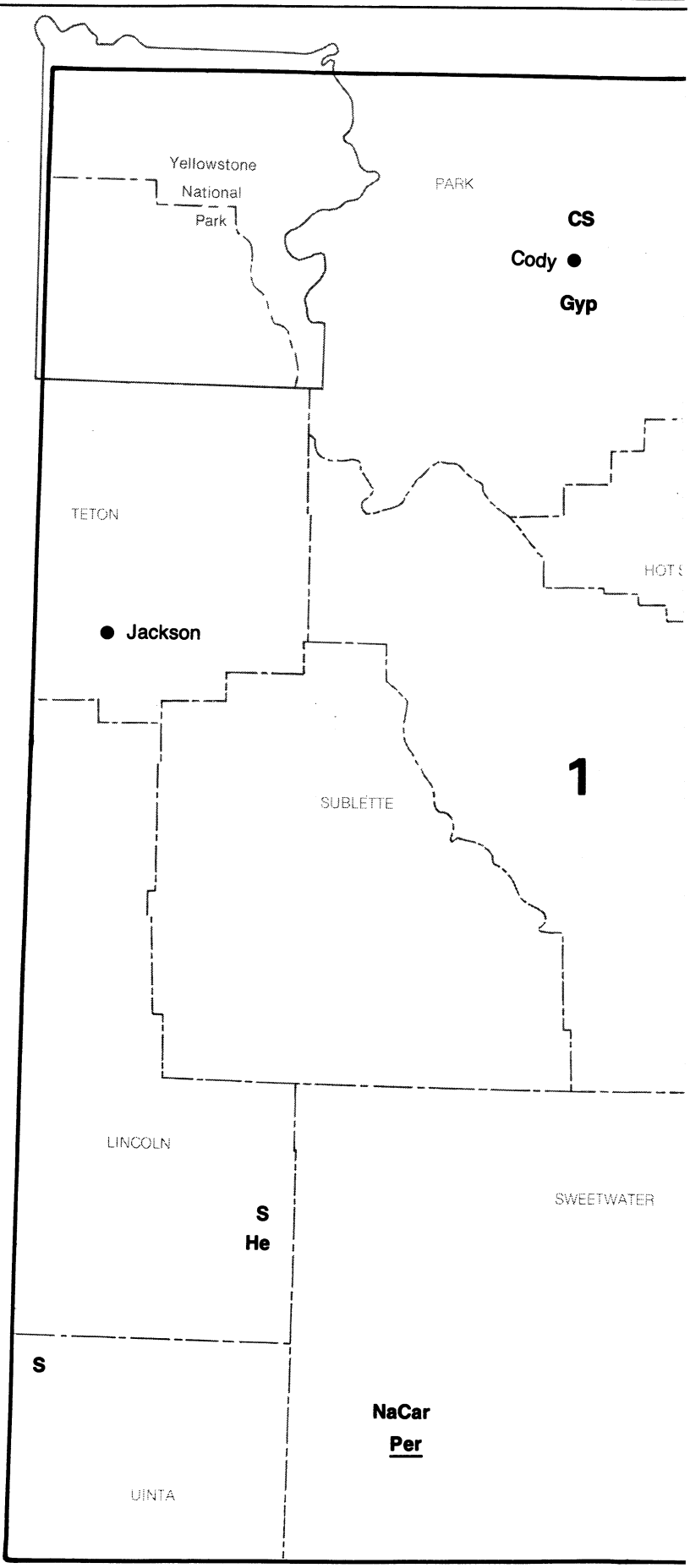
LEGEND

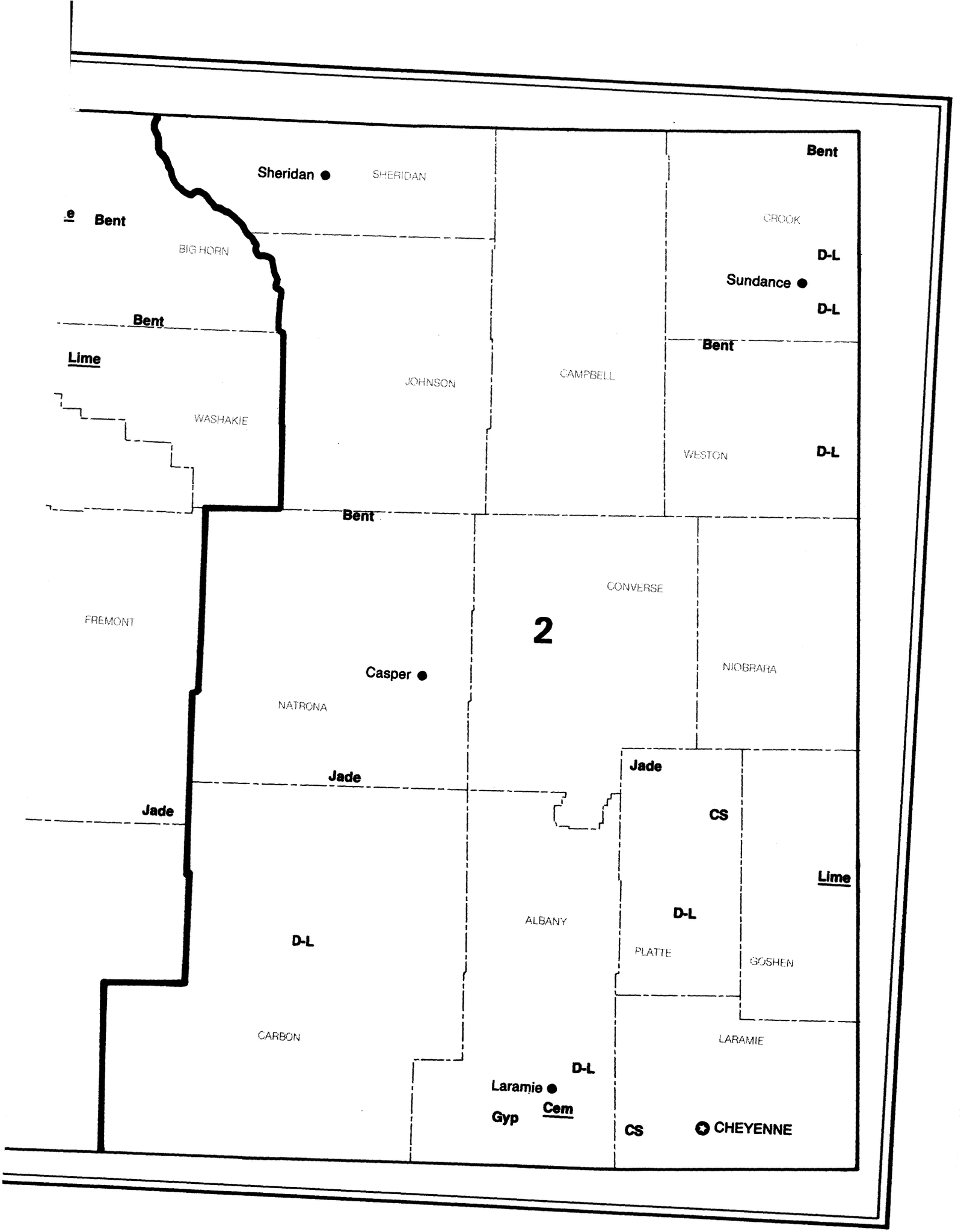
- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Bent	Bentonite
CS	Crushed Stone
D-L	Dimension Limestone
Gyp	Gypsum
He	Helium
Jade	Jade
Lime	Lime plant
NaCar	Sodium Carbonate
Per	Perlite plant
S	Sulfur

Principal Mineral-Producing Localities




Sheridan
SHERIDAN
Bent
Bent
BIG HORN
Bent
CROOK
D-L
Sundance
D-L
Bent
Lime
JOHNSON
CAMPBELL
WASHAKIE
WESTON
D-L
Bent
CONVERSE
FREMONT
2
NIOBRARA
Casper
NATRONA
Jade
Jade
Jade
CS
Lime
D-L
ALBANY
D-L
PLATTE
GOSHEN
CARBON
LARAMIE
D-L
Laramie
Cem
Gyp
CS
CHEYENNE

ash refinery, which would be the sixth such facility in the Green River Basin.

Of the five trona producers in Wyoming in 1988, the largest was FMC Wyoming Corp., with about 1,100 employees. According to the State Inspector of Mines, the company produced about 4.3 million tons of trona in 1988. FMC was followed in size by General Chemical Co., with 800 employees and 3.8 million tons of trona production in 1988; Stauffer Chemical Co. of Wyoming, with 520 employees and 3.4 million tons of production; Tenneco Minerals Co., with 300 employees and 1.8 million tons; and Tg Soda Ash Operations, with 340 employees and 1.7 million tons.

FMC began planning for new sodium bicarbonate, sodium cyanide, and caustic soda plants at its Green River facility. The sodium bicarbonate plant would have a 60,000-ton annual capacity and would begin operations in the second quarter of 1990. The new plant would compete with Church & Dwight's Green River bicarbonate plant, which had been the only facility converting the sodium carbonate to sodium bicarbonate. The FMC plant would use phosphates from the company's Pocatello, ID, plant in the process. Church & Dwight, in turn, opened a new plant to produce washing soda, laundry detergents, and similar products from soda ash.

FMC's 65,000-ton-per-year caustic soda plant was expected to be in operation in the first quarter of 1990. It was to produce cyanide for the planned sodium cyanide plant, which would be the only U.S. producer of sodium cyanide other than E.I. duPont de Nemours & Co. Most of the sodium cyanide produced would be sent by rail to FMC's Battle Mountain, NV, gold mine where it would be used to recover gold from low-grade deposits.

FMC temporarily halted solution mining of trona, which had accounted for about 10% of the company's yearly trona output. FMC found it more profitable to market the caustic soda used in solution mining instead of using it internally for mining. U.S. Bureau of the Census and Chlorine Institute data indicates that 1988 production of caustic soda, which is used in aluminum processing and by the paper and pulp industries, was more than that of 1987. However, many customers converted to soda ash because of caustic soda's higher prices. FMC expected to resume solution mining in 1990.

FMC's mine was the only trona mine in the Green River Basin not using a mobile continuous conveyor to carry ore out of the mine. The company's longwall mining system, which can cut 2.5 to 3 times more trona per shift than other equipment, remained idle through the year but was expected to be restarted in early 1989.

Stauffer Chemical increased productivity by installing a 4,000-foot mobile conveyor system to transport ore from its mine. The company developed a continuous miner that automatically roofbolts as it cuts trona. In 1987, Rhone-Poulene, a French-owned company bought 51% of Stauffer Chemical; the Union Pacific Corp. owns 49%.

Tenneco began building a 75,000-ton-per-year caustic soda facility and a 50,000-ton-per-year anhydrous sodium sulfite plant, both of which were expected to come on-line in late 1990 or early 1991. Efficiency improvements were instituted in the soda ash refinery to increase output capacity by 100,000 tons, to about 1.25 million tons per year by 1990. A continuous conveyor was installed to haul mined ore to the surface. The conveyor reportedly increased productivity between 40% to 50% in those areas of the mine where it was used. Productivity in nonconveyor areas increased by 25%.

In other efficiency moves, the company began phasing out its drum miners and ordered two more bore miners to supplement the two already working in the mine. Longer, more efficient shifts were established for surface production workers—12-hour days for 3 days one week and 4 days the next week. Federal regulations prohibited similar longer-than-8-hour shifts underground.

Tenneco began putting its tailings underground in 1987; the firm expected this practice to delay by 20 to 25 years the need to build a new surface tailings pond. Burial also avoided the environmental problem of wildlife, particularly ducks, getting into tailings ponds. The company was in its second year of offering incentive bonuses, about 6%, based on cost and productivity.

In addition to soda ash for manufacturing of glass, baking soda, etc., Tenneco produced, from trona, a rumen buffer that assisted beef and dairy cattle on high-grain diets to digest their feed better.

At its Green River operation, Tg Soda Ash Operations installed a short-wall mining system and mobile continuous conveyor system in its mine.

Bonneville Transloaders Inc. (BTI) had a successful fifth year of trucking soda ash 220 miles from the Green River Basin, which is served only by the Union Pacific Railroad, to the Burlington Northern Railroad railhead at Bonneville north of Riverton. BTI served all five soda ash producers in the Green River Basin, hauling about 7% of their output.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1986 and 1988 and actual data for 1987.

Wyoming's stone production was all crushed stone and included limestone, granite, and baked and fused rock clinker used for road surfacing material and crushed marble used for decorative purposes. The State Inspector of Mines estimated that more than 40 workers were employed in stone quarrying. Highway construction and railroad ballast provided the market for most of the State's crushed rock output. Limestone was used for cement manufacturing, burn

and emission control in coal-fired power plants, and highway aggregate. Basins Inc., a subsidiary of Georgia Marble, produced crushed marble at Wheatland for decorative stone in aquariums, landscaping, floor tile, and precast concrete in facings and pillars. Through efforts of the Geological Survey of Wyoming, several tons of one-half-inch-size red granite was shipped from the Lusk area to Kansas for use in precast concrete. In addition, a Colorado and a midwestern manufacturer of precast concrete also expressed interest during the year in using Wyoming decorative stone.

No dimension stone was reported produced in Wyoming in 1988. However, the rise in popularity of dimension stone as exterior and interior wall facing may offer additional demand for Wyoming granite, travertine, marble, limestone, sandstone, onyx, and other dimension stone found in quantity in Wyoming.

Sulfur.—Wyoming ranked second among the 26 States that produced elemental sulfur in 1988. The 991,000 metric tons produced was 14% of the total U.S. production. In Wyoming, all of the sulfur was produced as a byproduct of natural gas and petroleum processing. Production occured primarily in the Overthrust Belt of southwestern Wyoming; however, interest in a sulfur deposit 3 miles west of Thermopolis continued. The Wyoming Economic Development and Stabilization Board awarded a grant to Thermopolis to conduct surface studies on the deposit owned by the Wyoming Sulfur Corp.

Other Industrial Minerals.—U.S. Zeolite Co. studied the feasibility of opening a zeolite mine on Union Pacific Co. property with a $200,000 loan from the Wyoming Investment Fund committee. Zeolites are sodium and/or calcium silicate materials that are natural ion exchangers and can be used to purify or soften water.

FMC announced a 50% expansion, to 225,000 tons per year, in sodium tripolyphosphate fertilizer production at its plant near Green River. The company combined sodium from its Green River soda ash plant with phosphate from its mines in Idaho. Chevron Chemical Co. also announced expansion of its phosphate fertilizer plant near Green River, which combined phosphate from Utah with sulfur produced during natural gas processing in southwest Wyoming.

Glass manufacturers were interested in a silica deposit on Plumbago Creek in Albany County, estimated by the Geological Survey of Wyoming to contain 64.2 million tons of high-grade silica. The Geological Survey of Wyoming also defined another 82.8 million tons of high-grade silica rock at Cassa, south of Glendo in Platte County. Other silica deposits in the State also were being evaluated. The presence of good quality silica, soda ash, and other raw materials for glassmaking in relative proximity in the State presented the potential for glass manufacturing there.

Harborlite Corp. produced a filter aid from perlite brought in from Arizona and expanded at its plant near Green River.

Metals

Gold.—No significant gold production has been reported in Wyoming in recent years, although some nuggets and flake gold were recovered at several stream placers such as the Stout Creek placer mine on Rock Creek. The Gyorvary Mining Co. completed modification of a mill at the Mary Ellen Mine in the South Pass-Atlantic City District, but was unable to satisfy the Wyoming Department of Environmental Quality's requirements to start mining. High prices for the metal continued to stimulate interest in gold in the State, particularly in areas where gold has been mined in the past.

The Geological Survey of Wyoming has studied the characteristics of known gold deposits in Wyoming over the past 10 years. The entire 150- to 200-square-mile South Pass gold-belt area has been mapped. These maps are available to the public.

Four historic gold districts lie at the southern tip of the Wind River Mountains: (1) South Pass-Atlantic City, (2) Lewiston, (3) McGraw Flats, and (4) Oregon Buttes. The Geological Survey of Wyoming and the U.S. Geological Survey estimated that between 70,000 and 325,000 ounces of gold may have been recovered from the South Pass-Atlantic City area, mostly in the 1860 and 1910 Wind River Gold Rushes.

In addition to the South Pass-Atlantic City area, the Medicine Bow, Sierra Madre, and Laramie mountain ranges in southeastern Wyoming and the Bear Lodge Mountains of northeastern Wyoming were believed to have gold production possibilities.

Wyoming also had known deposits of strategic metals such as platinum, manganese, chromium, and cobalt, though little was known about their minable potential.

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[1] Chief, Branch of State Activities, Intermountain Field Operations Center, Denver, CO.

[2] Head, Metals and Precious Stones Division, Geological Survey of Wyoming, Laramie, WY.

[3] Head, Industrial Minerals and Uranium Division, Geological Survey of Wyoming, Laramie, WY.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Mountain Cement Co.[1]	Box 40 Laramie, WY 82070	Plant	Albany.
Clays:			
American Colloid Co.	5100 Suffield Ct. Skokie, IL 60076	Pits and plants	Big Horn, Crook, Weston.
Black Hills Bentonite	Box 9 Mills, WY 82644	do.	Johnson, Natrona, Washakie.
M–I Drilling Fluids Co., Greybull Div.	Box 42842 Houston, TX 77242	Pits and plant	Big Horn.
NL Industries Inc., Baroid Div.	Box 1675 Houston, TX 77251	Pits and plants	Big Horn and Crook.
Wyo-Ben Inc.	Box 1979 Billings, MT 59103	do.	Big Horn.
Gypsum:			
Celotex Corp.	Box 590 Cody, WY 82414	Surface mine and plant	Park.
Georgia-Pacific Corp.	133 Peachtree St., NE. Atlanta, GA 30303	do.	Big Horn.
Helium (Grade-A):			
Exxon Co. U.S.A.[2]	Box 98 Frontier, WY 83121	Plant	Lincoln.
Lime:			
The Great Western Sugar Co.	Box 5308 Denver, CO 80217	do.	Big Horn.
Holly Sugar Corp.	Holly Sugar Bldg. Colorado Springs, CO 80902	Plants	Goshen and Washakie.
Sand and gravel:			
Boatwright-Smith	Box 1129 Casper, WY 82602	Pits	Various.
Campbell County Highway Dept.	500 South Gillette Ave. Gillette, WY 82716	Pit	Campbell.
Casper Concrete Co.	Box 561 Casper, WY 82601	Pits	Natrona.
Pelesky, J. D. Construction	Box 1084 Sheridan, WY 82801	Pit	Sheridan.
Rissler-McMurry Co. Inc.	Box 2499 Casper, WY 82602	Pits	Various.
James E. Simon Co.	Box 347 Cheyenne, WY 82003	do.	Laramie.
Sims Corp.	Box 554 Lander, WY 82520	do.	Various.
Star Aggregates Inc.	Box 1437 Cheyenne, WY 82003	do.	Laramie.
Teton Construction Co.	Box 3243 Cheyenne, WY 82003	do.	Do.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sodium carbonate:			
FMC Wyoming Corp.	Box 872 Green River, WY 82935	Underground mine and plant	Sweetwater.
General Chemical Co.	Box 551 Green River, WY 82935	do.	Do.
Stauffer Chemical Co. of Wyoming	Box 513 Green River, WY 82935	do.	Do.
Tenneco Minerals Co.	Box 1167 Green River, WY 82935	do.	Do.
Tg Soda Ash Operations	Box 100 Granger, WY 82934	do.	Do.
Sulfur (recovered):			
Amoco Production Co.	Box 2520 Casper, WY 82602	Plant	Uinta.
Chevron USA Inc.	Box AA Evanston, WY 82930	do.	Do.

[1] Also gypsum.
[2] Also recovered sulfur.