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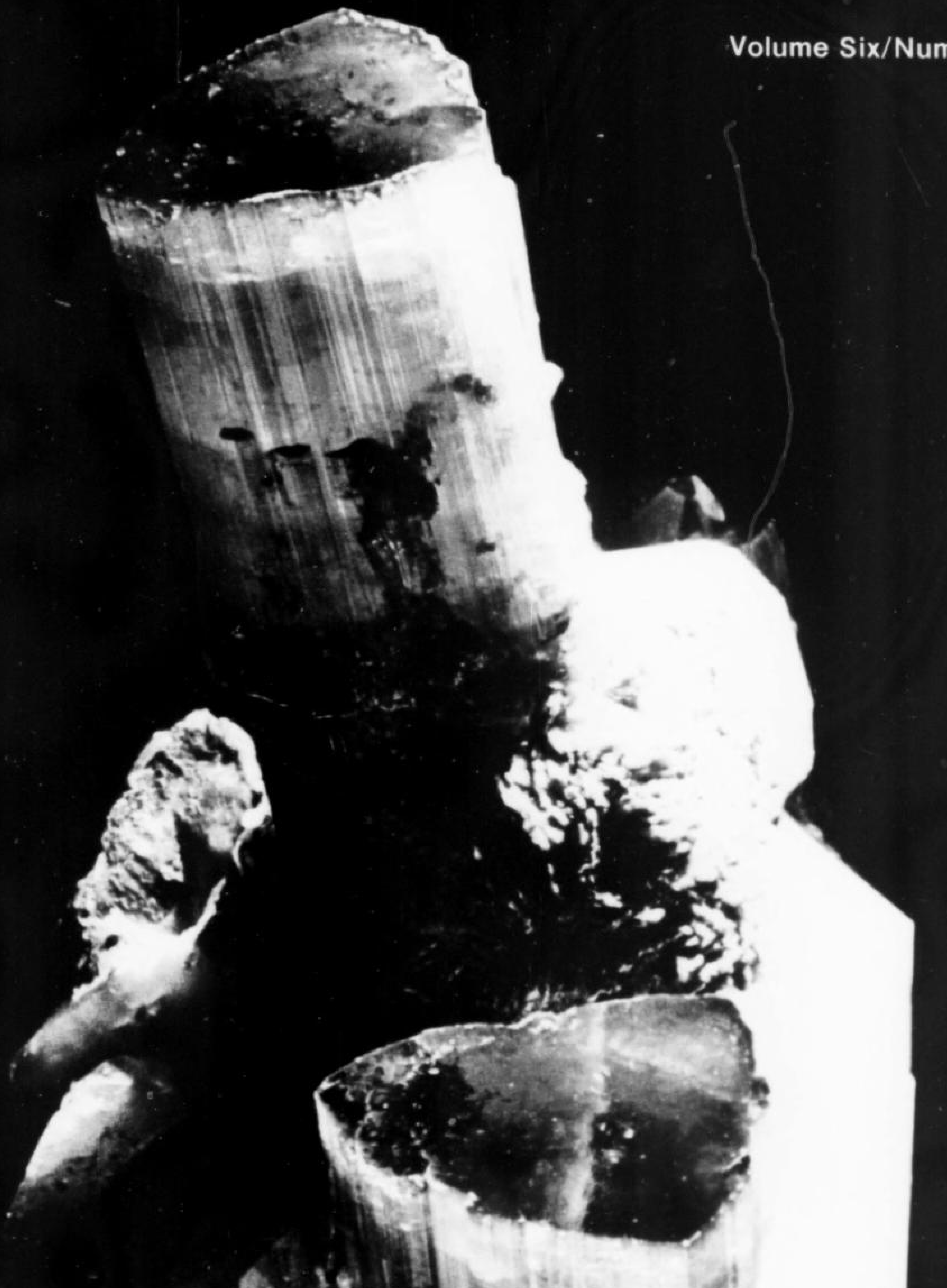

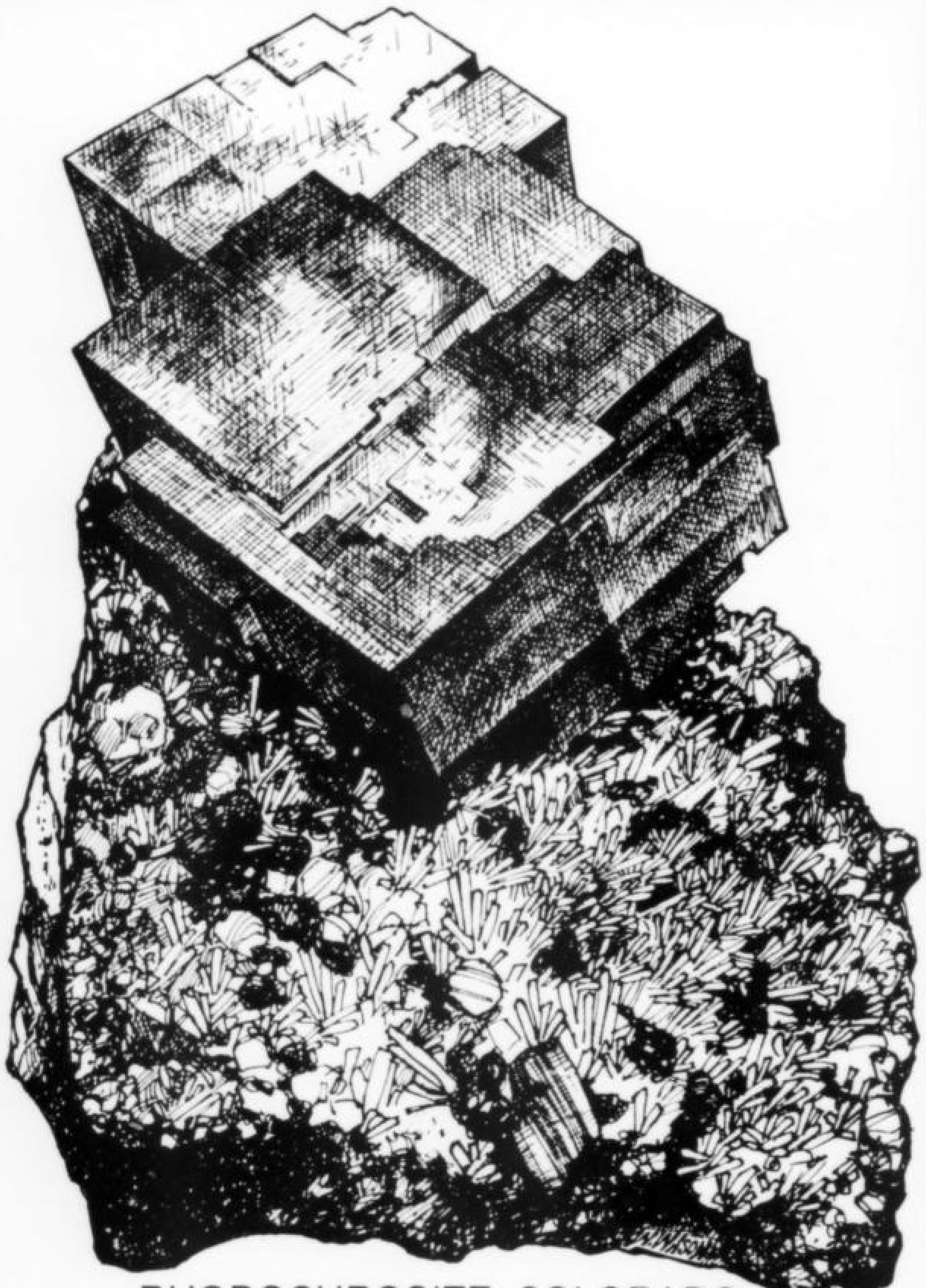

RHODOCHROSITE; COLORADO

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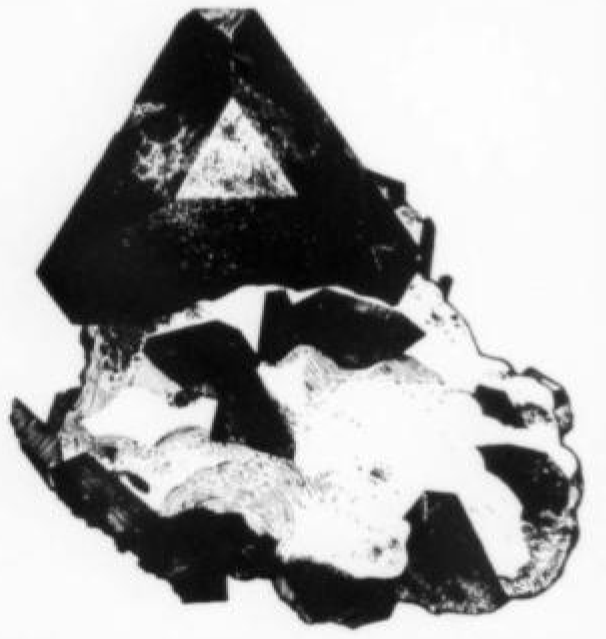

BENITOITE; CALIFORNIA

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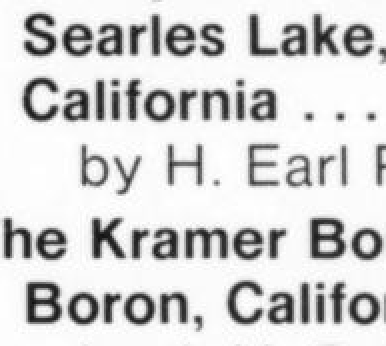

The "candelabra," elbaite crystals attached to quartz with albite and lepidolite. Tourmaline Queen mine, Pala, San Diego County, California. The overall size of the specimen is approximately 10 x 9 x 6 inches. It was removed from the mine on New Year's Day, 1972, by William Larson. Photograph by J. S. White, Jr.

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Guest Editorial

Some Observations on Collecting by Desmond Coke (1913)

from *The Art of Silhouette* (1913),
Condensed for *M.R.* by W.E. Wilson.

The collector is usually thought a crank by his acquaintances, a nuisance by his friends, a miser by his relatives, a blessing by the dealers, and a deluded idiot by everyone concerned. He is, as a matter of fact, the happiest—if the poorest—of God's creatures. He is the poorest because if some miraculous twist of the wheel made him a millionaire tomorrow, he would merely collect white elephants instead, and never have the cash to pay for all of them. But he is the happiest because he is obeying Nature's law—you cannot stop Man from collecting. All the world seeks something: curios, stamps, sovereigns, or adventures. What lies beneath it? Dangerous to ask, of anything; but I expect it has been long ago established that the collecting mania, like any form of sport, is based deep down upon a natural vanity.

Equally Man needs excitement; an old truth which explains things so diverse as football, juvenile crime, and collecting. Life, left to itself, sends along its thrills too slowly; but the collector, if always destitute of funds, never can lack expectation. He fares out, sure that fate will send him one of those historic finds that stand like milestones in the History of Art. With what joy does he bear it back! With what excited hands unwrap it, safely home; with what delirious haste find a small space for it upon his crowded walls; how often leave his work and ramble absently, to find himself before his latest treasure! Each day is too short for him. He is never lonely and cannot be bored. He is the favourite of fortune.

It is a popular fallacy that the collector must be a rich man. As a matter of contrary fact, it has been shown already that if he is worth his salt, he never has a penny! He simply must adjust the choice of subject to his means; what the ideal collector needs is knowledge; knowledge and a little pluck. He must discover for himself and not pay bigger prices for another's finds.

At first, of course, one buys at random anything. This seems cheap, that is old, the other is only a very little cracked...Later, however, one begins to realize two facts. Only a billionaire could hope to make a good collection of everything, and the man who wishes bargains must know more than any given dealer. Hence grows that modern malady, specialization. The young collector sells his early purchases, burns the forgeries that are his connoisseur wild oats, and fixes on a subject.

Certainly the man who keeps himself for even a few years to one particular collection—reading articles on it, asking prices, seeing the specimens of others, above all constantly on the hunt—has his reward. He has specialized and, never knowing it, he has become an expert!

Thus he will pass many happy days in rambles lit by an undying hope; make endless friendships; solace his old age, when sport or love and other hobbies die, with all the indexings that he had always meant to do; plan, during his last illness, how to rearrange his collection once more; and finally, from a more restful plane, look down on the sale, glorying in each big bid for objects he had bought so cheaply but with such pride; and possibly rejoice to find his stodgy relatives suddenly aware, as bid comes swift on bid, that he was no selfish idiot, after all, but something curiously like the saviour of his family!

Davis M. Lapham
(1931 - 1974)

Mineralogy has lost an outstanding scientist, and mineral amateurs a guiding spirit, in the death on Dec. 20, 1974, of Davis M. Lapham.

Davis became interested in minerals in 1949 while a high-school student in Glens Falls, New York. In attending an adult education course in geology and mineralogy, the fascination of minerals was brought home to him. His teacher was the well-known collector, Elmer B. Rowley, whose personality sketch was done by Davis for the *Mineralogical Record* (Vol. 2, No. 1, 1971). That led him after college to graduate work in mineralogy at Columbia University where he received his M.A. in 1955 and Ph.D. in 1957. In 1955 he was awarded the Kunz Memorial Prize of the New York Mineralogical Club for his paper "Epidote from Hawleyville, Connecticut," later published in the *American Mineralogist* (Vol. 42, 1957, p. 62-72). This paper, based on M.A. studies, revealed the touch of a creative scientist. Not only were the descriptive data and the geology and mineral paragenesis given exhaustive treatment, but epidote itself was investigated in a far-reaching, interpretive, optical and x-ray study. As an outgrowth of his Ph.D. thesis on chromium chlorites, there began Dave's special interest in the chlorite and serpentine minerals. He came to be regarded as a top expert in their research; and it was to him in the sixties that cores from the Mohole deep-sea drilling project were sent for study of their serpentine-mineral content.

In 1957 he went to the Pennsylvania Geological Survey in Harrisburg, to set up and direct a mineral-research department under State Geologists Carlyle Gray and, later, Arthur A. Socolow. From his laboratories came a stream of reports on Pennsylvania minerals, their occurrences, geochemistry and economic geology. Mineral amateurs and popular education were not forgotten, and many contributions in layman-oriented publications and services to effect closer ties with nonprofessional groups were made. The G-33 Survey Bulletin "Mineral Collecting in Pennsylvania," co-authored with Alan R. Geyer, is a model of its kind, has gone through three editions, and continues undiminished in popularity among collectors, students and the public.

Davis was the author and co-author of about sixty publications. Some of his most important scientific contributions in these have been: investigation of state' minerals and their occurrences; research on chlorites, serpentines and associated minerals and rocks of Lancaster County; geology and mineralogy of the Cornwall, Pa., magnetite deposit; research elucidating the structural evolution and concerned with the dating of serpentinites in southeastern Pennsylvania. A recent major work, co-authored with Carlyle Gray, was Bulletin M-56 of the Pennsylvania Geological Survey (1973, p. 1-343), "Geology and origin of the Triassic magnetite deposit and diabase at Cornwall, Pennsylvania."

He gave no less dedication to the groups and causes involved with amateur mineralogy. He was one of the founding members of Friends of Mineralogy and extremely active in its growth, outreach and organizational development. He was chiefly responsible for FM's nation-wide locality-preservation program; and he was a guiding force in the vigorous educationally-oriented activities carried on in Pennsylvania by FM Region 3, the largest and most active of any FM regional group. He was the fellow collector and friend of many in this group. But even more, his encouragement and aid reached out to mineral amateurs and their clubs everywhere.

None of this pictures the man. He was slight of build; a courteous gentleman, with a keen wit and twinkle in his eye; modest in demeanor, yet showing a warmth and regard for others that made him the friend of all. He remained always a deeply-dedicated scientist, a perfectionist in every job he did, undeviating in his search for knowledge, understanding and truth. For many years he fought a quiet valiant fight against the relentless illness, diabetes, which sapped his strength and finally took his life. He never gave in to it, in work or outlook. To his wife, Nancy, and his daughter, Heather and parents, we express our sympathy and sorrow. His loss of talents and creative science is to all of mineralogy; to us, it is of co-worker and friend. But let us remember that if we follow his example, and uplift our eyes to the marvel and true meaning of the minerals he loved, his spirit abides with us still.

Arthur Montgomery

FM friends of mineralogy

TRY A MINERAL SYMPOSIUM

by David E. Jensen
FM Director and past-President of the
Eastern Federation

Several excellent objectives have been chosen by FM in the field of mineralogical education. The aims to expand knowledge about minerals, their occurrence and associations, has great merit, and deserves more attention and positive action. The mineral symposium is one of the ways in which these objectives can be explored with very practical and worthy accomplishments.

FM's region #3 is among the areas that have taken initial steps to accomplish these objectives and the results have been very gratifying. The programs of their annual meetings have been developed to increase basic information about minerals, particularly the minerals of Pennsylvania. It is possible for the participants to hear reports by authorities on the minerals and their localities as well as to see and study actual specimens.

The member societies of the Federations usually include some study of descriptive mineralogy in their *raison d'etre*. Historically, some of the earliest mineral clubs were originally established to increase knowledge about the minerals of their own areas. The New York Mineralogical Club (founded in 1886) listed the minerals of New York City as its focus of interest. The Mineralogical Society of Philadelphia (founded in 1892) originally expressed the wish to encourage studies of the minerals found in the rocks of that city. When the Rochester Academy of Science was incorporated in 1881, it announced that one of its objectives was to study and publish information about the natural history of its region. Interest among academy members was first centered on the glacial geology of western New York, but it has now turned more toward the organization of mineral and other scientific symposia. All three clubs mentioned belong to the Eastern Federation.

The current need for more regional meetings with in-depth mineral studies on the agendas has come about because of a growing public and academic demand for extra-curricular experiences in the field of mineralogy. In recent years there has been greater use of sophisticated analytical methods, such as X-ray diffraction and electron probe, in research on the chemistry and the internal crystallographic structure of minerals. This has been a logical advancement of the science, yet it has sidetracked many investigations and volumes of literature on descriptive mineralogy that were so prevalent in previous decades. The great needs for classroom space in colleges has often relegated fine museum and study specimens to the oblivion of attic or basement storage. The increasing value of fine minerals often tempts pilferage even though good security may be available. The boards of many museums look nowadays at annual attendance figures and then make judgements on the future and the content of exhibits. Many fine mineral collections may gather dust when money is not available for research and other use is not proposed for the specimens. The "light ahead in the tunnel" for both FM and the Federations can be increasing use of well organized regional meetings and mineral symposia that should lead to greater educational enrichment for all.

The main ingredients of a symposium are people, the place, the materials and financing. The people include the program organizers, the participants in the program and those who attend the meetings. There are many fine potential regional centers where such meetings can be conveniently held. They should be within a 500 mile radius of an area where there would be experts and professionals who would be eminently qualified to speak or participate in panel discussions. Places to hold meetings are not difficult to find. A college, school or museum may have suitable space and good audio-visual facilities which are essential for slide programs. Parking space should be ample with good access by car from highways. Motels or hotels can be used as they combine lodging, food services, and meeting rooms as well. It is also highly desirable to have available suitable facilities for use of mineral specimens in display and/or study.

Typical examples of minerals are needed to provide the symposia participants with good examples of the materials of the earth's crust of the region.

A very respected educator has recently predicted that there will soon be a return to much greater use of specimens for classroom study and research in both the earth and life sciences at college and secondary school levels.

The financing of a meeting need not be a difficult problem. The meeting should be self sustaining with all costs balanced by receipts from registration fees. Costs would include the rentals of facilities plus honoraria and travel-lodging-meals expenses for speakers and panelists. It is essential to plan the timing of the meeting, its advertising, and the scheduling of the program so as to avoid conflicts and obtain maximum attendance. If local industries or schools are given adequate advance information, they may be willing to share in the costs of the meeting or provide special services.

Symposia can be an exciting challenge to both FM and to the Federations. There is no limitation to the topics that can be covered. Professionals and advanced amateurs from both groups can develop new educational directions and can lead the way. When one participates in such a project, one's own educational horizons become broadened.

One of the topics that should receive attention in mineral seminars is mineral nomenclature. This is especially important for the amateur and exhibitor. Even the professional has much to gain from this. When the authorities who write mineral texts disagree on treatment of some matters, the dilemma of the beginner, even the advanced amateur, can be very frustrating. The efforts of one who wishes to set up a prize-winning display may become an expensive and mind-boggling experience as one starts to prepare accurate, up-to-date mineral labels.

Mineral symposia can be a common meeting ground for closer coorperation between FM and Federation members, as fellow participants of organizations pursuing related educationally beneficial goals.

All news and material relating to FM, for Record publication, should be sent to Dr. Arthur Montgomery at: Dept. of Geology, Lafayette College, Easton PA 18042.

FOCUS ON FORT LEE

A Symposium on the Minerals of the Fort Lee, N.J. area
Presented by
The Micro-Mineral Study Group
Sponsored by
The Earth Science Field Association, Rutherford Campus
& Dr. Lois Luedemann
Date—Saturday, April 12, 1975 - 10 A.M. to 5 P.M.
Place—The Round Building
Fairleigh Dickinson University, Rutherford, N.J.

Restaurants Located Nearby or Bring Your Own Lunch
Lecture & Slide Presentation 1:30 P.M. to 3 P.M.
"Geology of the Palisades"
by Dr. Kurt Lowe, Prof. of Geology - City College of N.Y.
Fort Lee Micro Mineral Suite to be Presented to the
Paterson, N.J. Museum and Received by
Thomas A. Peters, Director
Program of Slides on Secondary Minerals
3:30 P.M. to 5:00 P.M.

AN AMERICAN MINERALOGIST
PART IX

QUARTZ CRYSTAL WORK

The last ten years (1942-1952) of Samuel G. Gordon's life were marked by a variety of experiences and occupations but they also reflect elements of deep discouragement and tragedy.

This period begins with his notable contributions to the war effort in the quartz-crystal oscillator-plate industry. He was on leave from the Philadelphia Academy of Natural Sciences from June, 1942, to August, 1943, in order to work with one of his former protégés and associates, William Parrish, in the quartz crystal coordination section of the U. S. Army Signal Corps. There had been a sudden tremendous demand for quartz oscillator-plates for use by the armed services in radio transmitting and receiving frequency control. To produce astronomical numbers of these in a short time from a few newly-created industrial centers was the critical need. Sam Gordon proved himself one of the most talented and practical-minded of the small group of crystallographers who in large part made it possible for that wartime demand to be successfully met. His work had mostly to do with developing new mass-production procedures, based on his expert knowledge of crystallography and optics, for the accurate orientation, cutting and testing of the vast quantity of rough pieces of optical-grade quartz flown in by the Air Force from Brazil. His innovative procedures played a crucial part in creating the mass-production methods necessary. The high merits of Sam's achievements here, both scientific and practical, were fittingly described later by Parrish in his "Memorial of Samuel George Gordon" (*Am. Min.*, **38**, 1953, pp. 301-308), which contains a complete list of Sam's publications.

In 1945 a special issue of *The American Mineralogist* (**30**, 1945, pp. 205-468) was devoted to a symposium on quartz oscillator-plates, with Sam one of the major authors. His articles included "The inspection and grading of quartz" (pp. 269-290); also with William Parrish as co-author, "Orientation techniques for the manufacture of quartz oscillator plates" (pp. 296-325), "Angular control of quartz-cutting by X-rays" (pp. 326-346) and "Cutting schemes for quartz crystals" (pp. 347-370). Sam furthermore was co-athor with Parrish of four manuals on the grading, cutting and production of quartz oscillator-plates put out in 1943 by the War Department.

RESEARCH AND PUBLICATIONS DURING THE FORTIES

Sam was back at the Academy by 1944 and as busy as ever with mineral research and a series of mineralogical publications. One of these was a major contribution to descriptive mineralogy, an eighty-page monograph, "The mineralogy of the tin mines of Cerro de Llallagua, Bolivia", printed in the *Academy Proceedings* (**96**, 1944, pp. 279-359). This stands today as one of his finest scientific contributions, not alone for the crystallographic data, wealth of exquisite crystal drawings and very complete mineral descriptions, but also for its thorough treatment of the geology and elucidation of the mineral paragenesis and occurrences.

His interest in all kinds of South American minerals never lessened, and during the forties he collaborated with an Argentine mineralogist, Victorio Angelelli, on the descriptions of two new minerals from Argentina, sarmientite (*Notulae Naturae*, *Phila. Ac. Sci.*, 92, 1941) and sanmartinite (*Not. Nat.*, *Phila. Ac. Sci.*, 205, 1948).

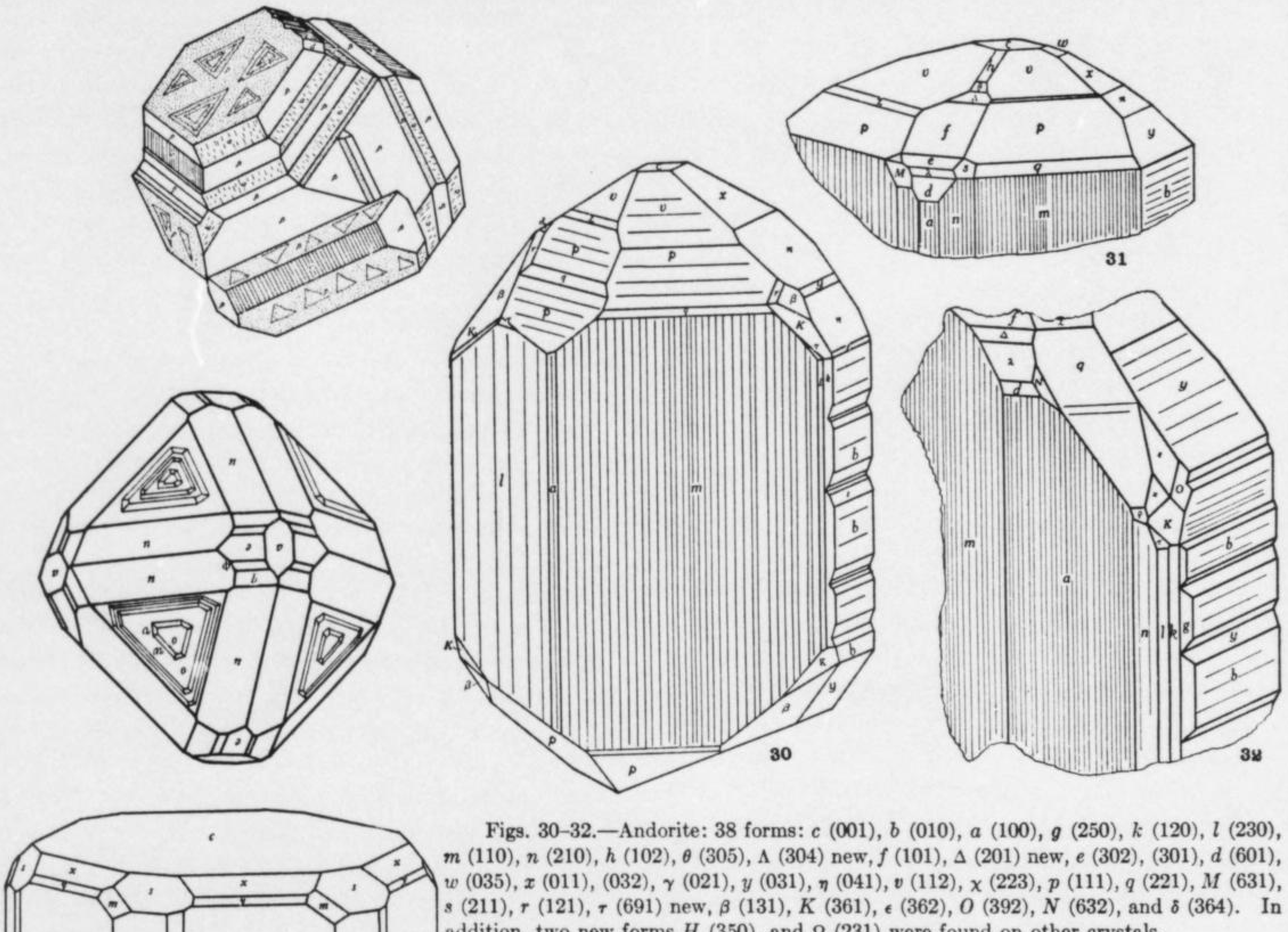
There were no more major foreign expeditions, but very active mineral collecting on a smaller scale continued, especially in New England, southern Ontario and Quebec, and the American Southwest. The desert areas of the latter region especially interested him, because of the specialized weathering conditions, since it tied in with his field studies of similar types of minerals he had collected in the Chilean desert. In 1944, and in summer four-week vacation periods during 1946, 1947 and 1948, he pursued field studies and specimen collecting in parts of southern Colorado, New Mexico and Arizona. In 1946 he studied the vesicular feldspathoid-bearing lavas of Johnson Mesa, New Mexico. On a number of occasions he collected at the well-known Mammoth mine in southern Arizona, and secured from miners and above all from the resident mining engineer, E. B. Daggett, many specimens of its rare and beautifully crystallized secondary copper and lead minerals. This led to his making a special crystallographic study of the richly-modified leadhillite crystals from there, in which at least fifty tiny crystals were measured and a multitude of crystallographic forms computed. Magnificent crystal drawings were the result, but this study, together with related research on the associated minerals hydrocerussite and paralaurionite, never was to be completed. It is to be hoped that these important and new crystallographic data, luckily preserved at the Smithsonian through the foresight of Bertha Gordon and Louis Moyd, may be brought out eventually in published form.

One more description of a new mineral, his ninth and last, was a by-product of his study of the minerals of the Mammoth mine. This was a lead-copper carbonate-sulfate to be named wherryite in honor of Dr. Edgar T. Wherry, his greatly respected teacher and long-time associate and friend. The paper describing this species, which was co-authored by J. J. Fahey of the U. S. Geological Survey and E. B. Daggett, the discoverer of the mineral, was not published until 1950 ("Wherryite, a new mineral from the Mammoth mine, Arizona": *Am. Min.*, **35**, 1950, pp. 93-98).

NON-PROFESSIONAL ACTIVITIES AND ASSOCIATIONS

Little has been told in this biographical series about Sam Gordon's personal life and those activities and associations set apart from his professional curating and mineralogical collecting and research. But these too form an essential part of the story.

Ever to be noted was his powerful guiding influence among mineral amateurs. Part of his efforts had always been expended in that direction, ever since his own early days of collecting, and they never weakened. For as long as he remained at the Academy, he was the driving spirit behind the Philadelphia Mineralogical Society; and in large part due to his stimulus, it remained one of the most active and best-attended of any mineral amateur group in the country. He was always responsible for great numbers of short collecting trips by amateurs throughout Pennsylvania and adjoining states. The strong interest



Figs. 30–32.—Andorite: 38 forms: c (001), b (010), a (100), g (250), k (120), l (230), m (110), n (210), h (102), θ (305), Λ (304) new, f (101), Δ (201) new, e (302), (301), d (601), w (035), x (011), (032), γ (021), y (031), η (041), v (112), χ (223), p (111), q (221), M (631), s (211), r (121), τ (691) new, β (131), K (361), ϵ (362), O (392), N (632), and δ (364). In addition, two new forms H (350), and Ω (231) were found on other crystals.

***Fig. 1.* Selected crystal drawings by Gordon of minerals from Llallagua (The mineralogy of the tin mines of Cerro de Llallagua, Bolivia, *Proc. Ac. Nat. Sci. Phila.*, 96, 1944): (from top to bottom) twinned stannite (p. 304, Fig. 10), pyrite (p. 310, Fig. 20), apatite (p. 334, Fig. 56) and (right) andorite (p. 320, Figs. 30-32).**

in Pennsylvania minerals still active today, especially among several large amateur groups in and around Philadelphia, without question stems from Sam Gordon's example, his numerous publications on state minerals, and his many friends and admirers who continue to feel his presence among them.

Among his many other contributions to amateur mineralogy and collecting, and not mentioned before in this biography, was his "Directory of American and Canadian Mineral Collections". It had been published in 1933 (*Am. Min.*, **18**, 1933, 313-324, 359-366, 407-418, 457-468, 504-509). Professional mineralogists have been slow to follow that example, and it is only recently that a *Directory of World Collections* has been compiled and published by the International Mineralogical Association.

What of Sam Gordon's home life, his non-professional interests? In 1931, he had married Bertha May Landrum, a school teacher from Texas. It proved an extremely happy marriage, with a congenial and close companionship for as long as he lived. When the discouragements came, she helped keep him on a steady course. And her loyal and genuine interest in his mineral work—she accompanied him on most of his shorter collecting trips—proved a constant encouragement both in the earlier times as well as in the later period when things began to deteriorate at the Academy. A great comfort too was his close association with such warm old-time friends as John Frankenfield, William Knabe, Fred Oldach and Harry Trudell.

Sam's great love was music, which remained his abiding interest, in addition to minerals, throughout nearly all of his life. Bertha Gordon, equally fond of music, tells of Sam's willingness to stand in line for hours, even in rain or sleet, in order to secure for a Saturday-afternoon concert at the Academy of Music a fifty-cent seat in the uppermost tiers of the "Peanut Gallery."

What made a home and comfortable home-life possible, was the fact that both Sam and Bertha held jobs. But those jobs paid so little, that simple living and drastic economising were always necessary.

FINAL YEARS

Sam Gordon's last years at the Academy, from 1945 to 1949, were marked by a growing sense of frustration and discouragement. The realization must have slowly come to him that all he had accomplished here rested on shaky ground so far as institutional recognition and permanence were concerned.

Funds had never been forthcoming for mineralogical equipment, and he had carried on his extensive research program with hardly more than a few battered and inadequate items of apparatus. With the marvelous tool of x-ray crystal diffraction beginning to come into use in mineralogical laboratories, he was determined to secure such equipment for the Academy. He even took a short course in 1948 under Fankuchen at Brooklyn Polytechnic Institute in x-ray operational procedures. And he did manage to get hold of a second-hand, war-surplus x-ray generator at very small cost. But for specialized diffraction cameras needed for single-crystal x-ray study, he was forced to try to construct these himself. Despite such almost insuperable handicaps, he put the wholly inadequate equipment to some slight use in mineral identification; yet how could anything of lasting value be achieved with no supporting funds!

***Fig. 2.* Sam and Bertha Gordon, not long after their marriage in 1931.**

In 1948 disaster struck. He returned from a trip to find his laboratory rooms on the second floor taken over by a newly-enlarged Department of Limnology. It was a total surprise; there was nothing he could do. At the same time, an administration communication informed him that in the future he would be required to go to industry and other outside sources for departmental funding; and that without such outside support, Sam's department could be expected to shrink and become increasingly inactive.

Some time later, Mr. Keeley died. He had been Sam's long-time friend, associate and boss, as well as for some years still remaining head mineral curator despite increasing inactivity due to advanced age. When Sam subsequently asked to be advanced to curator, he was told that he would have to continue in the position of associate curator, with the likelihood of someone else being appointed over him to Mr. Keeley's position.

There wasn't much left for him to do but resign, which he did in 1949. What must have made it an especially painful decision, was knowing that his thirty-six years of serservice were being recognized in this way by the Academy—with all he had done to make minerals and mineral research a creative force in this place, now fading off into a dark and hopeless future.

One must try to be fair in judging the Academy's treatment of Sam and his department for what appears on the surface, at least from any mineral-minded viewpoint, as both heartless and unjust. For there are always two sides to such controversial personality-involved matters. We must recognize that Sam could be cocky, set in his own way, disdainful of different viewpoints, and at times not easy to get along with. Some of his departmental reports reveal this side. The creation of the new limnology department, under the direction of a noted scientist, was an important progressive step for an old-fashioned institution to have taken. The resultant activities and research involving a large staff would touch many lives and lead into new conservationally-oriented directions. Sam's facilities and work, in contrast, mostly represented a one-man department, concentrated in a specialized and relatively unchanging field. Thus, there is a case to be made for the Academy in defense of its action.

But what still can be censured is the manner and spirit in which the action was taken. The tone of the directives to Sam (which are to be found in his records) was heartless where it could have been kind; mention of Sam's scientific and curatorial contributions in behalf of the Academy could have been made; and who ever deserved better, on performance and length of service, to be promoted to curator!

The clearest evidence to place the Academy's action in an unfavorable light concerns the aftermath. After Sam resigned, there was no active mineral curator for thirty years. Without proper care and use, one of the greatest of U. S. mineral collections was allowed to so deteriorate, lend itself to mishandling, and lose its up-to-date scientific stature, that it will never be able to reoccupy its former position. Its recent upgrading and improvement through renewal of curatorial care has been in large part the work of volunteer mineralogists outside the Academy, especially some of those active in Friends of Mineralogy, whose concern is inspired by Sam Gordon's example. This effort, combined with a changed attitude by a new Academy administration and vigorously promoted by two successive heads of the Academy's geology department, brings the Vaux collection and Sam Gordon's lifework back into fresh meaning and usefulness.

After Sam's resignation in late 1949, only a little more than two years were left. He had to find a new job, and turned to industry and the type of crystallographic work he had done so admirably for the Government during the war. He first held a position as a senior metallurgist doing crystallographic and x-ray research on intermetallic compounds and high-temperature alloys at Oak Ridge. When that project came to an end in 1951, his record of creative achievement brought him to the famed Los Alamos Scientific Laboratory in north-central New Mexico. A section leader there in the Chemistry and Metallurgy Research Division needed a crystallographer for x-ray crystal-structure analysis. It seems from the record that Sam was brought there under a misapprehension; for his experience in crystal-structure work, of the type required at Los Alamos, was wholly insufficient. For a short time he and Bertha greatly enjoyed their beautiful mountain surroundings. There were fine opportunities to collect minerals and he played an important role in starting an active mineral club at Los Alamos. But his inadequate experience, in the highly specialized research he was required to do, worked against him; and the section leader who had sought his services, appears to have been almost as heartless as the Academy in forcing Sam's resignation. After a little less than a year, he and Bertha had to leave.

Another disheartening wrench, to leave the mountains of New Mexico. And one more job had to be sought. It was found with the General Electric Company, in its Air Nuclear Propulsion Division, near Cincinnati, Ohio. But before that, during the winter of 1952, he had to undergo a serious operation in Philadelphia. After recuperation, several weeks were spent in Pennsylvania seeing old friends and even making a couple of collecting trips to two favorite localities, Cornog and Blue Ball. By May he and Bertha were getting established in Cincinnati. On May 17 he suffered a heart attack, perhaps related to the earlier operation; and he died before reaching the nearest hospital. He was not quite fifty-five years of age.

AN AMERICAN MINERALOGIST

It is important, for two compelling reasons, to evaluate Sam Gordon's career as an American mineralogist. There is, first, the need to do justice to his contributions to mineralogy, in different ways, in these two fields. There is also the fact that his career strikingly reflects, and so helps to make clear to us, the changes which so drastically occurred in all of mineralogical science during most of his lifetime.

The record of his scientific contributions, so fittingly described in the Parrish memorial article to which reference has been made, is undeniably impressive. Of a total of about eighty mineralogical publications, close to fifty are scientific papers and monographs. These are chiefly on descriptive mineralogy, morphological crystallography, and mineral paragenesis. Many mineral occurrences treated in his papers are related to and explained in terms of their geological surroundings. Some of the reports are lengthy enough to be of book size and treat the mineralogy of whole states, mining districts and large-scale collecting areas. Regions extensively covered include those of Pennsylvania, far southwesterly Greenland, and numerous mining localities in Bolivia, Chile and Peru. Standing out among the shorter papers, are the descriptions of eight new species; two more so described were later invalidated. The scientific stature of these publications is proven by their widespread use by mineralogists today through the inclusion of much of the contained data on a considerable number of species in such standard works as *Dana's System of Mineralogy* and the Larsen-Berman Optical Tables.

Two facts of unusual interest stand out in regard to this published record of scientific achievement. Nearly all of the publications appeared in journals of the Philadelphia Academy which reached few professional mineralogists. Even with a wide distribution of reprints, which seems to have been done, one both wonders why this unusual publishing procedure was followed (unless it was to insure prompt publication) and marvels that the Gordon research data nevertheless attained such ready acceptance and standardized usage. The second point is that this wealth of invaluable data was obtained by a largely self-taught investigator, isolated from other researchers, and with an absolute minimum of equipment and laboratory facilities. These two facts surely make Sam's scientific contributions still more impressive. At the same time, an added point of interest, and bearing on his standing among fellow scientists, is that the rather obscure publishing medium and the lack of close association with other mineralogists, kept his work from being widely recognized in mineralogical circles, especially during his later career.

His record in amateur and popular-educational mineralogy is no less remarkable. He proved himself one of the great field collectors of all time; most of the material he researched, indeed, resulted from his own field discoveries. He turned up rare and beautiful minerals wherever he went, and so often where others had tried and failed before him. No collecting area was too remote or difficult of access to deter him. And his stories of expeditions to far-off places are classics of their kind. Because of his deep appreciation of minerals, his curating at the Philadelphia Academy was a labor of love, out of which was assembled one of the finest of institutional collections. His own exhibits and the Mineral Hall he created remain today much as he built and designed them. The collecting and study of Pennsylvania minerals, still so active today, stems from his example and continuing guiding influence.

What else of special note stands out in his record? Among other accomplishments was his outstanding performance in the quartz oscillator-plate industry, his encouragement and training of a number of protégés who have gone far in science, and his major role in starting *The American Mineralogist.* These not only mark important and creative achievements, the wide variety of subjects and talents shown attest also to the versatility of an exceptionally gifted individual.

To try to define his place in American mineralogy is not easy. His work and interests span too wide a field. He was equally a scientist and an amateur-oriented collector. We cannot measure him by one side alone. In striking fashion, his career was closely bound up with the course of mineralogical science during the same period. When he began his work, mineralogy was a descriptive discipline. As he continued his training and career, becoming expert in mineral description, optics and geometric crystallography, these very concerns of the classical mineralogist sank into lesser significance, coming to be regarded simply as tools utilized in the acquisition of descriptive data, before the revolutionary onslaught of x-ray and analytical crystallography. Gordon, with few outside contacts and no funds for new equipment, was powerless to change the direction of his "old-fashioned" research. That he tried, and could have successfully modernized his approach, is proven by what he did do creatively with a few inadequate items of x-ray equipment.

But a vital fact remains. Sam Gordon, behind the times as a mineralogist in his final years, nevertheless never lost his amateur-oriented and popular-educational concern for minerals which the over-specialized mineralogists of the present seem to largely lack. The subject of minerals is more than a science: it is, indeed, part of nature; it is also the specimens which collectors dig out of the earth and place in collections available to the scientist for study; it is, further, a broad field of interest and endeavor inseparably bound up with society and culture. Mineralogy remains a relatively isolated and little-known science as long as it studies the individual trees and forgets the forest. The amateur has his part to play in mineralogy too. Perhaps only when the amateur uplifts his view toward the science — and the professional sees the specimens collected by the amateur as the cornerstone of all he does — can both come together in a larger mutually-beneficial fellowship.

Sam Gordon seems to have been one of the very few ever to have represented and practiced to an equal degree the two widely-separated approaches to the subject of minerals. He thus served, and so makes more real to our view, a greater subject. Let us therefore remember him, as a greater American mineralogist.

QA column

Q. Enclosed is a small specimen of fluorite from the Plumos Mountains, Mohave County, Arizona. Its color is green, but under artificial light it is colorless, or a light violet color. Is this an unusual thing for fluorite? I can find no reference to this property in fluorite, or any other mineral except chrysoberyl, variety alexandrite. Is there a specific name for this phenomenon?

David Shannon
Mesa, Arizona

A. We are indebted to George R. Rossman of the California Institute of Technology, for the following answer to this inquiry.

"Specimens of green fluorite which show apparent color changes under different sources of illumination are not difficult to find if one is willing to look carefully for a subtle effect. What I have observed most commonly are specimens which are light green in sunlight but which appear pale grey-green to almost colorless under incandescent lights. What is rare is to find one which shows the color change in a spectacular fashion. Several minerals, synthetics, and laboratory chemicals show color changes of this type, but few are as spectacular as alexandrite. The hydrated iron sulfates coquimbite and kornelite show easily noticeable color changes. Both are lavender under incandescent light but bluish-grey under sunlight. The effect has been called the "alexandrite effect" (White, *et al.*, *Amer. Mineral.* **52**, 867-871, 1967).

All of the minerals which show this effect have regions of maximum absorption of visible light between 560-590 nm (yellow-green to orange) and between 420-430 nm (violet) and show maximum transmission of light in the 460-490 nm (blue-violet to blue) and in the 660-680 nm (deep red) regions. The effect occurs in part becausethe relative amounts of red and blue-violet light differ among various sources of light. Incandescent illumination is especially poor in the blue-violet compared to sunlight. In the perception of color of a mineral specimen, the eye is sensitive to the relative amounts of light in the blue-violet and deep-red regions, especially when the central portion of the spectrum, the yellow-greens through orange, is reduced in intensity by absorption by the specimen. It is the combination of the particular color response of the human sensory system and the spectral distribution of the source of illumination which give rise to the "alexandrite effect".

Q. I obtained from a mineral dealer in Mexico several excellent specimens of celestine with fluorite. The celestine is colorless to white, and several crystals are up to 30 cm in length (see sketch). The fluorite is in cubes with a colorless core and a medium purple exterior composed of smaller cubes in parallel orientation.

The dealer said at first that they came from Durango, then he said Coahuita. As he was not above selling "fishtail" gypsum glued to matrix, I don't necessarily believe either. Do you have any information that might indicate the locality of these specimens?

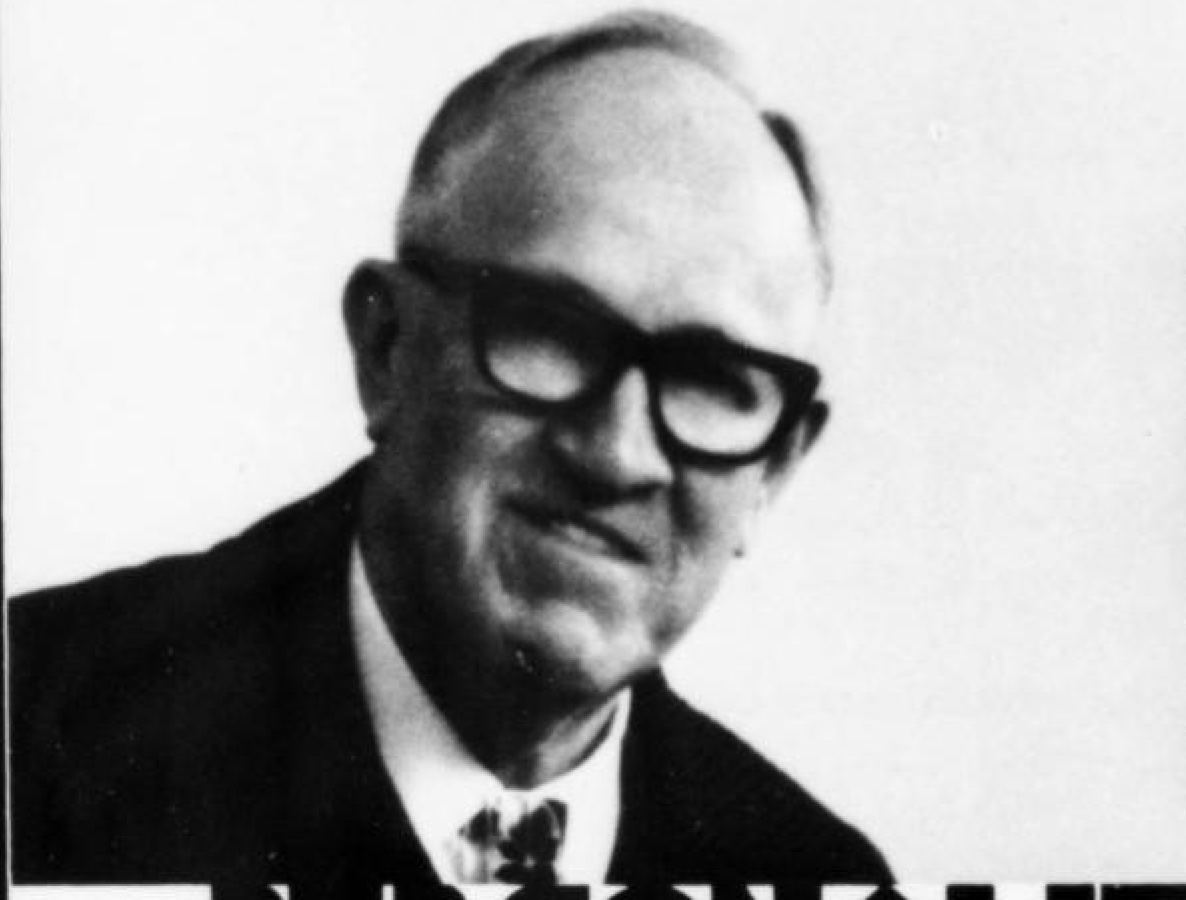
Douglas L. Rickman
Socorro, New Mexico

A. These specimens are moderately abundant and there seems little doubt that the correct locality is Coahuila, in Mexico.

Q. I have recently seen advertised "crystals of primary malachite". I cannot find, in any of our reference books, any information concerning malachite as a primary mineral. Would you please explain how this can occur and why the books fail to make note of it?

Marvin H. Deshler
Phoenix, Arizona

A. The term "primary malachite" is clearly a misnomer. It has been used incorrectly to describe individual crystals of malachite, as opposed to the more common form of malachite which is a replacement of other minerals, usually azurite. In the paragenetic sense malachite is never a primary mineral.



PERSONALITY SKETCH

DAVID E. JENSEN

by Paul Desautels

Trying to document the years of David E. Jensen's involvement with mineral specimens and the productivity of those years is a formidable task. If a detailed record had been kept it might assume the volume of a set of "Presidential Papers" and would include the names of everyone, here and abroad, who had an interest in minerals. Now, Dave has retired from 44 years of service to Ward's Natural Science Establishment of Rochester, New York. Obviously, to those who know him well, he has not retired from mineral specimen activities.

Ward's has been continuously in the mineral specimen business longer than any other supplier in the United States. During its long business career some rather well known and illustrious collectors have been in charge of their mineral department. Henry Ward himself began the tradition of minerals at Ward's to be followed later by such as George L. English, Charles Vance and finally, in 1930, by Dave Jensen.

Dave began his long tenure at Ward's in an inauspicious way but eventually became so well known that his name and Ward's seem synonymous to most collectors and curators. Probably during his time he has had pass through his hands more fine and rare minerals than anyone living except perhaps curators of the world's greatest collections. In the process he has undoubtedly encouraged scores of people, amateur and professional alike, to become deeply involved in mineralogy. Dave recalls that his first day at Ward's was two days after a disastrous fire on September 30, 1930. Hawley Ward had asked Dr. Alling, member of Ward's Board, to find help for cleaning up the debris. Dr. Alling promptly asked Dave and another student at the University of Rochester to volunteer their help. Then, in the winter of 1931, Dave became the first person to be hired by Dr. Gamble who, as the new president of Ward's, faced the task of rebuilding the company—literally from the ashes. Although Dave's chores have not been limited to the Mineral Department, this is where his interest centered and through the years—becoming a collector of books, glassware and other objects, a nature lover and an inveterate traveler—minerals were never far from his everyday occupations.

Along the way he met Katherine who had been busy testing Kodachrome film at Kodak before they began to market it. For Kay, minerals proved a perfect set of subjects. Before long, they joined their interests, married, and have both been almost totally involved with mineral specimens, and those who work with them, since that time.

Dave has never been daunted by the problems of handling minerals in any quality or quantity. On one occasion he was offered in exchange several tons of ore minerals by the Smithsonian. Unfortunately, the material was in the form of boulders weighing a ton or more each. Not to be discouraged, Dave went charging off to Washington in a flat-bed trailer truck, the enormous masses were loaded on by heavy crane, and all 22,000 pounds were hauled back to Rochester to be dumped and nibbled at for years to help make up some of their famous mineral, rock and ore sets.

Now, in retirement, Dave has not hesitated to take on new formidable tasks. In his capacity as President of the Eastern Federation of Mineralogical Societies he obviously is a glutton for punishment in the service of mineralogy. He is still available at a moment's notice as an adviser to Ward's also.

In short, through his years of active association with specimen mineralogy, Dave has become one of our legendary people in his own time. Our congratulations are due him on his retirement but he is also warned that his friends in mineralogy are going to count on his continued support.

In recent testament to Dave's numerous contributions to mineralogy, he was named a Fellow in the Mineralogical Association of America.

Note: The editor is anxious to have more readers submit Personality Sketches for publication in the Mineralogical Record. This will be a regular feature only if more such sketches are received. Ed.

The I.M.A. Meetings in Germany 1974

by Richard Gaines, **Hoffecker Road #1, Pottstown, Pennsylvania 19464**

INTRODUCTION

The International Mineralogical Association (IMA) was founded in 1958 to coordinate the work of mineralogists throughout the world, and to try to bring order into some of the problems which have beset the science since it began.

There are no individual members of the IMA, only countries which, each through a national mineralogical organization, have opted to join this cooperative effort. From the original group of 14 countries, the membership has expanded to a present roster of 29 countries.

The national organization representing each country appoints individual mineralogists to fill the posts in any or all of the seven commissions which carry out the main work of the IMA. These commissions cover the following fields:

Abstracts
Mineral Data and Classification
New Minerals and New Mineral Names
Museums
Teaching
Cosmic Mineralogy
Ore Microscopy

Appointments are normally for four-year terms.

The IMA also elects an overall governing board consisting of officers and councilors. There are no dues to the organization, and expenses of the various commissions and officers are normally borne by the local organizations with which the particular members are affiliated.

Meetings are held every two years. In the years of the quadriennial International Geological Congress (IGC), the IMA meetings are held at that Congress, such as in Prague (1968), Montreal (1972), and Sydney (1976). The alternate meetings are traditionally held in the city of residence of the president of the IMA, as Tokyo (1970), Berlin (1974) and Novosibirsk (1978).

In between the biennial meetings, the main work of the IMA is carried on by the members of the various commissions, and they work very hard at it. For example, in the Commission on New Minerals and New Mineral Names, at the current rate of discovery, about 50 to 60 new minerals are evaluated annually. Abstracts must be prepared for each one, these duplicated, sent out to all commission members, evaluated, voted on, tabulated, and reported. This is truly a monumental task for which the members receive no special compensation.

MEETING ACTIVITIES

The meetings of the IMA which are held jointly with the IGC necessarily differ somewhat in format from those where the IMA meets alone, because of the necessity of coordinating those IMA and IGC activities which would be similar. Nevertheless, each biennial meeting is built around a series of technical sessions in which papers are presented covering a wide range of subjects; commission meetings; field trips to places of mineralogical interest; and social activities. The duration of meetings is normally about a week, although pre-meeting and post-meeting field trips may stretch this time considerably.

Meetings are open to attendance by any interested individual who is willing to pay the registration cost, regardless of affiliation; however, voting on matters considered by the commissions is of course limited to the duly appointed national representatives.

1974 MEETINGS

The Ninth General Meeting of the IMA was held in West Berlin from September 12 through 14, and at Regensburg, Bavaria, from September 17 to 18. In between, on September 15 and 16, most of the attendees joined one of four excursions which had been organized, all of which included travel by bus from West Berlin to Regensburg.

Over 400 persons from 38 countries had registered in advance for the meetings. The actual number attending was somewhat greater, however, due to last-minute registrants and, especially, to the fact that the Regensburg meetings were scheduled to coincide there with a meeting of the Deutsche Mineralogische Gesellschaft (German Mineralogical Society) where the total attendance swelled to over 800 persons.

In Berlin, the meetings were held at the Technische Universität Berlin. About 180 technical papers and symposia were scheduled altogether at Berlin and Regensburg, on subjects ranging from the highly technical (i.e., "An independent check on the validity of the pressure correction in inclusion geothermometry, using hydrothermally grown quartz", "Thermodynamics of experimental sub-solidus silicate systems including mixed volatiles") to those of more general interest, such as "Phosphate mineralogy of the Tip Top pegmatite, Black Hills, South Dakota, U.S.A." and "A new blue axinite from East Africa". Of particular importance to those whose interests include mineral collecting or gems, were sessions on Pegmatites and Pegmatite Minerals; Secondary Minerals in

Ore Deposits; and Gem Minerals and Gemology. This latter group of 12 papers was the first time that the IMA had so recognized the important role which mineralogy plays in the geology of gem deposits and the identification of gems. It included an excellent address by Dr. E. Gübelin of Switzerland, who is recognized today as probably the world's outstanding authority on gems, entitled "Where gemstone research stands today".

The excursions between Berlin and Regensburg included: (1) granites and pegmatites of northern Bavaria; (2) eclogites of the Munchburg mass, Bavaria; (3) a study of metamorphism and tectonics of the Munchburg mass; and (4) a cultural excursion. The first, which the writer attended, was by far the most popular of the lot, and included as its high point a visit to the famous and still active Hagendorf pegmatite, which has produced a wide variety of pegmatitic phosphates in fine specimens. But not the least attraction of this and the other excursions was seeing the beauty of the Bavarian countryside and enjoying the hospitality of the Bavarian people, and especially enjoying the fine Bavarian beer.

At one stop in particular, a granite quarry at Epprechtstein, we arrived at lunch time. As the people piled out of the buses and trooped to a large storage area where freshly broken slabs were piled, we were greeted by the cheerful music of a local brass band, complete with *lederhosen* and typical national costume, which continued to play during our entire stay there. Lunch, consisting of truly incredible meat sandwiches on dark bread, with pickles and draft beer, was waiting, and there was as much of all as anyone cared for.

At Regensburg, the meetings were held at the University. They were a continuation of the program which started in Berlin. After the formal meetings terminated, a further series of nine excursions were available, lasting anywhere from one to four days, including visiting some sites in nearby Austria.

Of course, the principal attraction of any convention or meeting of this sort is, for most of the members, the opportunity to meet and talk with others of similar interests and activities. At the IMA meetings the roster of participants included certainly the majority of the top mineralogists who are active and productive throughout the world. The list included, as a sample, about 30 persons who have been honored by having minerals named for them. Among prominent American mineralogists could be found C. Frondel, M. Fleischer, C. Hurlbut, A. Pabst, P. B. Moore, P. E. Desautels, J. S. White, J. J. Finney, R. Thomssen, S. A. Williams, W. L. Roberts, D. Wilber, and Si and Ann Frazier. As can be seen, this list, which comprises only a small sampling of the U. S. delegation, includes both professionals and amateurs, and the same could be said for many of the other delegations.

Nevertheless, these meetings were predominantly serious and technical and in no sense like a mineral show. There were no dealers selling specimens, although there were representatives of companies selling technical books, and microscopes and other research apparatus.

One of the commission meetings of particular interest to the writer was that on New Minerals and New Mineral Names. The long time chairman of this Commission, Dr. Michael Fleischer of the U.S.G.S., who has held this post in a most important and distinguished way since the founding of the I.M.A., stepped down. Dr. Akiro Kato of Japan was elected to succeed him. This particular commission has at present representatives from 27 countries, who evaluate and vote on all proposed new minerals and mineral names which are submitted to them. The work of this commission has become increaingly influential during the 16 years of its existence, so that at present very few new minerals are proposed anywhere in the world that they do not evaluate, and *no* mineralogical publication of any consequence will now publish a new mineral description or name unless it has previously been approved by the Commission.

Another one of the commissions whose labors are of interest to the collector is the Commission on Museums. Under the chairmanship of Peter C. Zwaan of the Netherlands and Ole V. Petersen of Denmark, the commission has just published the long awaited *World Directory of Mineral Collections*. This compendium is designed primarily to contain information about public, national, or university museums, but a few private collections are also included. As a first effort, it is admittedly incomplete; only nine collections are listed for the U.S.A. and none at all for the U.S.S.R. Nevertheless, it has great utility, especially for anyone planning to travel, and future editions should be even more useful.

IMA publications can be ordered through Miss Marjorie Hooker (Secretary of the IMA), U. S. Geological Survey, National Center 958, Reston, Virginia 22092. They include the *World Directory of Mineral Collections* (1974; $4.00), the *World Directory of Mineralogists* (1970; $3.50), and the *IMA News*, a semi-occasional publication (3 or 4 times a year) containing announcements, reports from Commissions, and other IMA business. The subscription price is $2.00/year.

It was because the President of the IMA from 1970-1974 was Dr. Hugo Strunz of the Technische Universität Berlin, that the 1974 meetings were held in Germany, and he is certainly to be congratulated for the way they were organized and carried out. The new president is Dr. V. S. Sobolev, of the U.S.S.R., which means that after the 1976 joint meeting with the I.G.C. in Sydney, the 1978 meetings will be held in the great research complex at Novosibirsk, Eastern Urals, U.S.S.R.

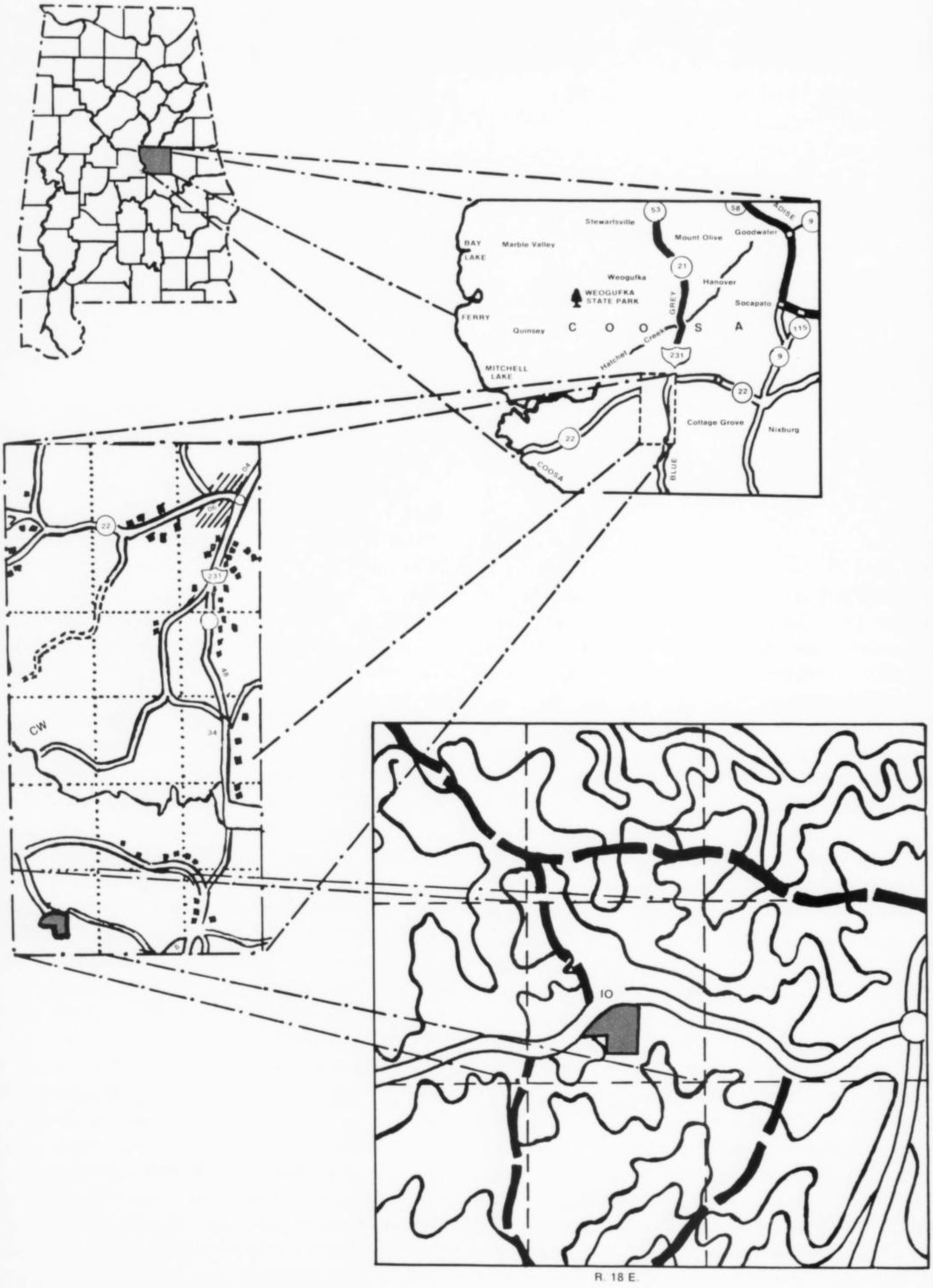


Fig. 1. **Location of Coosa County, Alabama, and the Williams property.**

IRON-MANGANESE PHOSPHATES OF THE WILLIAMS PEGMATITES

COOSA COUNTY, ALABAMA

Peter B. Leavens, **University of Delaware, Newark, Delaware 19711**

Thomas A. Simpson, **Geological Survey of Alabama University, Alabama 35486**

ABSTRACT

The Williams property, Pentonville, Coosa County, Alabama, contains several pegmatite bodies. Intense saprolitic weathering obscures field relations, as does the extensive bulldozing undertaken during prospecting. However, the pegmatite bodies are apparently roughly parallel to the regional foliation of the county rock. They contain quartz-plagioclase-perthite wall zones, perthite-quartz zones with local shoots or poorly developed zones of quartz-muscovite, and quartz cores. Commercial amounts of scrap mica and beryl may be recoverable from the pegmatites.

Masses of iron-manganese phosphate minerals weighing up to 150 pounds have been found in at least two of the pegmatites. The minerals in these masses include rockbridgeite, hureaulite, lipscombite, barbosalite, phosphosiderite, leucophosphite, bermanite, stewartite, strunzite, ferrisicklerite, heterosite, cacoxenite, manganese and iron oxides. The masses display a distinct banding; the inner parts are composed of hydrated species, principally rockbridgeite, barbosalite, and hureaulite, with successive outer bands of ferrisicklerite, heterosite, and iron and manganese oxides. In some of the masses the hydrated species are more or less oxidized and altered and may be associated with phosphosiderite, bermanite, stewartite, strunzite, and manganese oxides. Originally the nodules were probably giant triphylite crystals, although none now remains; ferrisicklerite and heterosite formed as pseudomorphs after the triphylite. The hydrated species formed later at the expense of the remaining triphylite in the cores of the nodules, leaving ferrisicklerite and heterosite, in which the iron is completely oxidized, unaffected. Phosphosiderite, bermanite, and other highly oxidized species formed during weathering of the nodules.

GENERAL GEOLOGY

The Alabama Piedmont province (Deininger *et al*, 1964) is underlain by northeasterly trending metamorphic and plutonic rocks which have been complexly folded and faulted. Quartz veins and pegmatites are found throughout the province and lie roughly parallel to the northeasterly strike trend of the rock contacts and schistosity.

Pegmatite deposits in the Alabama Piedmont have been heavily prospected, sampled, and mined since the 1870's, chiefly for sheet and scrap mica (Heinrich and Olsen, 1953). There also has been active prospecting for beryl, tin, feldspar, kaolin, and possible lithium and uranium minerals. Amateur collectors have explored for gem material and unusual mineral specimens.

THE WILLIAMS PEGMATITE PROPERTY

The Williams property is in the W 1/2, SE 1/4 and the NE 1/4, SW 1/4, sec. 10, T 21N, R 18E, about five miles south of Rockford and about 2-1/2 miles west of Pentonville (Simpson, 1964) (Fig. 1).

The property was formerly owned by Katherine Williams, but was transferred to Robert Russell in 1956 and is now owned by the Russell Land Company. Scrap mica was apparently mined from the property at some time, from two shallow vertical shafts, one inclined shaft, and a trench. Production and ownership prior to the Williams claim is uncertain, but the workings probably date from World War I, when Alabama produced some tonnage of sheet and scrap mica.

During World War II the U. S. Bureau of Mines and the U. S. Geological Survey, under the War Materials Programs, examined, trenched, and sampled the property (U. S. Bureau of Mines, 1946).

In September 1962, during an examination of the property by the Geological Survey of Alabama with the current owner, several beryl crystals about 2 by 5 cm were found. This prompted excavation of the site: several prospect trenches were opened and previous trenches were deepened. Subsequently, about 8 tons of beryl, including some aquamarine gemstock, were recovered by hand sorting from the pits.

The country rock of the Williams property is garnetiferous mica schist, probably of the Wedowee formation (Adams, 1926; Stose, 1939). Foliation of the schist strikes N10° E to N35° E and dips 62° to 72° NW. The schist is a well-defined unit, but to the east and northeast grades into muscovite-schists of the Ashland series and locally into feldspathic schist and phyllite. Within about one mile to the east and one mile to the north of the property scattered exposures of the Pickneyville granite can be observed.

Both the schist and the pegmatites are extensively weathered (Fig. 2). The schist weathers to a deep reddish and purplish saprolite. The schistose texture is obscure but discernible as a preserved feature. Feldspars of the pegmatite have been extensively kaolinized, and some of the muscovite books have been opened and show evidence of corrosion.

Apparently there are four pegmatite bodies on the Williams property. They are lenticular to dike-like; the largest is about 90 m long and 15 m wide. The three larger bodies are generally concordant with the foliation of the enclosing schist, but the smallest apparently is nearly perpendicular thereto (Fig. 3). It is difficult to determine attitudes and spatial relationships owing to the extensive trenching and excavation work.

The larger pegmatite bodies are zoned, including a border or wall zone of quartz-plagioclase-perthite, perthite-quartz zones with local shoots or poorly developed zones of quartz-muscovite, and quartz cores. The smallest body has a quartz-plagioclase perthite wall zone and a quartz-muscovite core.

Disoriented sheets of muscovite are abundant in layers adjacent to the quartz cores. Muscovite is present in lesser amounts in the cores. Microscopic flakes to sheets 30 cm across are scattered over the outcrop and embedded in veins showing on the surface. Generally, the mica is a mixture of fairly large flat sheets showing "A" structure or cross parting (two intersecting partings perpendicular to the cleavage) and flakes that are clear, some showing straining from iron oxide and other impurities. Some small

Fig. 2. **The main trench on the Williams property. Weathering is ubiquitous; pegmatite weathers white, schist dark.**

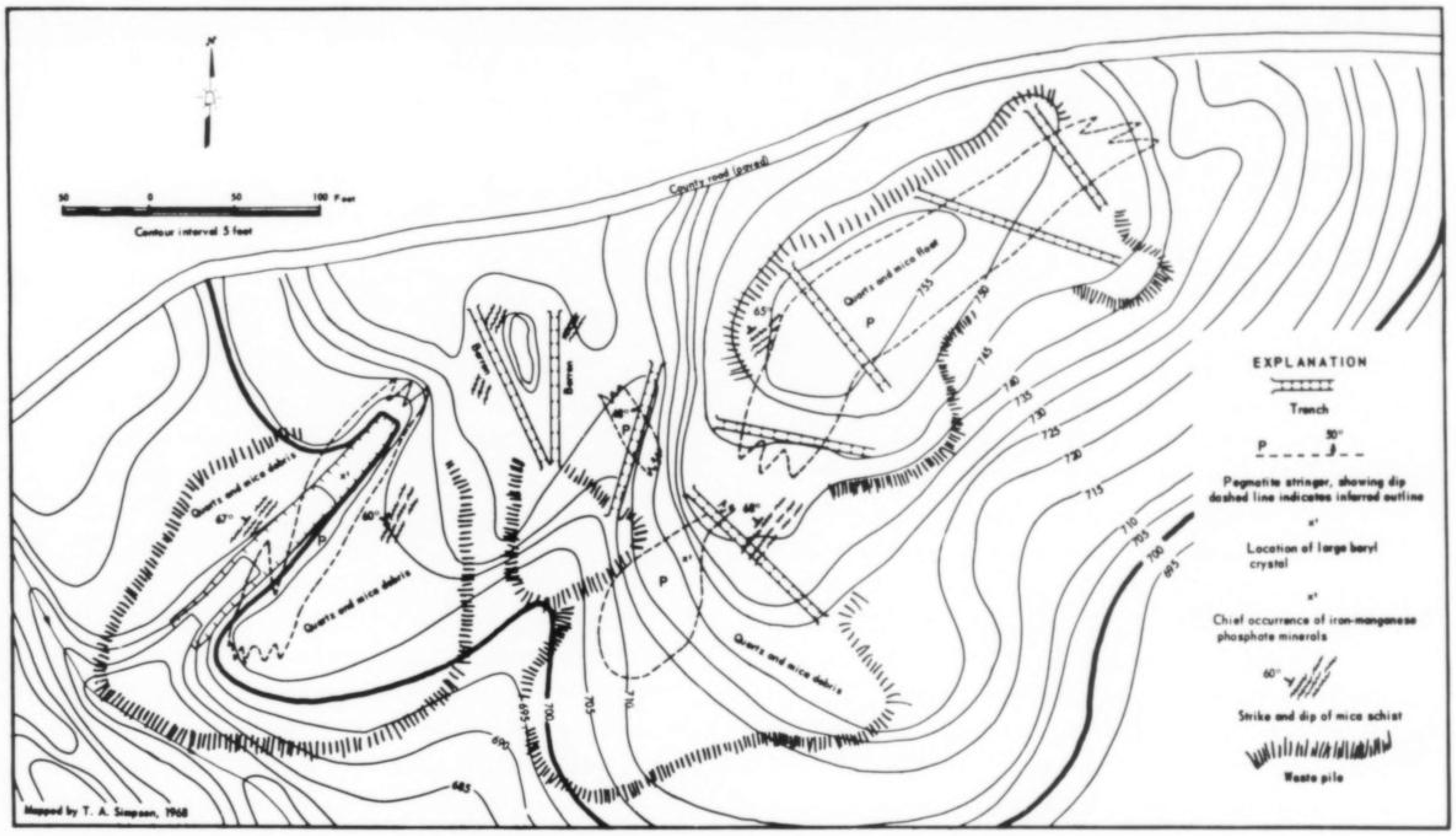


Fig. 3. **Generalized geologic map of the Williams property, Coosa County, Alabama.**

flakes associated with the feldspars have a faint greenish tinge.

Beryl crystals, ranging from less than 2 cm long to as large as 0.5 m in diameter and 1 to 1.2 m in length were found in all of the pits; they generally occurred in or near the margins of the quartz cores. The beryl is greenish, or yellow to brown. All of the crystals were badly fractured and corroded, but the interiors of some yielded gem quality aquamarine. In all of the pegmatites, black tourmaline is an accessory mineral.

Many of the contacts between the pegmatite bodies and the schist are sharp, but some are gradational. Gradational contacts usually show a fine-grained, greisen-like rock that further grades into a fine-grained granitic rock in the northeastern part of the property.

PHOSPHATE MASSES

Several masses of iron-manganese phosphate minerals have been found along the core margins of two of the pegmatites. The masses are ellipsoidal to subcircular in cross section and reach 1 m in maximum dimension. The heaviest weighs about 75 kg.

Typically, the bulk of a mass is a fine-grained mixture of rockbridgeite, lipscombite, and barbosalite, with scattered nodules of hureaulite up to 3 x 10 cm (Fig. 4). (The different minerals found in the masses are described individually at the end of this paper. Identifications are based on optical and x-ray study supported by a few chemical tests.) Tabular masses of hureaulite lie between this mixture and radiating masses of pure rockbridgeite, with crystal faces of hureaulite projecting into rockbridgeite. Pockets, up to 5 cm across, are lined with crystals of hureaulite, botryoidal surfaces of radiating rockbridgeite, and clear, orange crystals of phosphosiderite (metastrengite of Palache *et. al.*, 1951) (Fig. 5). The hureaulite crystals, which may be partly encrusted with rockbridgeite or overgrown by phosphosiderite, appear to be the first to have formed in the pockets; phosphosiderite was last.

The most complete masses we studied have thin (1-2 cm) outer bands of ferrisicklerite and heterosite. The contacts between the bands are sharp. The outermost parts of the masses are composed of Fe and Mn oxides, with small amounts of cacoxenite and granular, blue phosphosiderite.

The hydrated phosphates may be more or less altered and oxidized. In altered masses, the commonest mineral is brown, oxidized rockbridgeite (Moore, 1970; Palache, Berman, and Frondel, 1951). Granular, blue phosphosiderite is abundant locally. Hureaulite is altered to bermanite and Mn oxides, with granular phosphosiderite, stewartite, and strunzite. Ultimately, hureaulite is entirely converted to dense Mn oxides. Finally, the whole mass may be leached and oxidized to friable Fe and Mn oxides. Granular patches in the oxide masses apparently preserve the texture of the phosphosiderite.

Similar masses of phosphate minerals have been found in other pegmatites, including the Sapucaia pegmatite in Brazil (Lindberg and Pecora, 1955); the Palermo no. 1 and Fletcher pegmatites in New Hampshire (Cameron *et al*, 1954); and the Hagendorf pegmatite in Bavaria (Strunz, 1957). At these localities the phosphates are secondary, forming from the alteration *in situ* of triphylite or some other primary phosphate (Moore, 1973). Undoubtedly the masses from the Williams property pegmatite have formed in the same way, although no primary phosphate has yet been found. Otherwise they are similar to the others mentioned in size, shape, location within the pegmatite bodies, minerals, and mineral assemblages. Apparently, the alteration processes have proceeded so far at the Williams locality that all primary mineral has been consumed.

FORMATION OF THE PHOSPHATE MASSES

The minerals and associations we observed in the Williams property masses suggest a complex paragenesis. The first step was magmatic crystallization of triphylite at the core margins of the pegmatites, followed by the leaching of Li to produce the bands of ferrisicklerite and heterosite. Paul Moore (Moore, 1971) points out that ferrisicklerite and heterosite form only as pseudomorphs after triphylite or some other phosphate of similar structure, by the leaching of Li and the oxidation of Fe and Mn, retaining the lattice of the original triphylite. Ferrisicklerite, with its Li and Fe content, is a definite indicator of triphylite as the precursor. Specimens from the Black Hills of South Dakota show that the heterosite may in turn be replaced by alluaudite as the result of high temperature Na metasomatism (Moore, 1971). Therefore, ferrisicklerite and heterosite must in some cases be high temperature minerals, although they have also been interpreted as the products of weathering of triphylite (Mason, 1942). In our specimens, the ferrisicklerite and heterosite, forming as pseudomorphs after triphylite, must predate the rockbridgeite-rich assemblage, and most likely were formed by metasomatic leaching.

In the absence of a strongly oxidizing medium such as the atmosphere, ferrisicklerite and heterosite might form by acid leaching of triphylite with the release of hydrogen gas. The reaction for the leaching of a pure Fe triphylite to make a pure Fe heterosite would be

$$H^+ + LiFePO_4 = Li^+ + FePO_4 + 1/2\,H_2$$

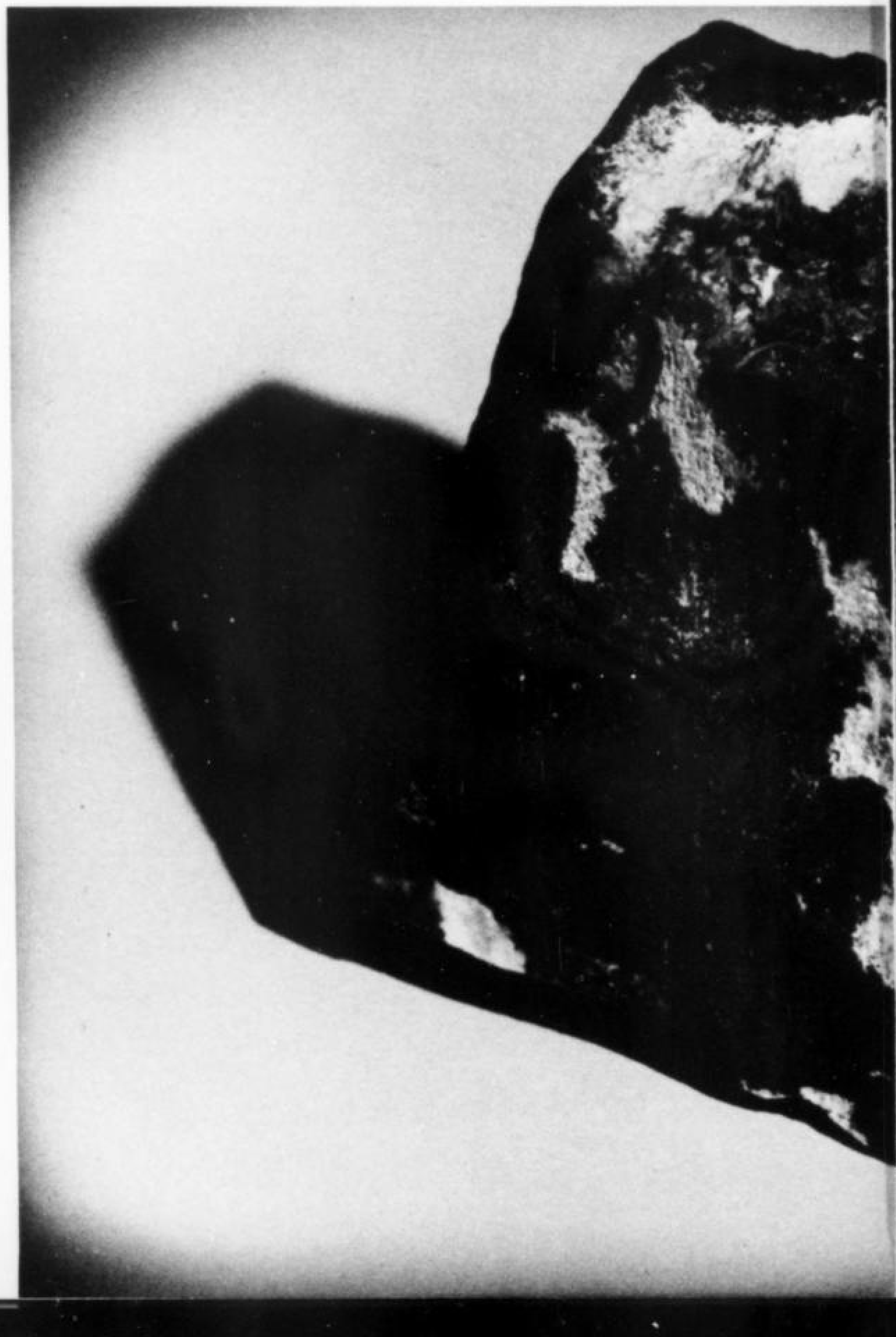
Artifical leaching of triphylite in hydrothermal experiments would be valuable in helping us understand the alteration processes in pegmatites.

The assemblage of hydrated phosphates, including rockbridgeite, lipscombite, and hureaulite, formed at low temperatures by the leaching, oxidation, and hydration of the remaining triphylite. We infer that the ferrisicklerite and heterosite, already containing only oxidized Fe, were unaffected by these processes. So much Li and phosphate is removed from the masses that the hydrated minerals occupy considerably less space than the original triphylite, assuming no Fe or Mn is leached; consequently, pockets and cavities are quite common in the masses. In addition, the euhedral crystalline texture of hureaulite against pure rockbridgeite and the long fibrous texture of that rockbridgeite suggest that these two minerals formed as fillings of open pockets or crystallized in a gel.

From the patterns observed in the nodules, the sequence of formation of the hydrated phosphates was lipscombite + rockbridgeite – hureaulite – rockbridgeite – phosphosiderite. Successive Fe-bearing minerals in this sequence contain higher ratios of ferric to ferrous iron (lipscombite 2:1, rockbridgeite 4:1, phosphosiderite 1:0), suggesting that their formation involved a process of continuing oxidation. Moore (1970, 1973) states that these minerals are the products of hydrothermal alteration of triphylite at temperatures below 250° C. However, they are also found in sedimentary deposits and, at the well-known vivianite locality at Mullica Hill, N. J., one of us (PBL) has seen them formed by the weathering of vivianite just above the water table.

Two features tend to support the hydrothermal origin of the hydrated phosphate masses in pegmatites: first, hureaulite is unknown in sedimentary or other undoubtedly low temperature deposits; although such deposits are usually low in Mn, so chemistry rather than temperature may be the controlling factor. Secondly, phosphosiderite is less common than its dimorph, strengite, in sedimentary deposits and may be an indicator of elevated temperatures. Experimental work on the synthesis and stability of hureaulite and phosphosiderite might help solve the problem of the origin of the hydrated phosphates in pegmatites. Careful mapping of the distribution of phosphates in pegmatites would also help.

The mineral assemblage characterized by oxidized rockbridgeite, and with hureaulite largely altered to other phosphates and to Mn oxides, almost certainly formed by the weathering of the 'fresh' hydrated phosphate assemblage in the zone of aeration above the water table. Bricker



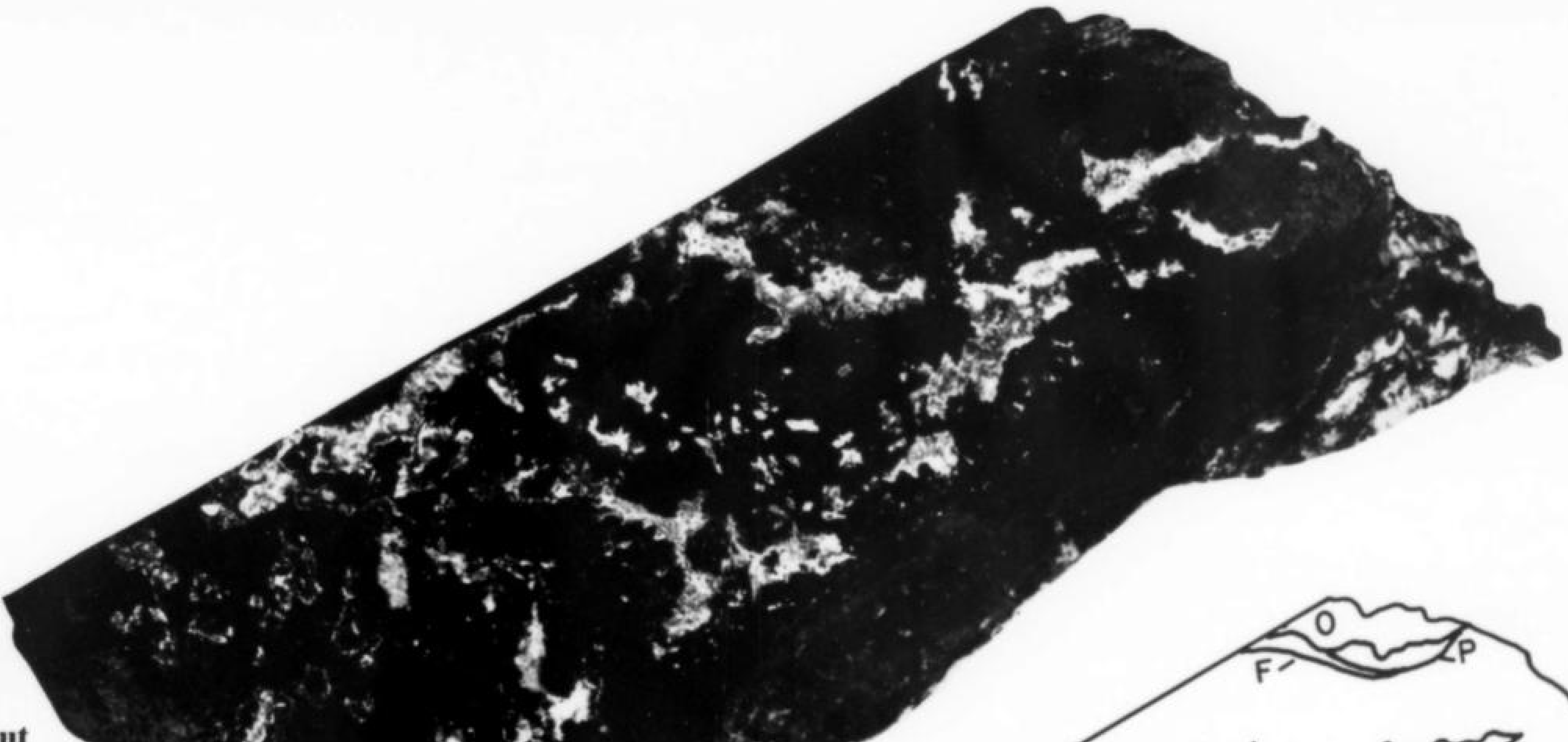


Figure 4a. **Slab, 60 cm by 25, cm, cut from a mass of iron manganese phosphates. One edge has been sawn flat, but the slab is nearly a complete cross-section of the mass.**

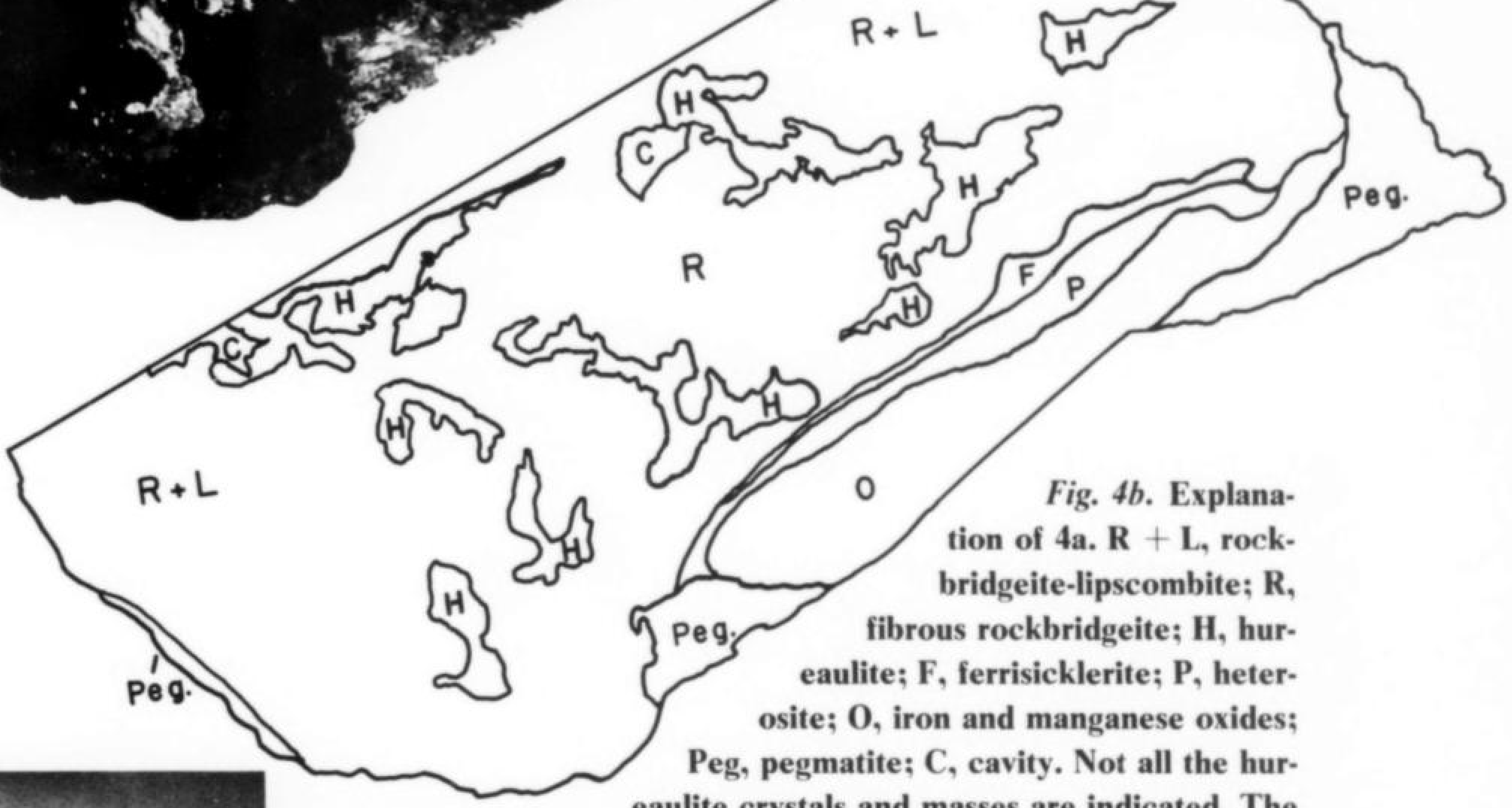


Fig. 4b. **Explanation of 4a. R + L, rockbridgeite-lipscombite; R, fibrous rockbridgeite; H, hureaulite; F, ferrisicklerite; P, heterosite; O, iron and manganese oxides; Peg, pegmatite; C, cavity. Not all the hureaulite crystals and masses are indicated. The cavity on the left contains clear, pink phosphosiderite crystals. The left quarter of the slab shows some alteration, with yellow-green rockbridgeite and small blue granules of phosphosiderite.**

(1965) demonstrated that Mn oxides formed by the alteration of rhodochrosite deposits require the circulation of large volumes of air; the alteration of hureaulite to Mn oxides would require similar air circulation. Thus, bermanite, stewartite, strunzite, and cacoxenite, which in our specimens are confined to the oxidized assemblage, are the products of weathering, rather than of hydrothermal activity. All contain only ferric Fe, and bermanite is unique among the phosphates in containing trivalent Mn.

Most of the phosphate specimens were collected before we examined the locality, and extensive bulldozing makes original relationships between the various assemblages impossible to determine. All specimens were recovered from above the present water table, but the latter may have been disturbed by trenching and mining.

Figure 5. **Slab, 15 cm across, with a pocket 5 cm long containing hureaulite crystals and botryoidal rockbridgeite. Individual blades of rockbridgeite on the broken surface are nearly 3 cm long.**

PHOSPHATE MINERALOGY

Formed by the hydrothermal leaching of triphylite:

Ferrisicklerite, $Li_{1-x}Fe_xMn_{1-x}PO_4$, occurs locally as a rim as much as 1 cm wide between the hydrated phosphates and heterosite. The presence of Li was confirmed by spectroscopic examination. Ferrisicklerite is less common than heterosite and does not occur everywhere between heterosite and other phosphates.

Heterosite, $(Fe, Mn)PO_4$, occurs locally as a band up to 2 cm between the other phosphate minerals and Fe and Mn oxides. A sample of ferrisicklerite and heterosite was analysed with the nondispersive electron probe; the minerals contain about twice as much Fe as Mn.

Formed by leaching, oxidation, and hydration of triphylite:

Rockbridgeite, $(Fe, Mn)Fe_4(PO_4)_3(OH)_5$, is the most abundant mineral in the masses. It occurs as fibrous aggregates with individual fibers as much as 3 cm long and botyroidal surfaces at the sides of pockets and as fine-grained fibrous material intergrown with lipscombite. Its color ranges from greenish black through yellow green to brown in different specimens; this difference in color appears to result from increasing oxidation of Fe rather than change in the ratio Fe/Mn.

Lipscombite and barbosalite, $(Fe, Mn)Fe_2(PO_4)_2(OH)_2$, are common as fine-grained black to blue-green granules intergrown with dark rockbridgeite. In thin section they are opaque. The two are found together and must be distinguished by x-ray examination. The crystal chemistry of lipscombite and barbosalite is quite confusing, and more work is needed on the group.

Hureaulite, $(Mn, Fe)_5(H_2O)_4(PO_3OH)_2(PO_4)_2$, occurs as grains, stringers, and nodular masses as much as 10 cm in maximum dimension embedded in lipscombite-rockbridgeite mixture or between this mixture and pure fibrous rockbridgeite. In the latter setting hureaulite is subhedral against lipscombite-rockbridgeite and euhedral against rockbridgeite. In rare open pockets it occurs as well formed, euhedral crystals.

Phosphosiderite, $FePO_4.2H_2O$, occurs in two generations; the first is euhedral, orange crystals on hureaulite or rockbridgeite in pockets. Much more common are blue to purple granular masses with bermanite.

Leucophosphite, $KFe_2(PO_4)_2(OH).2H_2O$, was found as pale, greenish powder coating a pocket in rockbridgeite.

Formed by oxidation (weathering) of the hydrated species:

Bermanite, $MnMn_2(PO_4)_2(OH)_2.4H_2O$ (Leavens, 1967; Hurlbut and Aristarain, 1968), occurs as aggregates of minute, red flakes associated with the granular, blue variety of phosphosiderite and with stewartite. It forms largely by the alteration of hureaulite and every gradation can be seen from bermanite intergrown with chalky hureaulite to pure bermanite to bermanite altering, in turn, to Mn oxides.

Stewartite, $MnFe_2(PO_4)_2(OH)_2.8H_2O$, is found sparingly as golden yellow, granular crystals intergrown with bermanite.

Strunzite, $MnFe_2(PO_4)_2(OH)_2.8H_2O$, is common locally as aggregates of straw-yellow needles intergrown with altered hureaulite. Stewartite is occasionally associated with it; bermanite and phosphosiderite are commonly found in the same specimen, but were not observed intergrown with strunzite.

Cacoxenite, $Fe_9(PO_4)_4(OH)_{15}\bullet 18H_2O$, was found in one specimen as 1 mm tufts of golden fibers embedded in iron oxides. A little phosphosiderite was found in the same specimen, but no other phosphates were associated.

Iron and manganese oxides coat the nodules and in some cases completely replace the phosphates. Much of the iron oxide is x-ray amorphous, but some is goethite. The manganese oxide gives a diffuse x-ray powder pattern for birnessite.

ACKNOWLEDGEMENTS

Grateful acknowledgement is extended to the late Robert Russell, owner of the Williams property, and to the late Ed Smith, whose interest in rocks and minerals led to the discovery of these unusual iron-manganese phosphate minerals on the property.

Much of the work on this paper was done while PBL was a National Academy of Sciences-National Research Council Postdoctoral Research Associate at the Department of Mineral Sciences, Smithsonian Institution.

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HONOR AWARDED TO PAUL B. MOORE

The **North** Jersey Mineralogical Society, at a recent meeting, honored Dr. Paul Brian Moore by awarding him Honorary Membership in the Society. Dr. Moore is currently a full professor in the Department of the Geophysical Sciences at the University of Chicago. He came to New Jersey from Connecticut at the age of nine and in the sixth grade became fascinated by minerals. He was a rabid amateur collector and a member of the North Jersey Mineralogical Society for a number of years.

Dr. Moore became a brilliant mineralogist and is responsible for many new minerals having been added to the list of known authentic mineral species. He is also responsible for a total of 74 publications.

Dr. Moore was awarded the Mineralogical Society of America Award for 1973 and is still fascinated by minerals. During the presentation, he was described as "a perfect example of how a first rate amateur can develop into a first rate professional".

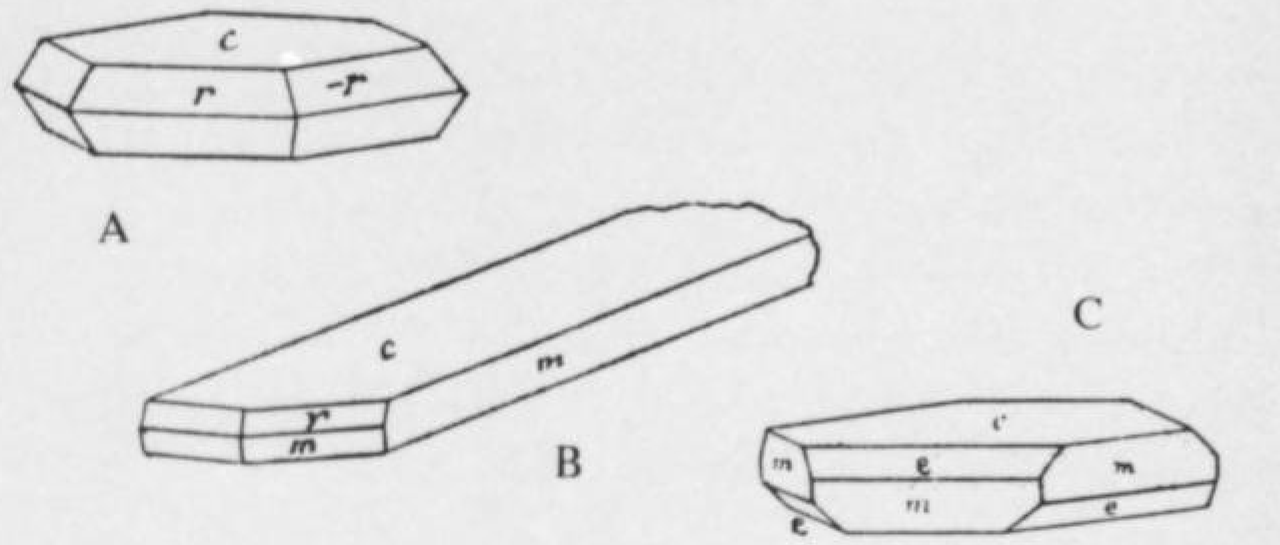

Figure 1. **Aphthitalite.**

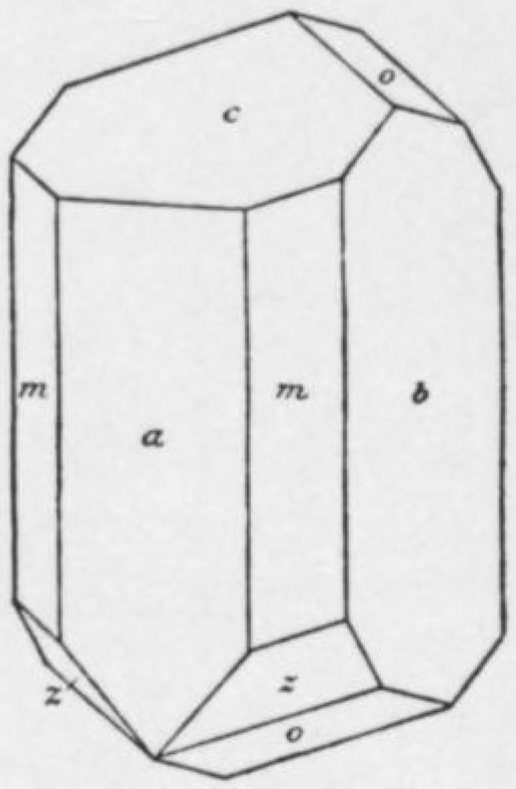

Figure 2. **Borax, Searles Lake.**

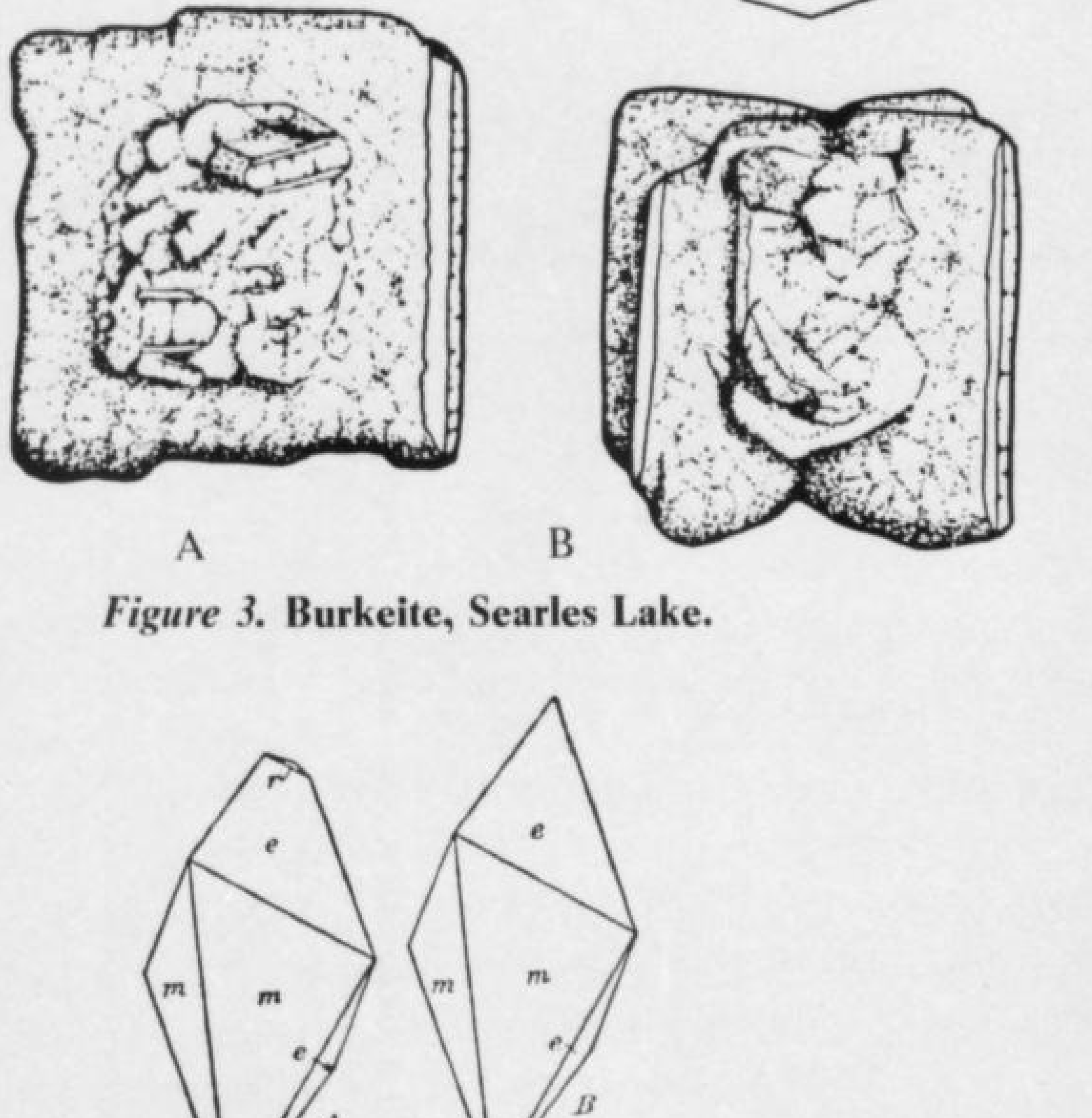

Figure 3. **Burkeite, Searles Lake.**

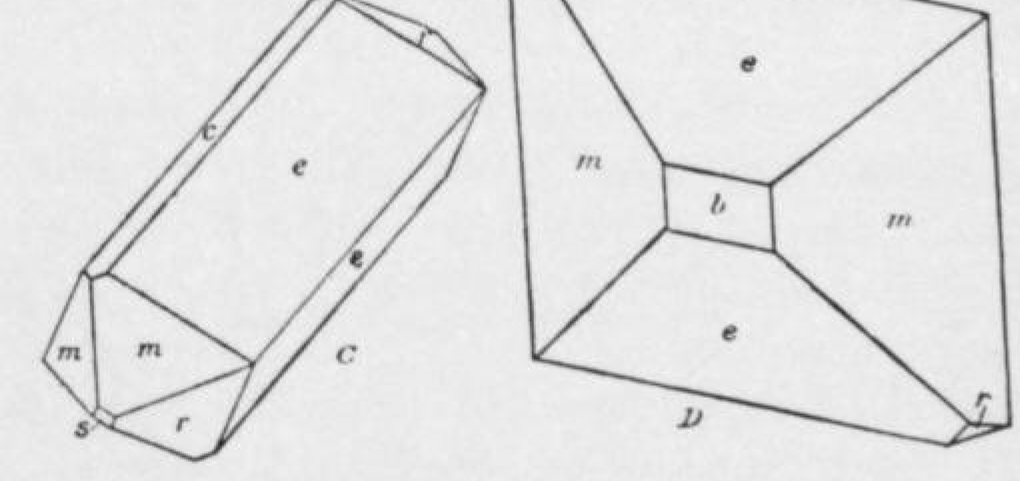

Figure 4. **Gaylussite, Searles Lake.**

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H. Earl Pemberton, **1638 Hill Street, Santa Monica, California 9**

The Searles Lake evaporite deposit in the southern part of the Great Basin geological province of California is well known for the variety of minerals occurring there. The deposit has been studied and reported on by many noted mineralogists. Nine currently recognized species have been described as new minerals from this locality. In 1964 George Smith and David V. Haines presented a detailed study describing the mode of mineral occurrences and the relation of the stratigraphy of the lake bed to the mineralogy of the deposit. They identified 25 minerals in the saline and mud layers of the lake.

This paper has been prepared to supplement the Smith and Haines study with some of the details of the crystal habits and forms of 19 of the 25 minerals, as those data have been reported by recognized mineralogists. The six omitted are not unique to evaporite deposits and do not occur here in a manner making them of any special interest. The six excluded are: adularia, analcime, aragonite, calcite, dolomite, and phillipsite. All six occur only in the mud layers at a depth of 120 feet or more and only to a few microns in size, except calcite, which is found up to 2mm.

Four minerals were reported from the deposit by Gale (1915), which are not included in the 25 listed by Smith and Haines or in this report: natron, gypsum, anhydrite, and glauberite. Smith and Haines give this explanation: "It is very possible that these minerals form either near the margins where waters from local surface runoff mix with the brines of the lake or locally on the surface of the lake during hot or cold days. Some may be present as clastic materials. It is not likely, however, that any of the four occurs in large quantities."

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It is also possible that Gale based his report of glauberite here on reports by Rath (1887) and DeGroot (1890), and his report of anhydrite on a report by DeGroot. There have been no substantiating reports of these two minerals at this locality.

To the best of the writer's knowledge natron has been reported here only by Gale and its occurrence is doubtful. From a temperature standpoint it could form under conditions which permit the formation of mirabilite in the Bottom Mud, but it has not been reported from cores containing the mirabilite. The possible formation of natron crystals on the surface of the lake or along the borders during cold weather is not supported by the occurrence of thermonatrite to which natron converts in dry air at 32°C. The occurrence of gypsum crystals around the lake is possible as they commonly occur on such playas, but no description of the habit at this locality is available.

None of the data on the habits and forms of the 19 minerals covered here is the result of original study by the writer. The Smith and Haines report has been used throughout this paper and it is suggested that those interested in the detail of this deposit obtain a copy of that report. (In some early literature this locality was referred to as Borax Lake, San Bernardino County. This reference distinguished it from Borax Lake, Lake County, in northern California, where borax was first discovered in the State. In later literature Borax Lake, San Bernardino County, has been identified only as Searles Lake.)

Aphthitalite — (K,Na)$_3$Na(SO$_4$)$_2$

Hexagonal scalenohedral - $\bar{3}2/m$

Aphthitalite was first reported from Searles Lake by Foshag (1920b) as colorless, thin to thick, tabular crystals

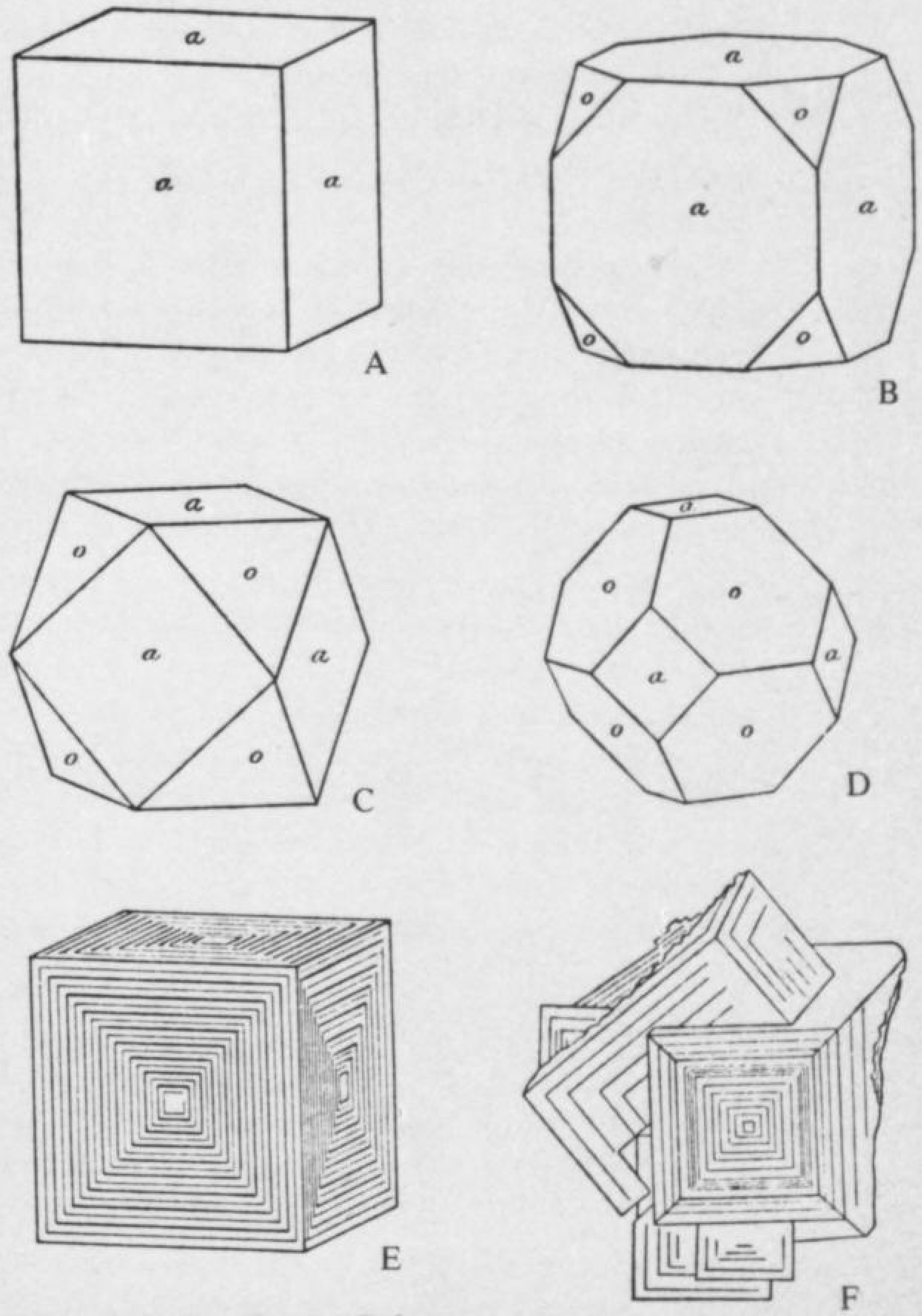

Figure 5. **Halite, Searles Lake.**

up to 20 mm in length. The habit he reported as very simple, showing only *c*{0001} and *r*{$10\bar{1}1$}. Smith and Haines (1964, p.8), on the basis of a wider variety of specimens, reported the mineral as colorless or yellowish groups of bladed or tabular crystals, 3 to 10 mm long and 1 to 2 mm thick, sometimes with a distinct hexagonal habit.

No drawings are available of aphthitalite from this locality. However, Figure 1 shows crystals with the habits described by the above studies. A and B, crystals from Vesuvius (Goldschmidt, 1918, Table 28, fig. 117,121), show the hexagonal and bladed habits with A showing only the forms noted by Foshag, while B shows in addition the prism *m*{$10\bar{1}0$}.C is a crystal from Douglashall, Germany (Bucking, 1889) with the rhombohedron *e*{$10\bar{1}2$} in place of *r*.

Borax — $Na_2B_4O_7 \bullet 10H_2O$

Monoclinic prismatic, 2*m*

Borax crystals here are colorless to yellowish or pinkish, due to microorganic inclusions, the surface altered to white tincalconite upon exposure to the air. Euhedral crystals are common but doubly terminated ones are rare. They have two distinct habits: (1) short prismatic with their length 1 to 2 times their width, and (2) elongate parallel to the *c* axis with their length 4 to 5 times their width. The crystals range in size from 0.5 mm to 40 mm in length.

The forms reported are shown in Figure 2 (H. S. Gale, 1915, p. 301): *c*{001}, *b*{010}, *a*{100}, *m*{110}, *o*{$\bar{1}12$}, *z*{$\bar{1}11$}.

Burkeite — $Na_6(CO_3)(SO_4)_2$

Orthorhombic

Burkeite occurs here as beds of white to pale buff or grayish crystalline material. No precise drawings of the habit and forms are available because the individual crystals and twins are rough and uneven and rarely exceed 4 mm in maximum dimension. (Figure 3, Foshag, 1935, p. 52) The tabular face is the front pinacoid {100}, and the narrow faces {010}, {110}, and {001}. (Palache et al., 1951)

The crystal shown in Figure 3B is a penetration twin with the twin plane {110}. When these twinned crystals are thin the X shape is obvious; when the crystals are thick they may resemble more closely hexagonal prisms with two pair of plane faces, {010}, each pair separated by a rough median line and two rough re-entry faces. When a large number of crystals are intergrown they form reticulating aggregates of plates. Small, pea-shaped nodules of burkeite have a surface composed of relatively bright faces of {010}.

Gaylussite — $Na_2Ca(CO_3)_2 \bullet 5H_2O$

Monoclinic prismatic, 2*m*

Colorless, transparent crystals of gaylussite occur in Searles Lake with the habits shown in Figure 4 (Gale, 1915 - adapted from Pratt, 1896) The forms as reported by Pratt are: *c*{001} , *b*{010} , *m*{110} , *e*{011} , *s*{$\bar{1}01$ } and *r*{$\bar{1}12$} .

Smith and Haines (1964, p. 28) report that euhedral crystals are wedge-shaped (Figure 4A and B), and up to 5 mm long, as individuals or as intergrowth clusters of two or three individuals. Pratt (1896) reported crystals of type A up to 10 mm and in his drawing depicted the habit as slightly less elongate. Pratt also reported euhedral elongate crystals of type C up to 20 mm, generally with rough faces, and that crystals with the habit of type D, showing *b*{010}, also occur but are not common.

Additional references for gaylussite: Hanks, 1892; Murdoch, 1951.

Halite — NaCl

Isometric hexoctahedral, $4/m\bar{3}2/m$

Halite occurs here in crystals from less than 1mm up to 75 mm in size. The crystals are usually colorless and transparent but may also be white or discolored gray to black from mud inclusions or pink to pale orange by inclusions of microorganisms.

The habits of the crystals are shown in Figure 5 (Gale, 1915) with the following forms identified: *a*{001} and *o*{111}. E and F are stepped (hopper) crystals.

Hanksite — $Na_{22}K(SO_4)_9(CO_3)_2Cl$

Hexagonal dipyramidal, 6*m*

Crystals of hanksite as much as 15 cm long have been found in Searles Lake but they commonly range from 5 to 30 mm and average about 10 mm long. The crystals are transparent, sometimes colorless but commonly tinted yellow to brown or gray from inclusions. The habits reported are shown in Figure 6 (A from Pratt, 1896; B and D, Gale, 1915; C and E, Hanks, 1889). Forms are: *c*{0001}, *m*{$10\bar{1}0$}, *o*{$10\bar{1}2$}, and *s*{$10\bar{1}1$}.

A, B, and C type crystals with the pyramidal development occur singly or doubly terminated and up to 3 inches in length. The crystals with the prominent basal pinacoid, D and E, range in length on the *c* axis from 1 to 16mm, averaging about 10mm. All types occur as individuals and as intergrown aggregates.

Additional references for hanksite: Dana and Penfield, 1885; Hidden, 1885; Rath, 1887.

Mirabilite — $Na_2SO_4 \bullet 10H_2O$

Monoclinic prismatic 2/*m*

Mirabilite occurs in Searles Lake at a depth of from 130-150 feet in the Bottom Mud but no detail is known about the crystal habit of the material. Since the mineral is stable only at temperatures below 32° C, the mineral may occur in pools on the lake surface during times when surface temperatures are below that point.

The common habit in such occurrences, e.g., in the pools of Soda Lake, Carrizo Plain, San Luis Obispo County, California, is acicular. Known habits of mirabilite (which casual inspection may lead to a judgement of acicular) include: acicular {010}; lath-like, flattening on *a*{100}; and elongation parallel to the *b* axis. (Palache et al., 1951).

Figure 7 shows forms which might develop in such a way as to lead to a judgement of "acicular". These drawings are by Rosicky (1908) and are based on a study of

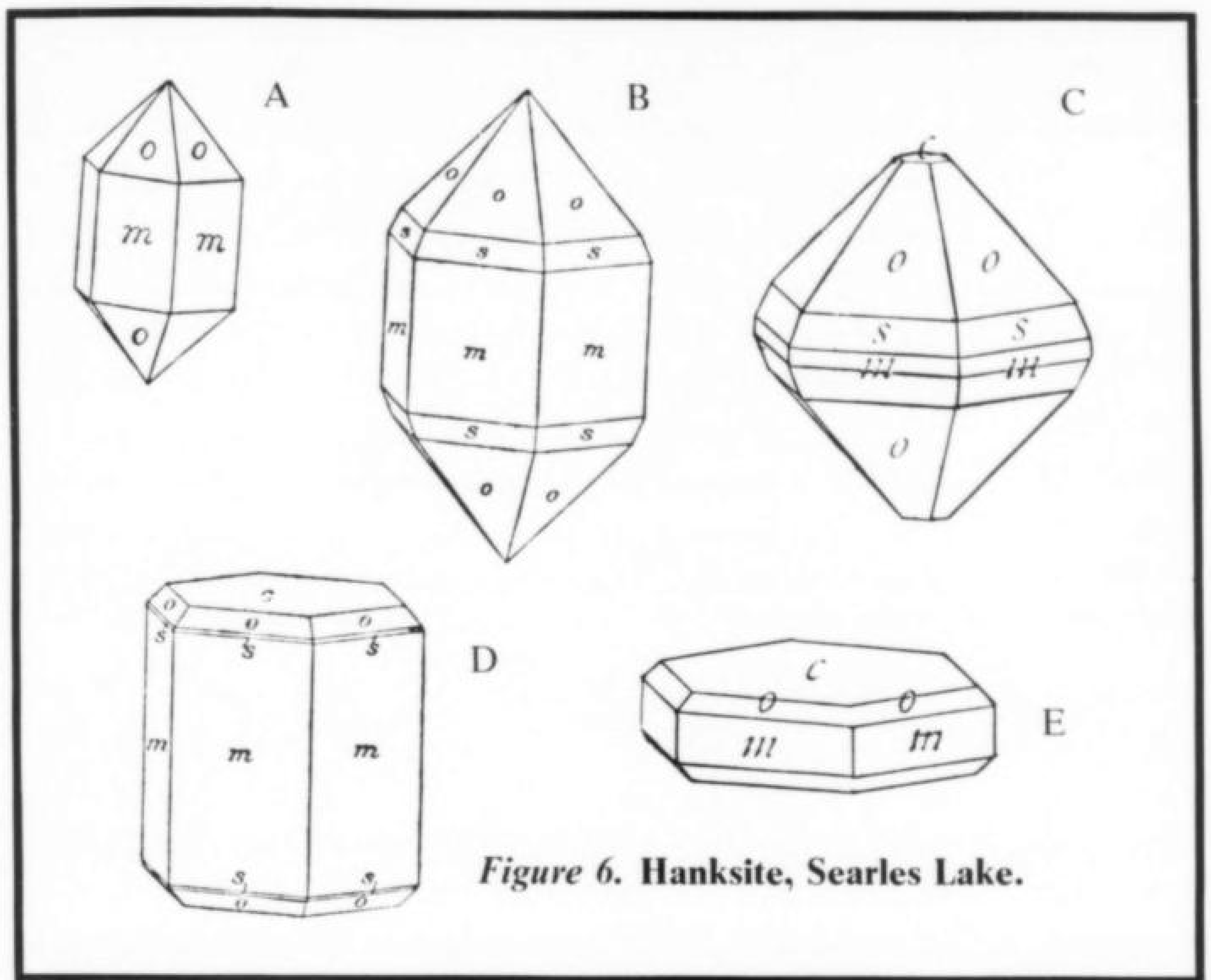

Figure 6. **Hanksite, Searles Lake.**

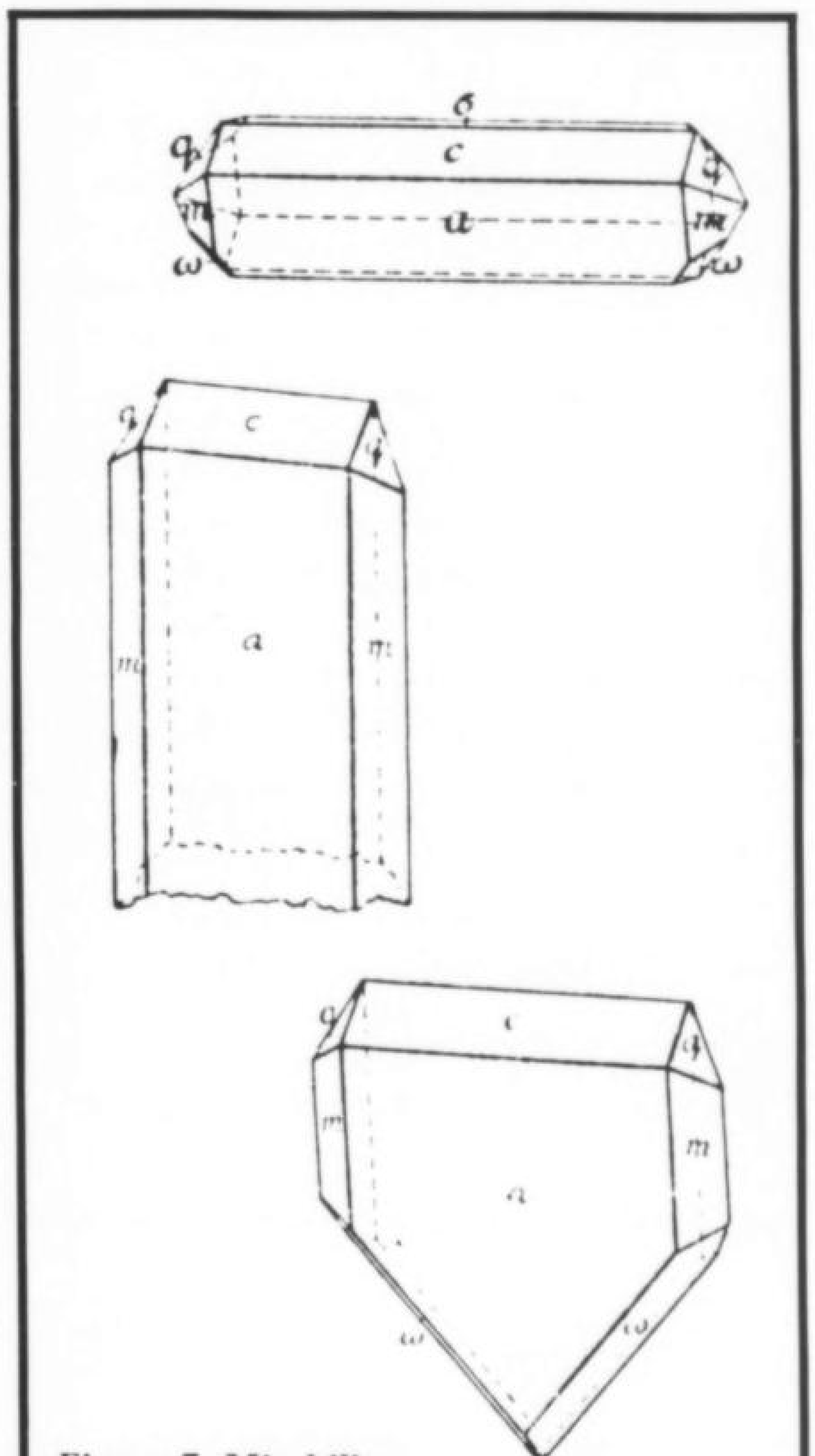

Figure 7. **Mirabilite.**

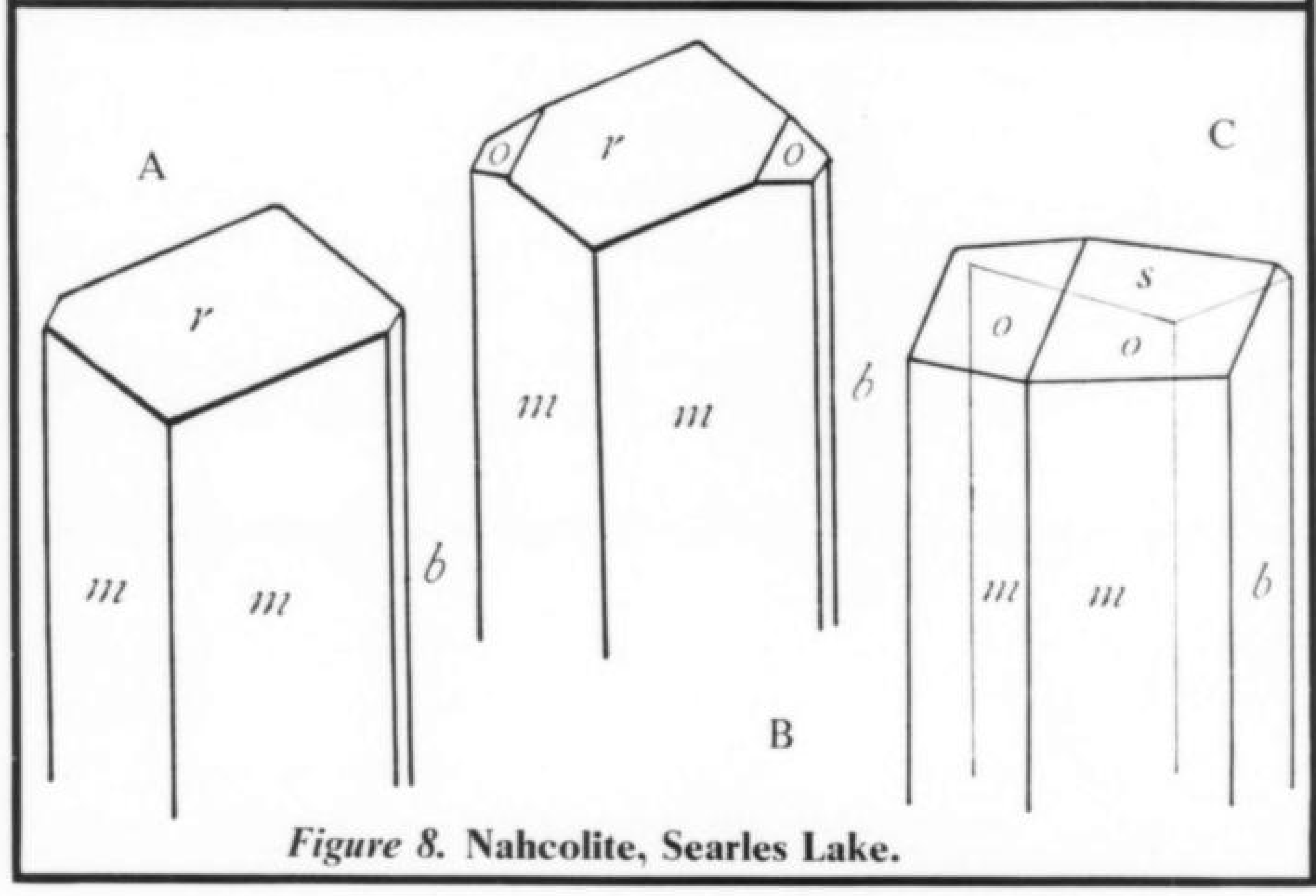

Figure 8. **Nahcolite, Searles Lake.**

artificial crystals. The forms are: *c*{001}, *a*{100}, *m*{110}, *q*{011}, *w*{11$\bar{1}$}, δ{$\bar{1}$02}.

Nahcolite — $NaHCO_3$

Monoclinic prismatic, 2/*m*

Nahcolite crystals here are usually colorless but sometimes shaded pale yellow or olive brown by inclusions. They range in size from 3 to 20 mm but seldom exceed 10 mm. Figure 8 (Foshag, 1940) shows the known habits. A and B are the usual types, and C an uncommon termination. The forms indicated are: *m*{110}, *r*{101}, *b*{010}, *o*{111}, *s*{$\bar{1}$01}, *n*{120}, and *a*{100}. *b* is usually a narrow face.

Twinning is common with *r*{101} the twinning plane and composition plane (Figure 9, Foshag, 1940). Both contact and penetration twins occur, often in combination and up to 2 cm in length. The obtuse contact shown in A is the most common. The acute contact of B is usually attached and is perhaps the acute end of penetration twins such as C. Repeated twins, pictured in D, occur in many combinations.

Northupite — $Na_3Mg(CO_3)_2Cl$

Isometric diploidal, 2/$m\bar{3}$

Tychite — $Na_6Mg_2(CO_3)_4(SO_4)$

Isometric diploidal, 2/*m*3

Northupite and tychite are treated together here because: (1) the two species are isostructural and a complete series is known to exist between the artificial materials (Palache et al., 1951); (2) the crystal habits of the two are the same—octahedral, *o*{111} (Figure 10A, Gale, 1915), perfect in the case of northupite, sometimes modified by minute cube faces, *a*{100}, in the case of tychite (Figure 10B); (3) they are both colorless and transparent except when shaded pale yellow or gray by organic or clay inclusions; and (4) both are usually small, ranging in size from a fraction of a mm up to 2-3 mm, averaging perhaps 1 mm. However, there have been reports of northupite up to 2.5 cm in size.

Additional references for northupite and tychite: Foote, 1895; Penfield and Jamieson, 1905; Smith and Pratt, 1957; Pratt, 1896; Foshag, 1935; Huang and Kerr, 1960; Keester et al., 1969.

Pirssonite — $Na_2Ca(CO_3)_2{\bullet}2H_2O$

Orthorhombic rhombic-pyramidal, *mm*2

Crystals of pirssonite are usually colorless and transparent but are sometimes clouded yellowish or grayish by inclusions. They occur up to 10 mm long, averaging about 3 mm. Pirssonite is hemimorphic in its development, with the *c* axis taken as the hemimorphic one. The forms observed are: *b*{010}, *m*{110}, *p*{111}, p^0 {11$\bar{1}$}, *e*{131}, and *x*{311}. (Figure 11, Pratt, 1896, p. 127)

The crystals show a considerable variety of habit. A, B, and C show (010) in front to portray the shape better. A and B habits are common. The pyramid *e*{131} is developed at one end of the *c* axis only, varies greatly in size, and sometimes alone terminates the upper end of the crystal. (C and F). The pinacoid *b*{010} is sometimes absent (D and E). The pyramid *x*{311} is rare and is not shown in the drawings.

Additional references for pirssonite: Foshag, 1935; Gale, 1915; Huang and Kerr, 1960.

Schairerite — $Na_{21}(SO_4)_7F_6Cl$

Hexagonal trigonal, $\bar{3}12/m$, 31*m*, or 312.

Galeite — $Na_{15}(SO_4)_5F_4Cl$

Hexagonal trigonal, $\bar{3}12/m$, 31*m* or 312.

These two minerals are treated together because of a number of similarities: (1) they have similar chemical formulae, with galeite having a slightly higher chlorine content; (2) galeite always occurs in association with schairerite, although the reverse is not true; (3) they belong to the same crystal class and occur as overgrowths and polycrystals; (4) both are colorless and transparent; and (5) both are microscopic, galeite ranging from 0.2 to 0.4mm and schairerite rarely exceeding 1mm in greatest dimension. The distinguishing characteristic is the difference in typical habits.

Schairerite was described as a new mineral species from Searles Lake by Foshag (1931). The common habit is shown in Figure 12, A.B,C. The pinacoid *c*{0001} shown on D is usually present only as a small face, often developed on only one end of the crystal. The prism *a* is often absent and varies from a line face to a size giving the crystal a prismatic aspect (C). The *r* face is the most prominent and common form, and the *e* form is usually present only as a narrow face.

Foshag identified the a face as the first order prism *m*{10$\bar{1}$0} and the *r* and *e* faces as the positive and negative rhombohedra, *r*{10$\bar{1}$1} and *e*{01$\bar{1}$2}. However, Pabst *et al.* (1963) pointed out that this setting of the crystal is inconsistent with the space group of both schairerite and galeite

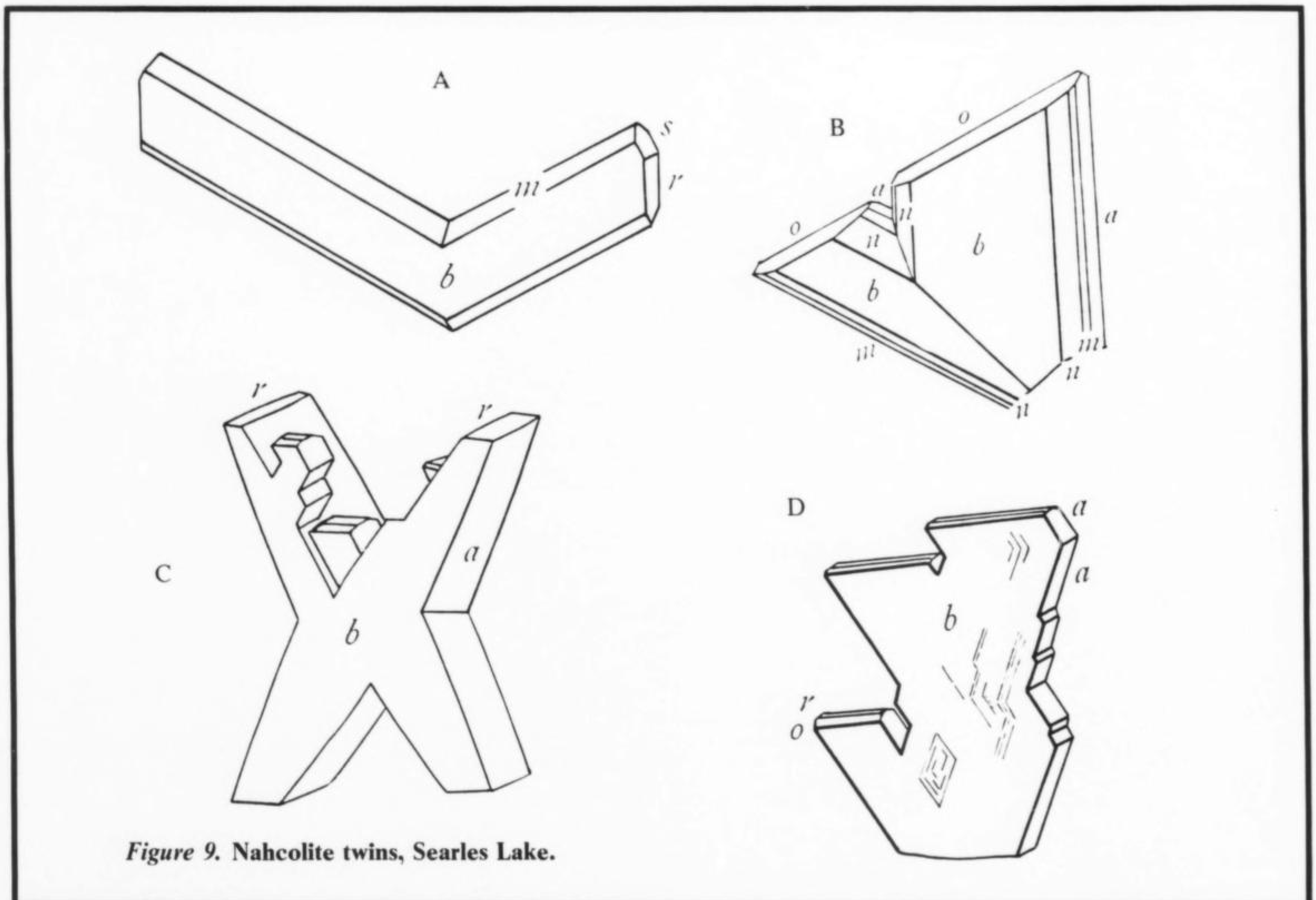

***Figure 9.* Nahcolite twins, Searles Lake.**

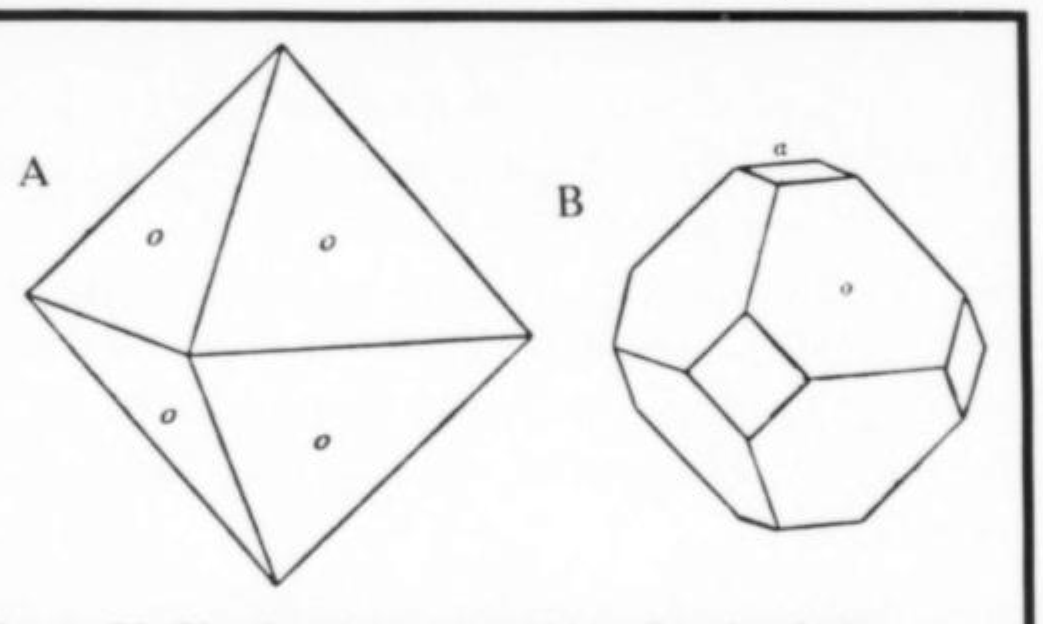

Figure 10. **Northupite and tychite, Searles Lake.**

and identified the forms as the second order prism $a\{1120\}$, and the dipyramids $r\{11\bar{2}1\}$ and $e\{2\bar{1}\bar{1}2\}$.* On this basis the symbol of the prism form in Figure 12 has been changed to *a* from the *m* used in Foshag's paper.

Galeite was described as a new mineral from Searles Lake by Pabst, Sawyer and Switzer (1955). The common habit is the barrel shape shown in Figure 13A. The mineral also occurs as minute tabular crystals in friable aggregates showing only {0001}, $\{11\bar{2}0\}$ and $\{11\bar{2}1\}$. Identification of this type of occurrence requires high magnification.

The structural identity of schairerite and galeite result in overgrowths and polycrystals, Figure 13 B,C. The original publication of this drawing of B showed the symbol $m\{10\bar{1}0\}$, the first order prism, instead of $a\{11\bar{2}0\}$, the second order prism. This was an oversight (A. Pabst, pers. comm., 1971).

Additional references for galeite: Pabst et al., (1963); Brown and Pabst, 1971.

Searlesite — $NaBSi_2O_6 \bullet H_2O$

Monoclinic sphenoidal, 2

Searlesite was described as a new mineral from Searles Lake by Larsen and Hicks (1918), occurring as white spherulites about 1 mm in diameter and consisting of radiating fibers. Since then it has been found as rectangular plates about 0.2 mm long imbedded in trona crystals and as radiating fibers embedded in siltstone cemented by pirssonite. There are no reports of the crystal forms on these minute specimens. However, Rogers (1924) described minute (1 to 2 mm) crystals from Coaldale, Esmaralda County, Nevada. (Figure 14) This habit could fit the fibrous material of Searles Lake. Rogers identified the forms as $a\{100\}$, $m\{110\}$, $r\{101\}$ and $s\{\bar{1}01\}$. $\{\bar{1}11\}$ and {010} also occur on some crystals, the latter as a line face.

Additional references for searlesite: Gale, 1915; Hay and Moiola, 1962.

Sulphohalite — $Na_6(SO_4)_2FCl$

Isometric hexoctahedral, $4/m\bar{3}2/m$

Sulphohalite is transparent and colorless, sometimes shaded greenish or gray by inclusions. Crystals occur up to

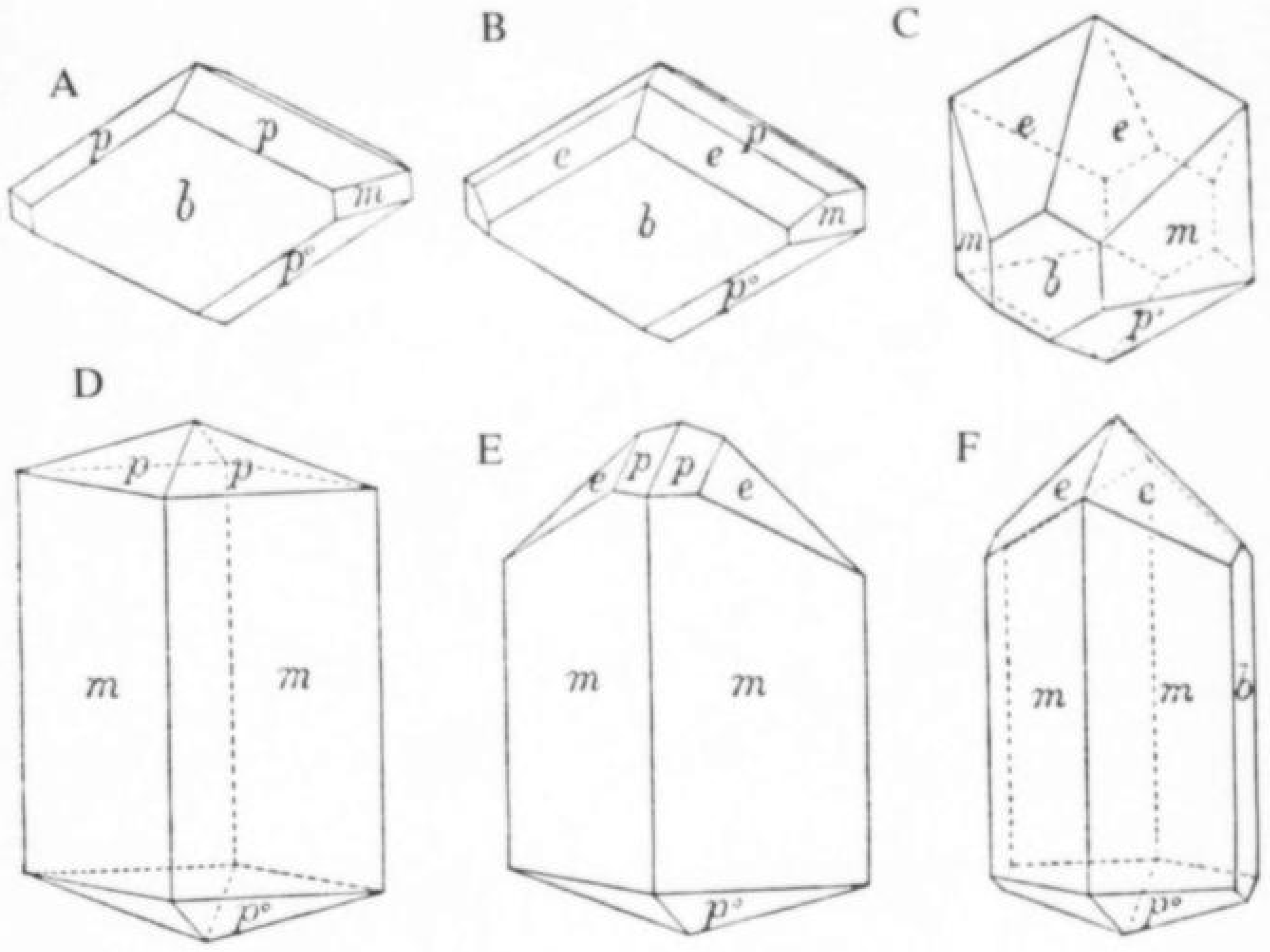

Figure 11. **Pirssonite, Searles Lake.**

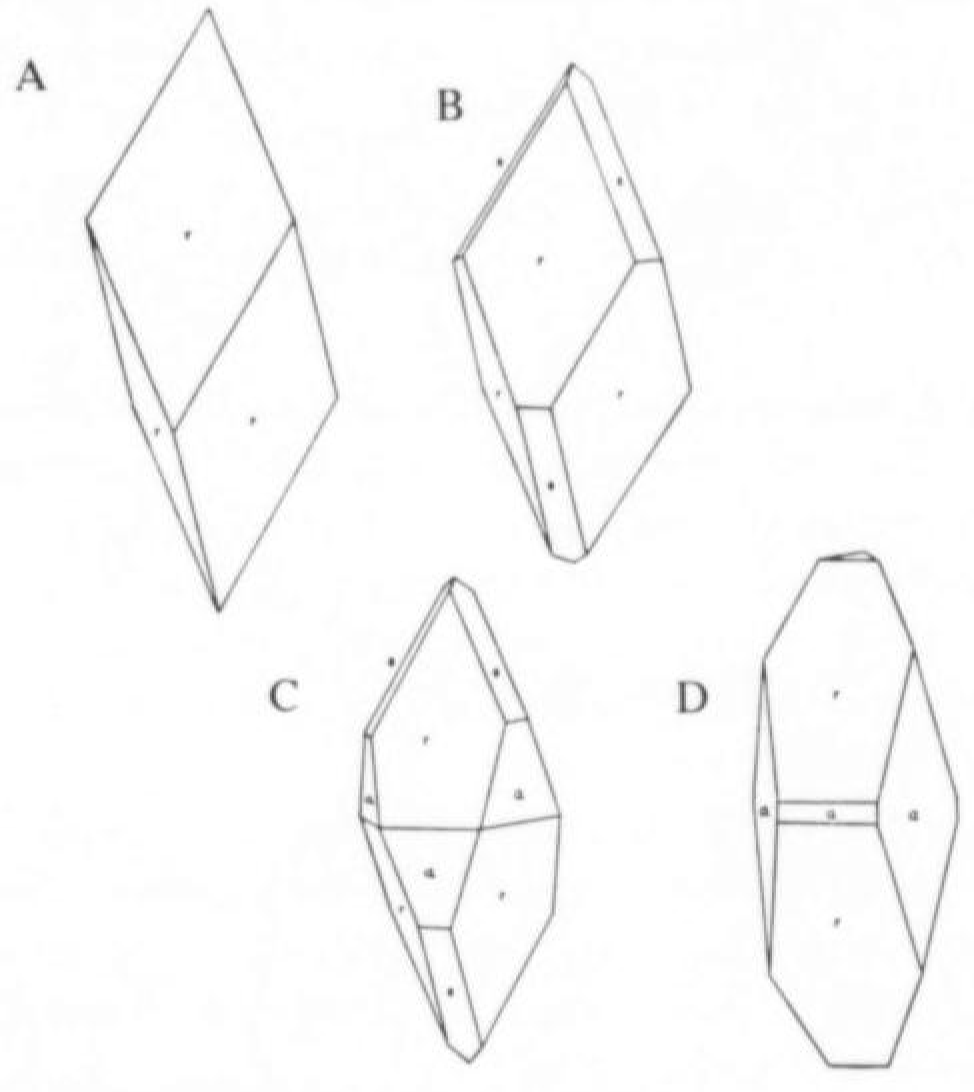

Figure 12. **Schairerite, Searles Lake.**

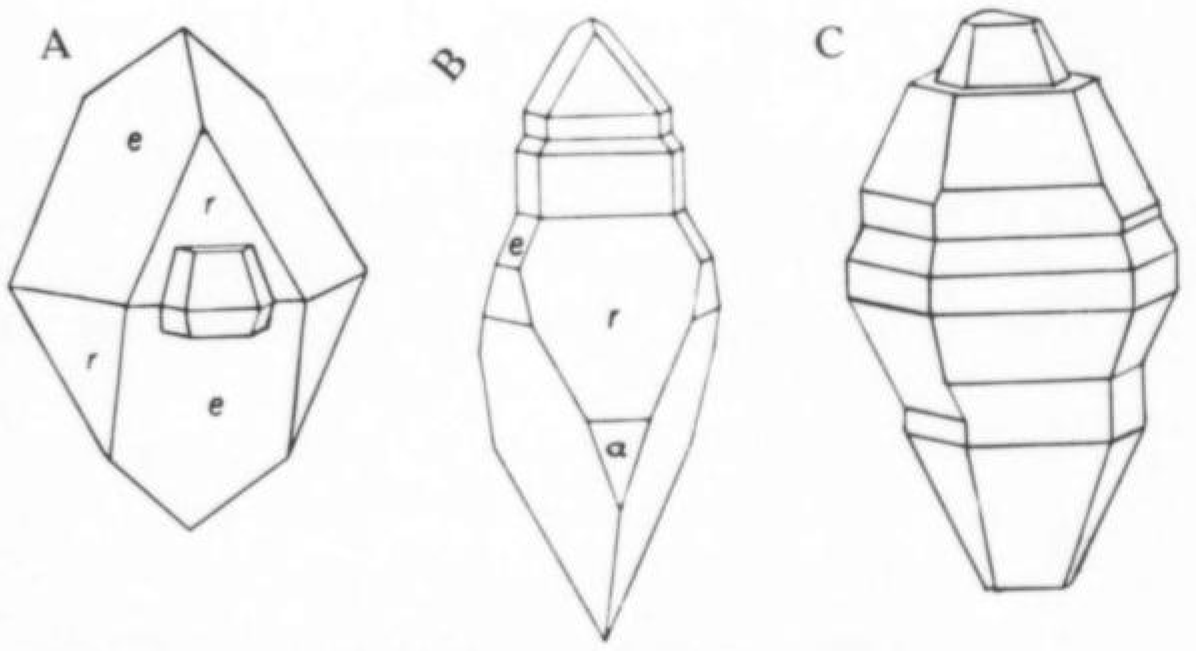

Figure 13. **A, Galeite; B, schairerite with galeite overgrowth; and C, schairerite-galeite polycrystal, Searles Lake. Forms labelled on schairerite parts only.**

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*The information about the space group with second order forms was not available at the time of Foshag's study and he followed the usual practice of designating the forms as first order. (A. Pabst, pers. comm., 1971)

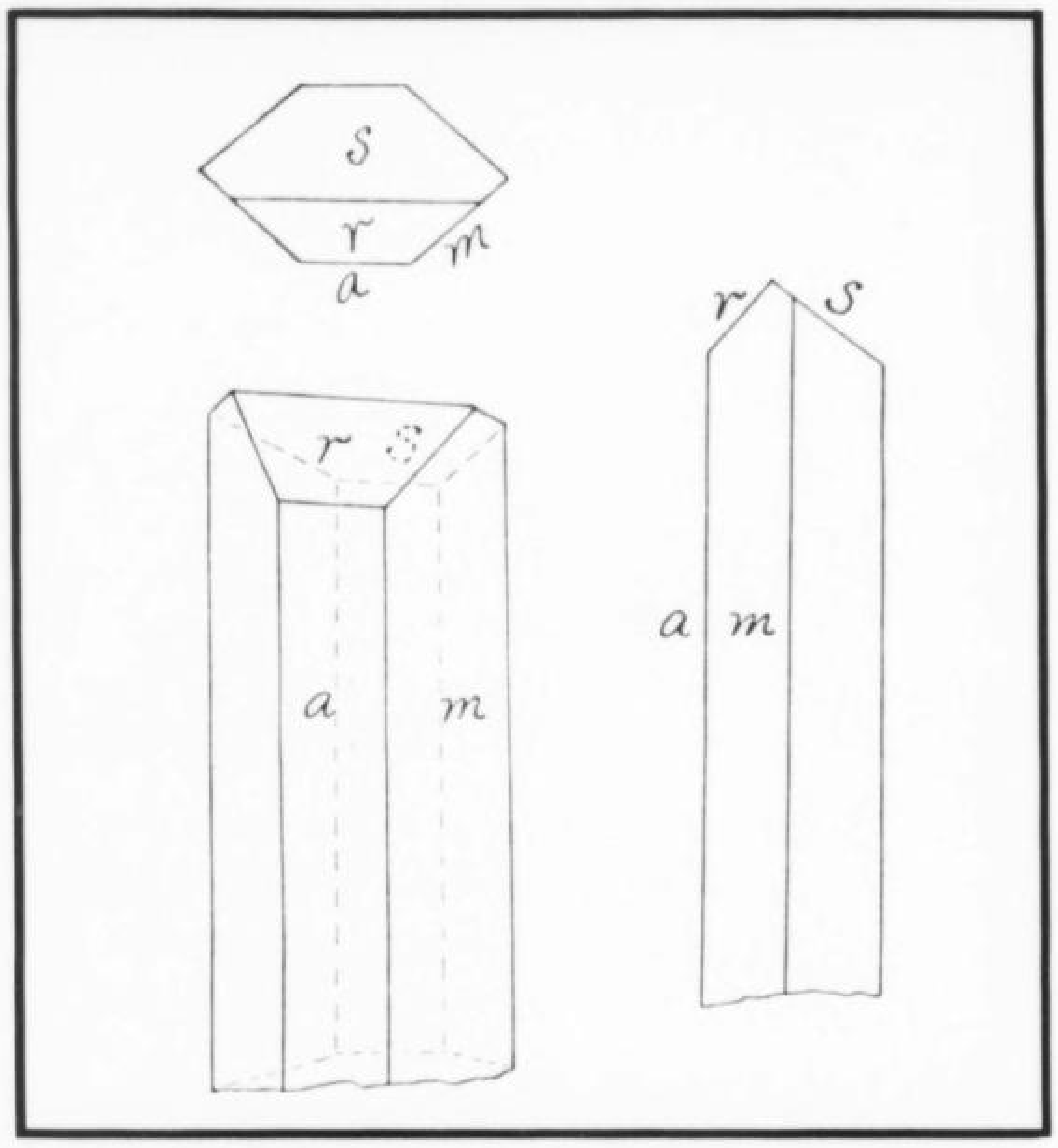

Figure 14. **Clinographic, plan, and side elevation drawings of Searlesite, Coaldale, Nevada.**

25 mm in dimension. The habits are shown in Figure 15 with the following forms: *a*{001}, *o*{111} and *d*{011}.

A and B are drawings by Penfield (1900) from the type specimens reported by Hidden and McIntosh (1888). B is a sketch rather than an exact crystal drawing. However, Penfield states that the crystals are represented in their proper proportions. The stippled crystals in the drawing are hanksite to which the sulphohalite crystals are attached. C and D are from Gale (1915). C is taken from Penfield with symbols added.

The crystals are simple rhombic dodecahedrons and octahedrons with a tendency to hemihedrism where the two forms are combined. These forms are sometimes modified by small cube faces, *a*{001} as in E and F (from Berry and Mason, 1959).

Additional references for sulphohalite: Foshag, 1920a; Gale and Hicks, 1914.

Teepleite, $Na_2(BO_2)Cl \bullet 2H_2O$

Tetragonal, Ditetragonal dipyramidal, 4/*m* 2/*m* 2/*m*

So far as is known, teepleite has been identified only once at Searles Lake - in a core from the lower part of the Lower Salt, a unit 100-120 feet in depth. It was associated with trona, burkeite, halite and hanksite, which are typical of this unit. The stubby borax crystals, also usually found at this level, were absent from the core. It is possible that the teepleite formed in place of the borax in this case.

The teepleite occurred as euhedral crystals up to 5 cm which altered rapidly to tincalconite on exposure. The habit of the crystals was the same as that of the type teepleite as described by Gale et al. (1939). (M. L. Leonardi, pers. comm. 1972) This habit is shown in Figure 16. The forms are *c*{001} and *e*{101}.

Thenardite — Na_2SO_4

Orthorhombic rhombic-dipyramidal, 2/*m* 2/*m* 2/*m*

Thenardite occurs here as colorless to pale yellow or brown crystals 5 to 95 mm long and averaging about 20 mm. They are tabular to short prismatic (Figure 17,A, Ayres, 1889b). Ayres identified the forms as: *m*{110}, *c*{001}, *o*{111}, *t*{106}, and *a*{100}. Oscillation on the {h01} rhombic prism often gives rise to a flat striated surface replacing *c*.

The twin drawing, B, familiar from its use in textbooks, was first drawn and described by Ayres: "Some specimens of thenardite recently obtained from (Searles Lake),... exhibit a method of twinning that apparently has not been described." The sketch of the twin from Searles Lake shown in C is by Schaller (Gale, 1915).

There is a difference of opinion among authorities as to the orientation of thenardite. The difference is shown in Figure 18. A is a drawing from Dana 6th (E. S. Dana, 1892); B is the same crystal in Dana 7th (Palache et al., 1951); and C is by Winchell and Winchell (1964). A becomes B by rotating the crystal 90°on the *a* axis, and B becomes C by rotating the crystal of B 90°on the *b* axis.

This difference is reflected in the description of cleavage and tabular habit by the several authors. Dana 6th describes the cleavage as perfect on {001} and the tabular habit as parallel to that plane. Dana 7 describes the cleavage as perfect on {010} and the habit as tabular on that plane. This is due simply to the fact that with the change in orientation {001} became {010}. However, Winchell and Winchell described the distinct cleavage plane as {001} and one of the habits as "basal plates." Ayres' orientation of Searles Lake crystals was apparently the same as that of Winchell and Winchell since the tabular habit is distinctly on the {001} plane.

Further references relating to the orientation of this mineral are: Baerwald, 1882; Gorgey, 1910; Larsen, 1921 (optical); Spencer, 1944; and Zachariasen and Ziegler, 1932 (structure cell).

Tincalconite — $Na_2B_4O_7 \bullet 5H_2O$

Hexagonal trigonal trapezohedral, 32

Primary crystals of tincalconite are very rare at Searles Lake, having been reported only twice: (1) from a depth of about 118 feet in a saline layer (Pabst and Sawyer, 1948), and (2) from a U.S. Geological Survey core in the Overburden Mud which covers the first 30 feet of the lake bed (Smith and Haines, 1964). The crystals are clear and colorless, 1 to 3 mm in size.

As shown in Figure 19A (Pabst and Sawyer, 1948), the only forms occurring on the crystals are *r*{10$\bar{1}$1} and *c*{0001}. This habit is very constant with the two forms combined in such a manner as to resemble an octahedron. However, in an ideal octahedron (Figure 19B) all the faces are equilateral triangles whereas only the *c* faces of tincalconite are

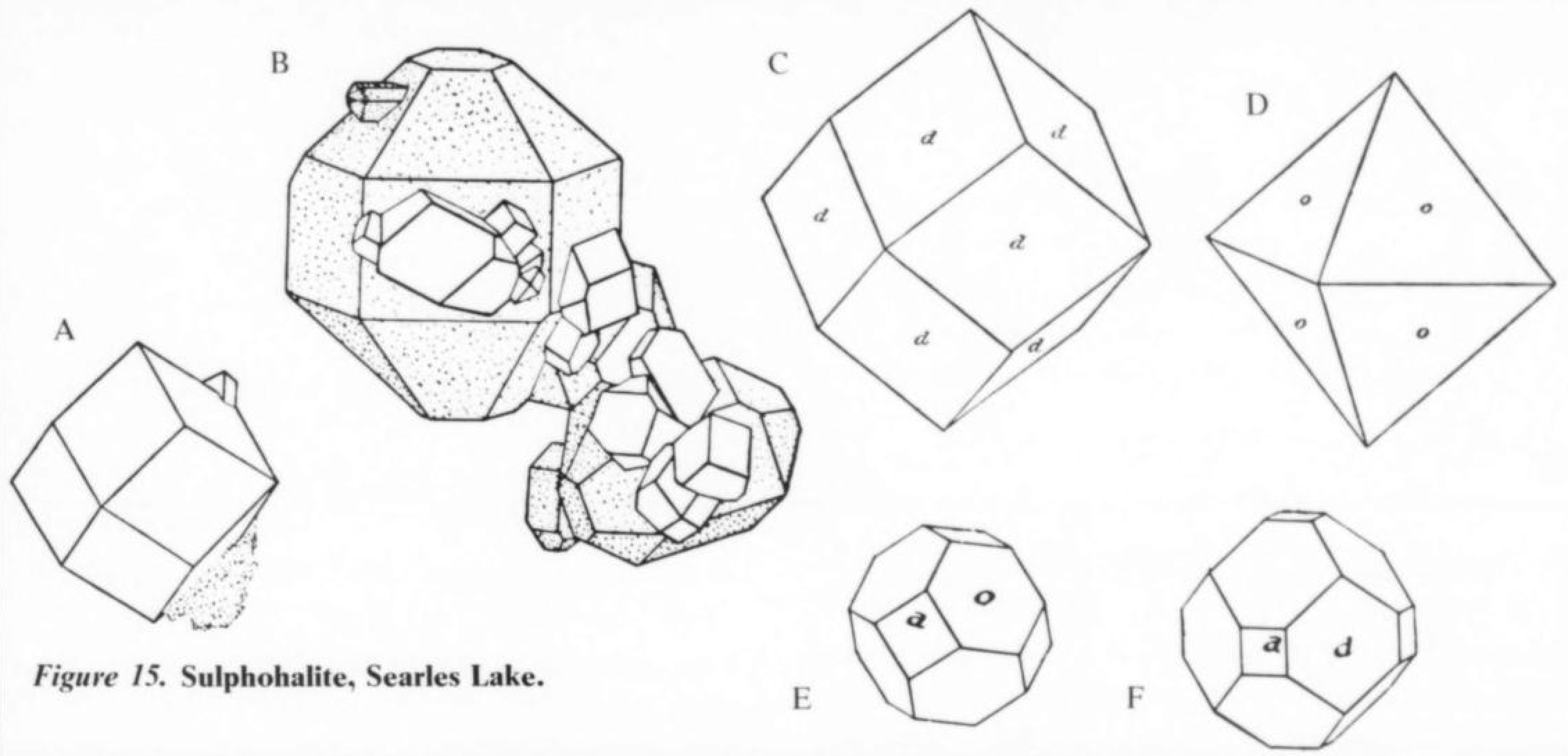

Figure 15. **Sulphohalite, Searles Lake.**

equilateral. The angle between edges of the *r* faces of tincalconite is about 12° larger than the corresponding 60° angle of an octahedron (Pabst and Sawyer, 1948).

Trona — $Na_3(CO_3)(HCO_3)\bullet 2H_2O$

Monoclinic prismatic, 2/*m*

Trona crystals here are transparent and colorless or translucent white, sometimes shaded pale yellow, orange, green or gray by inclusions. They occur as: (1) aggregates of microscopic acicular crystals; (2) coarse-grained aggregates of fibrous or acicular crystals, the latter up to 25 mm in length but averaging only 3 mm; and (3) as aggre gates of bladed or lath-like crystals up to 45 mm, averaging about 10 mm.

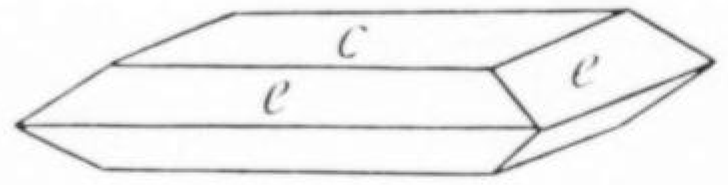

Figure 16. **Teepleite, Borax Lake, Lake County, California.**

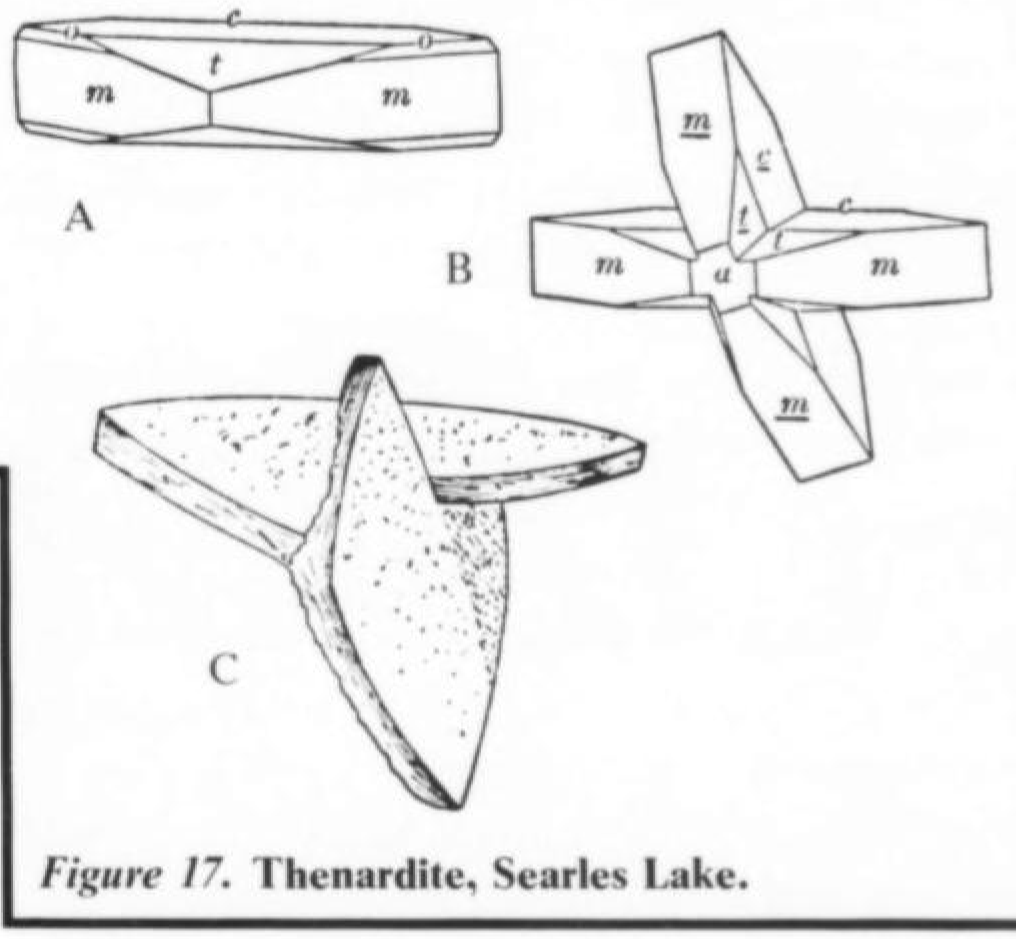

Figure 17. **Thenardite, Searles Lake.**

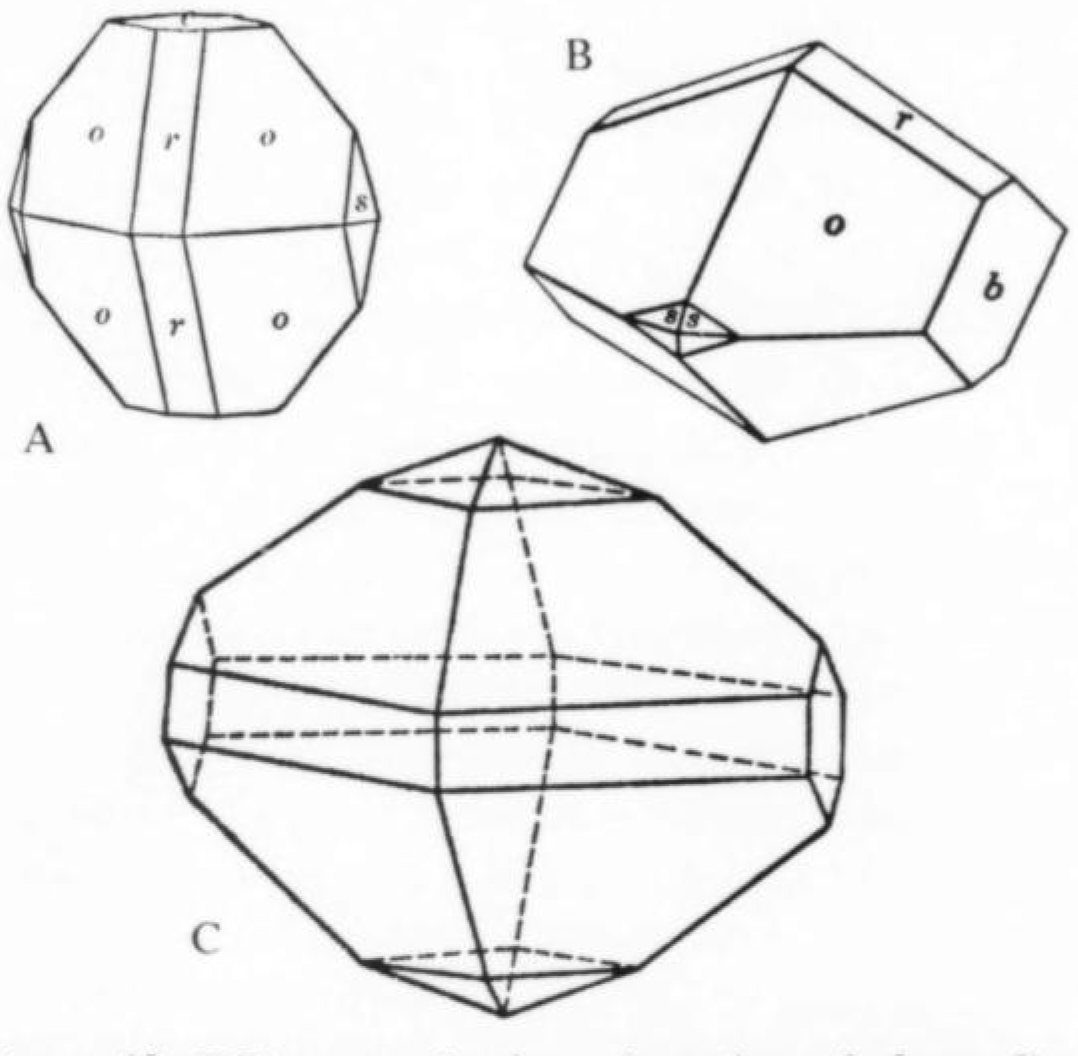

Figure 18. **Differences in the orientation of thenardite.**

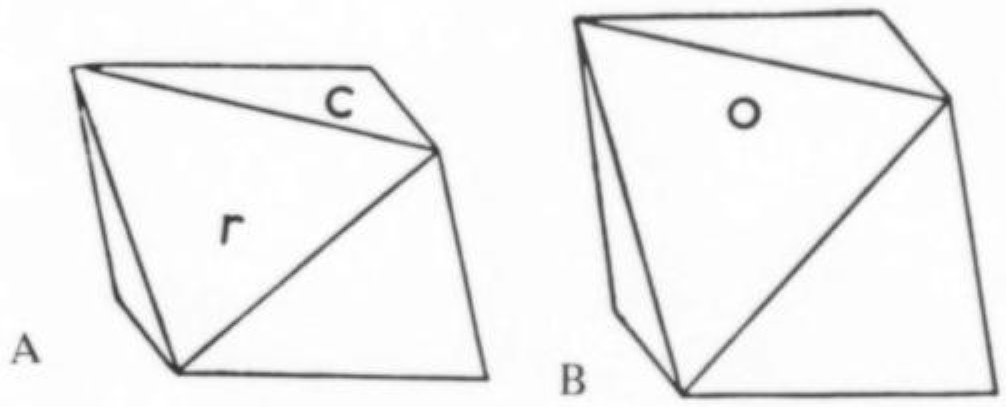

Figure 19. **Tincalconite, Searles Lake, and an ideal octahedron.**

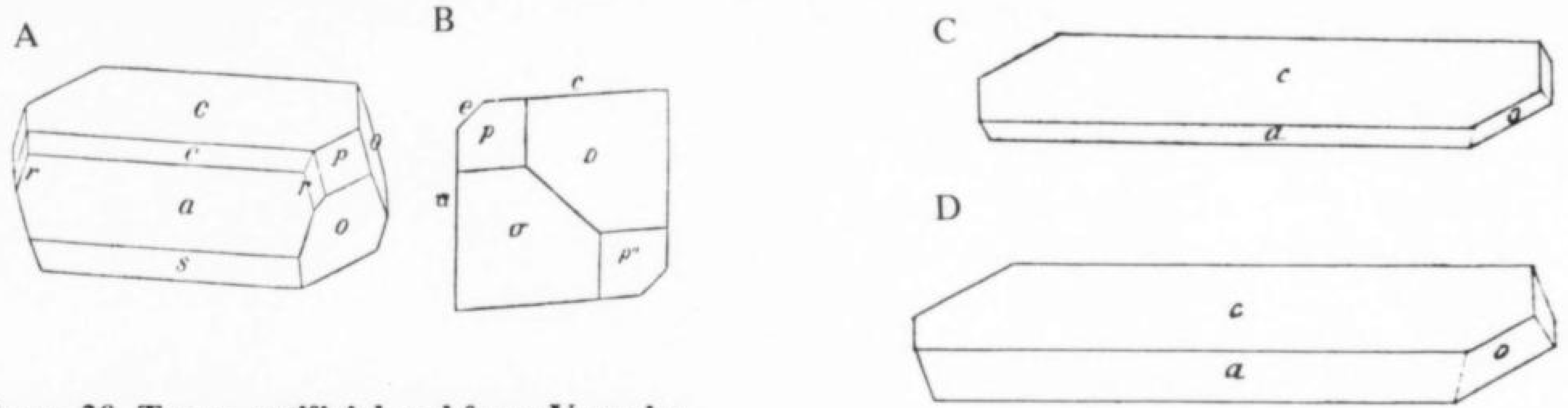

Figure 20. **Trona, artificial and from Vesuvius.**

The crystals are elongate parallel to the *b* axis and striated on {h01} parallel to the *b* axis. The bladed crystals are flattened on {001}. No drawings of Searles Lake trona crystals are available. However, the drawings in Figure 20 show the forms that occur and the bladed habit of trona. A and B are by Ayres (1889a) from artificial crystals. B is a projection on the clinopinacoid plane. C and D are crystals from Vesuvius (Goldschmidt, 1923, table 6, figures 8 and 9). The forms shown are: *c*{001}, *a*{100}, *e*{101}, *s*{$\bar{3}$02}, *o*{$\bar{1}$11}, *p*{111} and *r*{211}.

Additional references for Trona: Gale, 1915, p. 300; Foshag, 1935, p. 51, Huang and Kerr, 1960, p. 315.

Acknowledgements

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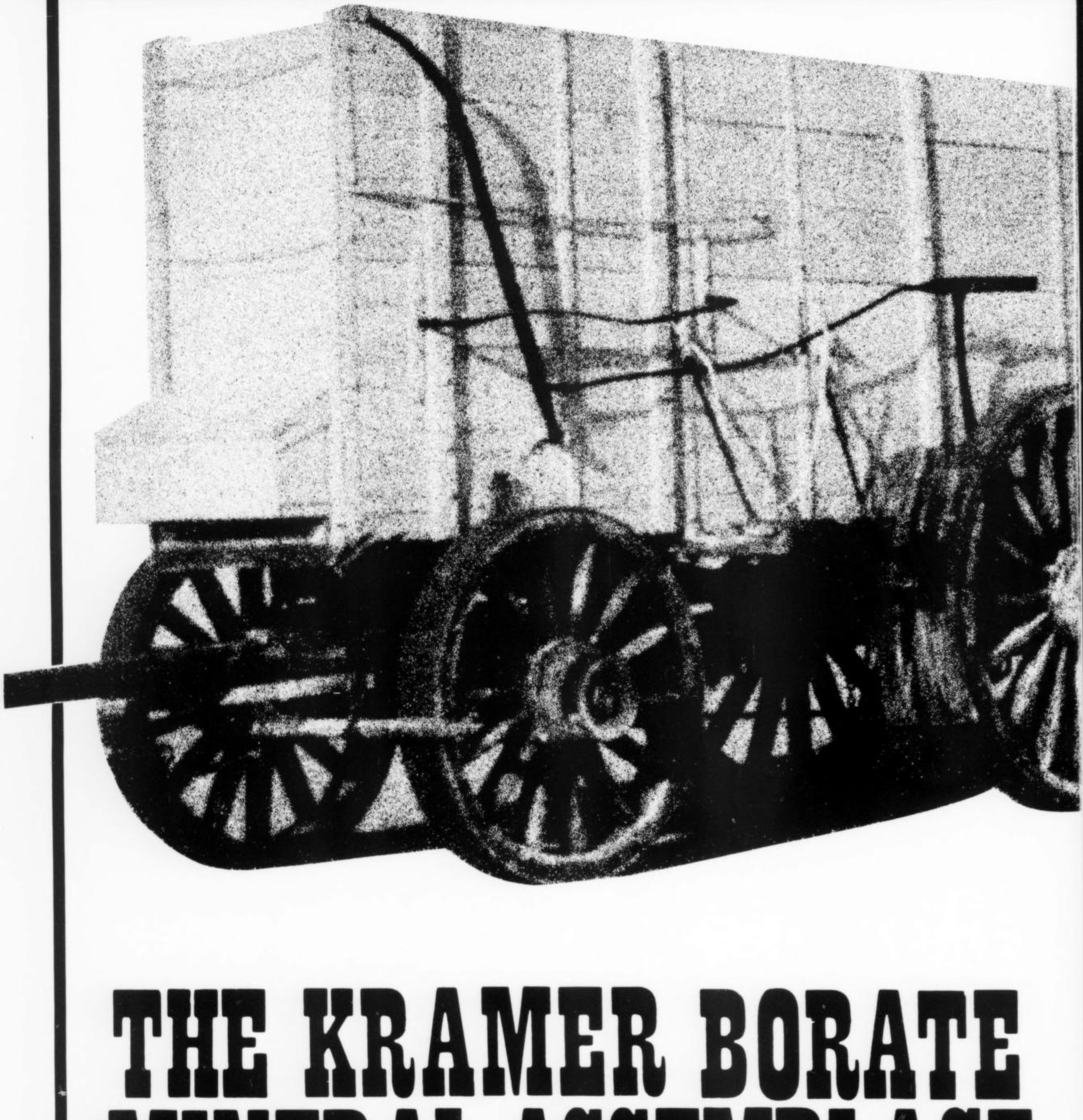
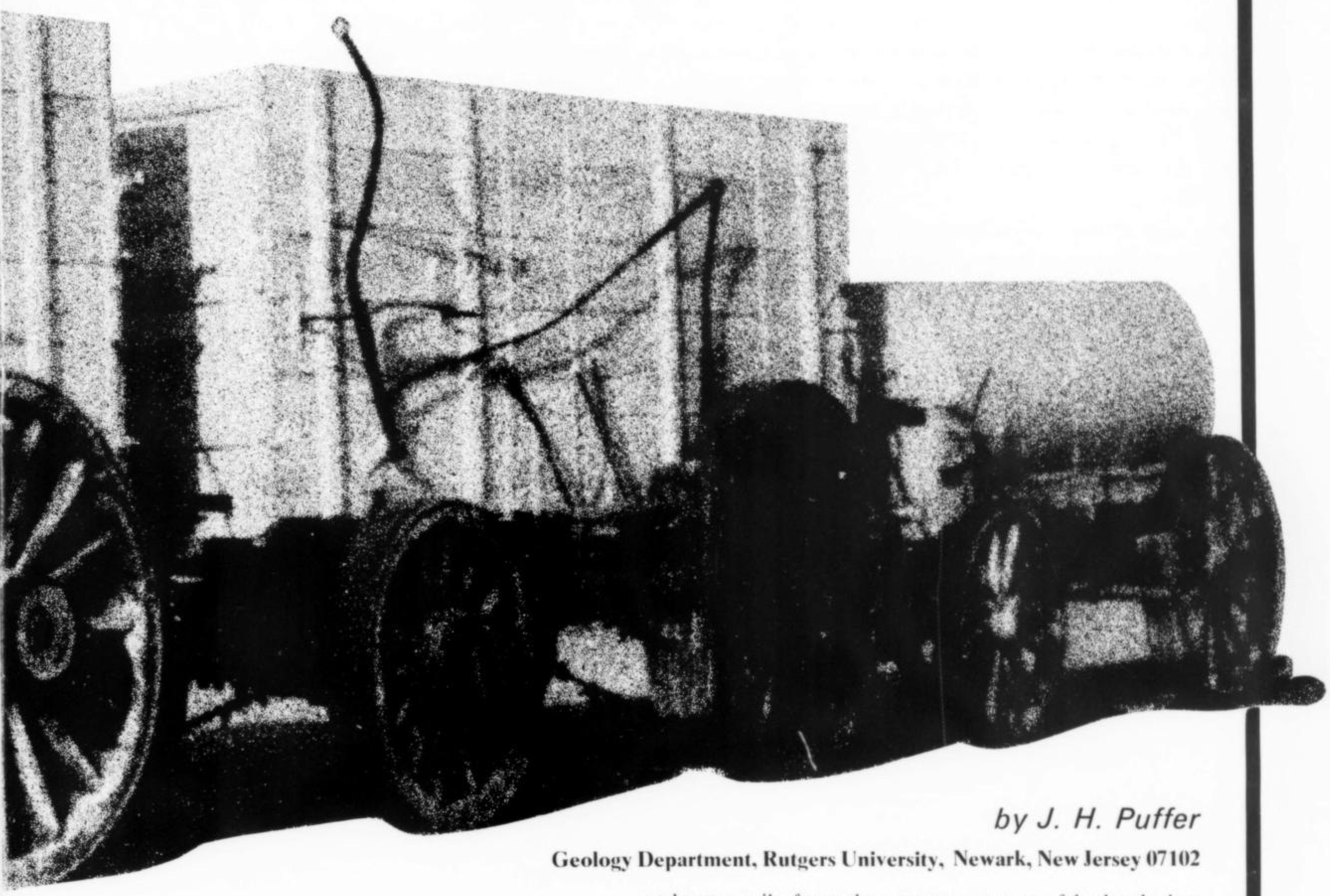


THE KRAMER BORATE MINERAL ASSEMBLAGE

BORON, CALIFORNIA

Fig. 1. **Twenty mule team ore train consisting of two ore wagons and a water tank.**



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The Kramer borax ore deposit is located just north of Boron, California, in the Mojave Desert, approximately 100 miles northeast of Los Angeles. The ore body consists primarily of massive borax in a green shale matrix. Abundant kernite, tincalconite, ulexite, and colemanite and minor amounts of several other borates are also found there (table 1).

Some of these minerals are quite uncommon elsewhere but at Boron they can be found as spectacular crystals or crystal aggregates that are extremely asthetic. Kernite, for example, commonly occurs as thick lath shaped crystals measuring two feet long, and seams of pure ulexite six inches thick are not difficult to find there.

The discovery of the deposit was purely accidental because it lies beneath a broad alluvial plain whose featureless surface of sand and gravel offers no clue as to what is beneath. According to Noble (1926) a well was drilled for water in this plain in 1913 on the ranch of Dr. J. K. Suckow, a physician from Los Angeles. The well site was at least a mile from the nearest outcrop of bedrock, but the drill penetrated the bedrock beneath the alluvium and struck colemanite. Dr. Suckow sold the discovery claim that he made to the Pacific Coast Borax Company which developed the prospect. The Pacific Coast Borox Company later became the U. S. Borax and Chemical Corporation which still operates the mine.

Underground mining operations began in 1924. Both room and pillar and block caving methods were employed. Then, in 1957, the mine converted to open pit mining (Fig. 2). Today the Kramer open pit is the world's largest producer of borates and yields up to 10,000 tons of ore per day. In 1971 U. S. Borax's plant capacity topped 500,000 short tons of B_2O_3 per year (Wang, 1971). The reserves of borate ore at Boron are second only to the deposit at Kirka, Turkey (Dunn, 1966).

The borax ore body is about four miles long and over a mile wide aligned north-south in a broad synclinal basin. Many of the underground workings have not been removed by the open pit and intersect the pit. Some of the mine drifts have been made easily accessible to the pit roads and it is possible to drive for miles through these drifts and 8 to 32 feet high rooms. A portion of the underground workings has been set aside as an air raid shelter to be used by Edwards Air Force Base located directly across route 58 from Boron.

A tourist attraction on the mine property is one of the famous 20 mule team ore trains (Fig. 1). The fully loaded trains consisted of two wagons plus a 9,600 pound water tank, a total of 36-1/2 tons. The mule trains were not used at Kramer but did haul ore 165 miles across the Mojave Desert from the Furance Creek deposit in Death Valley to the rail head at Mojave, California, during the 1880's and 1890's.

Most uses of borax ore have been developed during the last fifty years but some have existed for at least four thousand years. According to Travis and Randolph (1973) the Babylonians used borax for working and brazing gold, and the Egyptians used it to mummify their royalty.

In 1971, however, according to Wang (1971) 40 percent of the borax used in the United States went into the manufacture of heat resistant glass, glassware, and fiberglass, 15 percent in soaps, 10 percent in vitreous enamel, 10 percent in agricultural products such as fertilizers and herbicides.

The remainder found many miscellaneous uses such as welding flux, coating material in solar batteries, thermal absorber in atomic reactors, and in abrasives. Cubic boron nitride (Borazon) has a hardness approaching that of diamond and has better heat resistance (Massey, 1964). Other uses have been listed by Aristarain and Hurlbut (1972).

Geologic Setting

The Kramer ore body has been classified by Aristarian and Hurlbut (1972) as a class B, type 8 deposit. Class B refers to deposits related to volcanic rocks and type 8 refers to old playa or lake deposits that were buried and highly deformed but have undergone low to moderate chemical changes.

The borate ore of the Kramer deposit is concentrated in the early middle Miocene Kramer beds (Whistler, 1968) which underlie Quaternary alluvium. More specifically the borax ore is found in the shale member of the Kramer beds which is overlain by the Arkose member and underlain by the Saddleback basalt member. The stratigraphic details have been reported by Barnard and Kistler (1966) who have subdivided the shale member from bottom to top into:

(a) A barren facies consisting of green to brown shale and bentonitic clay with fragments of the underlying alkaline olivine basalt.

(b) A ulexite facies consisting of dark green to brown shale with ulexite nodules and veins.

(c) A sodium borate facies consisting of several hundred feet of massive crystalline borax, in a clay matrix, and thin interbeds of clay and tuff. Kernite is abundant near the base of this facies and realgar and stibnite are disseminated in the borax near the top.

(d) An overlying ulexite facies, consisting of ulexite, tuff, claystone, and green shale with massive ulexite and ulexite nodules and veins.

(e) A colemanite facies consisting of claystone and

***Fig. 2.* The U. S. Borax Co. open pit mine at Boron, California.**

Fig. 3. **Left, "borax" crystal cluster, dehydrated to tincalconite.**

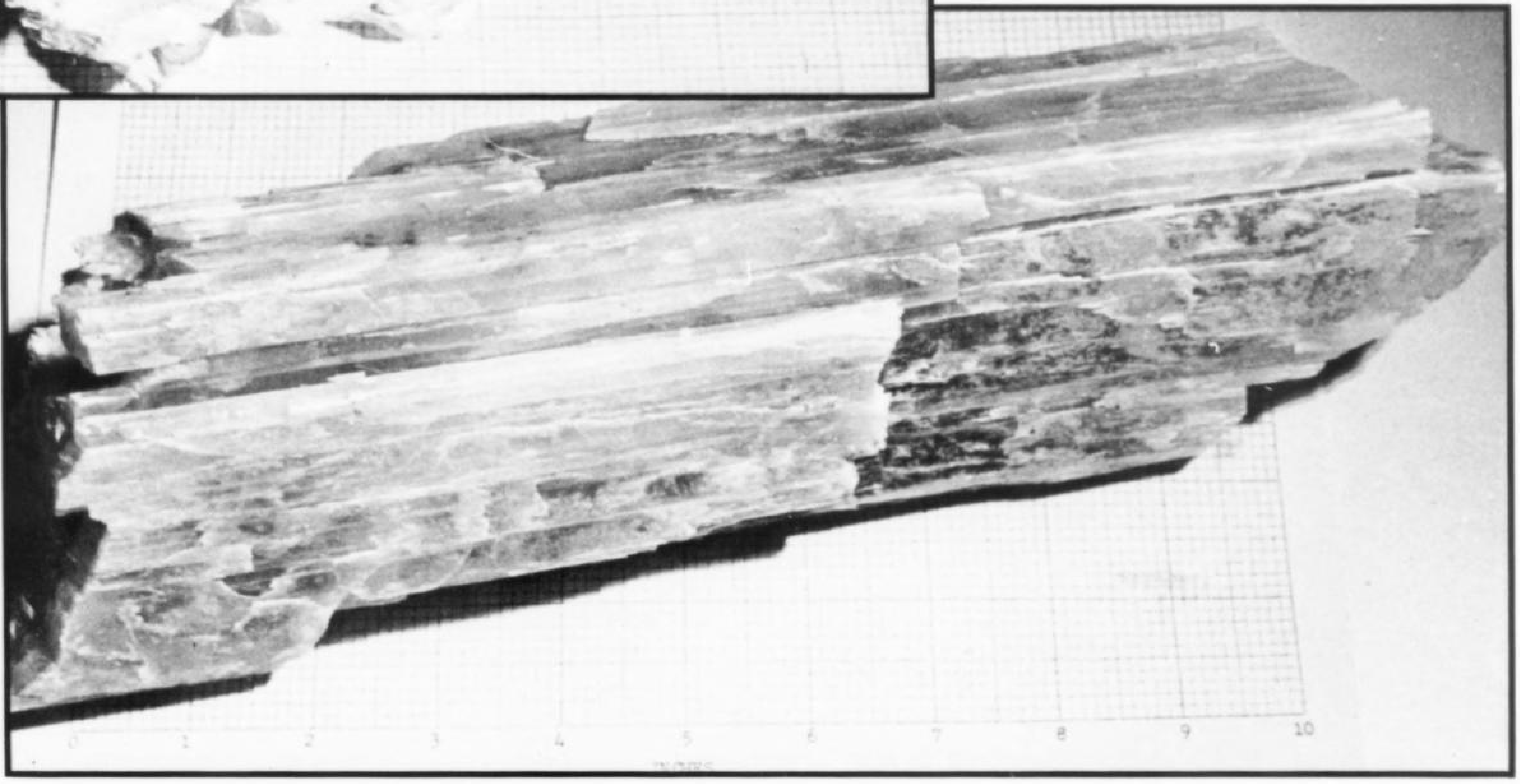


Fig. 4. **Below, kernite cleavage fragment 13 inches long from a crystal that measured about 2.5 feet in length.**

olive green shale with calcite and colemanite nodules, veins and masses.

(f) An overlying barrier facies consisting of olive green montmorillonite rich claystone and tuff with calcareous nodules.

The dip of these sediments and volcanic rocks averages about 3° usually to the northwest but varies between 0° and 20°. Near faults, however, drag folding increases the dip from 30° to vertical. One of the most important faults that has affected the deposit is known as the portal fault which strikes slightly north of west. Displacement of this fault has downthrown the south side 600 feet and strike slip movement has carried the south side approximately 2,000 feet to the west. No borates are found on the south side. Several other smaller faults also occur north of the portal fault and are aligned approximately perpendicular to it (Barnard and Kistler, 1966).

Borate Minerals:

1. Borax

By far the most abundant borate that occurs at the Kramer deposit, and the principle ore mineral, is borax. It occurs most commonly at Boron as sub-euhedral crystals from less than 1/8 inch to one inch across in a green shale matrix. Euhedral crystals are also common and are tabular and prismatic, very similar to pyroxene in form and habit. The borax is soft (H = 2 — 2.5), brittle, and has a conchoidal fracture. Throughout the majority of the district the borax is quite transparent with a greasy luster but is locally clouded with orpiment and realgar. These arsenic sulfides are commonly present in signifi-

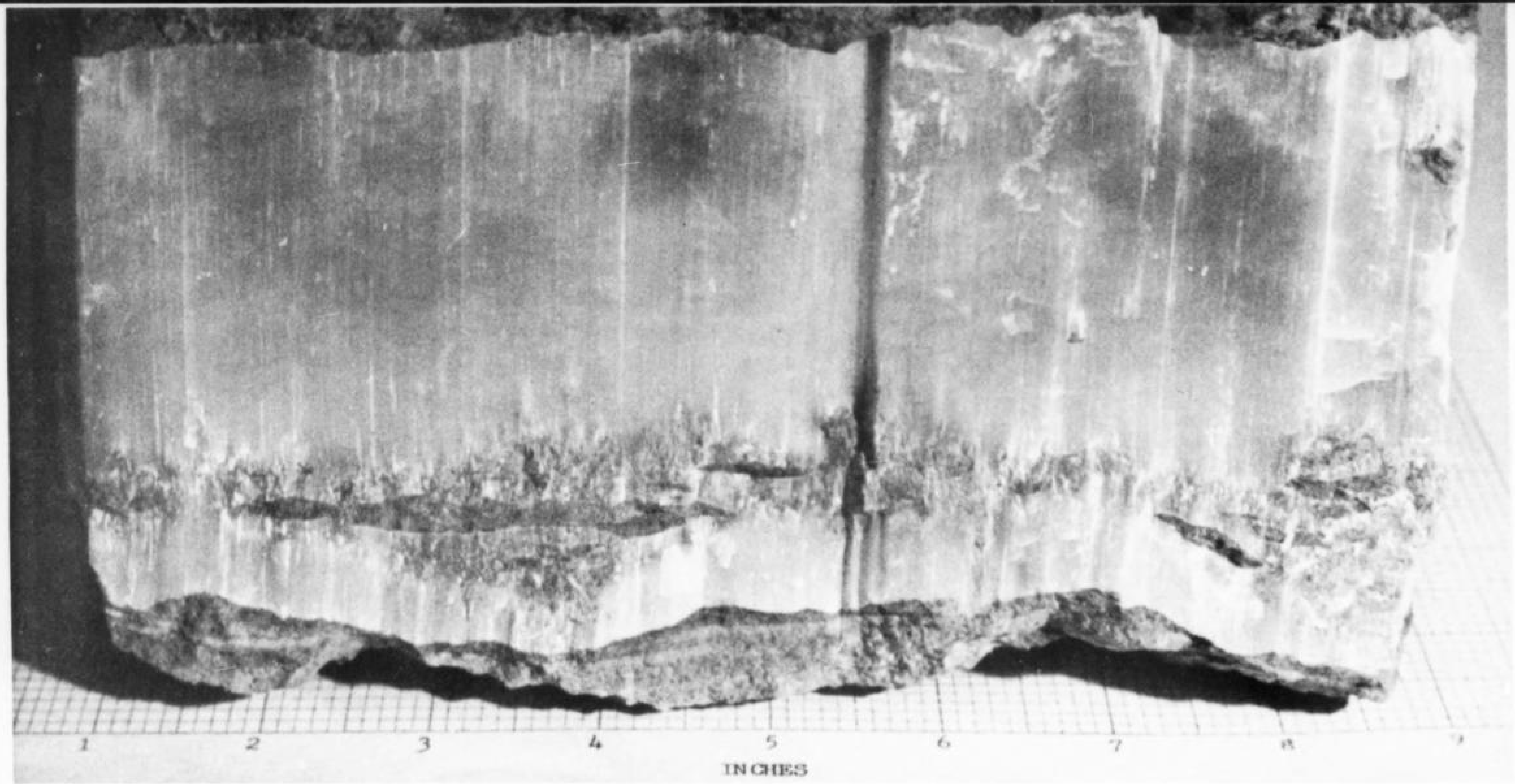


Fig. 5. **Vein of ulexite 3.5 inches thick in green shale.**

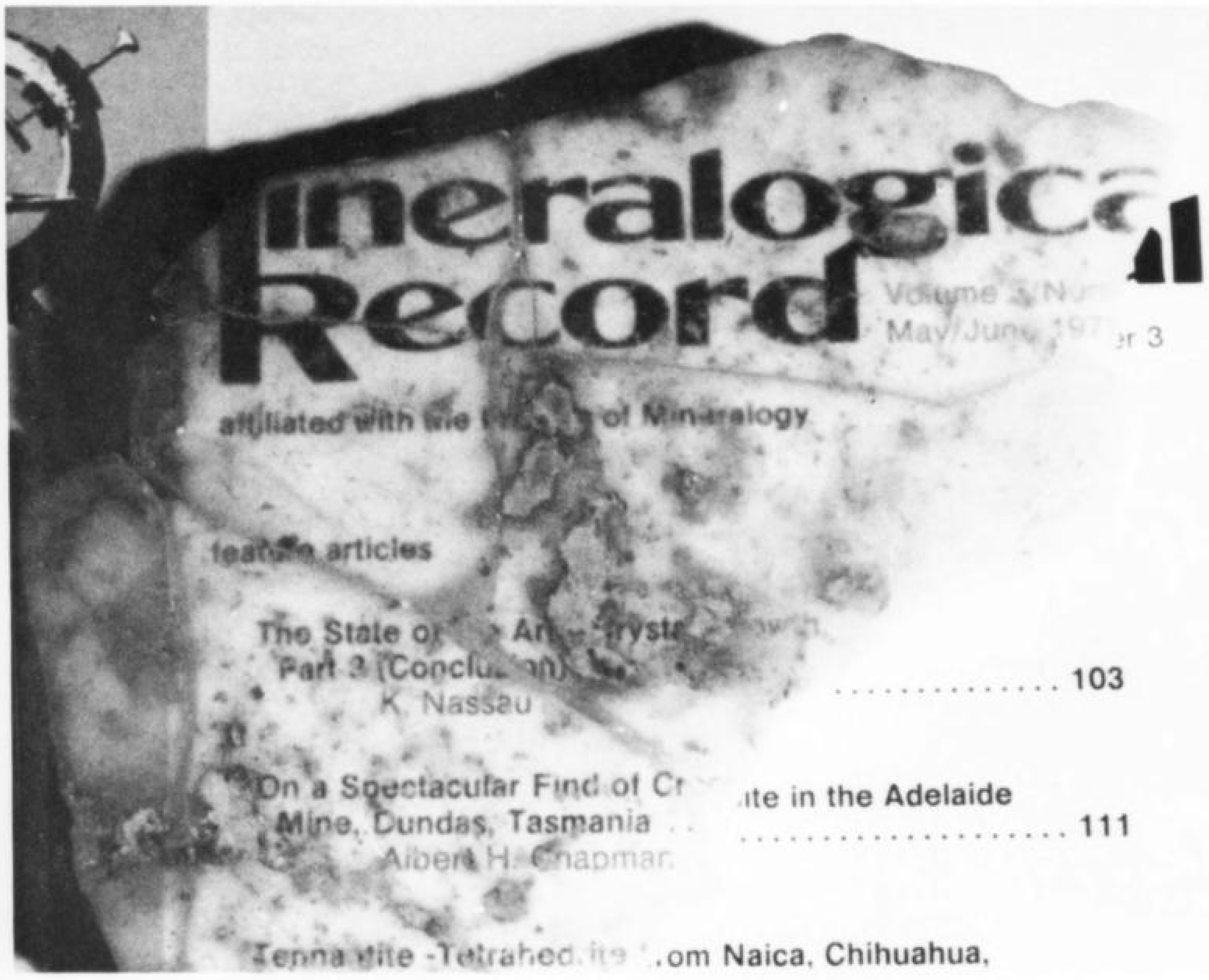


Fig. 6 **Polished slab of ulexite 1 inch thick. The image beneath has been transmitted to the upper surface. Note in particular the left half of the letter "a" in "Mineralogical" that has been lifted off the page and appears as if it was printed on the upper surface of the slab.**

cant amounts coloring the borax bright orange.

Most of the borax ore is interbedded with green shale. Individual beds of borax are about one to three cm thick and the crystals at the base of the beds are typically finer than the larger and sometimes euhedral crystals at the top. The largest and most euhedral crystals, however, are found in the underground workings where encrustations and clusters of borax crystals (Fig. 3) have precipitated from pools of water left standing along the floors of the drifts and in the dumps. Crystals occurring in these clusters measure up to four inches across and are perfectly euhedral.

Once these crystal clusters are carried out of the cool and humid underground workings and into the dry and hot desert air of the open pit they immediately begin to dehydrate. The dehydration process begins with the formation of patches of white tincalconite. The white patches begin to appear within a few hours and within a few days the originally clear crystals become completely coated with tincalconite and are eventually completely converted. Dehydration is difficult to prevent short of sealing off the crystals in an atmosphere close to 100 per cent humidity. But a thick coat of lacquer sprayed onto the crystals will slow down dehydration and keep them clear for months.

2. Kernite, monoclinic

Kernite is the second most abundant borate of the Kramer deposit. It is, however, more abundant in the deep thick central part of the ore body than around the edges. The crystals are nearly equant but are slightly elongated parallel to (100). The kernite is heavily striated parallel to (010). Other physical and optical properties of kernite are described in detail by Schaller (1930).

The kernite crystals at Boron are very coarse grained (Fig. 4) and measure up to 8 feet in length. They are typically completely transparent but some crystals are clouded with traces of green shale and/or realgar that occurs along the cleavage planes. When handling kernite, care must be taken to avoid sharp splinters since the crystals are very friable.

3. Ulexite

The ulexite of the Kramer deposit occurs most commonly as rounded "cottonballs" consisting of radial acicular fibers. Ulexite also occurs as horizontal veins or seams (Fig. 5) up to twelve inches thick consisting of capillary fibers aligned perpendicular to the upper and lower contacts. Some ulexite is also found in large vugs in the Saddleback basalt.

The ulexite from the Kramer deposit is known in Southern California as "T.V. stone" because of its almost unique ability to transmit images along its fibers. The ulexite fibers behave as natural light guides and obey the principles of fiber optics. The slab of ulexite illustrated in Figure 6 is a cluster of fibers that are not transparent across the fibers, but instead transmit the image to the upper surface.

Some ulexite at the Kramer district also occurs as cones resembling mushrooms (Fig. 7) found in beds of green shale. These cones are not common but some can be seen clinging to the roof of the underground room that is used by the mine geologists as a core storage depository.

4. Colemanite

Colemanite at Kramer occurs both as independent nodules and as intergrowths with ulexite. The colemanite nodules are closely associated with septarian calcite nodules that occur in the same stratigraphic horizon. The calcite nodules differ from the colemanite nodules only in their fine grained texture. The colemanite associated with ulexite veins, however, occurs as short prismatic crystals similar in shape and size to small thick thumbnails. As illustrated in Figure 8, the colemanite has clearly replaced some of the ulexite. The sample illustrated in Figure 8 was taken from an eight inch thick ulexite seam. Elsewhere in the deposit colemanite may have completely replaced small ulexite nodules.

5. Other Borates

Other boartes in the Kramer ore body are much less common than the minerals described above and probably make up much less than one percent of the borate mineral assemblage. Some of these less common minerals, such as kernakovite and probertite, are particularly asthetic. The kernakovite illustrated in Figure 9 appears as if it were clear ice but has perfect cleavage in one direction and occurs as a thick tablet. Probertite commonly occurs in rosettes or radial groups of needles.

Origin of the Deposit

During early middle Miocene time the Saddleback basalt was extruded onto older Tertiary sediments. The basalt flowed into a topographically low area where the combined thickness of the individual flows measures up to 250 feet. This low area was probably caused by the downward movement of the "Western Borax" fault which is located south of what is now the Kramer ore body. After the volcanic activity ended, the depression became a playa. Gale (1946); Muessig (1959); and Barnard and Kistler (1966) have suggested that thermal springs flowing through the cooling volcanics carried boron to the playa where it precipitated as borates.

Fresh water ostracod fossils have been found by Porter (1964) in the sediments that formed before many borates had precipitated, indicating that the waters were initially able to support life. But continued precipitation of borates was accompanied by several changes in the chemistry of the playa water and fossils are not found accompanying the borax.

The first boron to enter the playa waters combined with calcium and precipitated as ulexite in the playa muds. But when the supply of calcium was used up calcium borate precipitation ceased and sodium borate precipitation began. Bowser and Dickson (1966) conclude that the great majority of the borax at Kramer formed on bottom muds in contrast to ulexite which formed in the muds by replacement. Ripple marks associated with the borax beds indicate that the borax probably precipitated in relatively shallow water (10-20 meters). Experimental studies on the stability range of borax (Christ and Garrels, 1959) also indicate that the temperature of borax precipitation was probably between 25° and 35° C. As borate precipitation continued, mineralogical changes in the successively younger layers of sediments indicate that the temperature of the water gradually increased and the solubility of CO_2 gradually decreased (Porter, 1964).

Some surface water containing calcium probably flowed into the lake causing the ulexite that is found around the margins of the ore body to precipitate. But since sulfates and other minerals found in most playa deposits are rare in the Kramer ore deposit, Bowser and Dickson (1966) conclude that the lake that formed in the playa basin may have been fed almost entirely from thermal springs during most of its history.

As the lake filled with borates, silt, and tuff the water was displaced slightly to the north. As this occurred the lake became much smaller. During the last stage of borax deposition arsenic and antimony from the thermal springs precipitated as realgar (AsS) and stibnite (Sb_2S_3); disseminated in some of the upper layers of borax. Then after the final precipitation of the borates, continued mud deposition buried the ore body. Some of the ulexite around the edges of the ore body was then altered to colemanite (Fig. 8) through the action of calcium bearing ground waters. The magnesium rich borates, such as kurnakovite and inderite, may also have originated as secondary minerals through the action of ground water (Barnard and Kistler, 1966).

Other post borax changes in the mineralogy of the ore deposit are characterized by a decrease in the boron and sodium content of the sediment and an increase in the calcium content. As pressures near the base of the ore body increased under the weight of increasing thicknesses of sediment, some of the borax was then metamorphosed into kernite. Assuming an overburden of about 2,500 feet, Christ and Garrels (1959) have shown that the kernite must have formed from borax within a temperature range of 53-63° C. They conclude that "...the abundance of kernite in the lower part of the deposit and its absence in the upper part suggests burial was just sufficient..." If burial had continued any further, presumably all of the borax would have metamorphosed.

Instead of more burial, uplift occurred during a middle Pliocene orogeny. Tilting and faulting accompanied this uplift and subsequent erosion removed the portion of the deposit that was displaced to the west on the south side of the portal fault. This uplift also may have accompanied re-hydration of some kernite to a secondary sucrosic borax that is found in the lower parts of the ore body.

Smith (1968) believes that important amounts of borax were also removed by solutions after the primary ore was covered by younger (Miocene) lake sediments. The evidence of solution reported by Smith includes (a) the thinning and rounding of the borax ore body near faults which he maintains localized the solutions and (b) the presence of synclinal folds interpreted as a "sag" of the overlying rock into a depression that formed by subsurface solution.

Table 1. Borates and Borosilicates of the Kramer District*

Borates	
Borax	$Na_2O \bullet 2B_2O_3 \bullet 10H_2O$
Colemanite	$2CaO \bullet 3B_2O_3 \bullet 5H_2O$
Hydroboracite	$CaO \bullet MgO \bullet 3B_2O_3 \bullet 16H_2O$
Inderite	$2MgO \bullet 3B_2O_3 \bullet 15H_2O$
Inyoite	$2CaO \bullet 3B_2O_3 \bullet 13H_2O$
**Kernite	$Na_2O \bullet 2B_2O_3 \bullet 4H_2O$
Kurnakovite	$2MgO \bullet 3B_2O_3 \bullet 15H_2O$
Meyerhofferite	$2CaO \bullet 3B_2O_3 \bullet 7H_2O$
**Probertite	$Na_2O \bullet 2CaO \bullet 5B_2O_3 \bullet 10H_2O$
Tincalconite	$Na_2O \bullet 2B_2O_3 \bullet 5H_2O$
**Tunellite	$SrO \bullet 3B_2O_3 \bullet 4H_2O$
Ulexite	$Na_2O \bullet 2CaO \bullet 5B_2O_3 \bullet 16H_2O$
Borosilicates	
Garrelsite	$8(Ba,Ca,Mg)O \bullet 6B_2O_3 \bullet 4SiO_2 \bullet 6H_2O$
Howlite	$4CaO \bullet 5B_2O_3 \bullet 2SiO_2 \bullet 5H_2O$
Searlesite	$Na_2O \bullet B_2O_3 \bullet 4SiO_2 \bullet 2H_2O$

*After Morgan and Erd (1969)

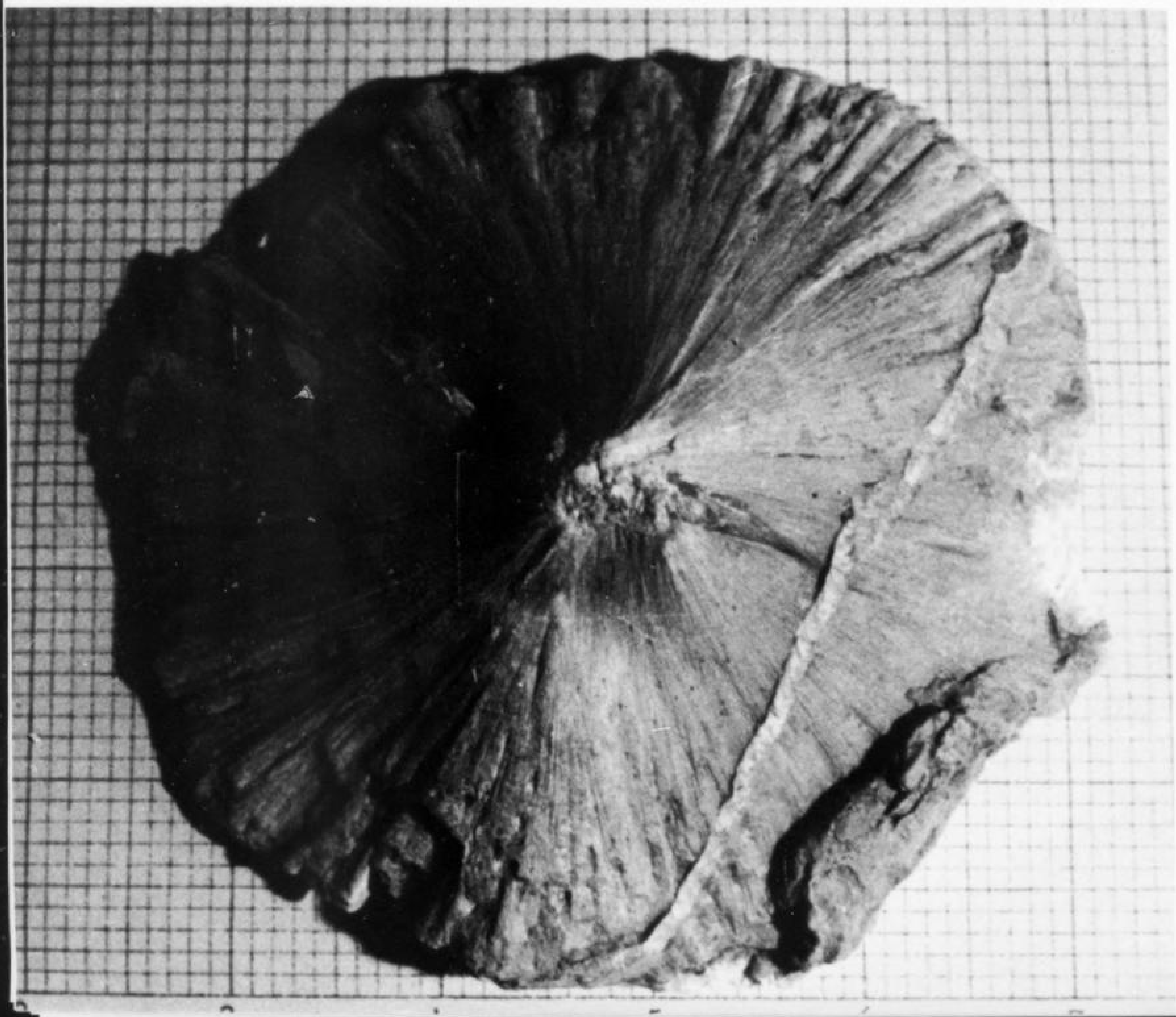
**First described from the Kramer deposit

Although many of the questions concerning the origin of the ore deposit are being worked out, many questions remain unanswered. Why is it (for example) that minerals such as halite, trona and gypsum are nearly absent from

Fig. 7. **Below left, cone of ulexite resembling a mushroom.**

Fig. 8. **Middle photo, vein of colemanite (gray) replacing ulexite (white).**

Fig. 9. **At right, kernakovite resembling slab of ice 1.25 inches thick with inclusions of green shale.**



the Kramer deposit? The composition of the playa water must have been extremely unusual to prevent halite, trona, or gypsum from forming since these minerals are very commonly found in most playa deposits. Even if the playa was exclusively fed by thermal springs emanating from the Saddleback basalt, the question remains: Why did the Saddleback basalt contain such an unusual quantity of boron? Such questions and the spectacular mineral assemblage that occurs there make the Kramer ore body one of the most interesting deposits of its kind.

Acknowledgement

I wish to thank Robert B. Kistler for many stimulating conversations concerning the origin of the Kramer ore deposit. I also thank the U. S. Borax Company for permission to sample and to study the entire Kramer ore body while in their temporary employment. Finally I thank Andreas Haji-Vassiliou for critically reviewing this manuscript.

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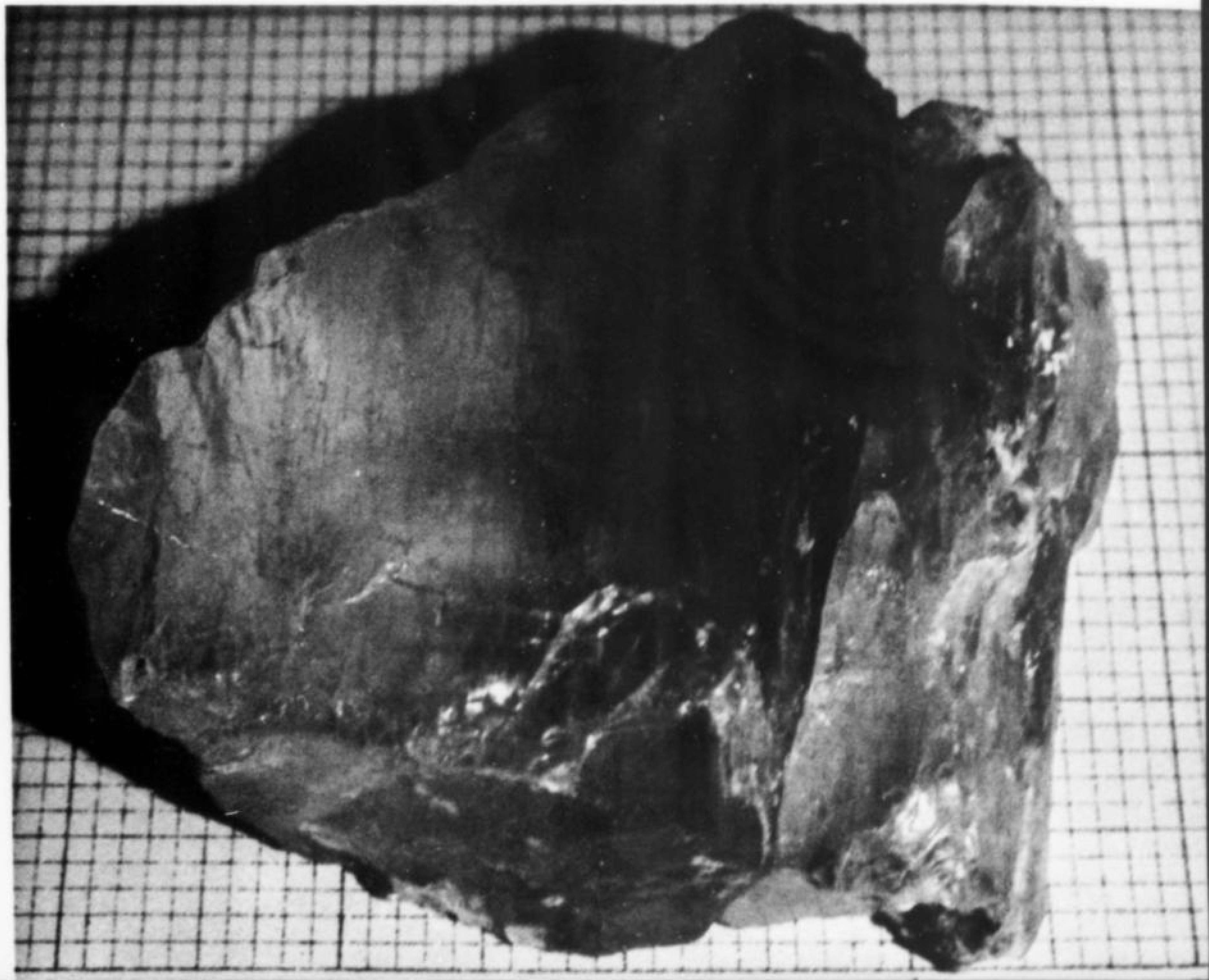

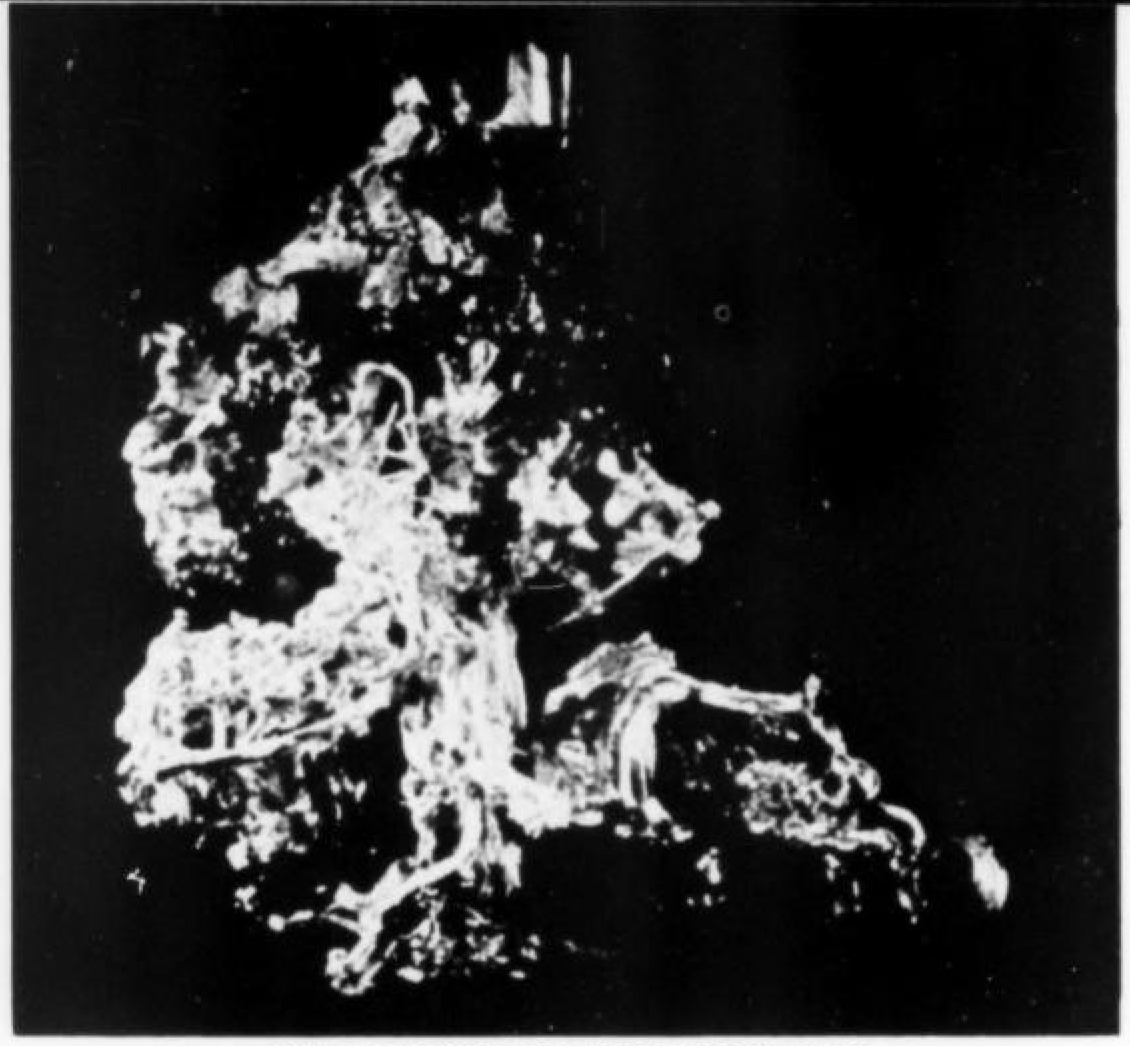

SILVER SPECIMEN STOLEN

On December 5 the specimen in the photograph was stolen from the home of Kenneth E. Bress, of Pleasant Hill, California. It is a Kongsberg, Norway, silver, approximately 2½" high by 2" wide and 1" thick on a small matrix of galena with two quartz crystals protruding from the bottom. It may be accompanied by labels from the Mineralogical Museum of the University of Oslo, Norway, dated 4-7-1900. A reward of $100 is being offered for information leading to its recovery. Should anyone have such information please call Mr. Bress collect (evenings) at 415-935-0920, or call the Contra County Sheriff's office. All information will be held confidential.

Mr. Bress also indicated that should the thief decide to return the specimen, there will be *no questions asked.* Address: P.O. Box 23117, Pleasant Hill, California 94523.

BACK ISSUES OF THE *RECORD*

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BALTIMORE MINERAL SOCIETY CONTINUES SUPPORT

The president of the Baltimore Mineral Society, Mr. Robert A. Jaxel, has decided that a donation shall be made in the amount of one hundred and fifty dollars ($150.00) to the *Mineralogical Record*, in support of the periodical publication.

This donation is being made in lieu of personal honoraria for the principal speakers at the 18th Annual Micromount Symposium, sponsored by the Baltimore Mineral Society and held in Baltimore, Maryland, on September 27, 28 and 29, 1974: Dr. Robert I. Gait, associate curator of mineralogy, Royal Ontario Museum; Mr. Louis Perloff, photomicrographer; Dr. Julian Reasenberg, chemist; Mr. Paul Seel, past president, American Federation of Mineralogical Societies; and Mr. Neal Yedlin, editorial board, the *Mineralogical Record*.

A similar donation was made after the 17th Annual Micromount Symposium, and the Society hopes that it will be able to maintain the precedent for future symposia. In this way, everybody, that is, the principal speakers and the participants in the symposia and the members of the Baltimore Mineral Society will directly assist in the support of a worthwhile periodical publication.

William Kennedy
Secretary-Treasurer

MINERALS STOLEN FROM UNION COLLEGE

More than 100 mineral specimens, valued at over $10,000.00, were stolen from the collection of Union College, Schenectady, New York. The theft occurred during the weekend of December 7-8, 1974. Elmer B. Rowley, the curator of the collection, believes that the thief (or thieves) was quite familiar with minerals because the specimens taken were the most important and valuable ones. The collection contained many fine specimens from Charles Wheatley, of Pennsylvania, which came to the college in 1858. A second collection, from Otto Pfordte, came to Union in 1938, containing many superb specimens from world-wide sources. A few other specimens have been added by gifts from students and friends of the college and, recently, a few through exchanges.

The list of specimens stolen is too extensive to reproduce here but just about everything could be considered classical material. The localities include Franklin, Bisbee, Chessy, Tsumeb, Cumberland, Cornwall, Girgenti, Elba, Pribram, Zinnwald, Butte and Fairfield.

If anyone should have information concerning this theft, please send it to Mr. Elmer B. Rowley, c/o Department of Geology, Union College, Schenectady, New York 12308.

To the Editor

REACTIONS

Dear Sir:

I would like to express my opinion on the magazine which you have published now for five years. The size of the magazine, to speak first of the face, is related to a very common size used in many countries and gives it a distinguished note. It was a great decision to print color pictures on the cover from the beginning on (without those color pictures it would have looked like a woman without make-up, although a real beauty does not need make-up). The number of pictures inside is quite good, not too few, not too many, not too small, but maybe sometimes too large.

The feature articles are well selected and give an excellent mixture of more scientific and more collectors' items. Please keep this *niveau!* Also, the articles are mostly well written, at least well edited. Especially excellent articles are Mineral Rings (1970), The State of the Art (1971), Crystal Growth (1972) and Metamict Minerals — A Review (1973). The many locality reports, among them the Boron minerals, the 79 mine minerals, and the Pikes Peak minerals. And, of course, the reports of the American Mineralogist (*S. G. Gordon*).

Especially important and most desired departments are What's New in Minerals?, Photographic Record, and the Museum Record.

I know many magazines of the kind that we collecting mineralogists like but, as far as I can compare with others and examine critically, the *Mineralogical Record* is by far the best that exists in the world in our days. I want to congratulate you for this big success. You made it only within a few years and, since I have edited a magazine myself for a limited time, I know how difficult it is, if one does not have enough money and not enough able co-workers.

Werner Lieber
Heidelberg, Germany

Dear Sir:

I read your editorial "A Record Five Years" with much interest. It has been obvious that you have done a superb job in running the show and keeping the magazine going through a hard period. It is also obvious that one major hurdle remains - increased circulation. I have talked to many collectors who are not now subscribers, trying to sell the *Record*. The usual reply is "Too technical". In your editorial you dismiss this com-

plaint a bit too quickly. Some years ago, you sent out a questionnaire to readers to learn what changes were wanted. The error in this survey was that it was sent to *readers*, whereas what you really need to know is what will attract *new* readers. I think there will be a serious problem attracting new readers until you do take their interests in consideration. This can best be done by making it more of a collectors' magazine.

Your editorial points out that it is relatively easy to get technical articles, whereas amateur articles are already being 100% used. The answer then lies in making the technical articles more readable and interesting to collectors.

I have reread the last few issues to see what was most interesting, and why. The best articles are obviously Art Montgomery's series on Sam Gordon. Why? Simple, he describes the collecting, the specimens, and the human side of collecting. I can just feel Gordon's passions, as he has to split a fine azurite find, or as he outwits an engineer in Bolivia. However, the key ingredient is that there is some idea of what he collected, not just a mineral name and table of x-ray data. He tells the size of the pocket, size of crystals, relative quality, etc., so that I know what it is all about.

In reading other articles, where the potential for detail was good, I was disappointed to find no idea of how big the crystals are, what they look like, etc. The article on the Palermo pegmatite was very intriguing, but left me with more questions than answers. There is frequent reference to fine specimens, but never once a description. Should I beat the bushes to try to acquire a fine "thumbnail" hühnerkobelite crystal, or is it only in the micromounters' province?

The second step that might help on the technically oriented articles is reduce the use of technical words where simpler, more widely understood, words will do...Really good writing seldom requires more than a high school education to understand it. In looking over some of the recent *MR* articles, a Doctor's degree would be needed to understand them.

I hope that these comments will prove useful in making *MR* the fine magazine it has always been as well as a financial success.

James Minette
Boron, California

Dear Sir:

The need to increase the subscription fee for the *MR* is regrettable but understandable in the face of all other rising costs. Even the higher fee is not too great a price to pay for your fine magazine and the pleasure many of us derive from it. I only hope that you will maintain the high standards you have set for the magazine so that we can continue to actively promote it among our friends and fellow mineral collectors. In this respect I must call you to task.

The most recent issue of *MR*, vol. 5, no. 6, contains an interesting article by Woodrow Thompson on the Palermo mine. The part dealing with the historical aspect of the mine ends with the summer of 1973 and the mention of one new mineral - bjarbyite. It is indeed unfortunate that you neglected to update the article and at least make mention of the fact that two fine collectors, Forrest Fogg and Bob Whitmore, acquired the mineral rights to the Palermo mine in 1974 *primarily* to preserve this locality for both professional and amateur collectors. I believe some credit could have been given to their invaluable effort to save this valuable site from wanton and commercial destruction.

I feel that my criticism is more just in view of your own editorial in the same issue in which you state that you have worked hard to improve articles so that they would be a credit to the author. It is also obvious that the luxury of a backlog of articles brings with it the need and responsibility to see that they are still current at the time of publication.

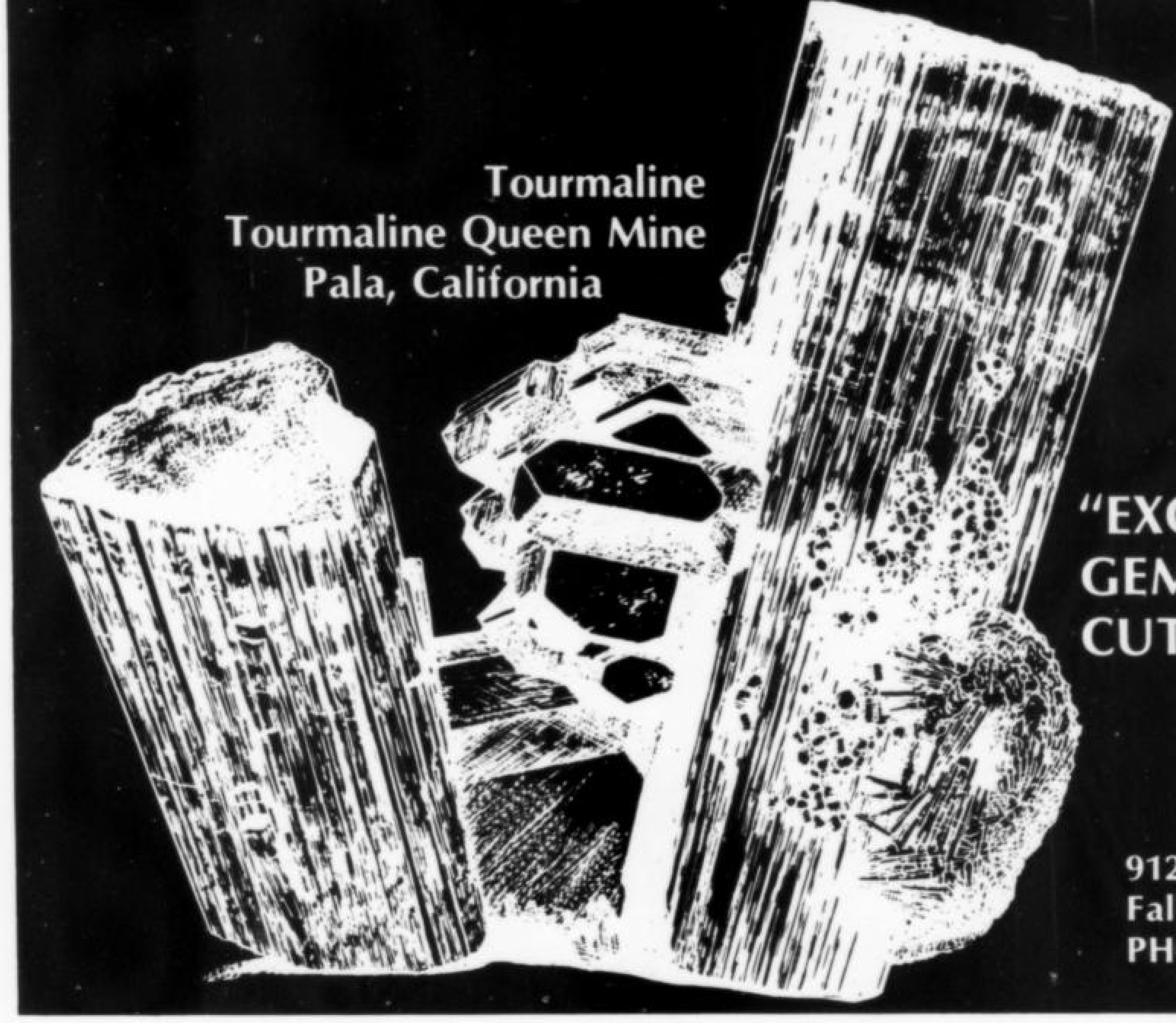
William P. Lindeyer
Windsor, Connecticut

I share reader Lindeyer's regret over this omission. Unfortunately, I was not aware of the details of the Fogg-Whitmore move, particularly of their motive for this action. Ed.

RESPONSE TO LOCALITY NOTE

Dear Sir:

In reference to a recent letter from L. M. Nulle of Rolla, Missouri, regarding the "nomenclature" of the new lead district in Missouri; I would like to describe some of the early history of the district and its relevance to the name "St. Joseph lead district". The lead district in the eastern part of Missouri has been actively mined for over one hundred years and the major company to develop this district was the St. Joe Minerals Corporation, hence the reference to the name "St. Joseph lead district". Core drilling in the new district began in the early part of 1960 and, according to the geologists and foremen we know who work in the district, it was and still is referred to as the St. Joseph lead district. St. Joe Minerals Corporation operates the majority of the mines in the district including; Brushy Creek (1972); Viburnum Div. (1960); Fletcher mine (1967); Federal Div. (1923); Indian Creek Div. (1954). However, the mine which has pro-



duced the majority of specimen material is Ozark lead mine (owned by Kennecott Copper Co.), Sweetwater, Missori. In 1970 over 1,200,000 tons of ore were milled.

I would also like to correct a mistake in my ad in reference to the "Pyrite Bars" from this district. Rather than Amex it should read Amax (Homestake Buick mine), Boss, Missouri. This error also appeared in "What's New in Minerals?", *MR*, **6**, p. 40, 1975.

Gary R. Hansen
Hansen Minerals, Inc.
St. Lois, Missori

WE ARE NOT WRONG

Dear Sir:

In reference to a recent Question/Answer column in the *Mineralogical Record* (vol. 5, p. 222), we would like to make the following correction with the hope that the *MR* will be more careful in choosing its sources of information in the future before publishing inaccuracies as truth.

Tong Wha register #12133 with the government agency of the Bureau of mines (Korea) is the correct location for scheelites sold by our company. A complete description of this location is Kyong Sang Buk Do, Andongkun, Kilanmyn, Chunjidong. Other mines with similar scheelite are Tong Ah, register #24462, and Tae Wha.

A final note would be that now the *finest* large orange scheelites do not come from the Wolak mine but are produced from an unnamed series of open pits and trenches approximately 15 miles west of Taegu.

William F. Larson
Pala Properties Int'l, Inc.
Fallbrook, California

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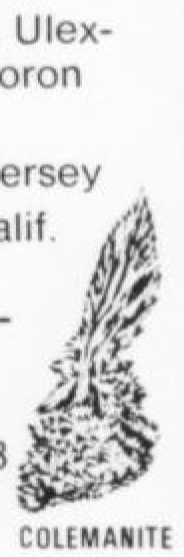
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Each entrant may submit more than one specimen if desired. Specimens for this contest should be mailed to Dr. J. A. Mandarino, Royal Ontario Museum, 100 Queens Park, Toronto, Canada, M53 2C6. The minerals should be identified and labelled, the package marked "St. Hilaire Contest" and the owner's name and return address clearly marked.

Specimens must be micros. They may be mounted or unmounted but in the case of unmounted specimens, which may contain several crystals or vugs, the contestant must indicate by an arrow, or otherwise, the one on which he wishes to be judged.

The winners will be announced at the Canadian Micro Mineral Association's Workshop Conference, April 26, 27, 1975, in Toronto. Entries should reach Dr. Mandarino by April 16, 1975.