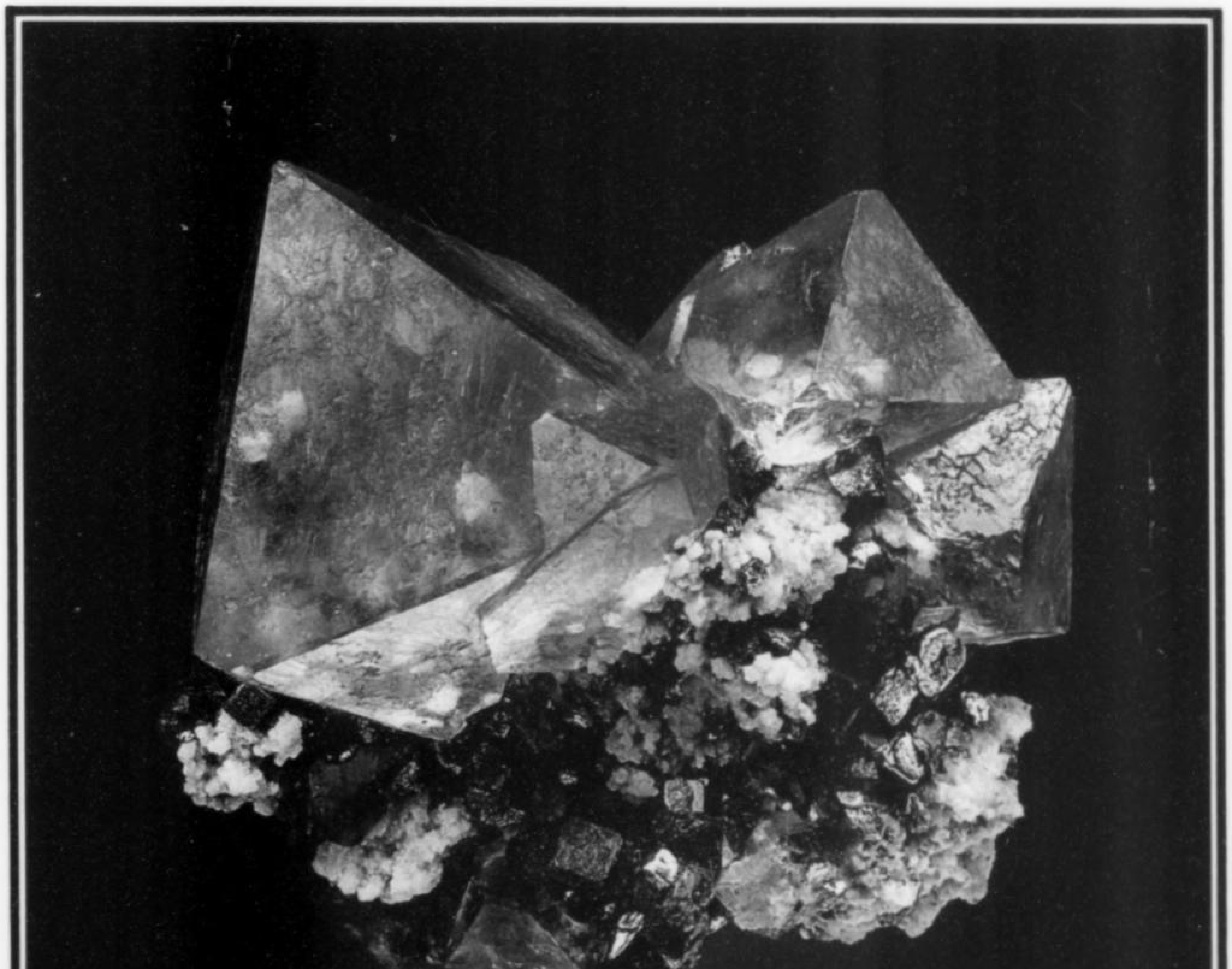
Mines and Minerals of Peru



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Mines and Minerals of Peru

Indian miner, Cerro de Pasco, Peru, 1869 (Simonin, 1869).

Mines and Minerals of Peru

by

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FRONT COVER:
Pink fluorite crystal group, 7 cm, from the Huanzala mine, Dos de Mayo Province, Peru. Marty Zinn collection; Jeff Scovil photo.

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Figure 1. **The departments of Peru. Most metal mining is centered in Ancash, La Libertad, Huanuco, Pasco, Junin, Lima and Huancavelica departments.**

Introduction

Peru has been the world's most prolific source of mineral specimens for the past 17 years, producing world-class pyrite, rhodochrosite, hübnerite, tetrahedrite, pink fluorite, pyrargyrite, chalcopyrite, rhodonite, orpiment and gratonite, to name just a few. Pyrite specimen production, in both quantity and quality, exceeds any other source in the world. Nearly every mineral dealer and every major mineral museum in the world has at least a few superb Peruvian specimens, and yet the details regarding specific localities, ore deposits and production histories are little known by most collectors and curators. With this special issue of the *Mineralogical Record*, dealing primarily with specimens found since 1970, we hope to cast some light on the mineralogy of Peru and to assist collectors in establishing the correct localities for their specimens.

One of the major problems encountered by collectors interested in Peruvian minerals is vague or incorrect locality data. Nearly half of the specimens currently on the market from Peru are mislabeled with respect to their true locations. Whether by accident or by intent to protect their location, these mislabeled specimens are a source of frustration to collectors. How many labels have we seen with "Huancavelica" as the only locality given? Is this Huancavelica District? City? Province? Department? Then there are the labels with the correct mine and the wrong department. This is like having a rhodochrosite labeled as Silverton, Arizona. A collector from Colorado or Arizona might realize the problem, but what about the collector from Europe? These problems are exacerbated by the lack of generally available information on mineral localities and mines within the country. Compared to many countries, very little Peruvian locality information is available in the English language. A fair amount of Peruvian data has been published internally, but most is in Spanish, and almost none of this information is available in American libraries. The labeling problems and the lack of readily available locality information have prompted the authors to write this paper.

Peru is a study in contrasts: jungle lowlands dominate the area east of the Andes, while a remarkably barren desert occupies the coastal plains. The Andes chain of mountains is a stark barrier to travel; jagged snow-covered peaks frequently extend to over 5,000 meters, and vertical to near-vertical kilometer-and-a-half deep chasms cut through them, frequently with roaring streams of glacier-fed water in their floors. Peru's highest peak is *Huascaran* at 6,768 meters. This chain of mountains, which bisects the country from north to south, is an awesome challenge to development.

The people of Peru reflect these same stark geographic contrasts, from the wealthy who reside in the large cities, to the masses living in poverty in the huge slums that surround these urban areas, particularly Lima. The mountain people live by subsistence farming, or work in the mines, which are usually miserable places. Very few Peruvian miners are old; most don't make it past middle age.

Peru is the third largest country in South America, and is about the size of Europe west of the Rhine River, or a little less than twice the size of the state of Texas. It is richly endowed with mineral wealth, the bulk of which is found in the Andes mountains. Thus, the very source of this wealth is, at the same time, the biggest impediment to its exploitation. In the high Andes, transportation is difficult and can be dangerous. Roads are poor and, on occasion, a real test of a person's bravery. Communication is often lacking and the comforts of life are few. The altitude alone makes life difficult. *Soroche*, altitude sickness, is a constant problem for the visitor and can sometimes be fatal. Often the only cure is to go to a lower altitude. A strong and healthy man finds work above 4,000 meters exhausting, and rapid changes in altitude are usually accompanied by headaches, nausea and lethargy. In addition, the nights are usually bitterly cold.

Discussion of the minerals of Peru in this paper is arranged by either district or mine. The order of presentation is by groupings developed by Cobbing *et al.* (1981) in their paper on the geology of the Western Cordillera of northern Peru. From north to south these groupings are: the ***Quiruvilca-Chilete Group***; the ***Cordillera Blanca Group***, which includes Pasto Bueno, and for convenience is referred to as the ***Pasto Bueno Group***; the ***Raura-Huanzala Group***; the ***Cerro de Pasco Group***; the ***Huaron Group***; the ***Morococha-Casapalca Group***; and the ***Huancavelica Group***. Southern Peru currently has no major mineral specimen-producing localities. This is probably due partly to the distance from Lima and its organized dealers, and partly to a simple lack of specimens in quantity.

Major mines and districts discussed by group are: the ***Quiruvilca District*** of the Quiruvilca-Chilete Group; the ***Pasto Bueno, Magistral, and Mundo Nuevo districts*** in the Pasto Bueno Group; the ***Raura, Pachapaqui, Huanzala, and Uchucchacua mines*** of the Raura-Huanzala Group; the ***Cerro de Pasco and Colquijirca districts*** of the Cerro de Pasco Group; the ***Alimon mine*** of the Huaron Group; the ***Morococha, San Cristobal, and Casapalca districts*** of the Morococha-Casapalca Group; and the ***Julcani and Castrovirreyna districts*** of the Huancavelica Group. These mines and districts are shown on Figure 2.

Geologic maps and large-scale locality maps for the various districts and mines are difficult to find. Boggio (1985, 1986) has produced maps for most of the districts and mines discussed herein; unfortunately many of them are of poor quality, and often difficult to read. Figure 2 shows the various geologic units used in Boggio's maps, and should be referred to for those of Boggio's maps that are reproduced here.

Each locality description has a table of minerals that are known to occur at that location. An asterisk (*) next to a mineral name in the mineral tables signifies that the mineral has been found in collector-quality specimens. Most mines and districts have had very little detailed mineralogical examination. Previously unreported minerals are continuously being found. All mineral tables shown in this report should be considered provisional.

In Peru the political boundaries are by province and department. A province is roughly the American equivalent of a county, and a department the equivalent of a state.

The authors have chosen to dwell on the well-crystallized minerals that are of interest to collectors because of their perfection, crystal size, color, rarity, or their associated minerals.

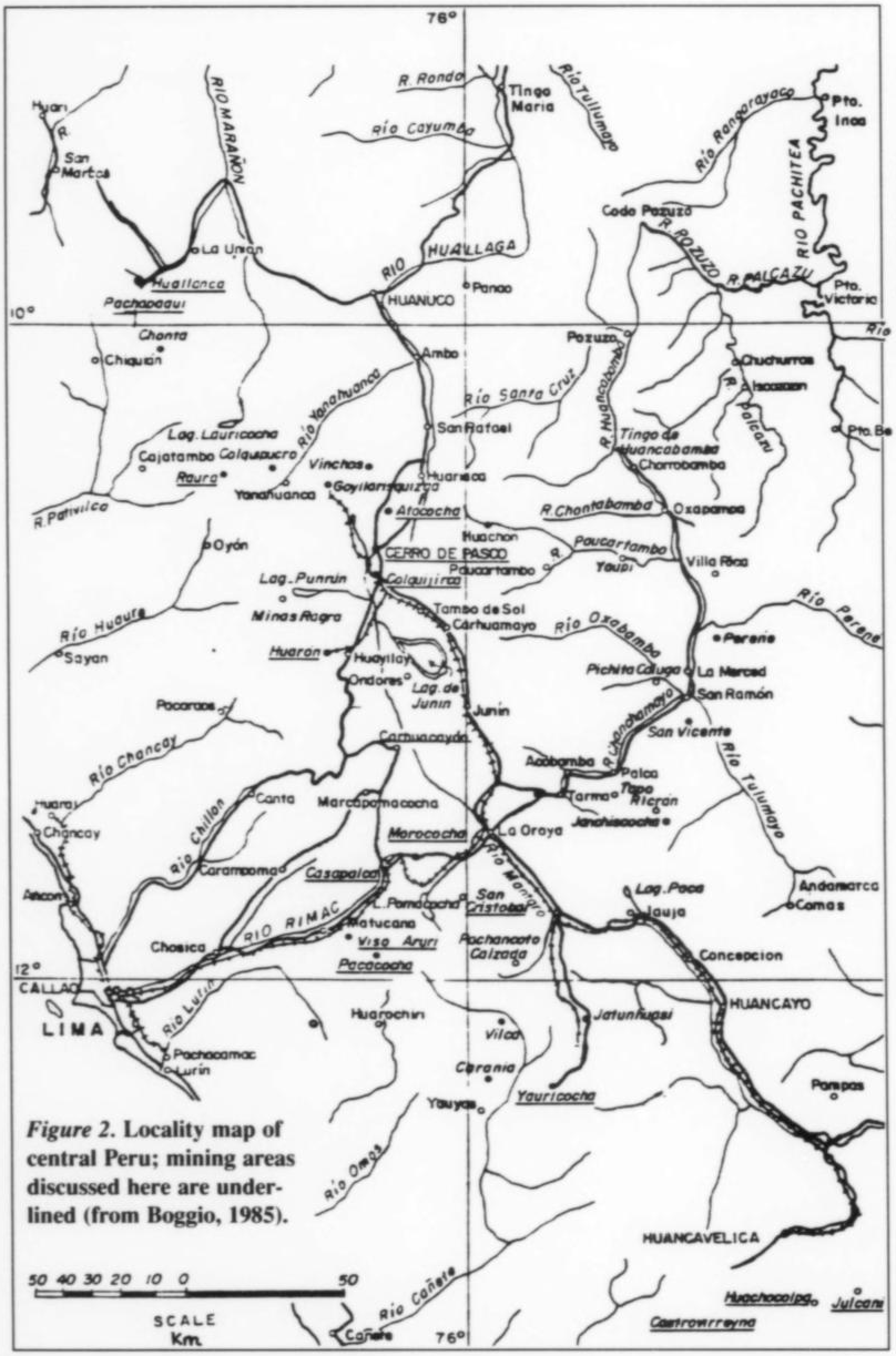


Figure 2. **Locality map of central Peru; mining areas discussed here are underlined (from Boggio, 1985).**

Q	Quaternary		
TQv		Tvrb	Río Blanco formation
Tv	Volcanics	Tvcf	Carlos Francisco formation
Casapalca formation: Tcl	Cerro Calera limestone; Yauricocha limestone; Casapalca Bellavista formation		
Casapalca formation: Tcc	Cerro and Colquijirca: Shuco ls-conglom.; Huarón conglomerate; Casapalca: Carmen conglomerate		
Casapalca formation: Tcrb	Red-beds		
Casapalca formation: Tcch	Yauricocha: France chert and limy chert		
KTs	Cretaceous-Tertiary sandstone		
KTb	Cretaceous-Tertiary breccia		
KTl	Cretaceous-Tertiary limestone		
Km	Machay formation	Kc	Huancavelica Chayliatacana volcanics
Kg	Gayliarisquizga formation	Kch	Chaucha limestone
RJP	Pucara formation		
Pmc	Catalina formation		
Pmm	Mitu formation		
CRc	Copacabana group		
Pal-es	Excelsior series		
Tf	Cerro de pasco: Lourdes fragmental and Rumialiana agglomerate; Colquijirca: Unish Tuff; Julcani fragmental		
Felsic intrusive			
qmp	Quartz monzonite porphyry		
gr	Granitic intrusive		
grd	Granodiorite		
d	Diorite		
t	Trachyte		
da	Dacite		
a	Alaskite		
rhd	Rhyodacite		
Mafic intrusive			
an	Andesite		
b	Basalt		
dia	Diabase		
cig	Contaminated intrusive		
Tactite of skarn in Morochocha		Jps	"Silicated limestone"
		Jph	"Hidrated limestone"
Mineralization in tactite			
Mineralization			
m	Hypogene mineralization		
ox	Oxides		
py	Pyrite		
pb-zn	Lead zinc mineralization		
Ag-py	Silver pyrite ore		
pq	Pyrrhotite		

Figure 3. **Legend for geologic maps in central Peru (from Boggio, 1985).**

History

The History of Peru

Mining and the recovery of mineral specimens in any country are always colored to some extent by the local historical and ethnic context. To better inform the discussions that are to follow, a capsule history of Peru is included here as background.

Humans are first thought to have settled in what is now Peru around 20,000 years ago. These original inhabitants were primitive hunter-gatherers descended from the first people to cross the Bering Land Bridge and colonize North America. Around 6,000 years ago agriculture was introduced. The llama was domesticated and the cultivation of potatoes spread. An advanced civilization had begun to develop by 1,800 B.C. (The Chavin Indians), which peaked around 800–400 B.C. It was followed by the Mochica, Tiwanaku and Chimu cultures until around 1,200 A.D. when the Incas began to consolidate vast areas under their leadership.

The Inca were initially a small tribe, almost constantly at war with its neighbors. Cuzco was their capitol, and it became the center of a rapidly expanding empire under the emperor Pachacutec (1438–1471), perhaps the greatest leader ever produced in the Pre-Columbian Americas. He and his son Tupac have been likened to Philip of Macedon and his son Alexander the Great. From the accession of Pachacutec in 1438 to the death of Tupac in 1493, the Inca empire grew to cover nearly 2,500 miles of Pacific coast and roughly 380,000 square miles (about the area covered by France, Belgium, the Netherlands, Luxembourg, Switzerland and Italy combined).

The conquest of this vast area by Francisco Pizarro and 180 Spaniards is one of the most amazing events in history. Tupac's two grandsons, Huascar and Atahualpa, had been fighting over the throne, and Huascar had been taken prisoner. Pizarro captured Atahualpa and ultimately had him executed, but not before Atahualpa had ordered the execution of Huascar. This ended the Imperial line of succession; Pizarro stepped into Atahualpa's shoes and, because Inca government was so well structured, was able to give orders in his place, allowing the routine of government to go on as before.

The structure of the Inca government was strictly socialist and rigidly regimented. Land was owned by the state and apportioned annually to the families according to their size. The harvests were distributed to the state, the church, and the people as needed, the state's share going to support the nobility and the military. Llamas were also the property of the state. In lieu of taxes, citizens were periodically drafted into compulsory military or civil service, or to work in the mines for a period of time.

The Incas had a highly organized religion in which human sacrifice was rare, their principal focus of worship being the sun. Medicine and surgery were highly developed despite the lack of a written language, and their works of engineering and architecture were outstanding. Particularly impressive was their system of well-made roads and bridges giving rapid access for communications and military movements throughout the empire. They also excelled in the production of handcrafted jewelry and other objects of gold, silver and copper.

Pizarro occupied Cuzco in 1533, and consolidation of Spanish control proceeded. The city of Quito (now in Ecuador) was subdued, and then most of what is now Chile. Pizarro established a Spanish-style municipal government in Cuzco, and founded a new city on the coast, Lima, to facilitate communications with Panama and Spain. Lands were allocated to individual Spaniards, along with a workforce of Indians. The Indians rebelled in 1536 and were put down; but conflict erupted among the Spaniards themselves over division of the spoils, resulting in several executions and the assassination of Pizarro. A Spanish viceroy was sent in 1544 but was executed as well. It was not until the Viceroyalty of Andres Hurtado de Mendoza in 1555 that the obstreperous conquistadors were reunited under a single accepted authority, and it fell to his successor, Francisco de Toledo, to re-establish systematic control of the huge Indian population. Fearing that Tupac's great-grandson, Tupac Amaru, might prove dangerous as a focus of insurrection, Toledo had him executed in 1571.

By the end of Toledo's administration the viceroyalty of Peru had assumed a stable structure

Figure 4. **Map of South America drawn by Linschoten in 1599.**

which persisted well into the 18th century. It encompassed all of South America with the exception of Venezuela and Portuguese-owned Brazil. Silver mining became the principal industry, especially at Potosí (now in Bolivia, discovered in 1545); and the Huancavelica mines (opened in 1563) produced mercury essential to the processing of silver ore. Because most mines were situated in Peru proper and "Upper Peru" (now Bolivia), those areas became the most highly developed.

The center of all this wealth and power was the viceregal capital of Lima, where viceroys of the 16th and 17th centuries ruled over most of Spanish South America. The viceregal court was the pinnacle of a rigidly stratified society based upon forced Indian labor; it attracted prominent politicians, wealthy aristocrats, artists and intellectuals, and was also a center for religious administration, commercial trade and the royal court of justice (the *audiencia*). The archbishop of Lima was the head of the Catholic Church in Peru, and many religious orders established monasteries and convents there, under the watchful eye of the tribunal of the Inquisition. Also situated in Lima was the premier educational institution in Peru, the University of San Marcos, modeled after the University of Salamanca in Spain.

Precious metals production declined during the late 17th century; this factor, combined with an increase in piracy and unregulated trade, caused increasing difficulties. Governmental reforms instituted in the late 18th century only made matters worse. Establishment of the new viceroyalty of New Granada took away Peru's control of northern South America and its thriving port of Guayaquil (now in Ecuador). Ultimately the reforms did improve conditions in Peru, improving defense, economic development and governmental efficiency. However, in 1778 the Spanish govern-

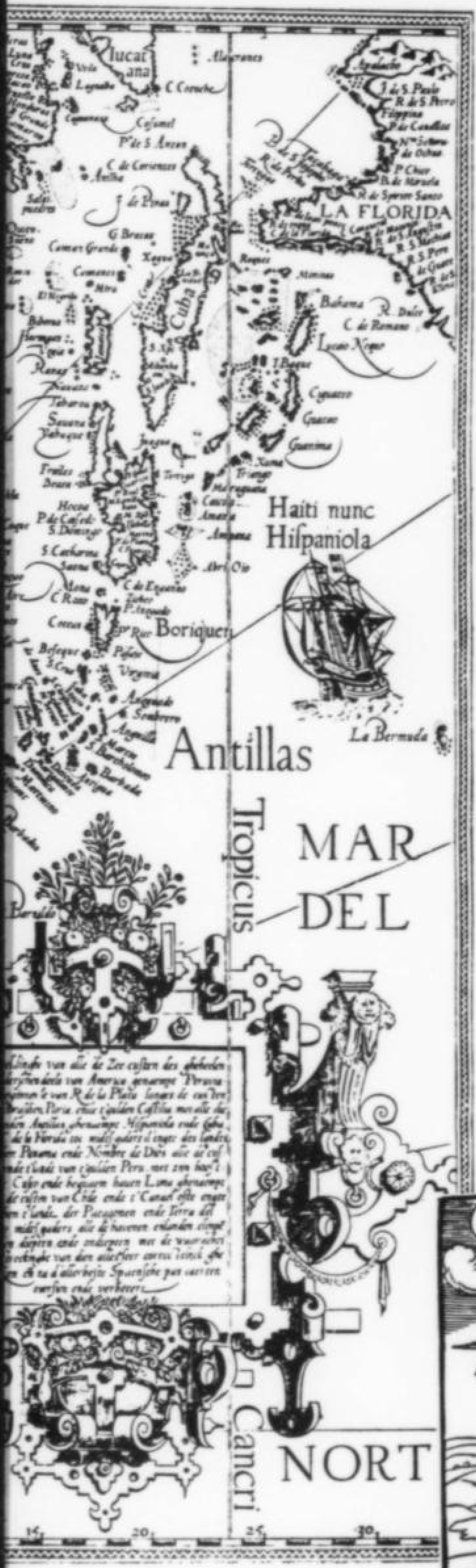


Figure 5. **Francisco Pizarro (1470–1541)**

Figure 6. **The city of Cuzco, capital of the Inca Empire, as drawn by Giambattista Remusio in 1556.**

ment created the viceroyalty of Rio de la Plata, depriving Peru of its authority over what are now Argentina, Paraguay, Uruguay and silver-rich Bolivia. Chile was also made autonomous, and reforms in the trade system destroyed Lima's commercial monopolies. To make matters even worse, the severely oppressed Indians revolted in 1780, under the leadership of Tupac Amaru II; he was captured and executed in 1781, but the Indians continued to wage a disruptive war until 1783.

Despite these many problems, an intellectual and literary revival took place in Peru as a result of utilitarian philosophies of the French Enlightenment. European scientists making expeditions to Peru in 1778 and 1793 exposed Peruvians to the new ideas. A literary and scientific club was founded in Lima, the *Sociedad de Amantes del País*.

The Napoleonic invasion of Spain in 1808 encouraged the Creoles (American-born people of Spanish descent) in most of the Spanish colonies to demand independence, but Peru remained royalist. General José de San Martín of Argentina fought for Argentine control of the Bolivian silver mines, and for the destruction of remaining Spanish power in South America. He liberated Chile and used it as a base for naval attacks on Peru; the viceroy withdrew his forces, San Martín entered Lima, and Peruvian independence from Spain was declared on July 28, 1821.

Following their declaration of independence, Peruvians called upon Simón Bolívar (who had recently liberated Bolivia) for help in attacking the strong Spanish forces still holding the interior regions. Bolívar assumed power in Peru, and defeated the Spanish at two major battles in 1824, breaking for good the Spanish power structure in Peru. Bolívar returned to Colombia in 1826, leaving Peruvians to govern themselves.

The establishment of self-government in Peru was made difficult by the loss of so many able loyalists, and by an illiterate population largely unexposed to the concept. The few remaining professionals and educated landholders appreciated the idea of economic independence but had no experience or traditions in self-government. The political vacuum resulted in governance being left to the military, but their bitter internal rivalries erupted in civil war and near-anarchy in the 1830's. Bolivia invaded in 1835, taking over Peru to form the Peru-Bolivian Confederation. Fearful of this new super-state, Chile declared war on the Confederation in 1836 and, with the support of Peruvian *émigrés*, restored independence to Peru in 1839. More internal disorder followed.

Finally in 1844 mestizo General Ramón Castilla defeated rival military leaders and took over undisputed control of Peru. From that time until 1862 the country enjoyed political stability and economic progress, aided by the discovery of huge quantities of bird guano which could be exported as high-grade fertilizer. Roads were improved, the first railroad was built, public education was upgraded, military and naval power were strengthened, and slavery and the payment of tribute by Indians were abolished.

The end of Castilla's regime in 1862 was followed by political corruption, economic mismanagement, and a war with Spain which debilitated the country. Manuel Pardo, Peru's first civilian President, took over a virtually bankrupt nation in 1872, and conditions worsened as the price of guano declined. Military expenditures were cut, the government payroll was reduced and a government monopoly was established on the Tarapacá nitrate deposits. Unfortunately a war broke out between Bolivia and Chile, and Peru was drawn in because of a treaty of alliance signed with Bolivia in 1873. Peru, as the most powerful of the allies, bore the main burden of the war and was defeated by Chile at virtually every encounter. Chilean forces occupied Lima for nearly three years until a treaty was signed which ceded the Tarapacá nitrate province to Chile.

During the early 20th century Peru's economy staged a comeback. Foreign investors exploited Peru's mineral resources, and the production of copper and petroleum rose. The opening of the Panama Canal, and a large influx of capital from the United States stimulated production and trade in the 1920's.

During this time the Peruvian government consisted of an oligarchy of landowners, military leaders and rich businessmen referred to by historians as the "Aristocratic Republic." Among the most influential presidents was Augusto Leguí y Salcedo, who ruled essentially as a dictator, unconcerned with improving the condition of the common people. A reform movement sprang up in the late 1920's, led by Victor de la Torre and José Mariátegui, and inspired by the recent revolutions in Russia and Mexico. Mariátegui assumed leadership of the Peruvian Communist Party while Torre headed the indigenous reform organization known as "Apra" (an acronym for *Alianza Popular Revolucionaria Americana*). Torre's ideology combined elements of Marxism, Italian fascism and democracy. Apra's program demanded welfare legislation, labor organization, nationalization of resources, increased industrialization, a rehabilitation of the Indian population through land reform, and an end to "Yankee Imperialism." When President Leguia y Salcedo was overthrown in 1931, Torre was elected president, but the military under Col. Luis Cerro seized power and outlawed Apra.

Apra and the Cerro regime engaged in a virtual civil war for the next two years. Cerro purged Congress of all Apristas and arrested Torre, threatening him with execution. In 1932 an armed group of Apristas seized Torre's home town of Trujillo. When government forces retook the town they found that the Apristas had murdered some 60 captives including many military men. In their rage they rounded up as many as 5,000 suspected Apristas, sympathizers and participants and summarily executed them. The Trujillo incident initiated a blood feud between the military and Apra which was to poison the Peruvian political atmosphere for decades thereafter. In 1933 a young Aprista assassinated Col. Cerro.

Cerro was replaced by Oscar Benavides, who was given dictatorial powers by Congress to prevent Apra from winning the 1936 presidential election. Benavides' successor, Manuel Prado y Vgarteche, was an enlightened member of the oligarchy. From 1939 to 1945 he guided Peru through the difficult war years, extended public education, encouraged the unionization of labor, and worked to reduce the suffering of Peru's impoverished majority. He pushed for rapid economic development, including hydroelectric and irrigation projects, and encouraged the exploitation of mineral resources. Succeeding administrations continued these policies, resulting in further improvement in the national economy.

The economic expansion of the postwar years brought with it demands by the working and middle classes for a greater share in the national wealth through better wages and educational benefits. The ruling oligarchy was split between those wanting no change and those willing to permit only very slow changes. Political conflicts between the oligarchy and Apra continued through various administrations.

The government was once again seized by the military in 1948, General Manuel Odría was installed as president, and the leader of Apra was forced to leave the country. Odría was elected president without opposition in 1950 and ruled essentially as a dictator. Nevertheless, his administration raised wages, extended the social security program, funded low-cost housing projects, improved the educational system, and worked hard for economic development. Assisted by technical aid and capital from the United States, and an increase in export prices resulting from the Korean War, the Peruvian economy improved significantly. Agricultural development increased food production, highways and railroads were improved, and construction of a steel mill was begun. Concessions were made to encourage foreign capital to increase mining activity in Peru, a new copper deposit was located in the south, and petroleum production soared. Odría even hired a firm of economic consultants from the United States to help manage the expansion.

In 1956 a new election put former president Prado back in power with the support of Apra. He worked to establish a true democratic regime which would continue to promote economic development while improving the conditions of the underprivileged, building up the educational system, placing more land under irrigation, and completing the Chimbote steel mill. Elections loomed again in 1962 and, when it appeared that Apra might take over, the military once again stepped in. Free elections were held again in 1963, and Fernando Belaúnde Terry, a charismatic, U.S.-trained architect, was chosen as president. For a time it looked as if Belaúnde might reach an agreement with the Apristas that would permit constructive legislation to be passed. But a controversial contract he had signed with Standard Oil, which controlled the north-coast oil industry, caused a national furor, and the military felt compelled to seize power once again in 1968.

From 1968 to 1975 the "Revolutionary Government of the Armed Forces" under General Juan Velasco Alvarado enacted sweeping reforms designed to create a more prosperous and socially responsible country which would be "neither capitalist nor communist." Banks, railroads, utilities and many foreign companies were nationalized, including the holdings of Standard Oil, Cerro de Pasco Corp., and W. R. Grace. Miners were given at least a small share of the profits and a voice in the management of the companies. All large, private farming estates were broken up into cooperatives or distributed piecemeal to small farmers and peasant communities. The school system was reformed, health care for the poor was provided, and the Indian language (*Quechua*) was proclaimed Peru's second official language. Peru became a spokesman for Third World interests, improved its ties with other socialist countries, and feuded bitterly with the United States over nationalization of the holdings of U.S. corporations.

Despite initial successes, Velasco's regime soon ran into difficulties. Falling metal prices and the government's huge investments in its nationalized mining operations combined to yield less than satisfactory profits. Ecological changes in coastal waters caused the fish-meal industry to collapse. Overoptimistic estimates of petroleum reserves in the interior prompted the construction of a billion-dollar pipeline; only when the project was completed were the oil deposits found to be much smaller than had been believed. Large sums of money were squandered on fancy weapons systems and luxurious office buildings.

The political situation became critical in 1975, as investments plummeted and unemployment and inflation rose steadily. Public protests were met with dictatorial repression. In August, General Francisco Morales Bermúdez took over in a bloodless coup. Over the next three years the military tried but failed to get the country back on its feet. President Belaúnde was returned to power by election in 1980, and Apra candidate Alan García Pérez succeeded him in 1985. The economy remained severely depressed, and a Marxist revolutionary movement—the "Shining Path"—waged relentless guerrilla warfare in the interior.

In 1990 an Independent candidate, Alberto Fujimori, was elected president. He worked to increase private enterprise, but the economic problems and associated violence continued. Fujimori suspended Congress and dissolved the Legislative in 1992, citing rampant corruption, and failure to enthusiastically oppose the drug trade and the "Shining Path" movement. Although much popular support was behind him, others denounced him as a dictator. Finally, in 1992, the leader of the "Shining Path" and ten of his top officers were arrested and sentenced to life in prison. In the November 1992 elections, Fujimori supporters won a majority of seats in the Congress. Fujimori was re-elected in 1995.

Under the 1979 constitution, Peru is a republic with independent executive, legislative and judicial branches. All citizens aged 18 or older, regardless of literacy, are not merely allowed but are obligated to vote. As of 1985, a candidate for the presidency must receive 50% of the popular vote to avoid a run-off election. Congress is bicameral, with a 60-member Senate and a 180-member Chamber of Deputies, all elected to 5-year terms. Civil liberties of citizens, including freedom of religion, are constitutionally protected. The state (military), however, has broad powers to intervene in the country's social and economic affairs. The Constitution was further revised in December of 1993, giving Peru a modern, socially responsible document on which to base its society.

Figure 7. **Peruvian mine captain, 1869 (Simonin, 1869).**

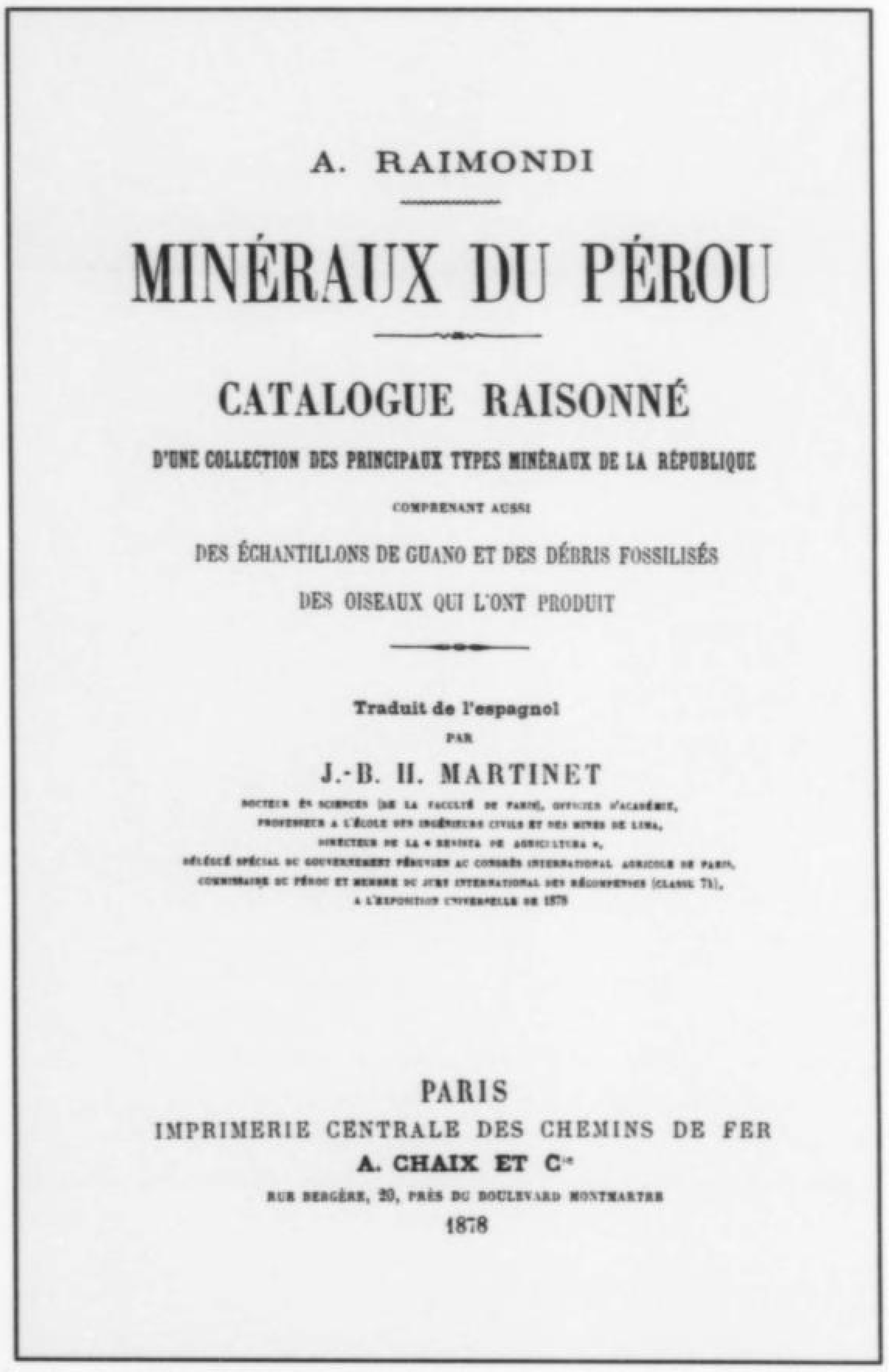
MINING IN PERU

Evidence of mining and metalworking in the sierra and west coast regions of South America is evident from the earliest cultures that inhabited Peru, but not until the Inca period are there any illustrative records other than archaeological artifacts. All the major pre-Inca cultures produced metal ornaments and small tools, largely made of gold, silver and copper. Articles made of platinum have also been found.

The Incas apparently centralized the metal-mining industry when they conquered Peru in the 15th century. Gold, silver, bronze and copper were used abundantly in their metalwork.

According to Purser (1971), with the arrival of (and subsequent looting by) the Spaniards, many of the Inca mines were "lost," as the conquistadors were too busy plundering Inca cities to give much thought to where the gold, silver and other metals actually came from. By the time the Spaniards began to think about these mines, many of them had been camouflaged by the Incas. As the Incas died off, the locations of their mines died with them. Thus, very few of the subsequent colonial mines were continuations of old Inca workings.

Through their exploration of the Andes in the late 16th and 17th centuries, the Spanish colonialists discovered an amazing number of deposits, considering the hardships they had to endure. Many famous silver mines were located by these early prospectors; these included Hualgayoc, Huallanca, Castrovirreyna, Oruro, Huancapeti, Cerro de Pasco, and most importantly the mercury mine in Huancavelica, which enabled the processing of silver ores by the amalgamation process. Production in the 1500's of silver alone is estimated to have been between 150 and 200 metric tons yearly (Purser, 1971). By 1759 Llano Zapato listed some 50 major mining districts and countless minor ones. In 1790, the census of mines showed 784 silver and 69 gold mines in Peru.


A. RAIMONDI

MINÉRAUX DU PÉROU

CATALOGUE RAISONNÉ

D'UNE COLLECTION DES PRINCIPAUX TYPES MINÉRAUX DE LA RÉPUBLIQUE

COMPRENANT AUSSI

DES ÉCHANTILLONS DE GUANO ET DES DÉBRIS FOSSILISÉS

DES OISEAUX QUI L'ONT PRODUIT

Traduit de l'espagnol

PAR

J.-B. H. MARTINET

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PROFESSEUR À L'ÉCOLE DES INGÉNIEURS CIVILS ET DES MINES DE LIMA,
DIRECTEUR DE LA « REVISTA DE AGRICULTURA »,
DÉLÉGUÉ SPÉCIAL DU GOUVERNEMENT PÉRUVIEN AU CONGRÈS INTERNATIONAL AGRICOLE DE PARIS,
COMMISSAIRE DU PÉROU ET MEMBRE DU JURY INTERNATIONAL DES RÉCOMPENSES (CLASSE 71),
À L'EXPOSITION UNIVERSELLE DE 1878

PARIS
IMPRIMERIE CENTRALE DES CHEMINS DE FER
A. CHAIX ET C^ie
RUE BERGÈRE, 20, PRÈS DU BOULEVARD MONTMARTRE
1878

***Figure 8.* Title page of the French edition of Raimondi's *Minerals of Peru*. All copies seem to have been printed on high-acid paper which is rapidly crumbling today; within a few decades there may be no surviving copies. (Mineralogical Record Library)**

The 1800's were marked by a series of ups and downs in the mining industry, partly related to the war for independence from Spain and the war with Chile. One event of mineralogical interest during this time was the immigration of Antonio Raimondi who arrived in Peru in 1850 and died there in 1890. He was a mineralogist, an astute observer, and best of all, a prolific writer. For a knowledge of the mines and minerals of Peru during this time frame, his works are as invaluable as they are hard to find. They are in Spanish, and most U.S. libraries, including university libraries, do not have copies of them.

The next period of major development for Peru's mining industry, after the tribulations of the early 1800's, began about 1890 with the commencement of serious foreign investment. In 1901 the Cerro de Pasco Copper Corporation was established, followed by other North American and European interests. This renewal of exploration and mining came about partly due to the passage of a Peruvian law in 1877 which allowed foreigners to own mines, and partly because of domestic monetary problems which allowed easy purchase of many of the mines by foreign investors. In 1904 the railroad to the Cerro de Pasco mines was completed. Other railroad lines were soon established which traversed north and south. These railroad lines opened central Peru to efficient transportation and aided development of the mines. In 1908, C. E. Velarde published a book titled *La Mineria en el Peru* ("The Mines of Peru") which gives detailed listings of the major mines and mining developments in Peru during the early part of this century.

In 1973 the government of Peru nationalized most of Cerro de Pasco Corporation's mining properties along with those of other foreign mining companies. Operation and management of all the large Peruvian mines was vested in the Peruvian government agency, Minero del Centro del Peru, better known as Centromin.

With the election of Alberto Fujimori in 1990, many of the mines that were previously nationalized are now being rapidly privatized, and the role of Centromin has been considerably diminished. Today, mining is Peru's dominant industry, and it is approximately 75% foreign owned.

The Mineral Specimen Business

In the early 1970's, the miners certainly were the best source of specimens, primarily by default. Knowledgeable mineral dealers were nonexistent in Peru. Then a few poor but enterprising Peruvians, most of whom had friends or relatives at some of the mines near Lima, found they could sell pyrite specimens to tourists and even to other Peruvians on the sidewalks in central Lima. They would spread out a newspaper or cloth on a sidewalk, cover it with specimens, mostly pyrite, and proceed to barter with interested pedestrians. They eventually congregated on the corner of the Avenidas Camana and La Colmena, near the Hotel Bolivar. This hotel fronts on the Plaza San Martin which many consider the center of Lima. Eventually the sidewalks of "La Colmena," which means "The Beehive" in Spanish had as many as 20 people selling specimens. They became known as *piriteros*.

Many of the piriteros were runners who made regular trips to the mines to buy specimens. During their absence they would often leave other family members on La Colmena to sell their specimens. The most popular containers for mineral specimens were card-

***Figure 9*. Street vendors selling pyrite on Avenida La Colmena in Lima. Rock Currier photo.**

board cracker boxes which didn't measure more than about 35 cm in any direction. The runners would put down a thick layer of newspaper and lay in a layer of specimens edge-to-edge without any intervening packing material and then repeat the process till the box was full. If you filled them up with pyrite specimens, they could weigh nearly 50 kg; this weight was really as much as anyone wanted to carry getting on and off trucks and buses.

At first, pyrite specimens from Casapalca, Morococha, and San Cristobal dominated the market. As the runners found they could sell other kinds of specimens, and the demand for pyrite increased, they fanned out across central Peru looking for other sources. Gradually the variety of specimens available in Lima grew.

In time, enterprising Peruvians began to export pyrite and other specimens to foreign markets. As foreign collectors and dealers became aware of specimens from Peru, more and more of them came to Peru to buy specimens, and this, in turn, further stimulated the mineral market.

As the variety of specimens available in Lima grew, wrapping techniques to protect valuable specimens improved. Although most specimens collected and sold by runners are still packed edge-to-edge in boxes with only intervening sheets of newspaper, a higher percentage are individually wrapped today than ever before. Some of the best specimens are even padded with extra cotton or some other material before they are wrapped in newspaper.

The single most important factor in establishing Peru as a major supplier of specimens was the existence of La Colmena itself. It provided an easily accessible place where potential buyers from all countries could meet and transact business. Without La Colmena the market would never have developed to its current extent and would probably be comparable to the unorganized state of affairs that exists today in Bolivia. The second most important factor to stimulate the market in Peruvian specimens was the appearance of world-class rhodochrosite specimens from Pasto Bueno in 1977. This event initiated a rhodochrosite rush that instantly put Peru on the map as a place many dealers and collectors just had to visit.

In June 1981, a new crusading mayor in Lima decided to clean up the center of the city. Among the steps taken was the eviction of all sidewalk salesmen (*ambulantes*), including the *piriteros*. This gave the existing local dealers a slight advantage because they had already established their foreign buyers. Some of the formerly independent *piriteros* now had to sell to the local export dealers because they could no longer sell their specimens on La Colmena as easily as before. This also strengthened the established foreign buyers, because they too had long-standing contacts, and knew how to find the *piriteros* at their homes. La Colmena still fulfills its traditional role, but in a more subdued fashion.

Today some of the Peruvian export dealers travel personally to the Tucson Gem and Mineral Show in February to sell specimens and make contact with customers. Exports of pyrite from Peru exceed by at least two orders of magnitude those of all other species. No one knows how much pyrite has been collected and exported from Peru, but it has to be on the order of many thousands of tons.

Figure 10. **Indian miner with ore sack, Cerro de Pasco, 1869 (Simonin, 1869).**

Collecting

Specimen Production

With the global economic recession and the relaxing of tensions with Russia, world-wide metal prices, for the most part, have declined markedly. Third-world countries, like Peru, in which the mining industry dominates the economy, are hurt the most by the drop in metal prices. This is then reflected in cutbacks at the mines, which result in a loss of jobs for the miners and a decline in metal production. The final result of lowered metal prices is a cutback in specimen production from the mines. Since 1989, Peru has been in this reduced condition, and fewer specimens have been forthcoming than previously. Many of the *piriteros* (which translates as "pyrite vendors") have simply vanished, and laid-off miners and their families have migrated to the slums of the cities hoping for better living and working conditions. Coupled with the civil unrest fomented by the Sendero Luminoso (the Maoist "Shining Path" guerrillas), and more dangerous travel conditions in central Peru because of them, there has been little improvement in the mineral supply. With the rise in privatization of the mines, and the recent declining influence of the Sendero Luminoso, the mineral situation may improve in the future.

Although minerals had been found in "collector quality" for many years, very little was offered by dealers in the United States and Europe prior to 1970. Before this date there were very few specimens from Peru in museums and collections around the world. During several centuries of mining in Peru almost all the specimens had been destroyed. Only in the last 25 years have specimens been saved in any quantity, and what we are now seeing is just a tiny amount of what the mines have produced, and almost certainly *not* a representative sample of what the country has yielded over the centuries.

As mentioned, it has only been since the early 1970's that any quantity of Peruvian minerals has been available to dealers and collectors in the outside world. The amount of available specimens increased dramatically in the late 1970's, and became a virtual "flood" in the 1980's. Sources of minerals have changed over the last 20 years; new mines have been discovered or re-discovered and come on line, and older mines have declined in production for various reasons. Prior to the 1970's, the mines of Cerro de Pasco, Morococha and, to a lesser extent, Quiruvilca were the principal sources of mineral specimens. Quiruvilca became a major source of minerals in the early 1970's, followed by the mines of Pasto Bueno, Casapalca, and to a much lesser extent Julcani and San Cristobal. Julcani and San Cristobal never produced more than a handful of specimens during the 1970's compared to the other major specimen mines and should not be ranked as big specimen producers during the 1970's. With the heightened interest in collectible Peruvian minerals in the 1980's, more dealers began traveling to Peru to shop for specimens. As a result of this increased interest, many other specimen sources began to appear in the minerals market, including the mines of San Genaro, Huanzala, Raura, Pachapaqui, and Pacococha (Castrovirreyna). The Huanzala mine came on line in the late 1970's and quickly became a major supplier of mineral specimens, with one of the more notable finds being the pink octahedral fluorites found in November 1980 (Belsher, 1982).

During the early 1980's, the Quiruvilca mine was a continuing source of many different types of specimens, but the volume seems to have dropped off considerably during the past few years. In the last several years a few new localities have produced some significant specimens. Examples of these new localities are: the Uchucchacua mines, which came on line and began furnishing bright pink to raspberry-red, sometimes transparent, rhodochrosite, as well as other species; the Chiurucu mine produced intense raspberry-pink, bladed, rhodonite specimens with pyrite and quartz; the Mercedes mine provided large, brilliant tetrahedrite; the Alimon mine at Huaron became a major source for specimens of quartz, sphalerite, chalcopyrite, and pyrite in the early 1980's, and continued to furnish a good quantity of collector minerals into the early 1990's. In 1990, the Santa Rita mine near Casapalca was the source of hundreds of bright pink, rhombohedral rhodochrosites reminiscent of the Silverton, Colorado, locality. Casapalca has been, and continues to be, an intermittent source for a variety of minerals, including quartz, galena, bournonite,

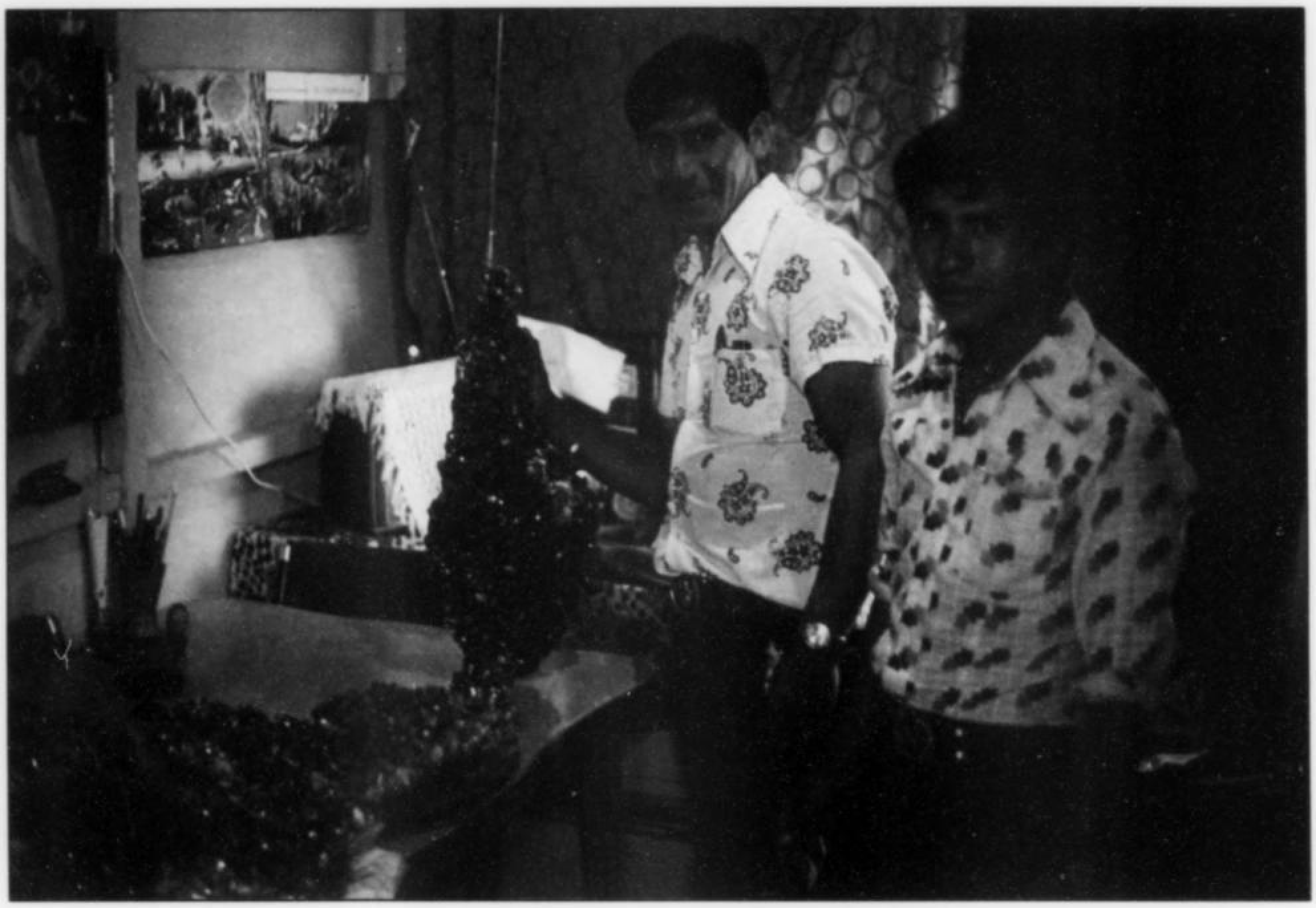


***Figure 11.* Specimen dealers selling orpiment out of a house in Lima. Rock Currier photo.**

tetrahedrite, and manganoan calcite. And most recently some spectacular epidote specimens have been coming from near Ica in Ica province and from nearby Rosario Mabel, Mapa Blanca, Castrovirreyna, Huancavelica.

Peruvians are very secretive about mineral-producing locations. Generally Peruvians will not even tell other Peruvians about locations, let alone the foreigners who come to Peru to buy specimens. When big pockets of minerals are discovered, miners conceal the information. Very few others ever know. Most mining companies are opposed to mineral collecting, and certainly will not divulge information on exposed pockets to the public. This secretiveness compounds the problems foreign dealers and collectors experience trying to acquire accurate mineral locality information. Many times the mine management is not aware or knowledgeable about what kind of specimens are being produced from their operation. An additional problem for collectors of Peruvian minerals is the occurrence of one-time finds of small quantities of minerals. Many of the approximately 1,200 operating mines in Peru are small family operations similar to the "Mom and Pop" operations found in the United States. If an isolated or one-time discovery of good mineral specimens is made, and the miners are savvy enough to know they can sell them, the specimens will probably be sold to one of the *piriteros* who happens to be nearby at the time. These specimens in all likelihood will be mixed in with specimens from a large local mine, or simply labeled for convenience as being from the nearest large mining complex, and then sold to the international market. One can readily see the problems this procedure can create.

A note of interest: many location names contain the component *cocha*, which means "lake" in Quechua, the Inca language spoken by the native people; "conococha" means "yellow lake," "Yauricocha" means "black lake," and so forth.

The Peruvian runners/dealers frequently dissolve off calcite or other carbonates from specimens that have coatings of these minerals, unless the carbonates are exceptional in crystal size or color. This is usually accomplished with hydrochloric acid (HCl), explaining why so many sulfide-bearing specimens are bereft of accompanying carbonate minerals. Apatite, fluorite and galena, when they occur, are frequently corroded and damaged, and minor soluble accessory minerals are missing.

Visiting the Mines

Most Peruvian road maps show the location of only a few mines. Sometimes small to almost nonexistent villages will be marked, but nearby large mining installations will be left off. (There has been speculation that someone in the old socialist government told the map makers to ignore their existence, especially if they were privately owned.) Governmental administrative boundaries are difficult to determine. Even if they are marked on the map, the almost complete absence of any road signs makes it hard to know where you are. A good highway map and a guide who speaks your language are usually essential for getting around in the country.

Buses and trucks travel on a regular basis to the mining camps and you can use them to get there if you are the sturdy type, have plenty of time and are on a restricted budget. If you can, however, travel in your own car. During the rainy season between October and April, you should consider a four-wheel-drive vehicle, and if possible, check on the condition of the road. Avoid renting vehicles with more than 40,000 km on the odometer. Keep in mind that the odometer may have been turned back by the rental agency or one of their clients. Before leaving the rental agency be sure to personally check out all the systems, particularly the brakes (including the hand brake). You may wish to practice discretion in telling the rental agency exactly where you are planning to take their vehicle.

When you stop and ask directions, always ask several people to see if you can get agreement between them. Most people in Peru do not own cars and their ideas of distance, direction and travel time may not relate to travel in vehicles.

Most mining activity is above 4,000 meters; when visiting the mines you will feel the effects of *soroche* (altitude sickness) to a greater or less extent. To minimize the effect you should spend the first night somewhere no higher than 3,500 meters. Also, it is advisable to eat only very small meals during the first two days and keep your physical activity to a minimum. There is a medication available over the counter in Peru called "coramina glucosa" that may be of help. If you have heart or breathing problems, see your doctor before going to high altitudes.

It is advisable to take some food and all your drinking water if you can. If you can't, a small portable sterile water filter is desirable, or at least some water-purification tablets. You will not find much clean water around the mining camps, and boiling water at 3,000 meters will not achieve a temperature high enough to kill all bacteria. A former company doctor from the mining camp at Pasto Bueno once told us that during his stay in the camp they had a tuberculosis rate of 70% and a hepatitis rate *in excess* of 100)% (yes, greater than 100%; you can catch it more than once and there are different kinds). A bottle or two of a good general purpose antibiotic and pain killers may be very helpful in case you get sick.

Finding good accommodation can be a chore. The best places to stay at the mines are in the housing built by the mining companies. Keep in mind that visiting a mine to buy specimens from the miners, who should be mining ore and not specimens, is usually not sufficient reason for a mining company to house and feed you. Failing access to company facilities, accommodations at the mines will be rather grim. Think of it as camping out. A dirt floor, a leaky roof, more than adequate ventilation, and undesirable visiting fauna (both micro and macroscopic) are the rule during the long nights. Toilet facilities will best go undescribed.

It is possible, in many instances, to collect your own specimens in the mines. The best way to arrange this is to chat up the professionals at the mines and, ideally, gain permission from the head office. If you work through the head office you will need to provide them with good reasons why they should let you run around in their mine. Any sort of legitimate mineralogical research may be sufficient. It also helps to work with smaller mines and mining companies. They are usually more sympathetic to the presence of mineral collectors. If nothing else, the professionals at remote mines are glad for someone new at dinner with whom to gossip. House-warming presents like bottles of alcohol-based refreshment, old copies of *Playboy* magazine etc. are greatly appreciated. Keep in mind however, that you will be working at a high altitude, that even a modest size mine can be much larger than you can comfortably explore in a week, and there is no guarantee that you will be able to find anything.

If you are really serious about obtaining a significant number of specimens you *must* get them from the miners. Don't go bothering those poor geologists and mining engineers. The mines are dirty, dark places, often cold or hot and/or wet, not really pleasant places to be. You cannot expect a well-paid professional to spend a lot of time in such a place, getting filthy dirty digging rocks for you. Of course, on rare occasions you may find a geologist or mining engineer who has a real interest in minerals, but these people are few and far between. The miners work most days, every day, in the mine. Those miners that have first access to the working face after a blast are going to get the best specimens. These are the men you go searching for with a pocket full of *soles* (the monetary currency of Peru).

At the mines, the workers usually live in long barracks-like structures that are divided into many rooms and apartments with common walls. These are called *pabellones* (pavilions). They typically have a concrete floor, corrugated tin roof and, if fortunate, a cold water tap and electricity. In each room or apartment will be a miner or a miner and his family.

Miners usually live in one section of the camp and the mill workers in another. If you want specimens you will need to find the section of the camp with the miners. In many camps you can just drive up, get out, start knocking on doors and asking for specimens. Saturday afternoons and Sundays are the best time because most miners are off-shift and home. As you talk to the miners, everyone who can will be eavesdropping on your conversation, and word will quickly spread through the camp that you are buying specimens. People, especially children, will start approaching you with specimens; a low profile is definitely recommended. Do not start passing out free candy or other gifts to the children because you will soon have a very noisy gang of 30 or 40 of them following you around the camp. Then the larger children will start beating up on the smaller ones to take away their candy, and a near riot will start. Pay one or two of the largest juveniles to pack and carry your specimens, and they will take care of any trouble makers.

Some mines have become rather restrictive about miners selling specimens, and the authorities have been known to fire miners, confiscate specimens from visitors, and on some occasions even throw the visitors in jail. The most difficult mines in this regard are Casapalca, because of its proximity to Lima, and Huanzala, because of the tons of specimens collected and sold by the miners. At most mines, however, you will not encounter great problems.

Foreign dealers now find visiting the mines less productive than buying their specimens from dealers in Lima. This is because at any given time runners are likely to be in residence waiting to buy specimens as the miners bring them out. On a trip to Huanzala some years ago, one of us (RHC) and Jorge Fitzgerald, a friend and dealer from Lima, arrived just as five *piriteros* were leaving. What they left for us to buy was hardly worth the cost of the gasoline to get there let alone the joys of the five star Huanzala Hilton hotel (yes you could actually count about five stars through the roof). This does not mean that you will always do better in Lima than at the mines, but the chances of success at the mines have diminished considerably. Scores of Peruvian mines still exist that have wonderful specimen-producing potential, but they are rarely visited by anyone interested in minerals.

In Peru, when dealing with a miner or a runner you are usually invited into their homes to view the specimens. Bargaining is usually the order of the day, and is usually pursued with considerable animation. The lady of the house usually stays in the background, often saying nothing while this goes on. Once a price has been agreed upon, the man of the house will then confer with her. If she does not find the price acceptable you are back to square one. Many women in Peru are business-minded and manage the household finances. They often do the selling while their men obtain more specimens. More often than not they are the ones who have the final say on any price reached with buyers.

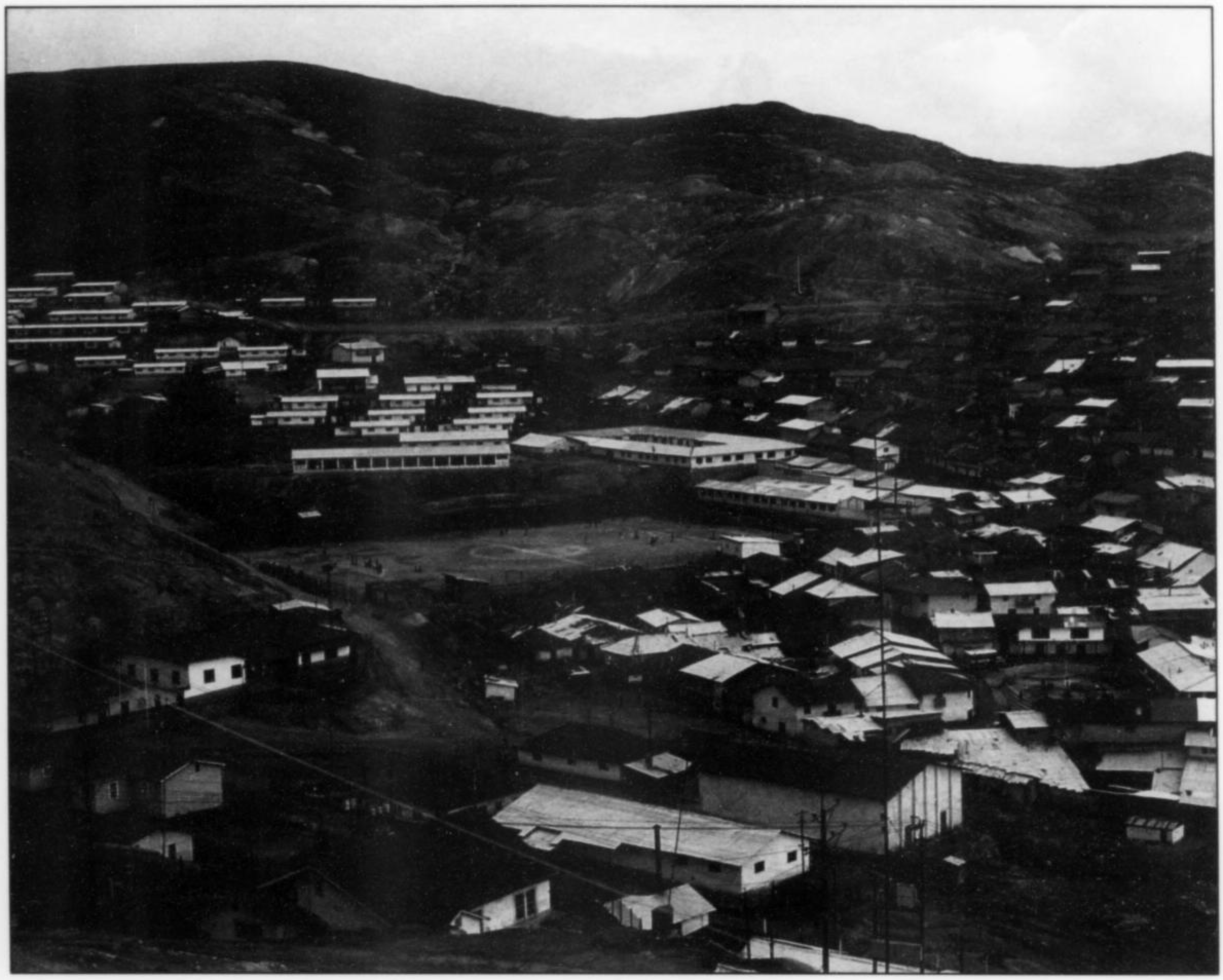


***Figure 12*. The city of Quiruvilca. R. Currier photo.**

The Quiruvilca-Chilete Group

THE QUIRUVILCA DISTRICT

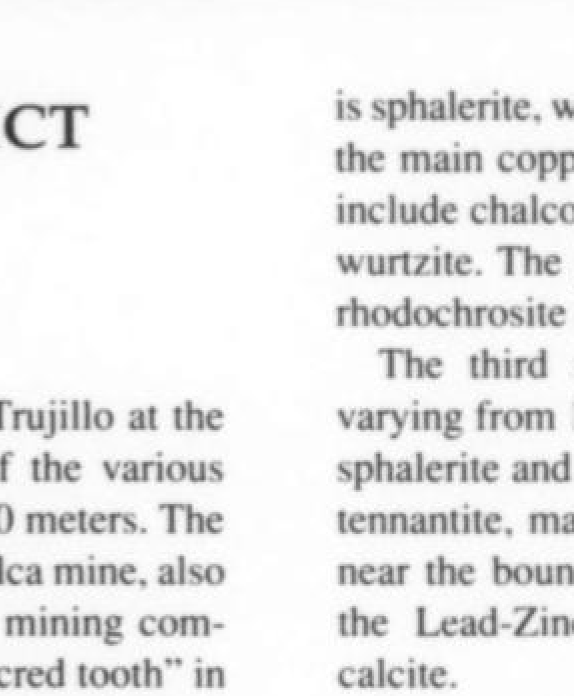
Santiago de Chuco Province
La Libertad Department

LOCATION

The Quiruvilca District is located 80 km east of Trujillo at the head of the Moche River Valley. The elevations of the various workings in the district vary between 3,800 and 4,000 meters. The many workings are collectively known as the Quiruvilca mine, also occasionally called the Asarco mine (for the parent mining company) or the La Libertad mine. *Quiruvilca* means "sacred tooth" in Quechua. The term refers to a prominently exposed volcanic neck several kilometers to the northeast (Bartos, 1987a). The geology and ore deposits of the district have been described by Lewis (1956) and by Bartos (1983, 1987a, 1987b, 1990); the discussion here is derived from those reports, particularly the works of Bartos.

GEOLOGY

The Quiruvilca district is an old lead-zinc-silver-copper district. The deposits are located in layered volcanic rocks of the Miocene Calipuy Formation, which includes andesite and minor basalt flows. The Calipuy Formation has an estimated thickness in excess of 2,000 meters. Intrusive rocks include andesite dikes and stocks.



Peru

The ore deposits have four distinct zones. Ores in the central part of the district are mesothermal and are dominated by enargite. The mesothermal deposits grade outward to the epithermal deposits. Lewis (1956) has described the various zones in some detail, and his descriptions are incorporated below, along with appropriate modifications by Bartos (1987a).

The inner zone is called the *Enargite Zone*, and encompasses the major part of the Quiruvilca mine. The surface expression is an oval about 2,800 meters long and 700 meters wide. In addition to enargite, associated sulfides include pyrite, tennantite, wurtzite, sphalerite, chalcopyrite, orpiment, galena and hutchinsonite.

The next zone outward, the *Transition Zone*, is up to 1,400 meters wide. Its dominant ore mineral is sphalerite, with pyrite the major sulfide and tetrahedrite-tennantite the main copper-bearing mineral. Other sulfides and ore minerals include chalcopyrite, galena, marcasite, arsenopyrite, covellite and wurtzite. The gangue is primarily massive quartz with occasional rhodochrosite and calcite.

The third zone outward is the epithermal *Lead-Zinc Zone* varying from 1,000 to 3,000 meters in width. It is characterized by sphalerite and galena, along with pyrite, chalcopyrite, tetrahedrite-tennantite, marcasite, arsenopyrite and gratonite. Wurtzite occurs near the boundary with the Transition Zone. Gangue minerals in the Lead-Zinc Zone are quartz, dolomite, rhodochrosite, and calcite.

Outermost is the *Stibnite Zone*, peripheral to the Quiruvilca district. In addition to stibnite, the other main sulfide mineral is arsenopyrite, with minor amounts of pyrite, sphalerite, galena, and chalcopyrite.

To simplify these various vein mineralization features, Bartos (1987a) divided the veins into three types based on the dominant vein fillings: pyrite, sphalerite-galena, and gangue. The gangue-dominant veins are mainly carbonate, but in some areas are quartz.

According to Bartos (1987a), the quantity of sulfide and ore minerals changes dramatically outward from the center of the district; pyrite is a good example, showing a rapid decrease outward. Copper-bearing sulfosalts are dominant in the Enargite and Transition Zones, sphalerite and galena are maximized in the intermediate Lead-Zinc Zone, and arsenopyrite and stibnite reach a maximum in the outer Stibnite Zone. Non-sulfide gangue minerals change in proportion laterally from the center of the district. In the Enargite Zone barite is most abundant; dolomite is most abundant in the Transition Zone; manganoan calcite becomes most abundant in the Lead-Zinc Zone; and rhodochrosite and quartz are most abundant in the Stibnite Zone.

Some mineral species occur only in certain zones. For example, enargite is restricted to the central Enargite Zone, whereas the other copper-bearing sulfosalts, tetrahedrite and tennantite, occur in the outer zones. Orpiment and realgar are only found within the Enargite Zone; native ar-

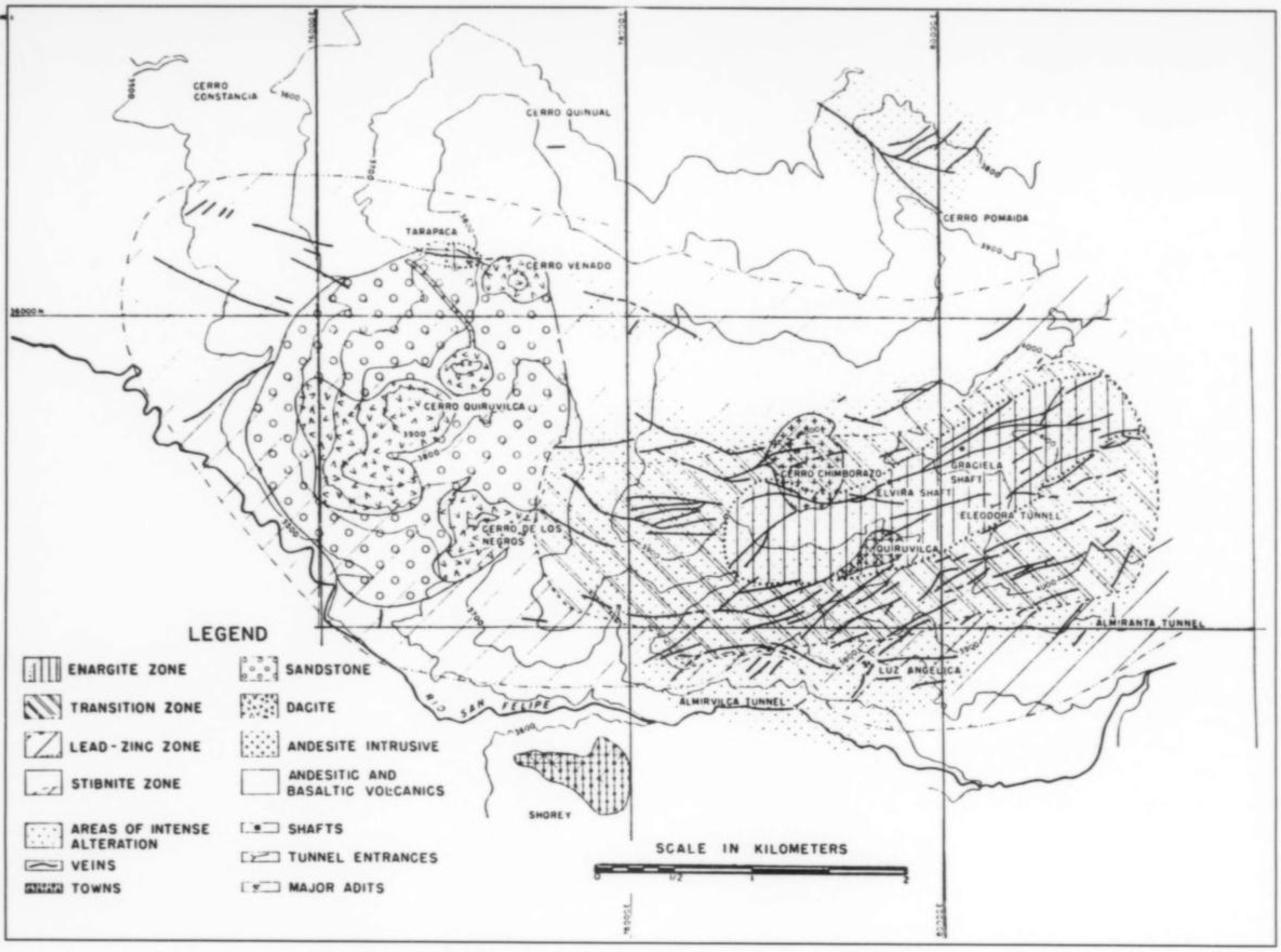


Figure 13. **Geology of the Quiruvilca district (from Lewis, 1956).**

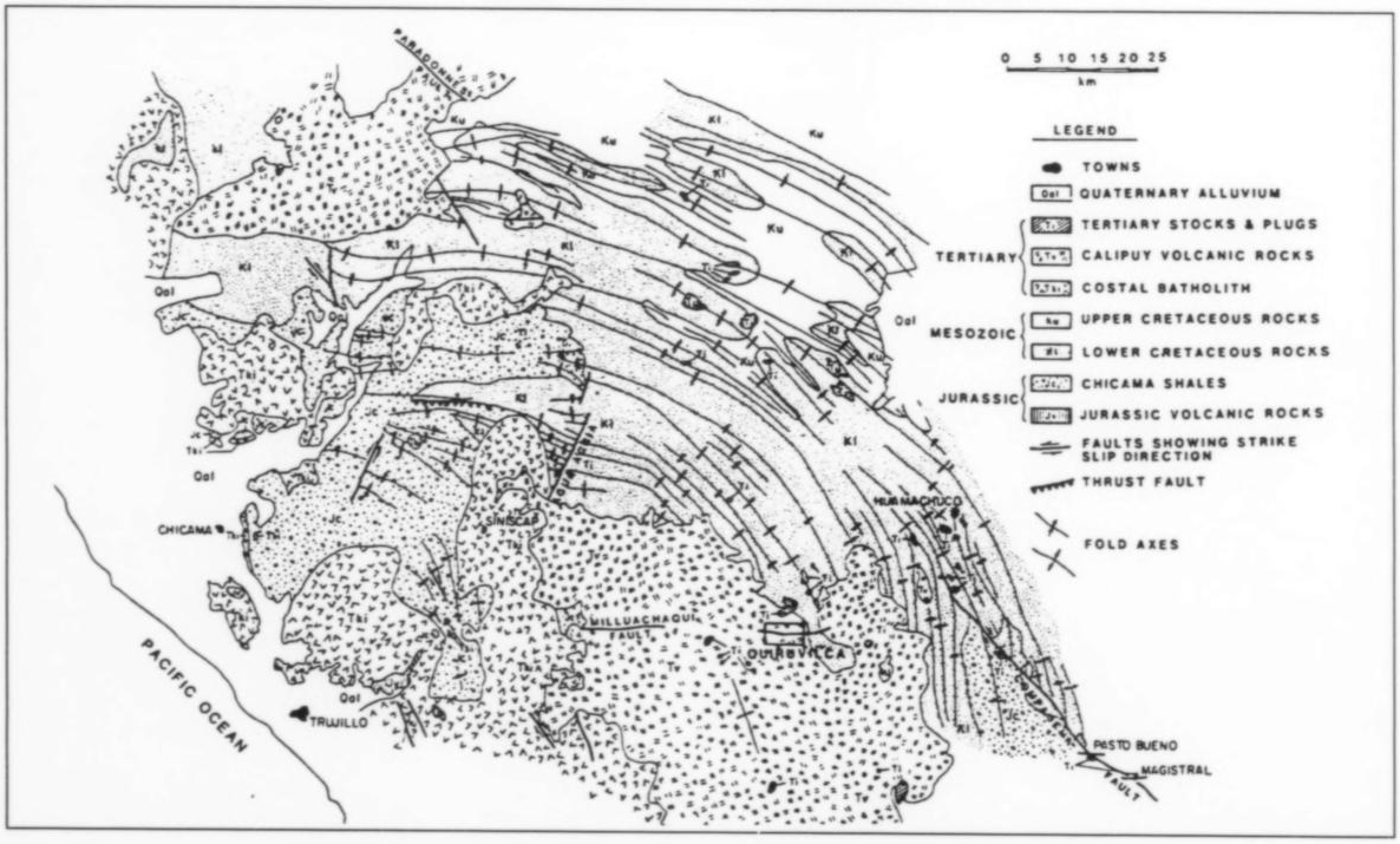


Figure 14. **Geology of the Quiruvilca-Pasto Bueno area (from Bartos, 1987b).**

senic and arsenopyrite are primarily found in the Stibnite Zone. Pb-As-S glass (sold as "revoredite" by dealers) and other sulfosalts are found in the intervening Transition and Lead-Zinc Zones.

PARAGENESIS

Mineralization in the district occurs in over 100 veins, about 60 of which have been developed for mining. The mineable veins average 30 cm in width reaching a maximum of 2.5 meters (Bartos, 1987b). The veins are typically coarse-grained and massive, with local vuggy areas. All veins, regardless of their zonal position in the district, exhibit the same overall paragenetic stages. These are, in order from earliest to latest:

(1) ***Pyrite stage:*** quartz, pyrite.

(2) ***Base metal stage:*** arsenopyrite, galena, enargite, tetrahedrite-tennantite, sphalerite, pyrite, chalcopyrite, stannite, chatkalite.

(3) ***Sulfosalt stage:*** alabandite, marcasite, pyrite, arsenopyrite, quartz, manganaxinite, clinozoisite, stibnite, robinsonite, jamesonite, barite, orpiment, realgar, hutchinsonite, geocronite, native arsenic, seligmannite, Pb-As-S glass ("revoredite," not a true mineral).

(4) ***Carbonate stage:*** manganoan calcite, rhodochrosite, dolomite, calcite, quartz.

Bartos (1983) also points out that "all paragenetic stages are present in major veins of any zone, but the relative abundance of late-stage minerals increases toward the periphery of the district."

Table 1. **Minerals reported from Quiruvilca.**

	Common or Abundant	
***Arsenopyrite**	Manganoan calcite	***Sphalerite**
***Dolomite**	***Pyrite**	***Stibnite**
***Enargite**	Quartz	***Tetrahedrite/ Tennantite**
***Galena**	Rhodochrosite	
	Rare or Locally Abundant	
Alabandite	***Chalcopyrite**	Marcasite
***Apatite**	Chatkalite	***Orpiment**
Arsenic	Clinozoisite	Realgar
***Pb-As-S glass**	Geocronite	Robinsonite
***Barite**	Gratonite	***Scheelite**
***Baumhauerite-2a**	***Hutchinsonite**	Seligmannite
***Bournonite**	Jamesonite	Stannite
***Calcite**	Manganaxinite	***Wurtzite**

*Collector-quality specimens

MINERALS

At various times over the past few decades, the Quiruvilca district has produced major quantities of specimens. Quiruvilca is best known for its fine pyrite, orpiment, hutchinsonite and enargite. The heyday for specimen production was the early to mid-1970's. Specimen production from Quiruvilca in recent years has been insignificant.

Arsenopyrite FeAsS

Arsenopyrite is uncommon in good specimens, but they can be quite attractive when found. Specimens seen by us have arsenopyrite as stellate twins which, when viewed end-on, show the typical starlike twin form, but when viewed from the side show rows of crystals that look similar to the teeth in a comb. These rows of crystals can be up to 2 cm long, with individual crystals about 1 cm in length. This habit of crystallization in Peru may be unique to Quiruvilca. Small 1 to 3-mm pink or tan rhombic dolomite crystals are a common associate on the arsenopyrite crystals. Arsenopyrite in tiny 1-mm crystals is a common associate of the stibnite specimens from Quiruvilca.

Barite $BaSO_4$

Barite is a ubiquitous mineral in the Enargite Zone. The crystals are distinctly bladed, varying from paper-thin to a few millimeters thick. It is colorless to cream, cream-yellow and gray. Crystals on specimens we have seen are up to 5 cm across and are commonly translucent to transparent. The mineral occurs both as an associate of the other minerals and as excellent specimens in its own right, as cabinet-size, bladed aggregates with the blades usually standing upright on the matrix. Barite is a distinctive enough association in many Quiruvilca specimens to help in confirming the locality.

Figure 15. **Bournonite crystal, 2.8 cm, on chalcopyrite from Quiruvilca. Bill and Carol Smith collection; Jeff Scovil photo.**

Bournonite $PbCuSbS_3$

Much confusion surrounds the occurrence of bournonite at Quiruvilca. A large find, initially reported as from "near La Oroya" (Wilson, 1984), was subsequently identified as from Quiruvilca in the "Letters to the Editor" section of the *Mineralogical Record* (vol. 15, p. 249). In turn, this was stated to be in error (Siber, 1987), and the specimens were said to be from "La Merced" near Huallanca in Huanuco. The only mine near Huallanca with a name similar to "La Merced" is the Mercedes mine. We have never been able to verify bournonite as occurring at the Mercedes mine; examination a few years ago of the ore piles at the Mercedes mine did not show any bournonite at that time. However, there are some workings in a section of the Quiruvilca mine that are referred to as "Merced."

Bournonite has been reported as a rare constituent of the Quiruvilca ores (Bartos, 1987a; Siber, 1987). Siber states that bournonite at Quiruvilca forms barrel-shaped crystals up to 3 cm long, and he cites a find in September 1985 where it occurred in crystals up to 1 cm with enargite and tetrahedrite. The bournonite from this find is bright and splendent, but the tetrahedrite, which occurs in simple tetrahedrons, often has a satiny luster. Calcite in dull, gray to cream, discoidal, bladed crystals is also associated. On at least some of the specimens, jamesonite (?) in small hairlike mattes, is nestled around the base of the bournonite crystals, and also contributes some of the gray coloration to the calcite crystals as an inclusion. Pyrite is a minor association, occurring as striated, pyritohedral crystals less than 1 cm in size.

Several lots of bournonite were offered for sale in 1982. One of these lots consisted of bournonite in small groups and clusters, many of which are sharp and bright. Large plates of solid bournonite,

Figure 16. **Bournonite crystal group, 11 cm, from Quiruvilca. Bill and Carol Smith collection; Jeff Scovil photo.**

with no other associated minerals, were also recovered at about this time. Some of these large plates are of outstanding quality, the bournonite crystals measuring 3 cm in the best specimens. In addition, there also appeared bournonite on bright pyritohedral pyrite crystals, commonly about the same size as the bournonite, and these were typical of bournonite-pyrite assemblages from this particular batch; again, the bournonite crystals in the best specimens measure about 3 cm. No other Peruvian bournonite locality produces specimens having quite the same look as these from Quiruvilca.

Calcite $CaCO_3$

The calcite from Quiruvilca usually forms white to gray, discoidal blades a centimeter or less in size. It occurs as a late-formed mineral on earlier minerals, and is not especially noteworthy. If it was present in any quantity as coating on well-crystallized minerals of other species, it may have been dissolved off in hydrochloric acid by the Peruvian mineral dealers.

Chalcopyrite $CuFeS_2$

Chalcopyrite is relatively common throughout the Quiruvilca district mines. In the Enargite Zone it was deposited simultaneously with, or just after the crystallization of wurtzite. It can partially replace the wurtzite, enargite and tetrahedrite. It also occurs on tetrahedrite, pseudomorphous after enargite. Specimens offered for sale frequently have chalcopyrite as bright, brassy, golden crystals up to about 1.5 cm.

Dolomite $CaMg(CO_3)_2$

Dolomite occurs as white, cream or pink crystals, often associated with pyrite. Dolomite also occurs as thick coatings on tetrahedrite, which when dissolved off in acid reveal fine thumb-sized tetrahedrite crystals. These coated specimens came out from 1982 to 1984. Dolomite coating or partially coating pyritohedral pyrite in "hand sized" plates of crystals was abundant from 1987 to 1990.

Enargite Cu_3AsS_4

In the recent past, more so than now, Quiruvilca has been noted for producing some of the world's finest enargite specimens.

Figure 17. **Enargite crystal group encrusted with pyrite, 14.2 cm, from Quiruvilca. Marty Zinn collection; Jeff Scovil photo.**

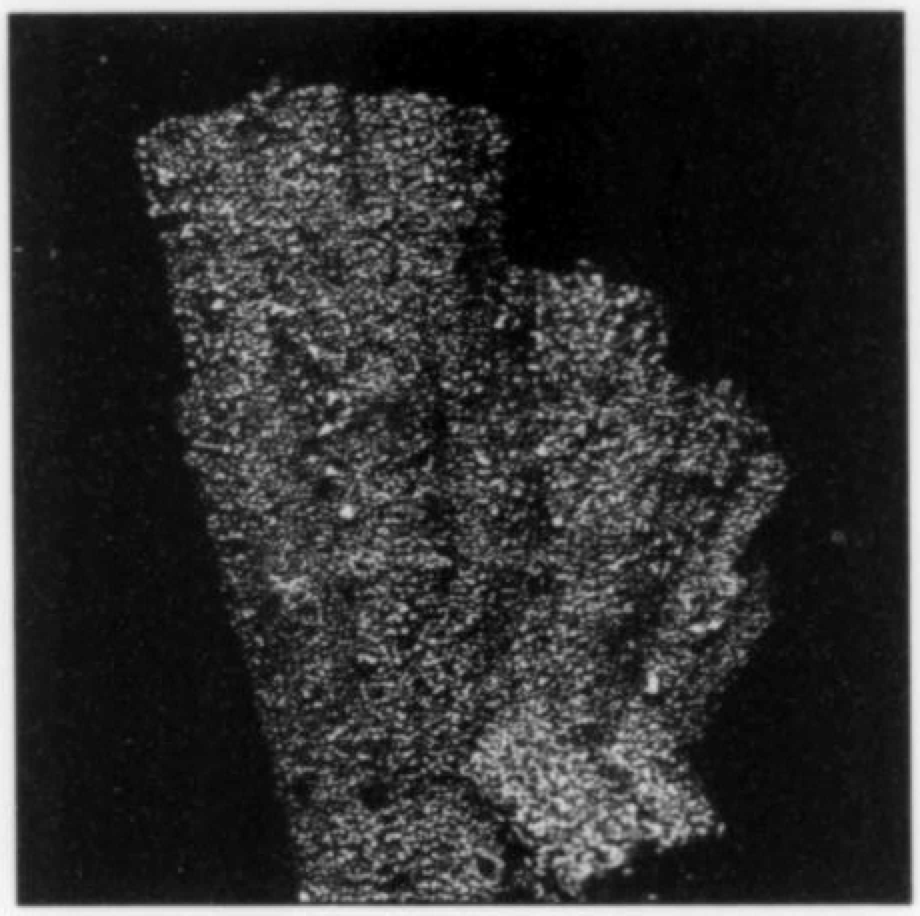


Figure 18. **Enargite crystal group encrusted with pyrite, 4 cm, from Quiruvilca. Rock Currier collection; Jack Crowley photo.**

During the mid-1970's such pieces were abundant, and good, hand-sized specimens were readily available. The best specimens consist of bladed, prismatic crystals, commonly wider at the termination than at the base, and also narrow, prismatic crystals up to 12 cm long. Terminations are flat (typical for the species) and lustrous.

We have purchased many rough crystals up to 10 cm in length which were usually cavernous or at least coated with small tetrahedrite crystals or other sulfides. They did not sell well, and it is suspected that most of these rough crystals were run through the mine mill. More popular with collectors are the smaller, sharper and more brilliant enargites that are still occasionally encountered. The average size of crystals collected from the district is 1 cm wide by 4 cm long. Prismatic crystals of excellent quality, up to 5 cm wide by 20 cm long, have reportedly been collected in fine groups (Lewis, 1956). It is interesting to speculate on the size of the vugs in which these must have occurred. Tons of these crystals undoubtedly went to the crushers. Large clusters of 1–3 cm long crystals were common.

The crystals themselves are sometimes coated with pyritohedrons of pyrite, creating one of the more aesthetically pleasing types of enargite. These are slightly fan-shaped enargite crystals usually less than 7 cm long, completely coated with small, shiny pyrite crystals. These particular specimens came out around 1980 and were relatively common for a short period of time. The largest may reach 12 cm in length. The pyrite-coated enargite crystals make particularly attractive specimens since the sparkling pyrite looks like golden diamonds coating the prismatic crystals of enargite. Enargite also occurs as second-generation crystals growing on the first generation prisms. During the 1980's thumbnail to miniature-size specimens of enargite in star-like twins were recovered. These specimens are generally flat and are composed of solid crystallized enargite in star-like twins up to 1.5 cm in width.

Commonly enargite may be partially or completely coated or even replaced by tetrahedrite. In some cases the replacement is so perfect that the specimen has to be studied closely to determine whether it is a very bright enargite or a bright tetrahedrite. The lack of striations on the tetrahedrite is usually the distinguishing factor.

Some years ago one of us (RHC) traded a very fine specimen of enargite to Bryn Mawr College. It consists of a cluster of large, somewhat rough enargite crystals about 10 by 15 cm each, with a star of twinned enargite crystals approximately 5 cm across perched on one end.

Fluorapatite (?) $Ca_5(PO_4)_3F$

Apatite is rarely present as bright, lustrous, hexagonal microcrystals, usually occurring on pyrite as a very minor association. Some of the more poorly formed crystals might be mistaken for microcrystalline fluorite. Occasionally the apatite may be coated with a thin crust of microcrystalline drusy quartz. It fluoresces a cream color in long-wave ultraviolet light.

Galena PbS

Quiruvilca is not noted as a source of good galena specimens, even though galena is present in all the zones except the Stibnite Zone. Galena is rarely found in the Enargite Zone, but where it does occur it is usually crystallized on pyrite or with sphalerite and quartz in the outer part of this zone. Much of the galena is etched or partly to completely replaced by later sulfides. The galena in the Lead-Zinc Zone is occasionally found partly replaced by gratonite. The galena occurs frequently on pyrite, associated with tetrahedrite, sphalerite and chalcopyrite. Galena can also be partly replaced by sphalerite and tetrahedrite.

Hutchinsonite $(Pb,Tl)_2As_5S_9$

First reported about the same time as the big orpiment finds, Quiruvilca hutchinsonite is the world's finest for the species. The black to silvery black prismatic crystals occur on nice plates, with the longest crystals perhaps a centimeter in length but most much smaller. The miners in the camp called them *estibina* (stibnite). Orange orpiment in small spherical masses, small to microscopic enargite, barite and pyrite also occur with the hutchinsonite. A few specimens have a powdery coating of baumhauerite-2a (Robinson and Harris, 1987; Pring, 1990). Most of the hutchinsonite is associated with orpiment, and less frequently with barite crystals.

Jamesonite (?) $Pb_4FeSb_6S_{14}$

Jamesonite (?) occurs in trace amounts as shiny, web-like to hairlike mats in vugs and nestled among larger crystals of other minerals. It can be easily overlooked.

Figure 19. **Orpiment crystal cluster, 3.7 cm, from Quiruvilca. Ken Roberts specimen; Wendell Wilson photo.**

Orpiment As_2S_3

First found in the period from 1972 to 1975, in crystals up to 7 cm in size, fine orpiment has been recovered sporadically since then in crystals from 1 to 3 cm, but never in the size and quality of the first material that came out. Orpiment specimens in large numbers were collected from the Quiruvilca mine in 1976, 1978 and 1981. Large plates with 2 to 3-cm crystals of orange to burnt-orange color were common. Quiruvilca has produced some of the

Figure 20. **Orpiment crystal group, 15 cm, from Quiruvilca. Steven Neely collection; Jeff Scovil photo.**

best orpiment crystals in the world. The largest specimen known to us is nearly 30 cm across and consists of lustrous crystals averaging 2 cm wide by 5 cm long. Occasionally pyrite and barite are associated with the orpiment, but more frequently the specimens consist totally of orpiment crystals. A few orpiment specimens collected in 1978 have beautiful lustrous faces, but these faces are mostly covered with a white flaky material that subsequent X-ray powder analysis has shown to be variscite. Orpiment is a very soft mineral, and almost all specimens from Quiruvilca that make their way to market have some damage. Quiruvilca orpiment has seldom appeared on the market during the last several years. Hutchinsonite is associated with as much as 10 percent of the orpiment collected during the early years. Runners have brought in several hundred boxes of orpiment specimens over the years.

Pyrite FeS_2

Pyrite occurs throughout the district. Crystal forms, in order of abundance, are: pyritohedrons, octahedrons, dodecahedrons and cubes. Pyritohedrons up to 5 cm in size, in large groups, are commonplace, as are octahedrons of about the same size. Larger crystals to 15 cm have also been collected. Commonly the pyrite, particularly from the Enargite Zone, is coated with tiny to large enargite crystals, small, later-growth pyrite crystals, or a thin film of iridescent red to blue enargite that dulls what otherwise would be a brilliant luster. The cube form of pyrite is uncommon at Quiruvilca and usually occurs as disseminated crystals away from the main veins. Pyrite is also found as dull to bright coatings of small pyritohedrons covering euhedral enargite crystals. From 1984 to 1987, occasional lots of pyrite pseudomorphous after enargite in a "jackstraw" style were found. The enargite crystals are hollow, with the pyrite forming botryoidal-like crystalline surfaces that faithfully replace the enargites. Some individual enargite crystals thus coated are up to 7 cm long. One of the features of Quiruvilca pyrite that aids in distinguishing it from other Peruvian locations is the fairly common occurrence of tiny groups of pyrite microcrystals implanted on the larger pyrite crystals. This is more notable on the pyritohedral groups than on the octahedral crystals. Quiruvilca has produced many extraordinary clusters of sharp octahedral pyrite crystals, some with modified edges. Some of these crystals measure as much as 10 cm on an edge, and rarely even larger. Until the discovery of the enormous clusters of octahedral pyrite crystals from Huanzala, Quiruvilca

Figure 21. **Enargite crystal group, 5.2 cm, from Quiruvilca. Fred Pough collection, Jeff Scovil photo.**

produced the finest specimens of octahedral pyrite in the world. Some of the most attractive arrangements are the large, brilliant, octahedral crystals, with large, shiny, prismatic enargite crystals implanted on them; this creates an attractive contrast to the pyrite. These specimens are unique to Quiruvilca.

Quartz SiO_2

Although quartz is common in the Lead-Zinc Zone and the Stibnite Zone, most quartz-bearing specimens offered on the mineral market from Quiruvilca have been collected from the Enargite and Transition Zones. Although it is common in these areas, it does not form good specimens and usually is present as microscopic crystals that form drusy layers on the matrix or are scattered around on the dominant minerals. As a general rule, this distinctive appearance is sufficient to help identify specimens as coming from Quiruvilca. If quartz is at all well-developed on any specimen labeled to have originated from Quiruvilca, it is likely that the specimen is mislabeled.

Scheelite $CaWO_4$

Scheelite occurs in octahedral crystals and crystal groups up to several millimeters across; it has a white or gray color. The crystals fluoresce a bright yellow-white to white. Scheelite is best detected by examination under ultraviolet light. Scheelite from Quiruvilca is rare.

Sphalerite (Zn,Fe)S

Sphalerite from Quiruvilca is generally of mediocre quality. It is usually Fe-rich and very dark in color. In most specimens it is black in reflected light, but in transmitted light may be a dark reddish amber color. Despite its generally low quality here, sphalerite is found with many of the minerals that occur in the mines. Within the Enargite Zone it is usually associated with galena and quartz. In the Transition Zone, the dominant occurrence of sphalerite is on or with pyrite, with or without quartz, followed by pyrite-sphalerite-galena, plus or minus quartz and tetrahedrite.

Stibnite Sb_2S_3

Stibnite occurs in the Stibnite Zone as sprays of bright, 1.5 cm or longer, acicular crystals, on and with minute 1 to 2-mm arsenopyrite crystals.

Tetrahedrite-tennantite $(Cu,Fe)_{12}Sb_4S_{13}$ - $(Cu,Fe)_{12}As_4S_{13}$

Tetrahedrite-tennantite was available in limited quantities up until just a few years ago. Splendent tetrahedral crystals up to 3 cm or more have been collected, with the average crystal size being about 1 cm, in specimens exceeding 10 cm across.

Some of the more striking tetrahedrite specimens are pseudomorphs after enargite. On these specimens the finger-shaped enargite crystals may reach 3 to 5 cm in length, have been partly to wholly replaced by splendent tetrahedrite; in some cases this gives the specimens a distinctly cactus-like appearance, commonly with skewed pointy tetrahedrons covering the enargite. In other specimens the tetrahedrite has replaced the enargite so perfectly that a casual look may leave the impression that the enargite is just brighter than usual. A closer look will show the differences, the most notable being the lack of striations so common to enargite, plus just a general "not rightness" in the appearance of the specimen. Tennantite also occurs as oriented overgrowths on pyrite. Anthony and McLean (1973) reported that octahedral and dodecahedral pyrite had well-developed tennantite in parallel crystallographic orientation and that this combination made for unusual and attractive specimens.

Most tetrahedrite from Quiruvilca is in the simple tetrahedron form, the tetrahedrons varying in color from dull black to very bright, silvery black. The most commonly seen specimens in collections are quite bright. Good sized groups, up to 10 cm or so across, were common in the late 1980's. The best specimens have tetrahedrite in tetrahedrons over 3 cm wide, scattered across the matrix; in some cases bladed calcite is scattered on and around the tetrahedrite, the matrix pieces exceeding 25 cm across.

Wurtzite (Zn,Fe)S

Wurtzite is the usual form of ZnS in the Enargite Zone. It has been found sporadically throughout the Enargite Zone and the Transition Zone, usually with a distinctive honey-orange color. It is rarely found on mineral specimens from Quiruvilca. Chalcopyrite and pyrite are associated with the wurtzite. In the few specimens checked, wurtzite is fluorescent with a deep brick red color in longwave ultraviolet light.

REMINISCENCES ON AN EARLY TRIP TO QUIRUVILCA, 1976

The jumping off point for Quiruvilca is Trujillo, and you can get there comfortably with an eight-hour bus trip or, better yet, a short plane trip from Lima. All of Peru's western coast is in the rain shadow of the Andes, and any travel along the coast will encounter severe desert, which is only relieved when you descend into the occasional river valley that concentrates the watershed from the huge mountains to the East. The transition from stark desert to lush river valley can be quite startling. As you near Trujillo, you suddenly drop from severe desert down into the Moche River valley, verdant with crops of sugar cane and pineapples. Arriving by air you can view the kilometers of Pre-Colombian Indian ruins known as "Chan Chan"; these are billed as the largest prehistoric Indian barrio in the world. There are no five-star hotels in Trujillo, but a number of decent ones with hot water are available. They are infinitely better than any non-company housing you will find in the mining camps.

Jorge Fitzgerald and I (RHC) rented a Volkswagen "bug" for our first trip to Quiruvilca in 1976. The road east up the scenic Moche River valley is rough, and you gradually leave all cultivation behind as you wind up into the barren mountains. After about five hours, if you make all the correct turns and the road is in good condition, you will arrive at the little town of Quiruvilca, with mines, prospects and dumps punctuating the hills around the town. As you enter the town you will see a small concrete monument. If you stop and examine it you will find it studded with weathered pyrite crystal clusters and a round metal plaque proclaiming the existence of Quiruvilca.

We arrived in late afternoon, thoroughly pounded by the rough roads. We arranged for a room at the hotel, "La Cueva" (the cave), an entirely appropriate name. Our room, the only available room, in this six-room "pleasure palace," was occupied by a truck driver who, we were assured by management, would be vacating the room some time that afternoon.

Feeling somewhat under the weather from the change in altitude but with time to spare, we climbed the hill to the *pabellones* (pavilions) in the mining camp and began knocking on doors. We hoped to scare up some specimens but had little luck. With the sun setting on the mountains behind the camp we disconsolately made our way back down the hill to the hotel. On the way we stopped to barter for some *laques*, the local word for specimens. As we bartered a group of uniformed school children gathered around to watch the proceedings. With the bargaining complete, I pulled a giant fistful of *soles* (Peruvian bank notes) from my pocket to pay for the specimens. At the sight of all that money the children let out a collective gasp, and Jorge quickly told them that we wanted to buy more specimens, and that we would be down at the hotel Cueva. The children vanished as quickly as dropped mercury, scattering to their homes all over the camp.

Back at the hotel we discovered that the truck driver was still in residence in our room. With nothing to do, we hung out around the Volkswagen in front of the hotel, speculating about the likelihood of spending the night in the car. Soon a child came running up with a mineral specimen to sell. It wasn't bad, and we paid him about 25 cents. By the time that transaction was complete three other children and women had arrived, then six, ten, 20, then God only knows how many; it was a near riot. Soon the car was surrounded five and six deep with men, women and children thrusting specimens at us from all directions for inspection. Jorge worked on one side of the car, and I on the other, to try and split up the mob. As soon as I bought a specimen, I would open the car door a crack and with one hand firmly on the pocket with my money, I used the other to quickly put the specimen somewhere, anywhere inside. The floors and seats were rapidly covered with good pyrite and enargite specimens, and we were soon piling them one on top of the other. There was no time to organize packing materials. Finally it became so dark we had to turn on the head lights of our car to get some idea of what we were buying.

At last our room was ready. Leading a turbulent line of budding, shoving, specimen dealers, we climbed the ladder over the privy, up through a trap door in the floor of the balcony that ran along the front of the "hotel" above the smelly, hand-cranked gas pumps, and down the short swaying central corridor to the room. The crude adobe walls had cracks so wide that previous occupants had stuffed wadded up balls of newspapers in them to control the already more than adequate ventilation. A crowd of people selling specimens quickly formed up and crowded into the room and overflowed into the corridor. The floor of our room swayed more than I really wanted to think about, and immediately brought to mind visions of the floor giving way, and crashing a room full of screaming women, children, miners, a few hundred pounds of rocks, Jorge and I down to the ground floor. Jorge hired two of the biggest men to control the crowd and feed them through to me in the room, one or two at a time. I sat there on a frail, complaining chair, on a heaving floor, behind a thoroughly trashed, wobbly wooden table, beneath a bare light bulb, like some tinhorn potentate, buying specimens.

I particularly remember one lot of orpiment specimens that covered most of one of the beds. Some specimens were almost 30 cm across and consisted of wall-to-wall crystals about 4 cm long. All these we bought for a total cost of about $60. After the excitement had died down, we went out to stretch our legs. We were standing in front of the hotel next to the little add-on room where they kept the pigs and turkeys at night, when a young man wearing a voluminous poncho approached. He asked if specimens were still being purchased. Hearing the affirmative, a hand came out from under the poncho with a piece of almost massive pyrite. We told him the piece had no value, but fortunately asked if he had anything else. After some fumbling around under the poncho, out came the other hand holding a cluster of octahedral pyrite crystals. It took a full ten seconds for me to realize that the piece was the best pyrite specimen I had ever seen. It was about 20 by 20 cm, with the largest pyrite crystal measuring almost 10 cm on an edge. The young man asked 500 soles, which at the then current exchange rate was about 8 dollars. We did not even argue the price. This wonderful specimen eventually found a good home at the University of Paris.

The next morning we needed to find a place to store our specimens. We did not wish to subject them to the rough road that we would soon be taking to Pasto Bueno, and thought it better to pick them up on the way back. We spent the next day scrounging up boxes and packing material, which was no easy task, and packed up all the specimens that we had bought the evening before. We solved the specimen storage problem by taking a lease on our room for a whole week at a cost of about seventy five cents a day.

RHC

The Pasto Bueno Group

THE PASTO BUENO DISTRICT

Pallasca Province
Ancash Department

LOCATION

The Pasto Bueno district is located in the northern-most extension of the Cordillera Blanca in the north-central Andes, just west of the Continental Divide, approximately 90 km east of the Pacific Coast. Elevations vary from approximately 3,300 to about 5,000 meters. The Pasto Bueno mining camp has not been inhabited for many years. The main settlement for mining in the area these days is at Consuzo, with smaller camps at Region de Maria Ofelia, Region de Huaura, Region de Huayllapon, and Mundo Nuevo. The Huayllapon mine area is located on the north side of the Consuzo quartz monzonite stock, 2.5 km north-northeast of the camp at Pasto Bueno (Fig. 23).

HISTORY

In 1910 wolframite was discovered at Pasto Bueno. The Peruvian mining company *Fermin Malago Santolalla e Hijos* was established to mine the deposits in 1934, and, as of 1991 was still the owner. On February 14, 1990, "Shining Path" guerrillas blew up the mine's hydroelectric plant, causing a cutback in production. In 1991 the mines were producing a total of about 50 tons per day.

GEOLOGY

Pasto Bueno is a vein-type tungsten deposit. Mineralization occurs in steeply dipping quartz veins associated with the late Tertiary quartz monzonite Consuzo stock. Sedimentary rocks in the area comprise part of the Jurassic and Cretaceous sequence of the Chicama Formation shale and the Goyllarisquizga Group shales, quartzites and limestones of northern and central Peru. Landis and Rye (1974) discuss the detailed geology, and the reader is referred to their work for further detail. Much of the following geologic data on the Pasto Bueno area are abstracted from their paper.

Peru

Although not clearly defined, a zonal arrangement of mineralization from the quartz-monzonite stock in the center to the edge of the mineralized areas is as follows: molybdenite-pyrite; wolframite-tetrahedrite-chalcopyrite-pyrite; galena-sphalerite-tennantite; and last, fluorite and carbonates. No single vein has all these assemblages, so the sequence has been determined through observations of a number of veins in the various workings.

Mineralization is classified as greisen, vein, and vug. The vug period is a late phase of vein deposition. Open vugs are common, but only minerals characteristic of final vug crystallization typify the vug period. "Phantom" quartz crystals are common in the veins; these are indicative of breaks in quartz deposition.

The greisen assemblage is typified by coarse-grained, fractured fluorite in varying shades of blue through green, purple and brown. Associated minor minerals occurring as coatings in fractures, include tourmaline, topaz, apatite, titanite, rutile, stolzite, arsenopyrite, bornite, chalcopyrite and molybdenite (in no particular order).

The first major mineralizing episode resulted in molybdenite-pyrite deposition. The second major mineralizing episode resulted in tungsten mineralization, with two depositional periods, which were followed by the sulfide assemblages. The first tungsten period produced thick, stubby brown blades of hübnerite in quartz. The second tungsten period resulted in deposition of black, prismatic, euhedral hübnerite crystals in vugs. Some are a deep blood-red color in transmitted light.

Minor quantities of enargite occur in early-formed sulfide veins, associated with tetrahedrite, pyrite and galena: these minerals apparently crystallized after the tungsten period. Early-formed tetrahedrite is Sb-rich and gradually grades to As-rich tennantite, which is typical of late-stage mineralization. Botryoidal native arsenic is found rarely as an accessory mineral to the late sulfide vein assemblage.

The third major mineralizing episode was the crystallization of galena and sphalerite. Galena preceded sphalerite and continued to be deposited during the sphalerite crystallization. Early-formed sphalerite is dark brown; later-formed sphalerite is pale, transparent green; and the latest-formed is

Figure 22. **The town of Pasto Bueno. Rock Currier photo.**

very dark opaque brown. These color differences apparently reflect changes in Fe content of the hydrothermal fluids. Sericitic mica, in the third depositional sequence, was deposited as a late-stage hydrothermal mineral in veins, filling cracks and cleavage planes in hübnerite, earliest late-stage galena, and in fluorite. Sericitic mica was also deposited at the base of open-vugs, as coarse plates to 6 mm in diameter, before the period of major fluorite deposition.

The fourth major mineralizing episode is characterized by fluorite crystallization in large amounts, as a late-stage vein filling. The fluorite is color-zoned, the earliest-formed phase alternating between green and colorless, then a colorless phase, then a brief period of purple, and finally a major period of green. Scheelite is a rare accessory mineral occurring as non-fluorescent yellow to purple crystals in vugs. Rhodochrosite and other carbonates also occur as late crystallizations in the vugs, and are usually found occurring on quartz.

The ore-producing veins are near vertical, quartz-rich systems that are found on either side of the upper intrusive contact of a quartz monzonite stock that has penetrated an older sequence of shale and quartzite. Principal vein minerals of interest are wolframite (usually hübnerite), tetrahedrite-tennantite, sphalerite, galena, quartz, fluorite, pyrite and rhodochrosite. Native arsenic and enargite occur, but are uncommon. Purple apatite, scheelite and molybdenite are rare.

The two veins that have produced the most collector-quality

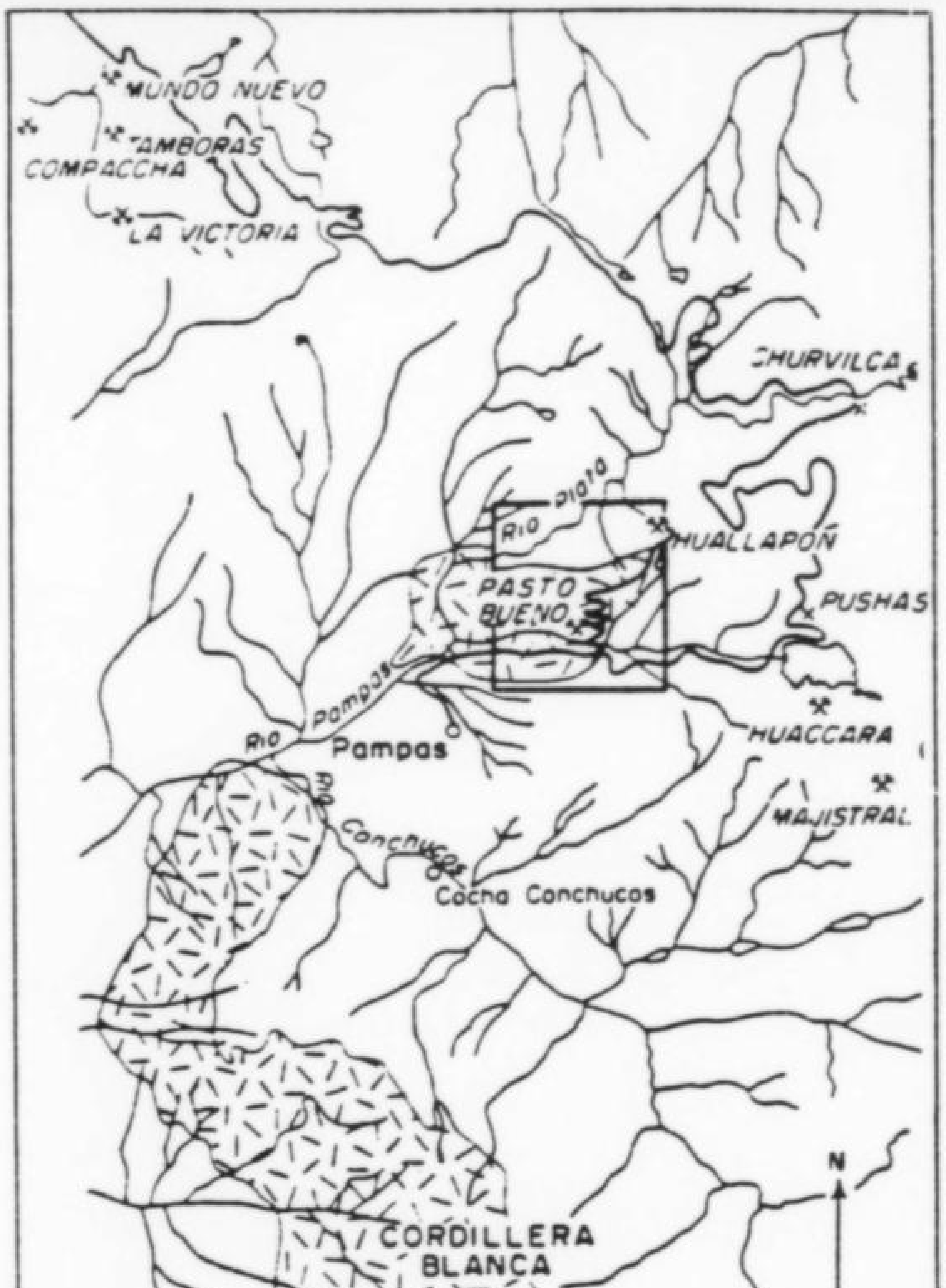


Figure 23. **Map of the Pasto Bueno-Mundo Nuevo-Majistral region (from Landis and Rye, 1974).**

specimens are the Chabuca and Santa Isabel veins. Vugs as large as 80 cm across are common in the Chabuca vein. Minerals reported from these vug occurrences are quartz, hübnerite, ferberite, pyrite, galena, sphalerite, tetrahedrite, fluorite, rhodochrosite and rarely native arsenic, tungstite, calcite, dolomite and scheelite. The centers of these veins have the gemmiest quartz, and also tend to have more translucent hübnerite. Brown sphalerite occurs sparingly with the hübnerite in these centers.

La Magistral is located 10 km southwest of Pasto Bueno. The Magistral deposit is a contact-metamorphic skarn assemblage which contains scheelite, chalcopyrite and other minerals in a limestone adjacent to a hornblende-rich granodiorite. La Magistral produced good specimens of arsenopyrite with quartz, sphalerite and hübnerite, all of which have been collected within the past ten years.

The Mundo Nuevo-Tamboras area is about 30 km northwest of the Huayllapon mine in the district of Cachicadan, Santiago de Chuco Province, Department of La Libertad. The camp of Tamboras is about 500 meters north of Mundo Nuevo. The entire area around Mundo Nuevo is criss-crossed by quartz veins penetrating the black shale and quartzite country rock. Vein walls are frequently slickensided; the slickensides are thought to be the result of post-mineralization movement (Boit, 1955). The veins are sometimes vuggy, with white quartz grown normal to the vein walls. Hübnerite, tetrahedrite and pyrite dominate, with minor amounts of arsenopy-

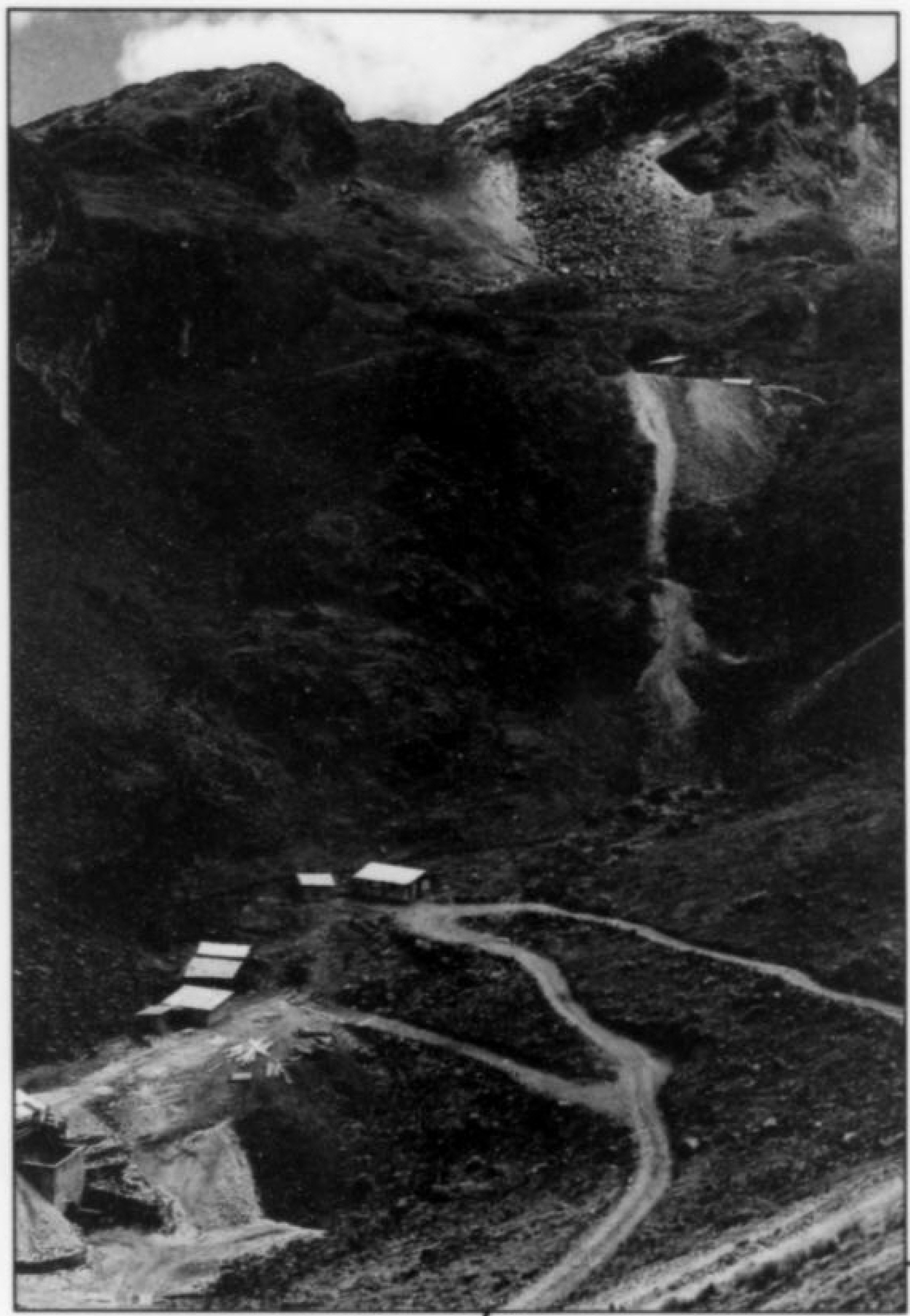


***Figure 24.* The Huayllapon mine at Pasto Bueno. Rock Currier photo.**

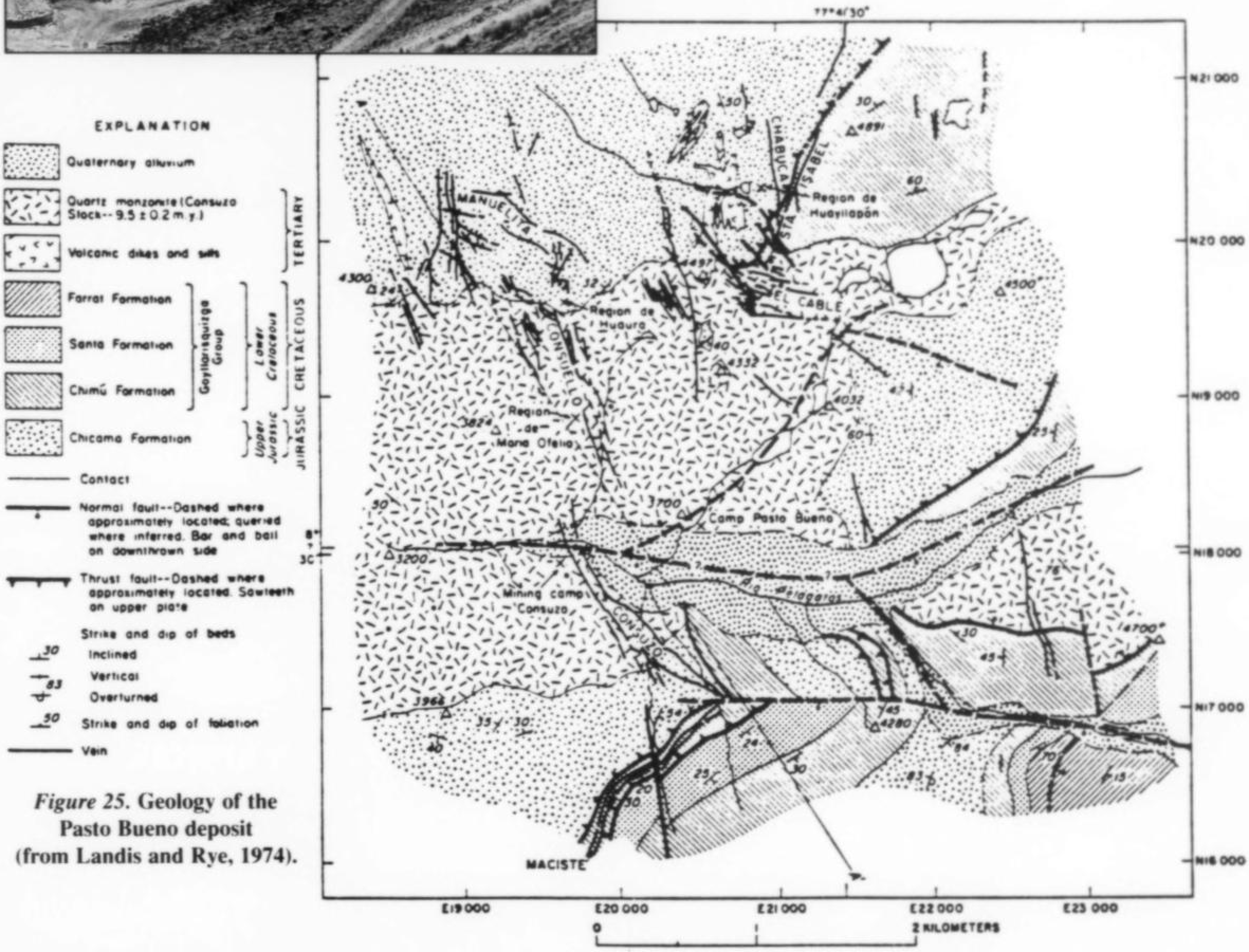


***Figure 25.* Geology of the Pasto Bueno deposit (from Landis and Rye, 1974).**

rite, sphalerite, chalcopyrite, bornite, stibnite, polybasite, bournonite, covellite, galena, gold and rarely pyrrhotite. Siderite can also be present. No single quartz vein has all of these minerals in it, although the three dominant minerals are present in the great majority of them. Many mines and prospect pits are scattered throughout the district, most small in size, but some open stopes may exceed 100 meters in length. Tabular wolframite, As-rich tetrahedrite, and Fe-rich sphalerite came from the principal vein, the Veta Pueblo, which was being mined in 1974. The La Victoria and Tambora veins, which are no longer actively mined, have similar mineralogy to the Veta Pueblo vein. Wolframite-hübnerite specimens from the La Victoria mine, about 1 km south of Mundo Nuevo, were available until 1974 when the mine closed. These occur as black, bright-lustered, thin, bladed crystals with quartz, and as stout bladed crystals similar to those from Pasto Bueno.

Most minerals currently seen for sale from this area are from the Huayllapon mine at Pasto Bueno.

Table 2. **Minerals reported from the Pasto Bueno district.**

	Common or Abundant	
***Fluorite**	***Pyrite**	***Sphalerite**
***Hübnerite-Ferberite**	***Quartz**	***Tetrahedrite**
	***Rhodochrosite**	
	Rare or Locally Abundant	
Arsenic	Enargite	Topaz
Arsenopyrite	***Fluorapatite**	Tungstite
***Augelite**	Molybdenite	***Vivianite**
Bornite	***Scheelite**	Zinnwaldite
Chalcopyrite	Stolzite	

*Collector-quality specimens

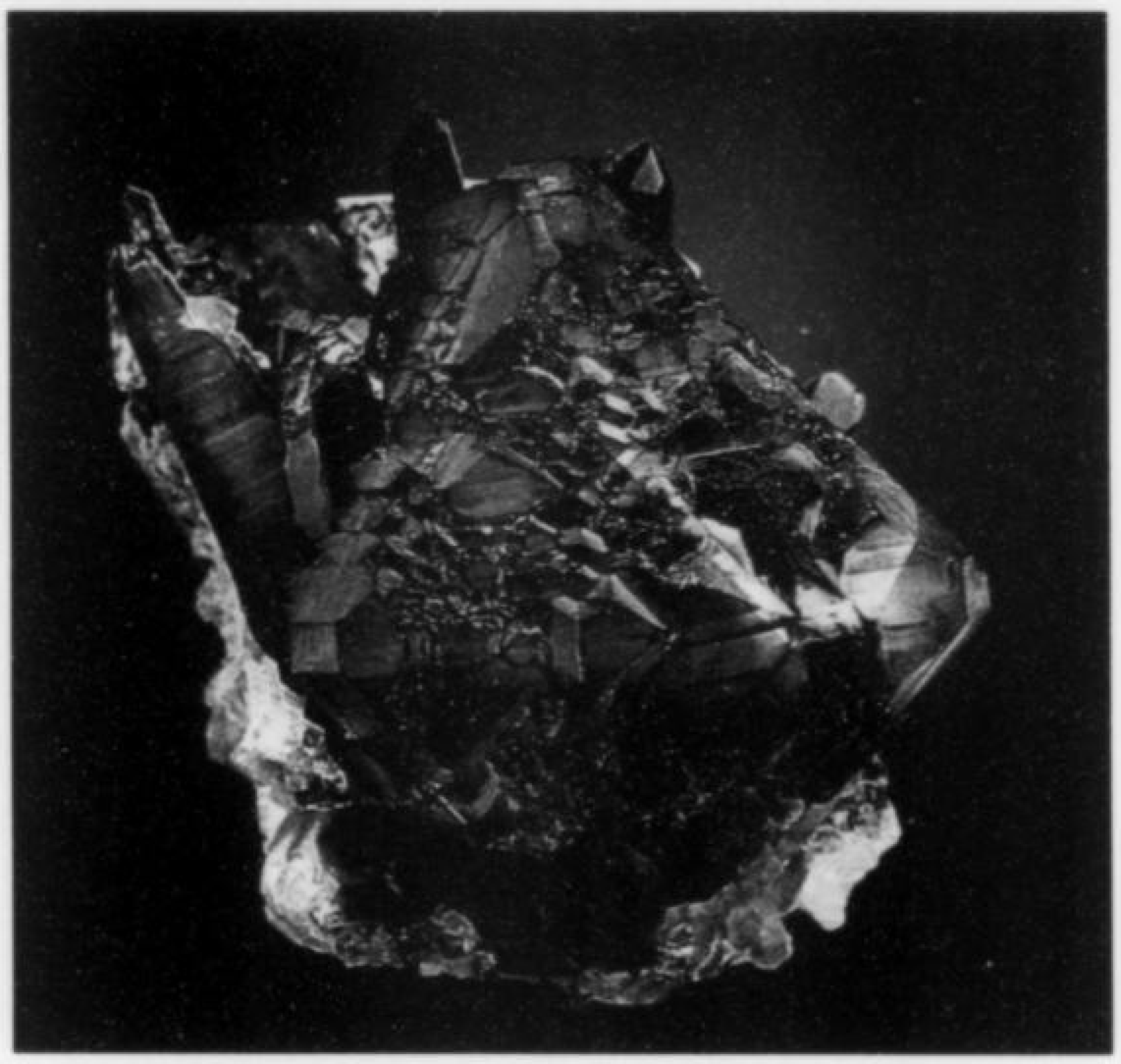


Figure 26. **Fluorite with quartz, 6 cm, from Pasto Bueno. George Witters collection; Jeff Scovil photo.**

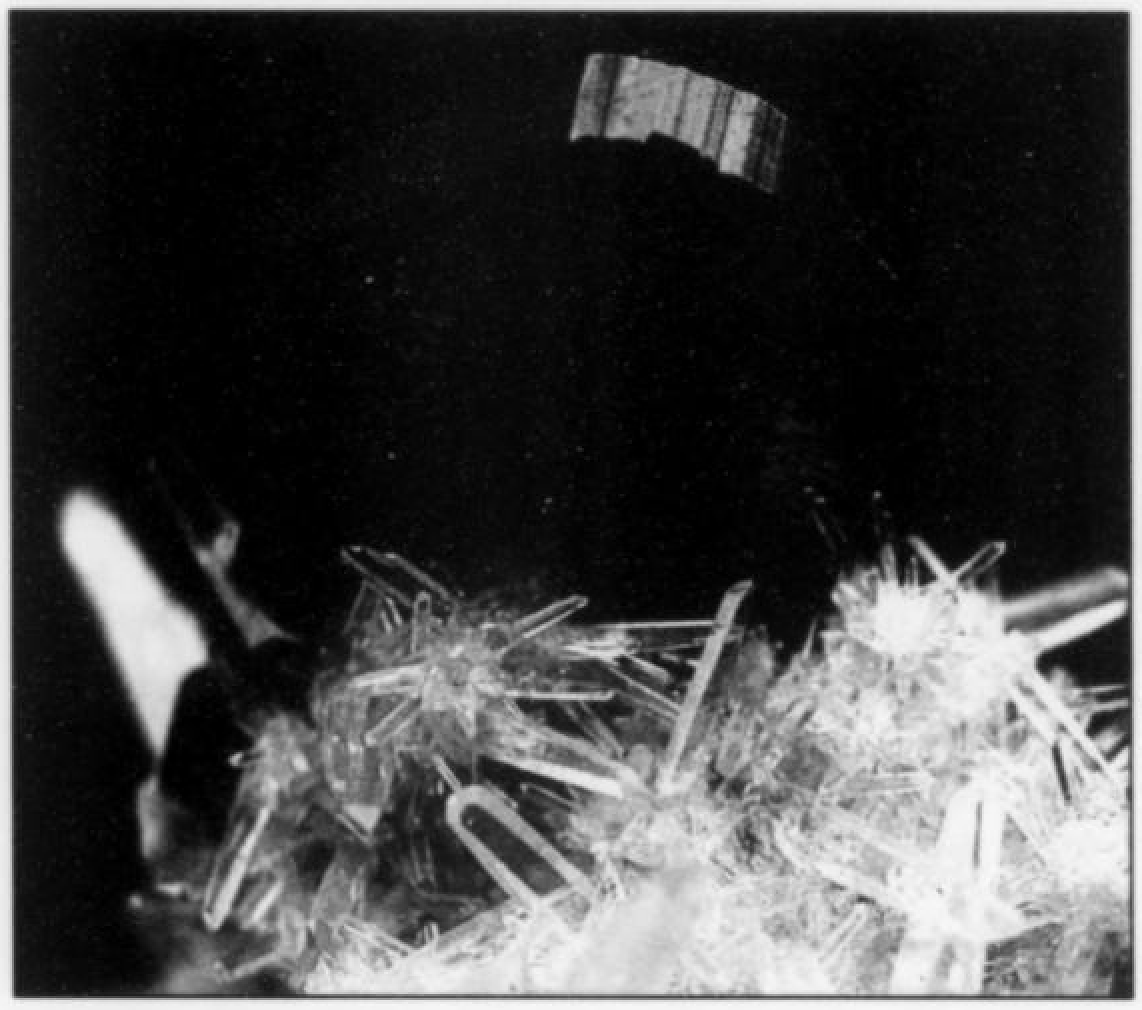


Figure 27. **Hübnerite crystal with quartz, 5.5 cm, from Mundo Nuevo. Rock Currier collection; Jack Crowley photo.**

MINERALS

Augelite (?) $Al_2(PO_4)(OH)_3$

Augelite (?) in pale blue to green crystals about 1 cm in size has been found in Peru, although there is some doubt as to the authenticity of Pasto Bueno as the specific locality.

Arsenic As

Native arsenic occurs in superb botryoidal aggregates up to 10 cm across which are commonly penetrated by clear quartz crystals. One specimen of this type is now in the Los Angeles County Museum of Natural History. Although uncommon, some hübnerite crystals have 1 to 3-mm spheroids of native arsenic implanted on the prism faces.

Fluorapatite (?) $Ca_5(PO_4)_3F$

Apatite in blue-green crystals up to 2.5 cm long have been found at Pasto Bueno. During the early 1980's a very few lilac to purple apatite crystals up to 6 mm in length were collected by one of us (TS). These are thumbnail-size specimens, associated with quartz and rhodochrosite.

Fluorite CaF_2

Fluorite usually occurs as pale green crystals, often in association with quartz. Crystals up to several centimeters across have been found. Fluorite occurs rarely as fine octahedrons to 8 cm or more in size on and associated with hübnerite and quartz. Overall, most fluorite from Pasto Bueno is of mediocre quality and not lustrous.

Hübnerite-Ferberite $MnWO_4$-$Fe^{+2}WO_4$

The hübnerite from the Huayllapon mine at Pasto Bueno is without doubt the world's best. Crystals up to 25 cm in length have been collected, usually in association with attractive, lustrous quartz crystals. Smaller hübnerite crystals can be a translucent deep cherry-red color in transmitted light, and black in reflected light. Crystals in the 5–10 cm size range are relatively common. They are usually prismatic with flat terminations; parallel growth of crystals, rather than individual crystals, is quite common. They vary from smooth and glassy prisms to somewhat abraded-looking prisms. Carbonates may originally have occurred on the crystals, but in specimens offered for sale these have usually been etched away. Some fine specimens of hübnerite are associated with tetrahedrite and fluorite, but these are rare.

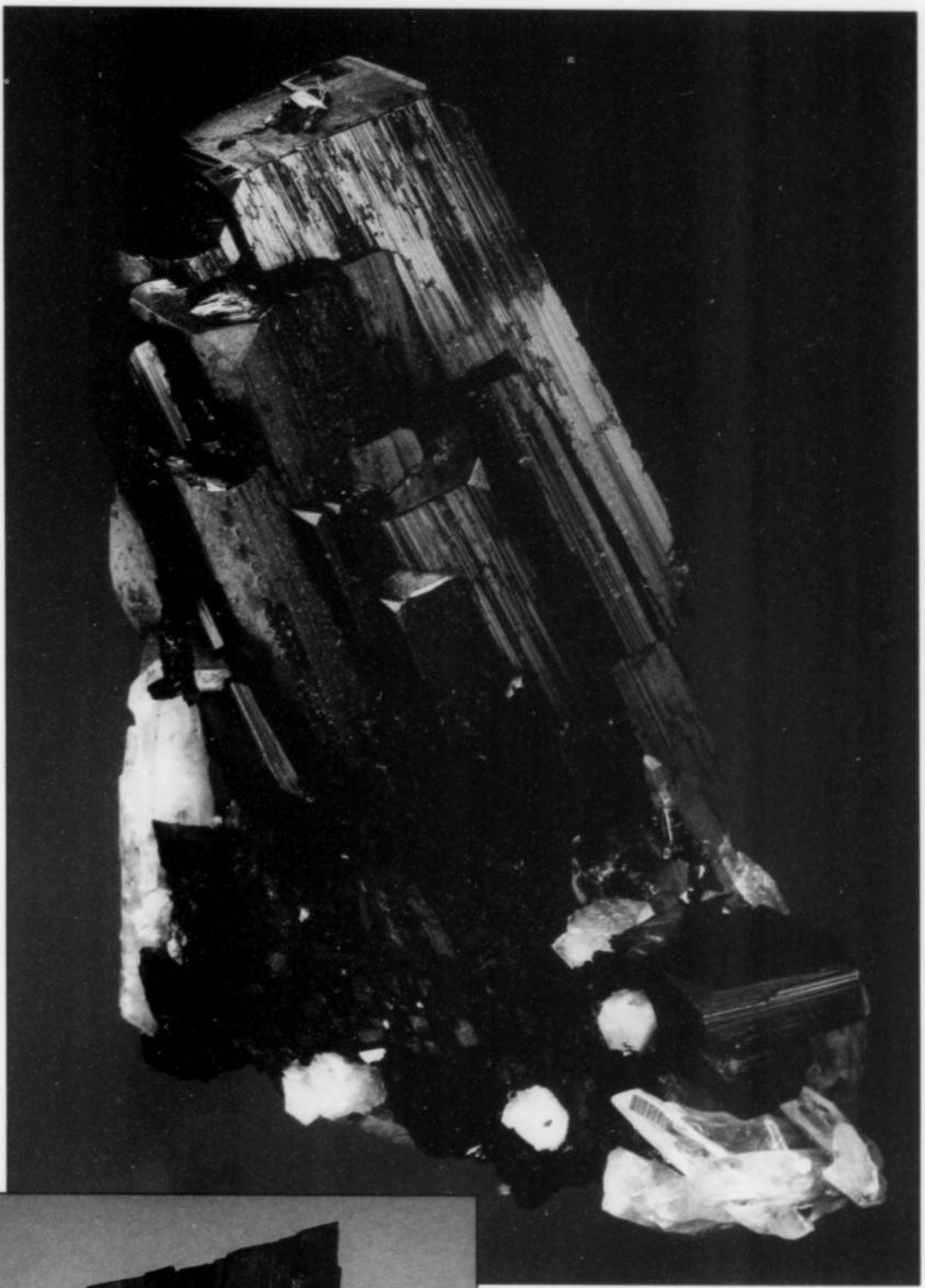


Figure 28. **Hübnerite with quartz, 12 cm, from Mundo Nuevo. Steven Neely collection; Jeff Scovil photo.**

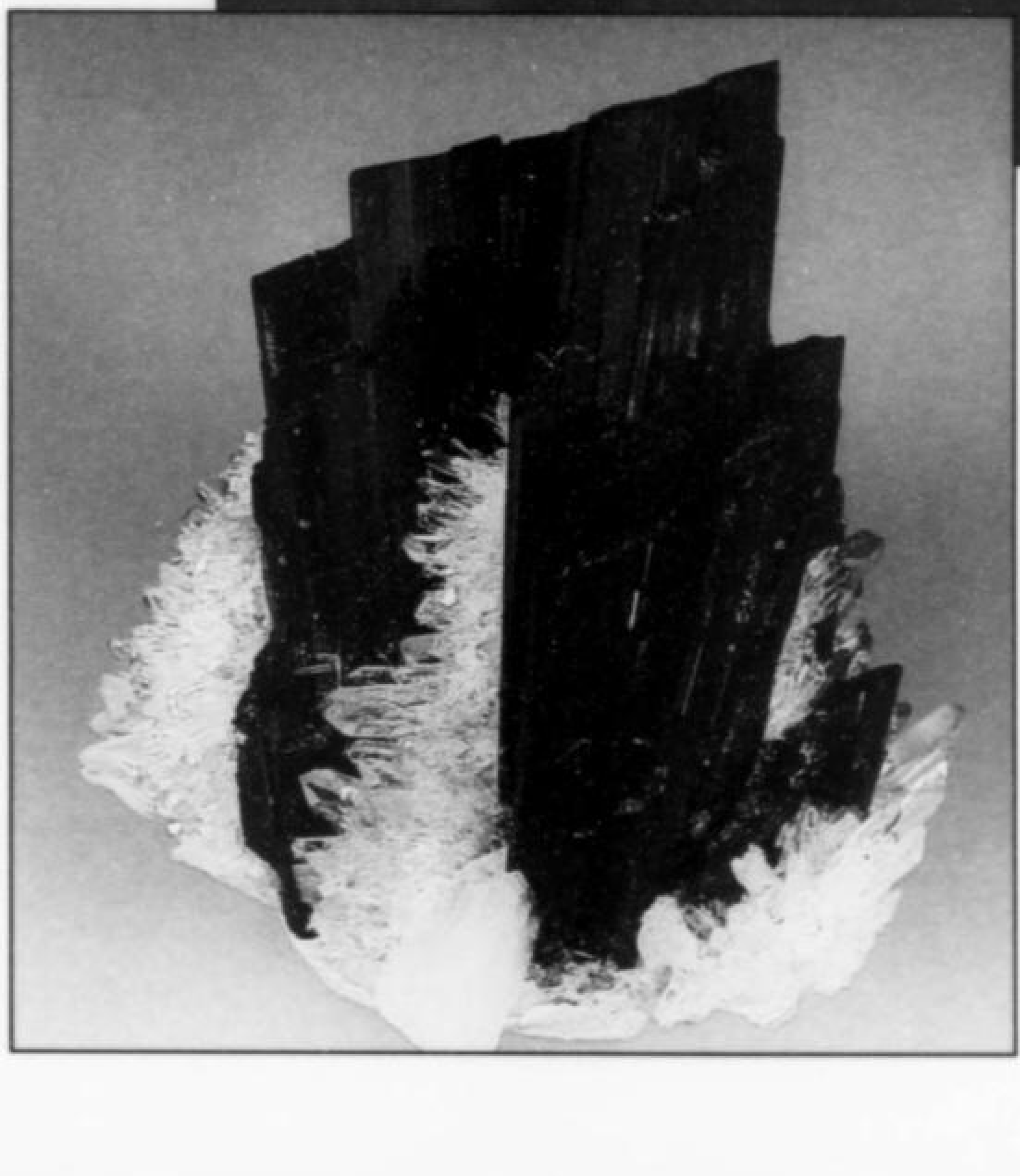


Figure 29. **Hübnerite with quartz, 7 cm, from Tamboras (?). S. Alexander collection; Rock Currier photo.**

In 1985 hübnerite in good crystals was collected from Mundo Nuevo, just northwest of Pasto Bueno. This particular lot of specimens is distinctly different from those collected at Pasto Bueno. The crystals are usually short and stout blades, commonly twinned, with a translucent deep red color toward the edges when backlit, and with a black opaque band vertically oriented within the crystal. Terminations are usually wedge-shaped rather than flat, as is common for hübnerite from Pasto Bueno. Rarely are the crystals from Mundo Nuevo as bright as the ones from Pasto Bueno.

Pyrite FeS_2

Pyrite is common as bright pyritohedrons, usually associated with quartz and sometimes with fluorite. Pyrite crystals are frequently striated to a moderate degree. It also occurs as lustrous, slightly modified cubes. Pyrite crystals rarely exceed 2.5 cm in diameter. It has never been an abundant mineral at Pasto Bueno.

Quartz SiO_2

Quartz at Pasto Bueno is one of the more common minerals. The crystals are attractive, with good luster, and can reach over 40 cm in length. They are frequently transparent in the terminations, with the prisms either translucent white or near colorless. Many of the larger quartz groups have "nests" of needle-like crystals radiating out from the base of the larger crystals, reminiscent of the quartz from Huaron, but on a much larger scale. Japan-law twins have been collected, and Dauphiné twinning is common. Some of the larger clear quartz crystals have within them invisible phantoms that fluoresce a pale green color under shortwave ultraviolet light (Dan Belsher, personal communication, 1992). Good specimens of smoky quartz crystals have been collected rarely from this area, sometimes with pale green fluorite on the quartz (Dan Belsher, personal communication, 1992).

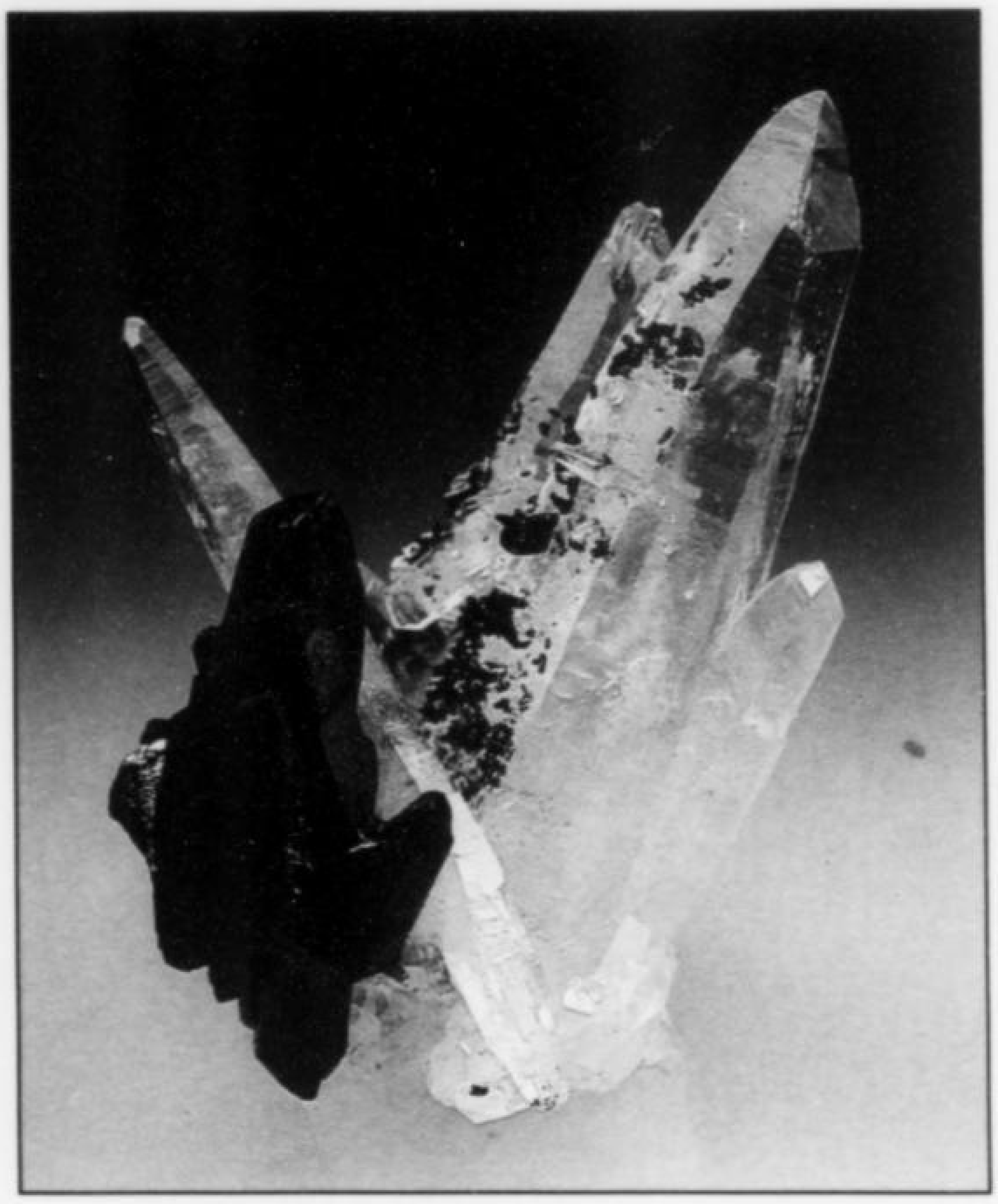


Figure 30. **Hübnerite crystals on quartz, 3.2 cm, from Mundo Nuevo. Tim Sherburn collection; Wendell Wilson photo.**

Quartz from Mundo Nuevo occurs in stout, prismatic, white to clear crystals, sometimes in Japan-law twins to over 10 cm in size. The average size for the quartz crystals from Mundo Nuevo is about 6 cm in length.

Rhodochrosite $MnCO_3$

The Huayllapon mine has produced rhodochrosite of exceptional quality, some of which is considered among the best in the world. It comes in several shades of pink to near red, including a deep rose-pink similar to that of rhodochrosite from Alma, Colorado. Some of the more spectacular specimens include brilliant, lustrous, translucent to transparent, zoned, raspberry-red rhombohedrons nestled in attractive groups of quartz crystals. Bancroft (1984, p. 181–184) shows several of these. Crystals of rhodochrosite up to 16 cm in size have been collected (Bancroft, 1984).

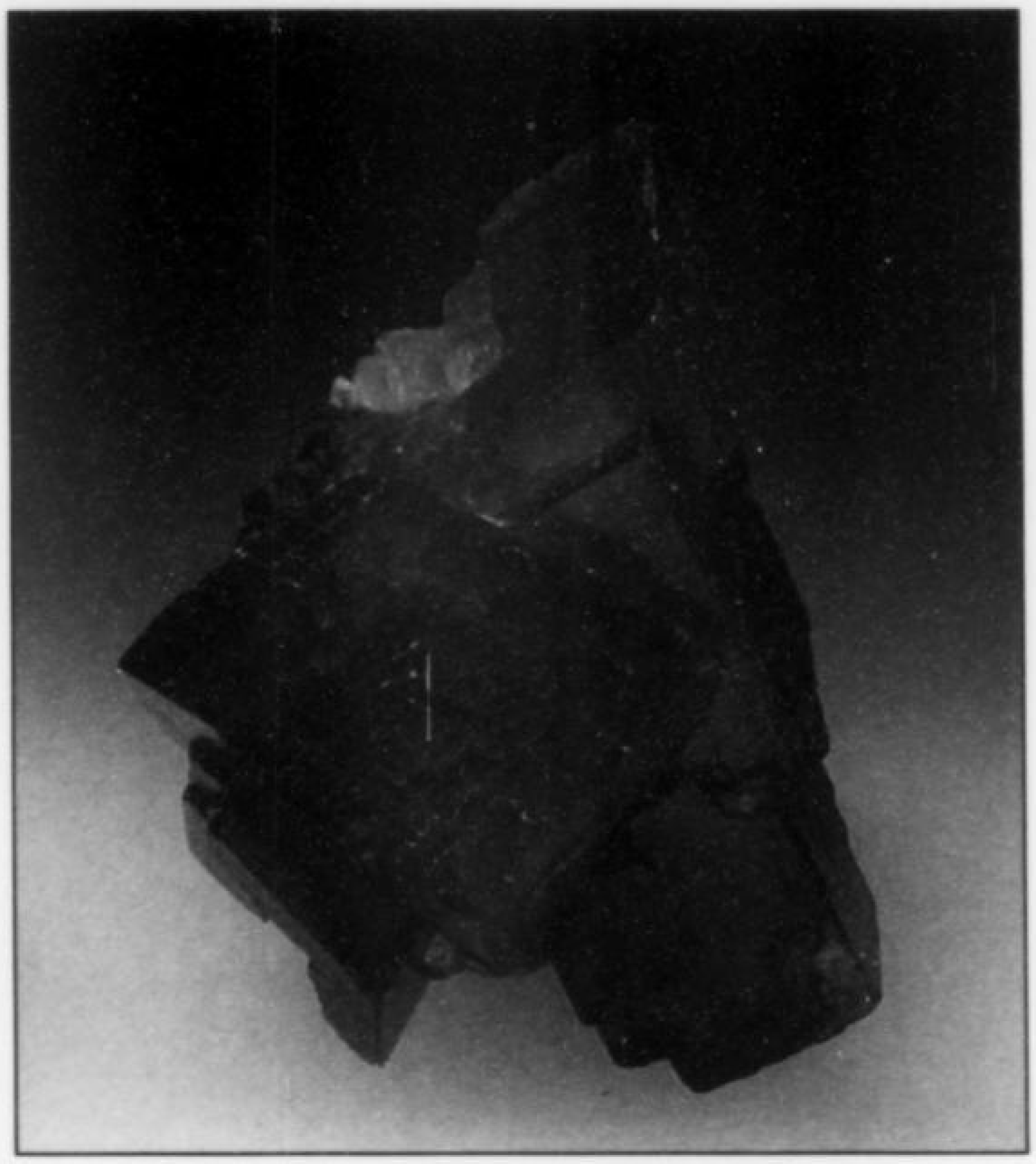


Figure 31. **Rhodochrosite crystal group, 4.3 cm, from Pasto Bueno. Chris Wright specimen; Wendell Wilson photo.**

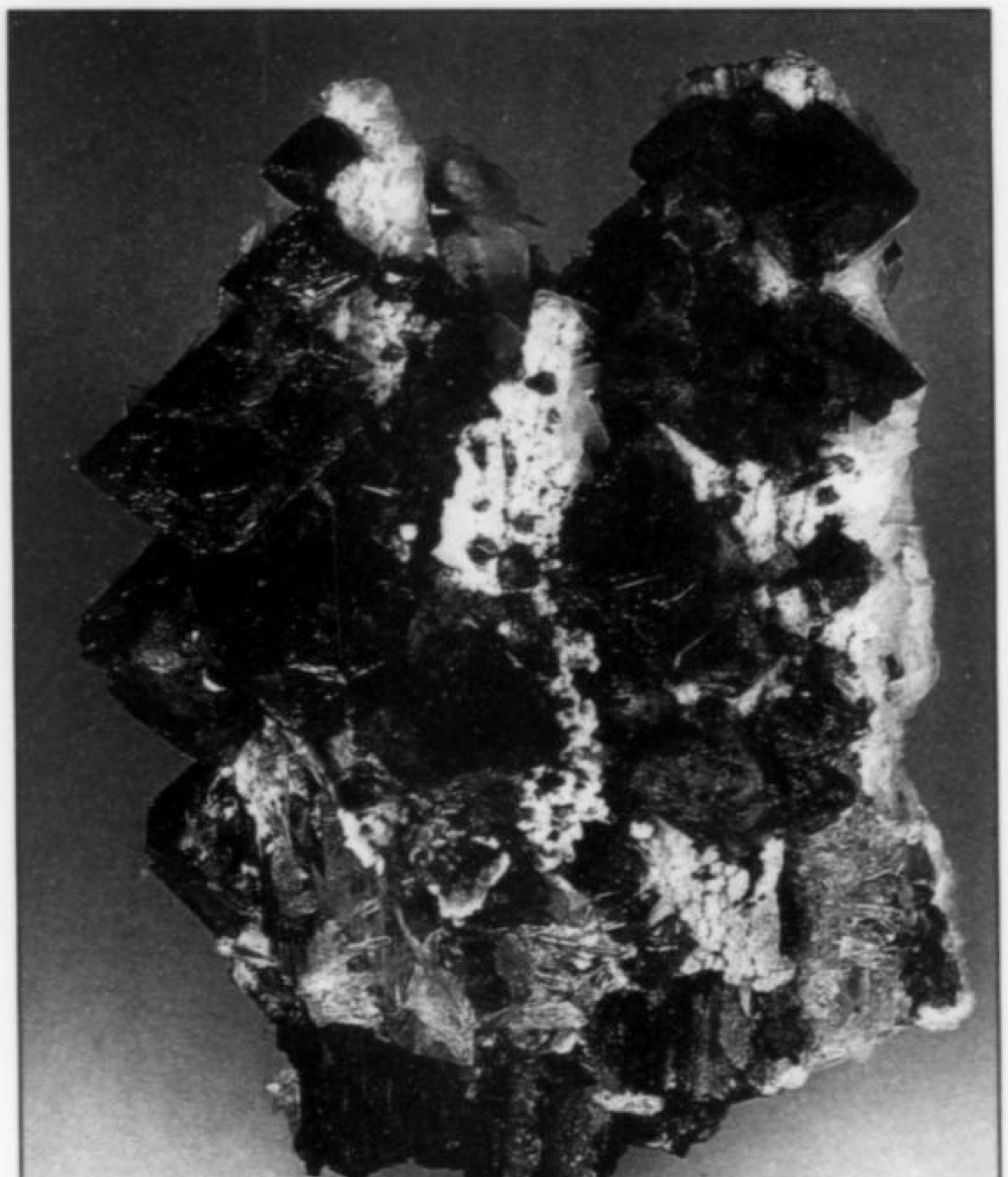


Figure 32. **Scheelite crystals on hübnerite, 8.6 cm, from Pasto Bueno. Richard Kosnar collection; Rock Currier photo.**

Some of the cherry-red hübnerite crystals have rhombic rhodochrosite crystals implanted on them, but the best of these "just escaped greatness" because of damage. Altogether there were probably not more than two dozen really outstanding rhodochrosite specimens produced from Pasto Bueno.

Figure 33. **Rhodochrosite crystal, 3 cm, on quartz from Pasto Bueno.** ***Roberts Minerals*** **specimen; photo by Harold and Erica Van Pelt.**

Figure 34. **Hübnerite with chalcopyrite-coated tetrahedrite, 3.7 cm, from Pasto Bueno. Terry Wallace collection; Wendell Wilson photo.**

Scheelite $CaWO_4$

Scheelite occurs in grayish white to purplish gray pseudo-octahedral crystals. Their average size is 5–6 mm and the largest are about 1 cm.

Tetrahedrite $(Cu,Fe)_{12}Sb_4S_{13}$

Tetrahedrite has been found rarely as classic tetrahedral crystals, 2–9 cm across, on white to colorless, long prismatic quartz crystals; sometimes this assemblage produces very attractive groups. Tetrahedrite is black with a silvery reflectance. It has a luster that varies from satiny to mirror-bright. Crystal forms are generally simple tetrahedrons, but sometimes range to more complex tetrahedral forms. One of the more rare and unusual occurrences from Pasto Bueno is tetrahedrite on hübnerite. An unusual and very fine specimen of tetrahedrite in the collection of one of us (RHC) is a perfect 2.2-cm tetrahedron perched on the termination of a 7-cm-long hübnerite crystal blade.

REMINISCENCES ON AN EARLY TRIP TO PASTO BUENO, 1976

The road from Quiruvilca to Pasto Bueno is brutal. Although the distance is something less than 100 km we were told to allow at least five hours for the trip. If the weather had been bad, it would have taken much longer. In a country of remote mines, Pasto Bueno is considered truly remote. In several places we had to stop and engage in road-building to get through, and in places if our tires had slipped, our Volkswagen "bug" would have been left balancing on the high center with our tires dangling in air with nothing ahead of us but hours of road building. There were times when you would just stop and look at the road ahead and think "Am I really supposed to try to drive over that? If I make it over that, will it get worse further on, and if we must turn around, can I drive back over this thing?" The road would snake sharply down into a canyon, and we would struggle back out on a series of ragged zigzags, to cross yet another ridge. Sometimes the drop-off was so great that we thought we could fall a thousand feet before the first bounce. In many places we could not even see the bottom of the canyon. On the edge of the road we passed a number of little crosses put there in memory of those poor unfortunates who missed the road. We met not a single vehicle or person on the road and were told that it was used perhaps only twice a week. At last we rounded a curve and there, clinging to the wall of the steep canyon below us, was Pasto Bueno.

Mines and prospect holes dotted the mountainsides. Down we twisted through a series of jagged switch-backs that eventually brought us to the camp. There was only one main street down to the mining offices at the bottom of the camp. Down we wound past the workers' houses, past the concentrating mill, to the mine offices at the bottom of the camp. Houses and mine buildings were jammed against the mountain on one side, or hugged the road on the other, some with their posteriors hanging over the canyon. In such camps the "high rent" district is always at the bottom of the camp because there is more oxygen to breathe.

We were indeed fortunate to have the permission of management to stay in company housing; and since the mine manager was not there, we were given the use of his house. It seemed to us the lap of luxury with actual hot water and our meals prepared for us. They even repaired minor damage on our Volkswagen and gave us gas for our return trip. We were also able to arrange an actual visit to the Huayllapon mine.

The road to the upper camp where the Huayllapon mine is located, is so steep and so high that our poor little "bug" could only make the grade carrying the driver, assisted by a little push from a breathless passenger, but we made it. We entered the mine through the lower adit and after several hundred yards we climbed a series of ladders to reach the working face. They were mining a nearly vertical quartz vein about 2 meters across. This vein carried hübnerite and other metallic sulfides near its center, which frequently opened into pockets filled with brilliant, transparent, prismatic quartz crystals, with an occasional slender crystal of blood-red hübnerite pointing into the pocket. The mine itself was a rather small (60 miners), primitive operation that did not even use mucking plates to make things easier for the miners.

We were only able to collect one specimen of poor quality quartz and tetrahedrite from one pocket. Before returning to the lower camp we managed to break free of our management guides and spent some time buying specimens from the miners. One specimen that I particularly remember is a single terminated crystal about 1 x 3 x 8 cm that glowed red when you held it up to the sun. It cost about 60 cents. We bought a lot of specimens that day, and that night our dreams were of caverns full of arm's-length red hübnerites and basketball-size rhodochrosites.

After an exhaustive tour of the mill and concentrator, we spent the remaining two days wandering around the camp and socializing with the geologists and engineers, all the while buying and trading for specimens. We were particularly in the market for rhodochrosite because another American, Thomas Nagin, had preceded us to the camp a few months earlier and had come away with a fabulous rhodochrosite specimen that was reportedly later sold for many thousands of dollars. We found only scraps, but we did find the young geologist who had sold Thomas the specimen. I asked him if he felt that he was paid enough for the specimen and he said he didn't think so because later someone else came to the camp and bought a much inferior specimen for 15 dollars.

From another miner in the camp Jorge bought a 30 x 30-cm quartz specimen of beautiful, sharp, lustrous crystals up to 20 cm in length for a dollar. For another dollar I bought a fabulous cluster of quartz and hübnerite that I speculated might bring as much as $2,500. It turned out that the miner had constructed this specimen from six separate quartz and hübnerite specimens using candle wax, which matched exactly the color of the quartz. In this case the fabrication was not done to deceive, but merely as a diversion to pass the time. From another miner I bought a specimen of hübnerite and quartz more than 30 cm in diameter, with one terminated hübnerite crystal measuring about 25 cm long. This specimen is now in the collection of Bryn Mawr College near Philadelphia. At the time I remember thinking "If this is what we can buy on one trip, what has and will the mine produce in years to come?" As it turned out, however, that was the largest hübnerite I ever saw from Pasto Bueno. Those were just the highlights and we came away with our Volkswagen "bug" so full of specimens that we wondered how we were going to squeeze in the rest of the specimens we had stored back in Quiruvilca.

Soon after our trip an enterprising dealer offered the miners a year's salary for another big rhodochrosite and the cost of specimens in the camp escalated 10 to 100 times. In later years the company doctor became the source of many of the good rhodochrosite specimens that came from Pasto Bueno. The most common association with the rhodochrosite was quartz, but a few were associated with pale green fluorite crystals and some with red hübnerite. We never saw a good undamaged combination specimen of red hübnerite and rhodochrosite. In total, I do not think more than one or two dozen fine to superb rhodochrosite specimens were produced. The mine has been operating since World War II; who knows how many fine specimens were destroyed during the mining process or ground through the mill.

In recent years the management of the mine has taken a dim view of people visiting the camp to gather specimens, and has at times controlled access to the camp. This has had little apparent effect on the flow of specimens from the mines. Mineral specimens from Pasto Bueno during the last few years have been intermittently available in Lima and are noticeably inferior to those produced during the 1970's. We are not aware of any really fine specimens of hübnerite or rhodochrosite coming from the district since about 1986. RHC

The Raura-Huanzala Group

The Raura District

Cajatambo Province
Lima Department

LOCATION

The Raura district is a polymetallic deposit of veins and replacement orebodies located northeast of Lima and northwest of Cerro de Pasco. It is about 15 km due north of the town of Oyon, along the Maranon River. Raura is situated in a spectacular setting: it is at the source of the Amazon River and is surrounded by rugged peaks, with glaciers perched above the mines.

HISTORY

Raura is one of the more important copper-lead-zinc-silver mining districts in Peru. It was certainly worked in the last century and probably in the 17th and 18th centuries as well. Old workings are situated at over 5,000 meters, and are accessed by dizzying llama paths along the cliff faces. One wonders how the Spaniards discovered these rugged, remote ore deposits. The modern development of the mines began on a small scale in 1890. The high-grade ore was transported on llamas to a smelter at Quinchas, some 20 km away. Production was intermittent until the mines were acquired in 1945 by the Cerro de Pasco Corporation. The current company, Compania Minera Raura S.A., was founded about 1960, when all of the Raura mines were consolidated under one company. As of 1991, about 25% of the annual production was coming from two open pit mines operating in the Nino Perdido and Tajo Grande orebodies.

Peru

GEOLOGY

The Raura district was briefly described by Miller and Singewald (1919), Porturas (1954), and Purser (1971); their data are summarized below. The geology of the Raura district is shown in Figure 35.

The main sedimentary unit in the Raura area is the Cretaceous Machay Limestone, a non-fossiliferous, pale gray limestone that occurs on both sides of the Raura depression. Known mineralization covers about 24 square kilometers. The veins are associated with a diorite porphyry intrusion to the southwest, which apparently erupted as dacite flows to the northeast. Several small stocks also occur in the mining district (Purser, 1971).

The Raura depression contains several orebodies. The Catuvo orebody occurs along the contact of an intrusive stock, and is predominantly a Pb-Zn producer. Another orebody is located in an area of colorful oxide zones near Lake Ninacocha, which is the official source of the Amazon River. The ore-bearing mineral in this area is Ag-rich galena. The Esperanza orebody is north of the Catuvo orebody. A potential orebody, according to Purser (1971), is the Toramina, situated in limestones northeast of Raura. He reports that there are nice garnets along the contacts in this limestone.

The Esperanza and Restauradora vein systems host the main orebodies, with several smaller mineralized fractures adding to the reserves. Individual ore-bearing veins are usually less than 300 meters in length. Ore minerals of the Esperanza orebody and veins are tetrahedrite, galena and sphalerite, with pyrite, quartz and manganoan calcite as the major gangue minerals. The tetrahedrite shows a characteristic red streak. The main Esperanza vein averages 80 cm in width in its richest portions. Other veins have an east-west strike and are about 1 meter wide. The ore veins are banded, with a central zone of quartz, then tetrahedrite, sphalerite, and galena, followed successively by calcite, and then dolomite. The ore is Cu-rich and Ag-rich, and occurs in shoots.

The order of crystallization for the metallic minerals is (first) pyrite, sphalerite, chalcopyrite, tetrahedrite, galena, and (last) sulfoarsenides. Quartz crystallized up until the period of galena crystallization. Carbonates crystallized last.

MINERALS

Minerals offered for sale at Raura in recent years include: fine transparent gypsum in stout, water-clear classic-shaped crystals; cubic pyrite in crystals reminiscent of those from Spain; stibnite in very fine acicular to bladed crystals with a satiny luster and, less commonly, a bright metallic luster; rhodochrosite; and green fluorite with chal-

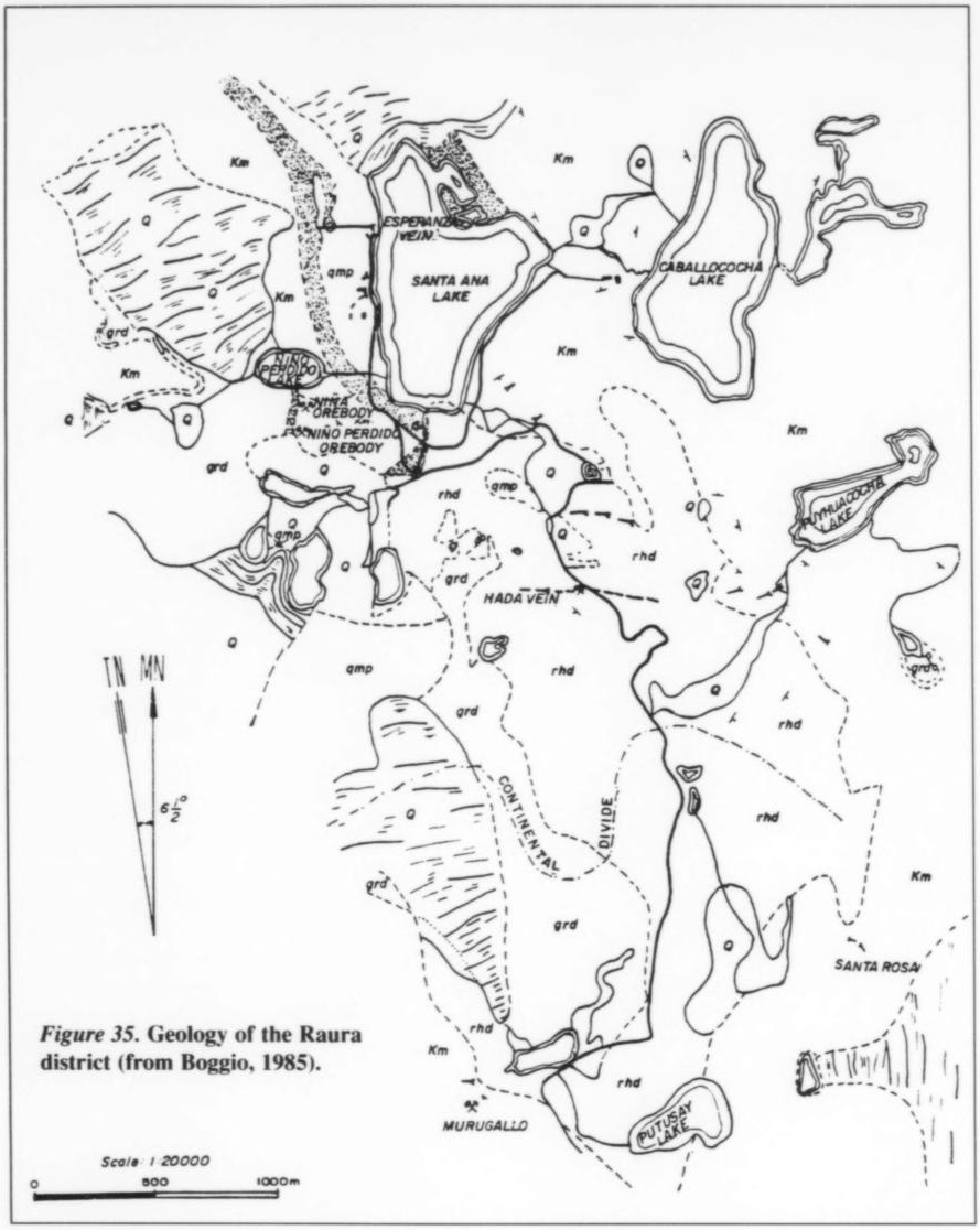


Figure 35. **Geology of the Raura district (from Boggio, 1985).**

Table 3. **Minerals reported from the Raura district.**

	Common or Abundant	
***Barite**	Galena	***Rhodochrosite**
***Calcite**	***Gypsum**	Sphalerite
***Chalcopyrite**	***Manganoan calcite**	***Stibnite**
Dolomite		***Tetrahdrite**
***Fluorite**	***Pyrite**	
	Rare or Locally Abundant	
Gratonite(?)	Scheelite	
Realgar	***Seligmanite**	

*Collector-quality specimens

copyrite. Raura is known for the similarity of its specimens to those from Romania, especially the dull, stout stibnites and the pale pink drusy rhodochrosites.

Barite $BaSO_4$

Barite occurs at Raura in bladed crystals and crystal aggregates that may reach several centimeters across. The color is white to gray and beige. These can make high-quality display specimens.

Calcite $CaCO_3$

In the early 1980's calcite was common as white, rhombohedral crystals in groups and also in a peculiar "witches hat" crystal habit with a cream-white color. These unusual calcites occur as thumbnail-to miniature-size specimens.

Gypsum $CaSO_4 \cdot 2H_2O$

Gypsum occurs in crystals over a meter in length. According to Dan Belsher (personal communication, 1992), Peruvian collector/dealers broke the gypsum crystals into thirds in order to transport them to Lima in their backpacks, where they could sell the specimens. In 1980 and 1981 a few lots of gypsum, with crystals up to 10 cm long appeared on the market. These gypsum crystals are associated with massive pink manganoan calcite; most of the gypsum crystals are damaged.

Pyrite FeS_2

Pyrite is more common at Raura as pyritohedrons than as cubes,

Figure 36. **Barite crystal group with stibnite and tetrahedrite, 11.5 cm, from Raura. Rock Currier collection; Jack Crowley photo.**

and it usually does not occur as quality specimens. It is a common accessory mineral with the other sulfides.

Rhodochrosite $MnCO_3$

In the mid 1970's literally tons of rhodochrosite were produced from this locality. Apparently very little has been forthcoming since. The rhodochrosite occurs as pale pink to bright pink semi-crystalline masses and as good crystals with a rhombic form up to about 5 mm in size. Galena is a common association, usually as the matrix mineral. Quartz is also frequently associated, both as matrix and as crystals on the rhodochrosite. The associated quartz is usually present in small needle-like transparent crystals or in drusy aggregates. Needle-like microcrystals of quartz are also common on the rhodochrosite crystals.

Raura has never produced the outstanding rhodochrosite specimens that some other Peruvian localities have. A help in distinguishing Raura rhodochrosite from those of other Peruvian localities is the distinctive presence of coarse cleavages of galena on the back, or underlying matrix, of the specimens. Rhodochrosite from Raura also looks very similar to that collected from Silverton, Colorado, especially in regards to color, form, habit and drusy quartz association. However, the galena from Silverton is much finer grained than that from Raura.

Seligmanite $PbCuAsS_3$

Seligmanite is a rare mineral collected at Raura around 1990. It has only been sight-identified, and to our knowledge has not been verified otherwise. It occurs on flat plates of quartz; the quartz, in turn, is partly coated by a microcrystalline layer of manganoan calcite. Seligmanite is scattered around the specimens as small black crystals up to 5 mm in length.

Stibnite Sb_2S_3

Raura has produced very nice prismatic stibnite blades which have a satiny metallic luster and lead gray color. Terminations have a somewhat rounded look, although they are essentially flat. Crystals range to about 7 cm in length, and fine groups to over 25 cm across have been recovered. These groupings are not abundant and are rarely seen for sale. The main finds of this material were collected in the early 1980's. Less commonly stibnite occurs in sharp, bright, metallic crystals which look very similar to the stibnite from Romania; these crystals tend to be considerably smaller than the satiny blades. Stibnite may be associated with barite and pyrite, and many specimens were coated with calcite that was etched off. Some of the first lots of specimens that came out were ruined; *piriteros*, attempting to remove the calcite with too strong a solution of HCl, badly damaged the stibnite.

The Pachapaqui District

Bolognesi Province
Ancash Department

LOCATION

The Pachapaqui district is at the headwaters of the Rio Pativilca, in the northeast corner of Bolognesi Province. It is 20 km southwest of the Huallanca district, where the Huanzala mine is located, and is about three to four hours' drive south from Huanzala. The town of Pachapaqui is at the south edge of the district, 22 km north of the town of Chiquian.

The area has been extensively glaciated, and the *quebradas* (valleys) are generally U-shaped, some of them still having active glaciers near their heads. The mining district occupies an area 18 km long by 9 km wide. Elevations for the various mine workings vary from about 3,800 to over 4,500 meters. The area around Pachapaqui is one of the more starkly beautiful areas of Peru, with snow-covered craggy peaks and large glaciers dominating the scenery in many areas. Some of the mines have been worked since Spanish Colonial times, and very old prospect pits, trenches, shafts and open stopes are scattered throughout the district.

HISTORY

The Spanish worked the mines by hand-drilling holes in the rock, then filling them with water and allowing it to freeze overnight; the expansive force of the water freezing would then break up the rock (Cavanagh, 1993?). The name *Pachapaqui* is Quechua for "broken earth," probably in reference to the intensely folded, twisted and broken rock strata that are visible in the local road cuts.

Pachapaqui is a polymetallic mining district with varied types of ore deposits. Although some mining on a small scale was done as far back as the early 1900's, modern development first began in 1949, when the Cia. Minera Argenta Bolognesi, a family-run enterprise, installed a 30 tons-per-day concentrator. The oldest mines are the Vetilla or Santa Teresita, Arabia, Patria, and Esperanza. The major mines in the district in the 1950's included the Patria, Esperanza, Otito, Sinchi Roca, San Antonio, Abandonada, and San Judas Tadeo. In 1965 the Moro and Vetilla mines were opened on each side of the mountain, Cerro Potosi. Shortly thereafter the Riqueza mine was opened. More recent mines, established by the

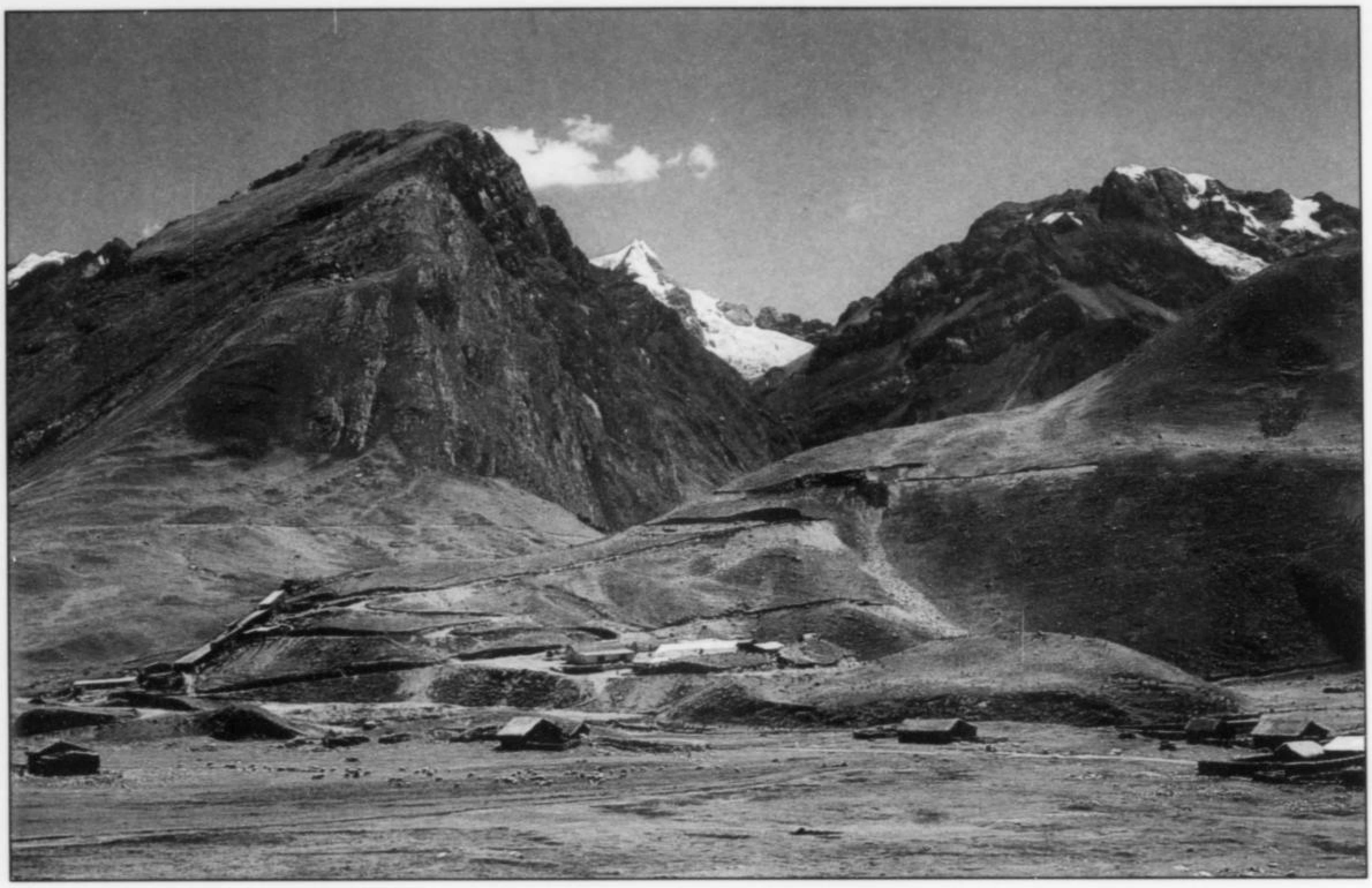


Figure 37. **The Huallanca mine and mill, Pachapaqui district. Rock Currier photo.**

mid-1970's, include the Pucarrajo, Pozo Rico, Patria-Ishanca, and Ishanca.

In February 1971, Jorge Ganoza, owner of Minera Pachapaqui S.A., bought the Pachapaqui mines for $4,000. It was a good deal; by late 1990 the mines had produced over $75 million worth of ore. Prior to 1989 Pachapaqui was primarily a silver mining area, but in that year the company decided to develop the lead and zinc ores, which had largely been ignored up to that time. This change resulted in a tripling of the ore production from Pachapaqui by late 1990.

The mines are scattered around the area, mostly north and northeast of Pachapaqui. Some of the mines are nestled in the cirques under the glaciers. A few of the roads leading to the mines have actually been paved with crushed and broken manganoan calcite and rhodonite from the mines!

GEOLOGY

The following geologic information on Pachapaqui is summarized from Bodenlos and Ericksen (1955) and Bernal (1975). Figure 38 is a geologic map that also show the major mines in the district.

Rocks in the Pachapaqui district are similar to those found at Huanzala. They are composed of complexly folded rocks of the Cretaceous Goyllarisquizga Group, including quartzite, sandstones, shales, coal beds and limestones. The Goyllarisquizga Group underlies the Pariahuanca Formation of the Cretaceous Machay Group of limestones. The sedimentary rocks are punctured by several igneous stocks, dikes and sills. Mineralization occurs mainly in the Pariahuanca Formation, in or near the contact with the stocks, and to a lesser extent in the limestones of the Santa Formation of the Goyllarisquizga Group.

Three main types of deposits are recognized: fissure veins and replacement, contact metamorphic (skarn), and stratabound. The deposits are epigenetic and polymetallic, and are considered mesothermal to epithermal.

The fissure veins and replacement deposits are 20 cm to 3 meters thick, averaging 1 meter. Vugs up to 20 cm in size are common in these veins and in some of the replacement bodies. The vugs are usually lined with quartz and calcite; various sulfides and sulfosalts may also be present, as well as other minerals. Calcite and manganoan calcite often occur in these vugs as a nearly complete coating on the other minerals. Tetrahedrite, pyrite and rhodochrosite are the most common minerals present in vein pockets, but most of the other sulfides may also be present.

Replacement bodies reach up to 80 meters across. The Sinchi Roca, San Antonio and Riqueza mines are good examples. Veins contain quartz and pyrite with lesser amounts of galena, sphalerite, chalcopyrite and tetrahedrite. The replacement bodies contain quartz, rhodochrosite and rhodonite with lesser amounts of galena, sphalerite, chalcopyrite, pyrite, arsenopyrite and pyrrhotite.

Contact metamorphic (skarn) deposits are located in limestones and, to a lesser extent, in shales and quartzites which have been intruded by quartz diorite. The Pucarrajo mine is typical, with mineralization consisting mostly of Fe-rich sphalerite and galena with lesser amounts of chalcopyrite. The gangue is principally pyrrhotite, arsenopyrite, pyrite, calcite and quartz.

Stratabound deposits are typified by the Ishanca (Otito) and San Judas Tadeo mines. Ore mineralization consists of iron-bearing sphalerite with lesser amounts of galena and a trace of gold in a gangue of pyrite, pyrrhotite, marcasite, arsenopyrite, magnetite, quartz, siderite and ankerite. Parallel to the strata are a series of ore shoots from 10 to 50 meters thick and 100–200 meters long which

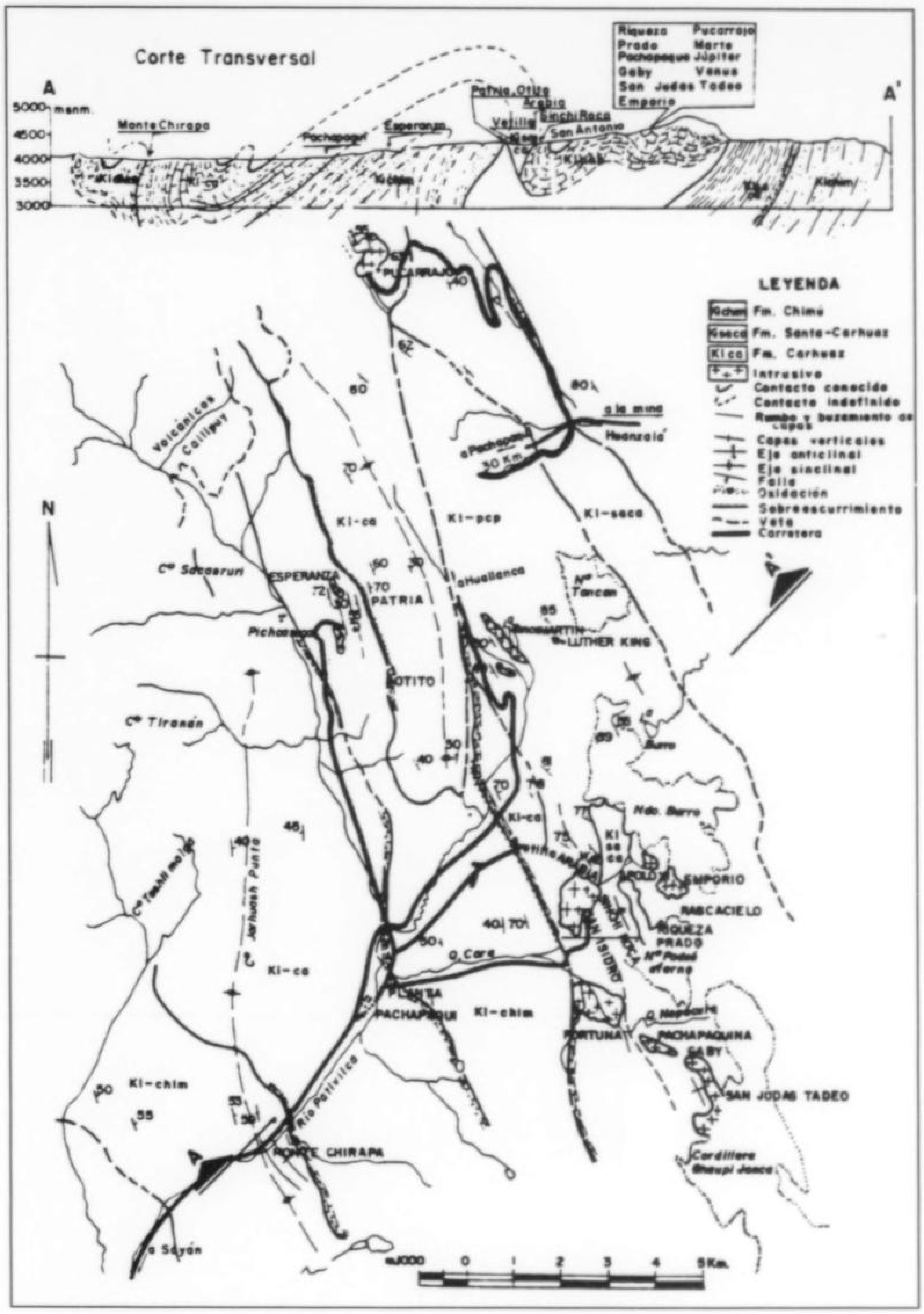


Figure 38. **Geology of the Pachapaqui district (from Boggio, 1985).**

contain concentrations of Zn and Pb. Other common minerals include calcite, siderite and ankerite.

Table 4. **Minerals reported from the Pachapaqui district.**

Ankerite	***Galena**	Pyrrhotite
***Arsenopyrite**	***Helvite**	***Quartz**
***Bournonite**	Magnetite	***Rhodochrosite**
***Calcite**	***Manganaxinite**	***Rhodonite**
***Manganoan Calcite**	Marcasite	Siderite
	Muscovite (sericite)	***Sphalerite**
***Chalcopyrite**		***Tetrahedrite-tennantite**
***Fluorite**	***Pyrite**	

*Collector-quality specimens

MINERALS

Pachapaqui mineral specimens often mimic those from other Peruvian locations; this makes differentiation of localities difficult at times. As an example, several small lots of quartz, sphalerite and pyrite came out of Pachapaqui around 1990; these are similar in appearance to the same type of specimens from Huaron, but with the Pachapaqui quartz a little shorter and stubbier in appearance. A distinguishing aspect of this material is the presence of tiny, bright tetrahedrite crystals on the sphalerite, which are not present on the material from Huaron.

Most of the Pachapaqui mineral specimens are from the vein deposits. Many specimens that were once covered with carbonates have since had the carbonates dissolved in HCl to expose the underlying minerals. A common clue to this treatment is galena, which had a bright luster on cleavage faces when it was first collected, but is now dull-looking. Examination of cleavage breaks on the galena specimens will show this, as will the dulling of any galena crystal faces present on the specimen.

Specimens from Pachapaqui gradually increased in quantity, beginning in 1986 and peaking in 1989, with very fine specimens of manganoan calcite, tetrahedrite, bournonite, chalcopyrite, sphalerite and rhodochrosite being produced. Occasionally the bournonite

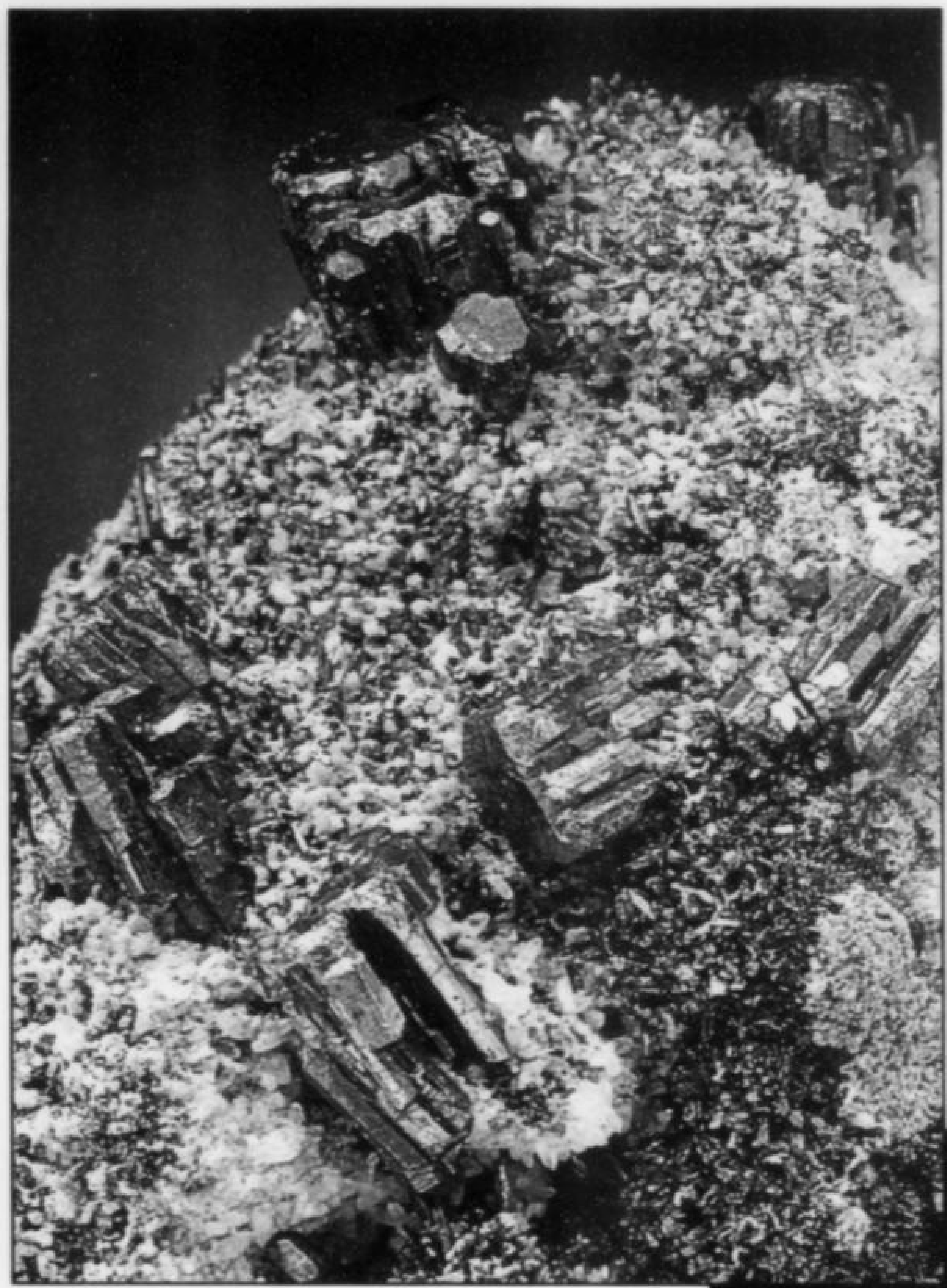


Figure 39. Bournonite crystals to 1.2 cm, from Pachapaqui. Fred Pough collection; Jeff Scovil photo.

Figure 40. Rhodochrosite with black bournonite and pyrite, 4.1 cm, from Pachapaqui. Peter Faust collection; Wendell Wilson photo.

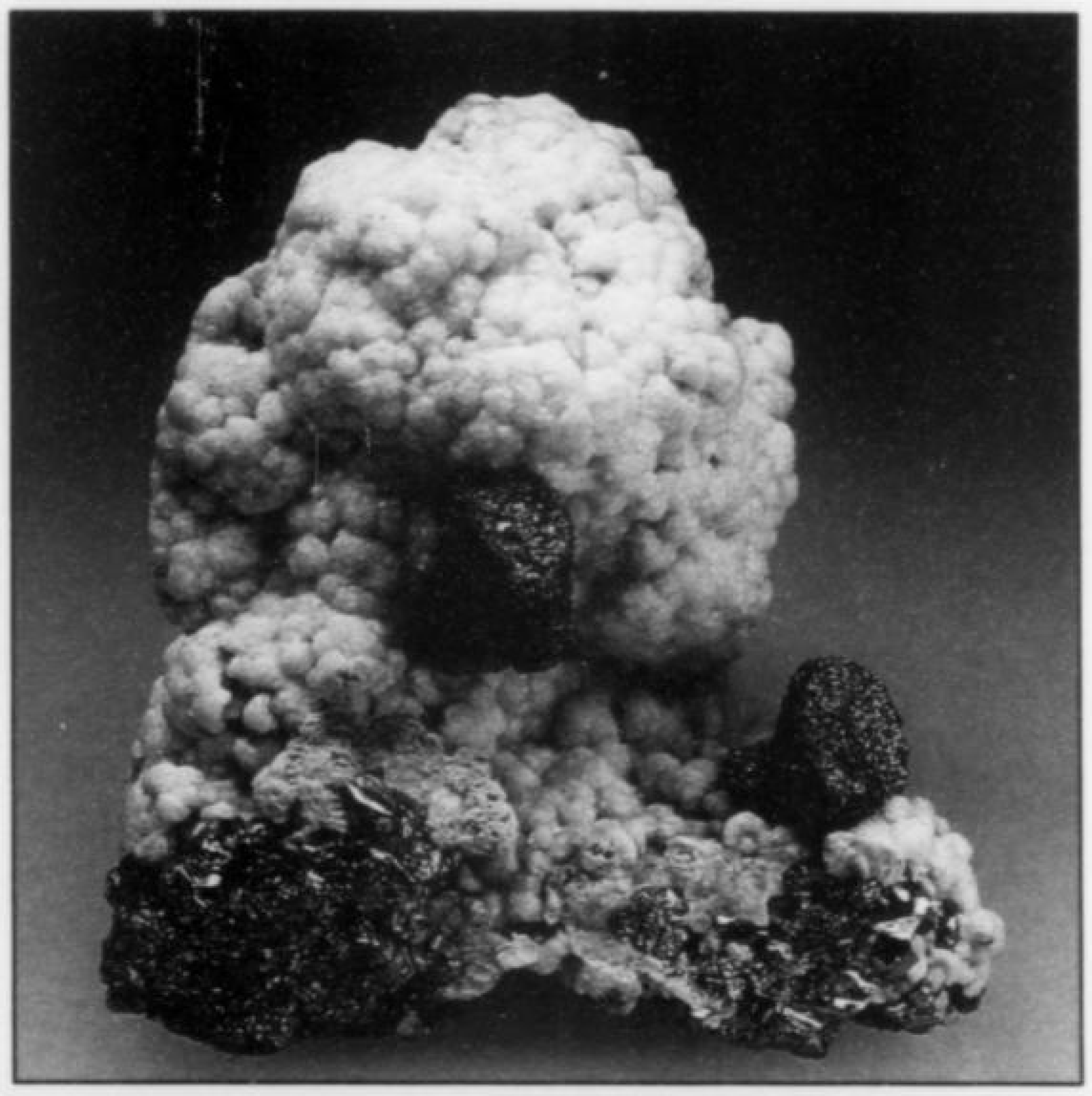
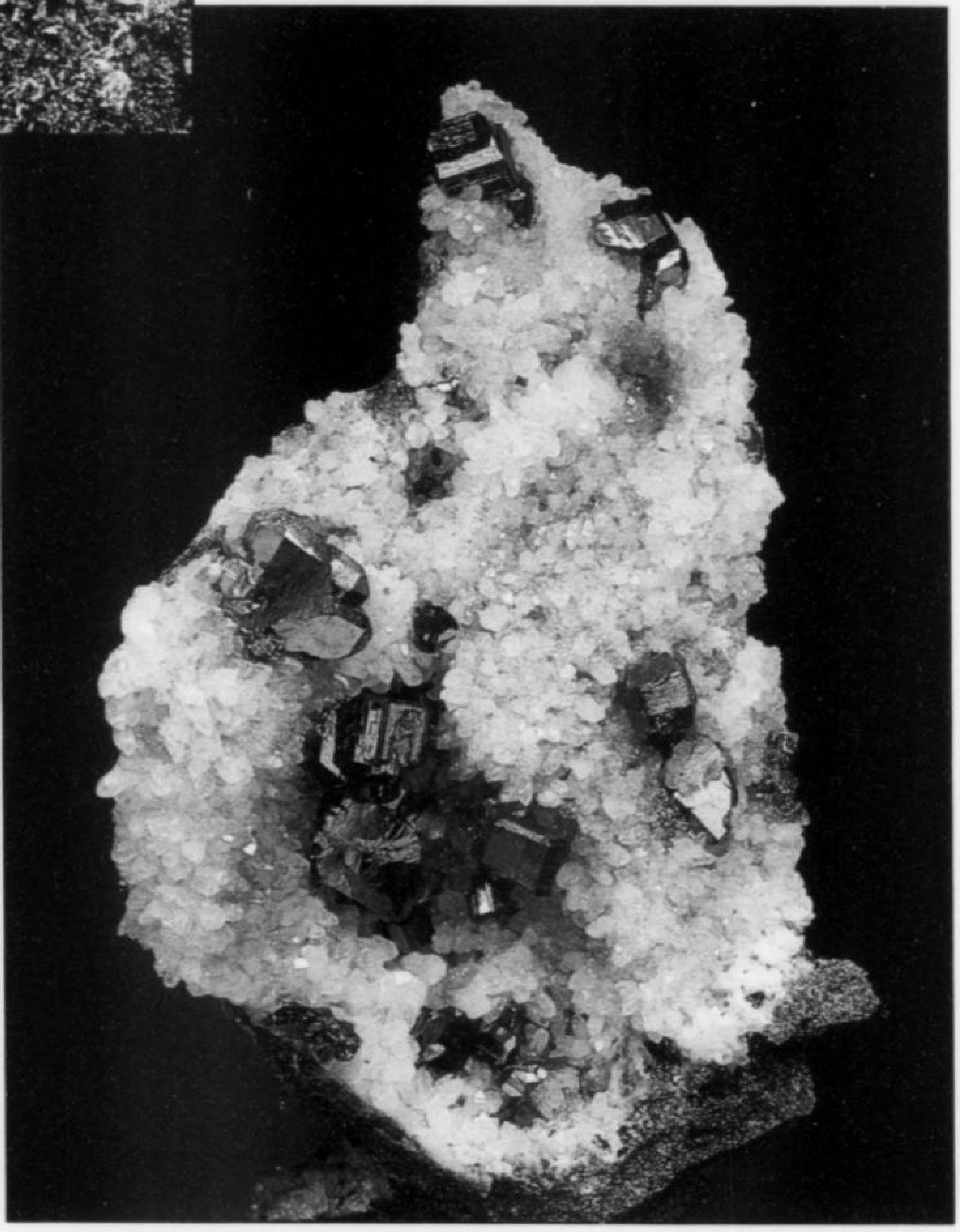


Figure 41. Bournonite crystals on quartz, 11.7 cm, from Pachapaqui. Bill and Carol Smith collection; Jeff Scovil photo.



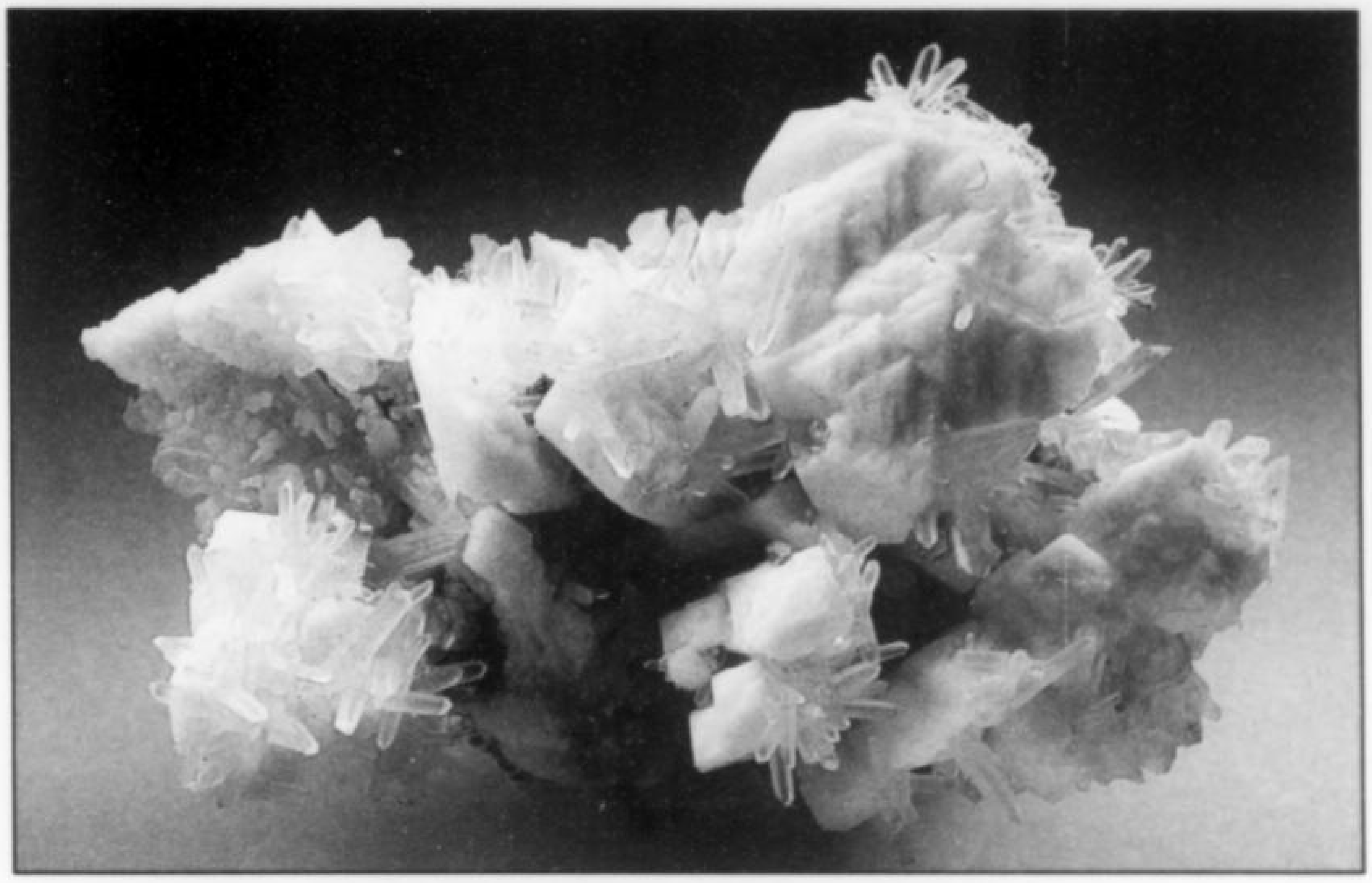


Figure 42. **Manganoan calcite crystal group, 5.6 cm, from Pachapaqui. Cal Graeber specimen; Wendell Wilson photo.**

crystals are found growing on rhodochrosite. A tantalizing prospect is the very real possibility that the mine will some day produce a pocket with 5 cm bournonite crystals growing on rhodochrosite. Bournonite in crystals up to at least 2.5 cm in size, sometimes of the "cogwheel" type, has been available recently. However, even the best of the bournonites from this locality are not likely to be confused with those from the classic Cornish locality. Rhodochrosite similar in appearance to that from Silverton, Colorado, has also been recovered in crystals up to about 1 cm. Rhodonite, associated with small yellow manganaxinite and bright yellow helvite crystals, has been found on occasion. In 1992 the quantity of mineral specimens from Pachapaqui dropped off dramatically, probably indicating that the particular mine that was producing the preponderance of specimens (whichever one that was) closed down.

Arsepyrite FeAsS

Arsenopyrite from Pachapaqui can be very similar in appearance to that from Huanzala. Associated minerals, such as quartz, acicular white calcite in "bundles" and pink manganoan calcite, can help to differentiate Pachapaqui arsenopyrite from Huanzala specimens. Arsenopyrite crystals are generally tapered, nearly to a point. Masses of hedgehog-like crystals, in specimens up to at least 10 x 10 cm in size, some partly overgrown with manganocalcite and with associated galena and other sulfides, have been collected. Individual crystals are somewhat needle-like, are slightly barrel-shaped in the middle, and taper toward the termination.

Bournonite $PbCuSbS_3$

Pachapaqui bournonite is usually black to gun-metal blue, with a dull to bright luster. Crystals can be over 2.5 cm in size, and some occur in fine "cogwheel" style crystals up to nearly 4 cm. Bournonite is most commonly associated with quartz and calcite; the calcite sometimes forms thin scalenohedra. Manganoan calcite is also a common coating. Bournonite also occurs with tetrahedrite in bright, simple tetrahedrons associated with sparkling pyrite and chalcopyrite crystals. The dark colored bournonite and tetrahedrite, coupled with the bright gold-colored chalcopyrite and pyrite, give a nice contrast to the specimens.

Calcite $CaCO_3$

Calcite is common on specimens at Pachapaqui as a late-stage mineral. Scalenohedral crystals followed by bladed crystals and bubbly masses are most abundant. The scalenohedral crystals often occur in bundles of long, almost acicular crystals. Calcite can be so thick on specimens that it has been etched off by the *piriteros* in order to show the underlying minerals.

Pink manganoan calcite, sometimes with a satiny luster, occurs as large, often crude, scalenohedral crystals and as bladed rhombohedral crystals frequently modified by other forms. Manganoan calcite specimens commonly reach large sizes, and although crystals are usually not lustrous they make beautiful specimens. Large "poker chip" manganoan calcite crystals were collected in the 1980's from a watercourse some 10 meters wide by 50 meters long (Dan Belsher, personal communication, 1992). On some pieces the manganoan calcite crystal groups have the shape of a pineapple, with multiple terminations forming the "leaves" of the "pineapple"; others look like pink flowers with divergent sprays of crystals forming the petals. Individual manganoan calcite crystal clusters may exceed 10 cm in size, with 5-cm individual crystals. Pink scalenohedrons of pearly manganoan calcite exceeding 15 cm have been collected by the miners. (Some of the manganoan calcite is possibly kutnohorite, but this needs to be verified.) Calcite from Pachapaqui sometimes fluoresces a very weak whitish cream color under shortwave ultraviolet light. Longwave ultraviolet light elicits no response. The manganoan calcite usually fluoresces a dim pinkish orange inclining to magenta under shortwave ultraviolet. Longwave ultraviolet light produces a much stronger bright red-orange to pinkish orange fluorescence. The kutnohorite(?) is not fluorescent, or very weakly fluorescent.

Most manganoan calcite specimens have been briefly dipped in HCl, apparently in an effort by the Peruvians to remove late-formed calcite or sulfide dust and dirt. This treatment can be detected by close examination of the edges and undersides of specimens. Cleavages and broken areas have a slightly waxy and rounded look where the acid removed some of the carbonate. Sometimes the acid treatment leaves the crystals with a chalky look, and some of these crystals have been sprayed with some type of clear lacquer in order to give the crystals a shiny luster. We have

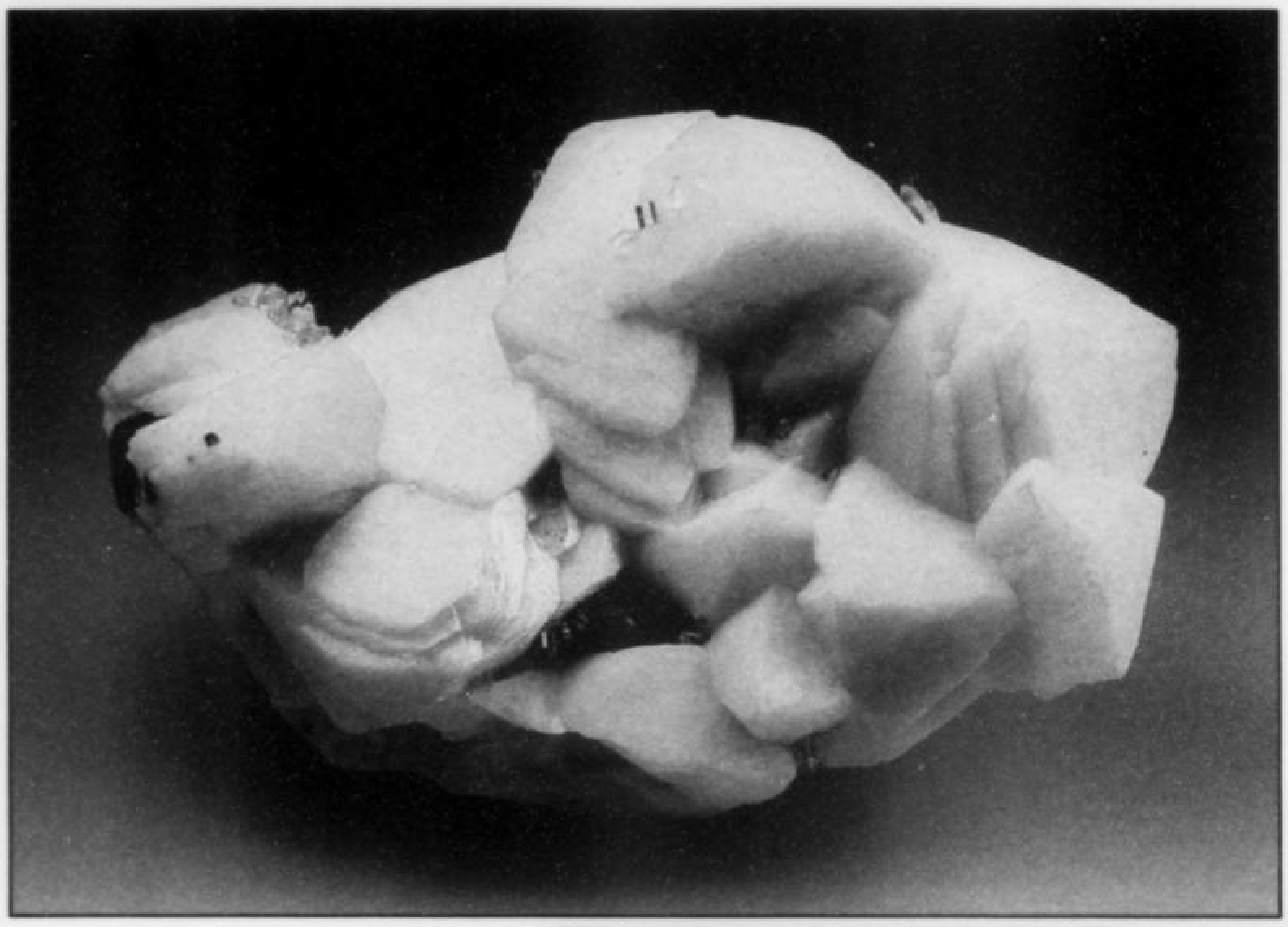


Figure 43. Manganoan calcite crystal group, 6.5 cm, from Pachapaqui. Peter Faust collection; Wendell Wilson photo.

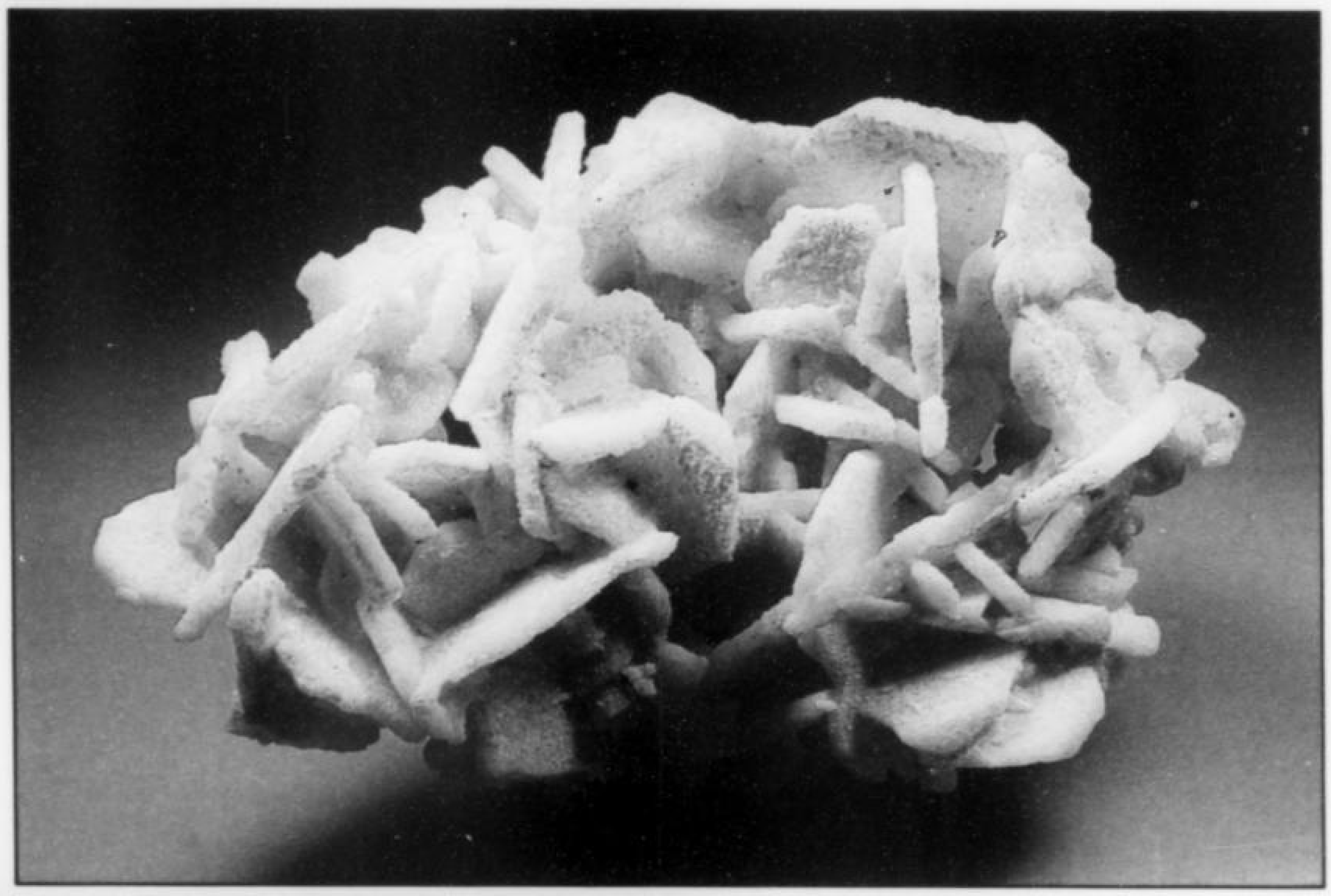


Figure 44. Manganoan calcite crystal group, 16.3 cm, from Pachapaqui. Mary and Gardiner Miller collection; Wendell Wilson photo.

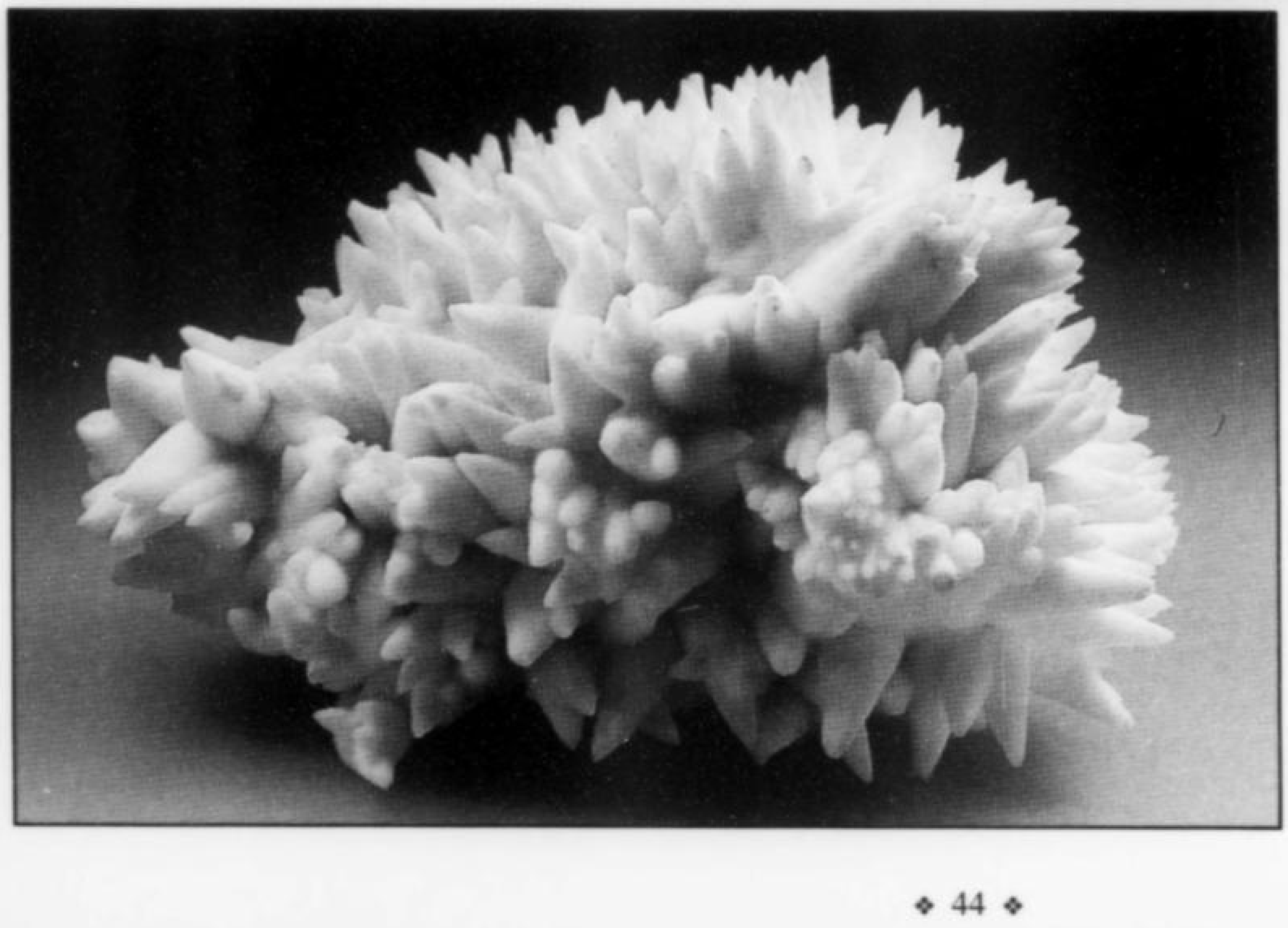


Figure 45. Manganoan calcite crystal group, 10 cm, from Pachapaqui. Cal Graeber specimen; Wendell Wilson photo.

seen some of these lacquered crystals with fingerprints showing on the sprayed faces, caused by handling of the specimens before the coating has dried.

Chalcopyrite $CuFeS_2$

Chalcopyrite occurs as bright sphenoidal centimeter-size crystals that are commonly twinned. The chalcopyrite crystals frequently have pockmark holes in their faces, with mounds of microcrystalline pyrite present in these holes. Tetrahedrite is commonly scattered on, or nearly solidly coats, the chalcopyrite.

Fluorite CaF_2

Most of the fluorite from Pachapaqui was produced during the initial surge of material onto the world market in 1986 and 1987. The volume of fluorite specimens, however, was always far less than that from Huanzala. Fluorite has cuboctahedrons and cubo-dodecahedrons as the dominant forms, followed by cubic crystals and modified cubes, sometimes rather complex in habit. Crystals can be several centimeters in diameter. Individual crystals are usually transparent, with lilac, light purple to purple, light pink or greenish tints, or they may be colorless. Crystals sometimes have fluid inclusions with moveable bubbles within them (Dan Belsher, personal communication, 1992). A common matrix mineral is white dolomite. Pachapaqui fluorite can be very difficult to differentiate from Huanzala fluorite.

Galena PbS

Uncommon in good crystal specimens at Pachapaqui, galena occurs as steel-gray to brilliant silvery gray cubes, as cubes modified by the octahedron, and as octahedrons. Galena is found in crystals that measure at least 2.5 cm in diameter and are sometimes coated by bright crystals of tetrahedrite.

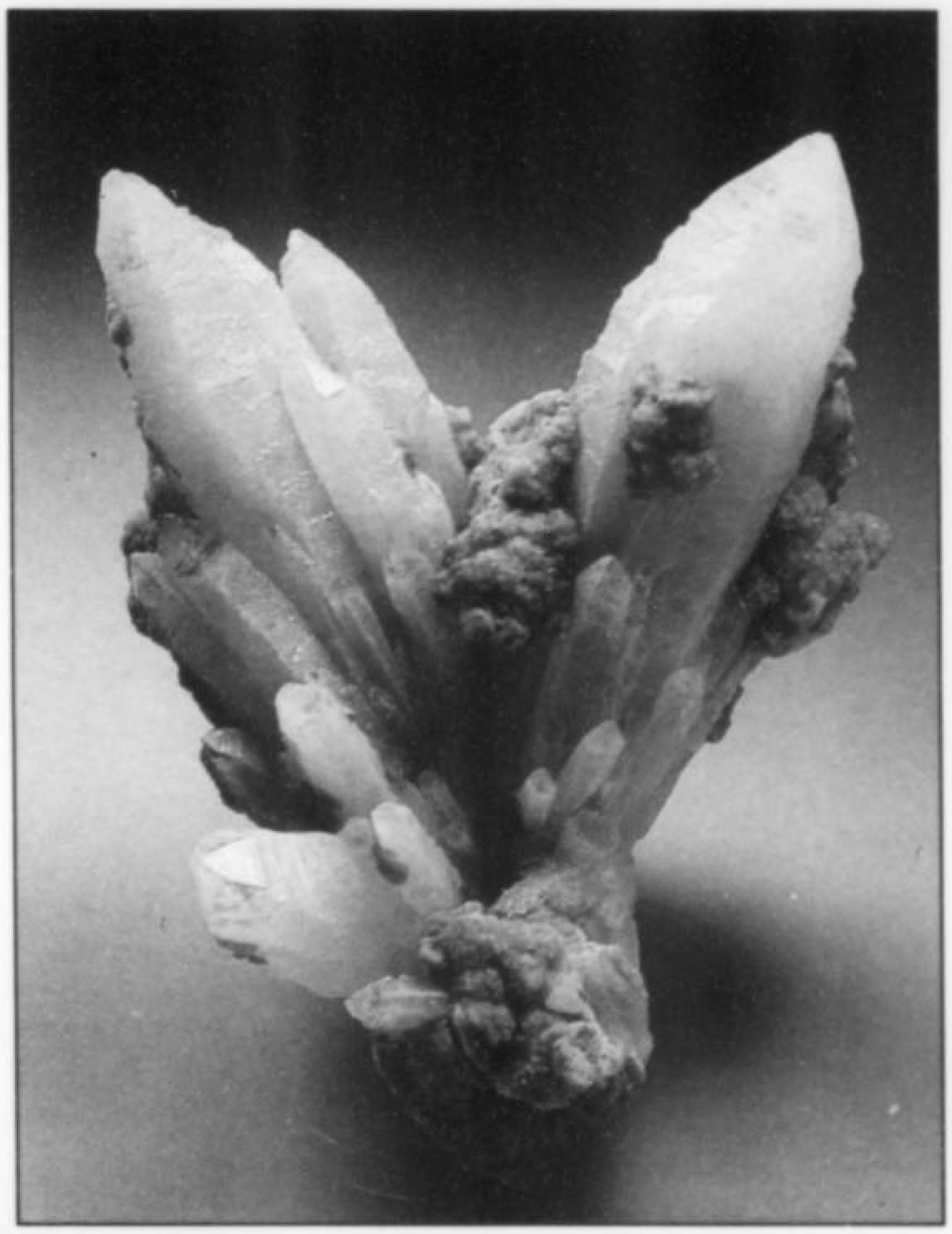


Figure 46. **Quartz crystal cluster with rhodochrosite, 11.5 cm, from Pachapaqui. Cal Graeber specimen; Wendell Wilson photo.**

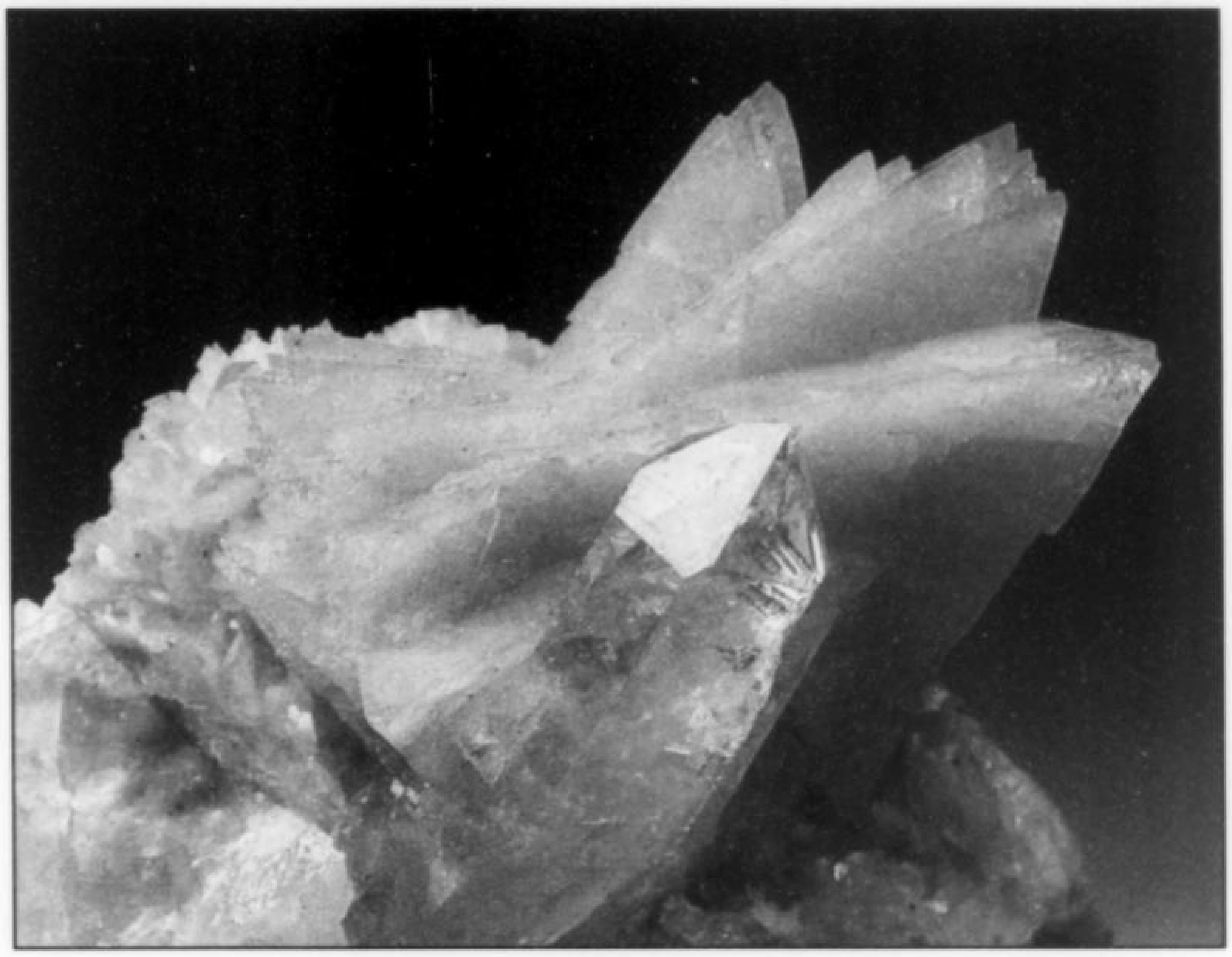


Figure 47. **Helvite crystal cluster, 1.5 cm, with quartz and rhodochrosite, from Pachapaqui. Ralph Clark collection; Wendell Wilson photo.**

Helvite $Mn_4Be_3(SiO_4)_3S$

Helvite occurs as bright canary-yellow tetrahedral crystals, commonly 1–2 mm across, and rarely to a little over 1 cm, usually perched on rhodonite. A very fine Pachapaqui helvite specimen in the U.S. National Museum (Smithsonian) has crystal faces about 1 cm on an edge. Others exist in private collections.

Manganaxinite (?) $Ca_2Mn^{+2}Al_2BSi_4O_{15}(OH)$

Axinite is an uncommon association on some Pachapaqui specimens. It is usually found as yellowish brown to purple-brown microcrystals. On one occasion some years back, one of us (RHC) kicked over a rhodonite-rich boulder on the dump and found a small pocket containing a well-formed axinite crystal measuring about 2 cm. Similar crystals up to 5 cm were occasionally found in the mine, yet nothing larger than microcrystals from here has ever been offered for sale.

Pyrite FeS_2

Pyrite at Pachapaqui is typically found in bright crystals less than 3 cm in size. Pyritohedrons, frequently highly striated, are the most common forms, followed by modified cubes. Pyrite is usually associated with other minerals and has not been collected by the miners in the solid monomineralic masses so commonly found at the nearby Huanzala mines.

Quartz SiO_2

Quartz occurs in good crystals to more than 10 cm long; the color varies from slightly milky to a very pale smoky cream, to colorless and water-clear. The crystals have a bright luster and commonly occur with bright pyrite. The quartz is not tapered and has a moderate aspect ratio. In many cases the crystals are thickened near the middle; this gives them a slightly barrel-shaped appearance. Crystal terminations frequently tend toward a triangular shape, due to the dominance of one terminal rhombohedron form over the other. Scepter-shaped quartz crystals are present on some specimens but they are not common.

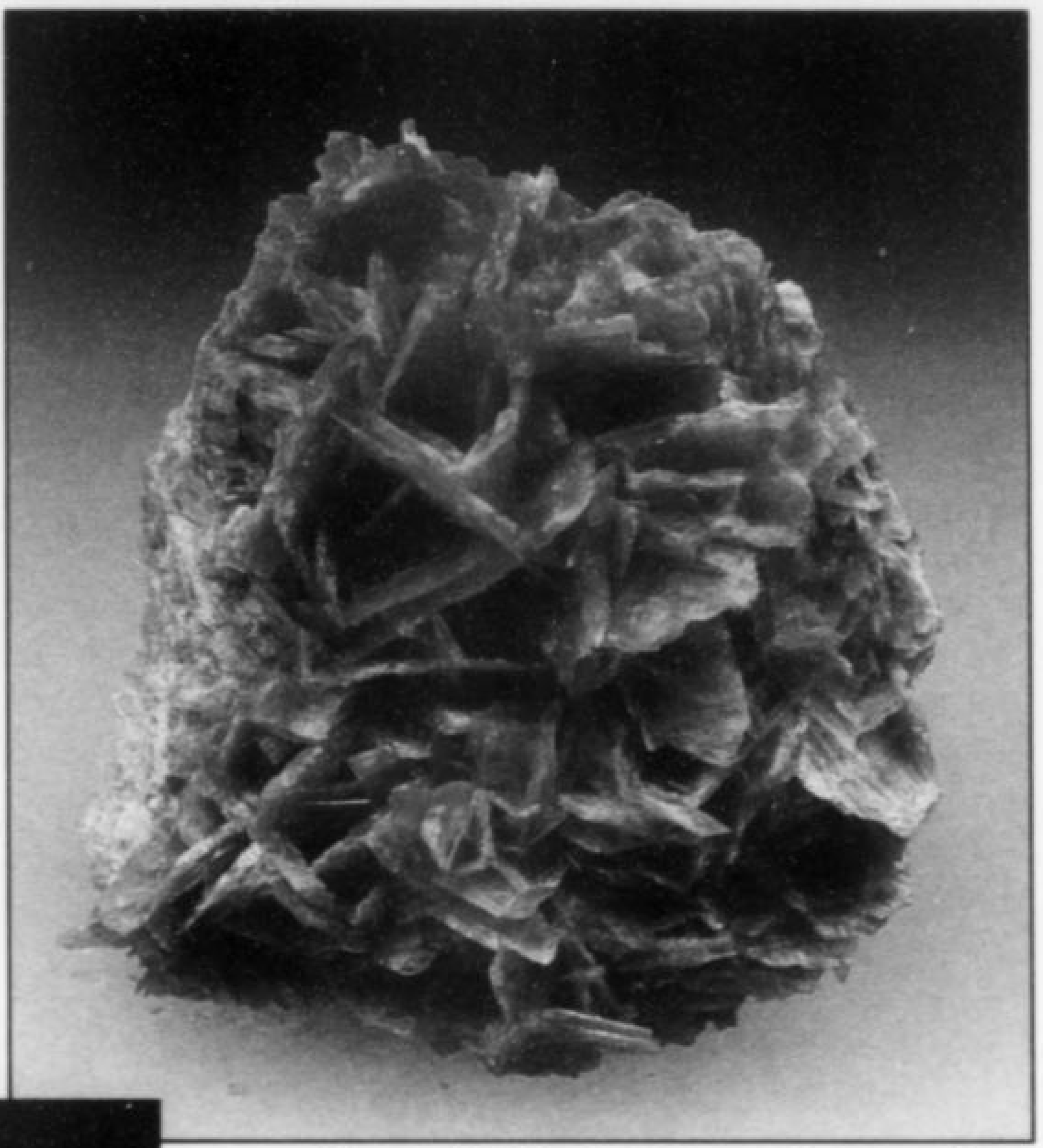


Figure 48. **Rhodonite crystal group, 3 cm, from Pachapaqui. Peter Faust collection; Wendell Wilson photo.**

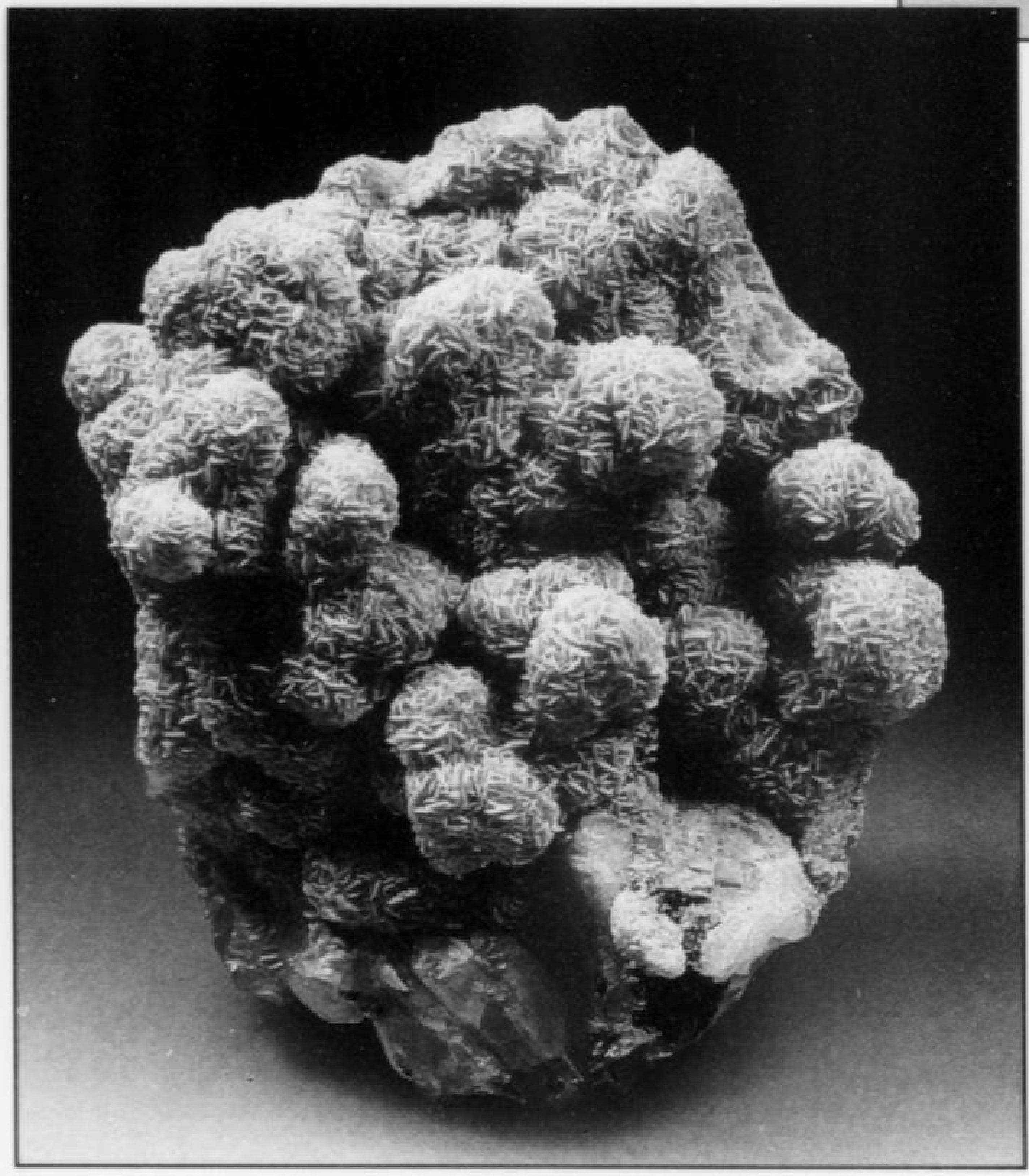
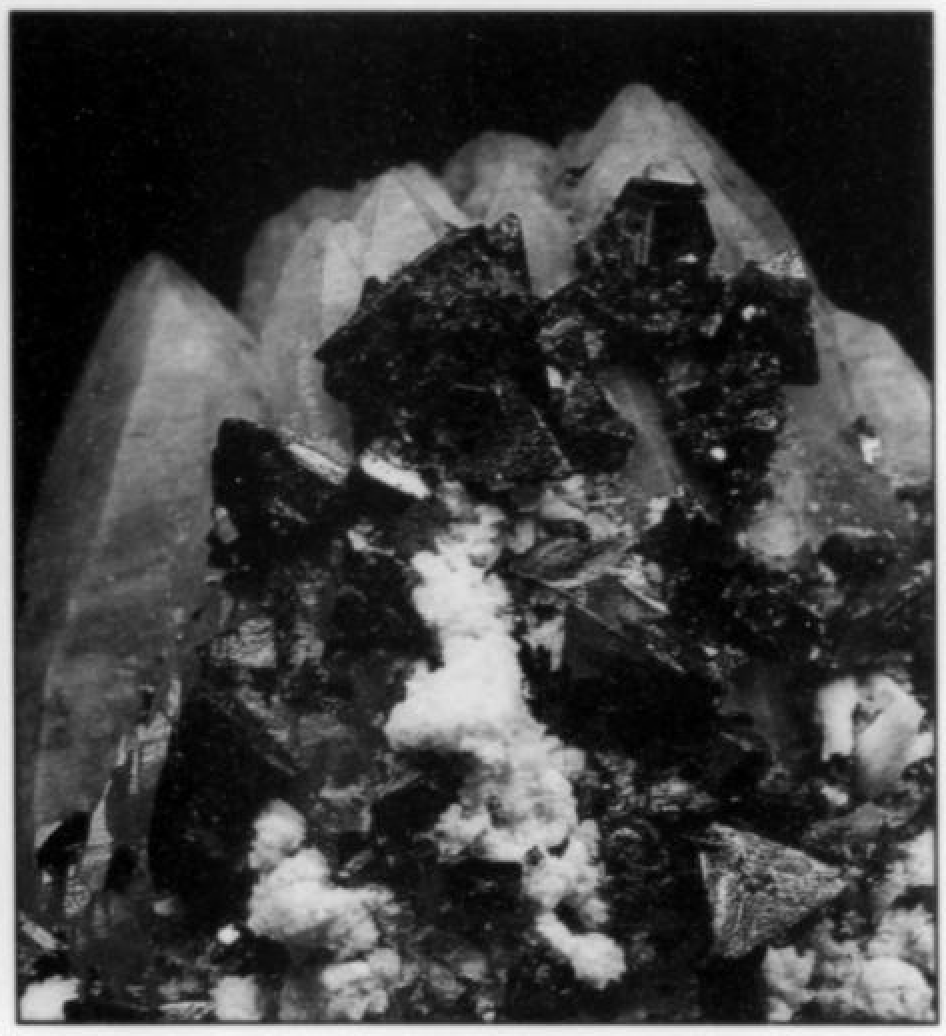


Figure 49. **Rhodochrosite with quartz, 6.6 cm, from Pachapaqui. Cal Graeber specimen; Wendell Wilson photo.**

Figure 50. **Tetrahedrite crystals to 1 cm, with rhodochrosite and quartz, from Pachapaqui. Peter Faust collection; Wendell Wilson photo.**



Rhodochrosite $MnCO_3$

Rhodochrosite occurs as pale pink to pink, bladed, moderately to highly curved, saddle-shaped rhombic crystals up to about a centimeter in size. During the last several years many rhodochrosite specimens from Pachapaqui have appeared on the specimen market. Pachapaqui rhodochrosite is reminiscent of that from Silverton, Colorado. Solid coatings and masses of very small crystals are common, and these may merge to produce a nearly botryoidal or bubbly appearance. In 1993 rhodochrosite specimens with a vivid raspberry-pink color were collected. The specimens are mostly flat plates with 5-mm or smaller rhombic rhodochrosite crystals. The crystals have an odd, almost etched look to them, and closer examination shows evidence that they were coated with a clay-like material that has been scrubbed off, but they do not appear to have been acid-etched by the Peruvians. The Pachapaqui rhodochrosite specimens we have checked are not fluorescent in ultraviolet light.

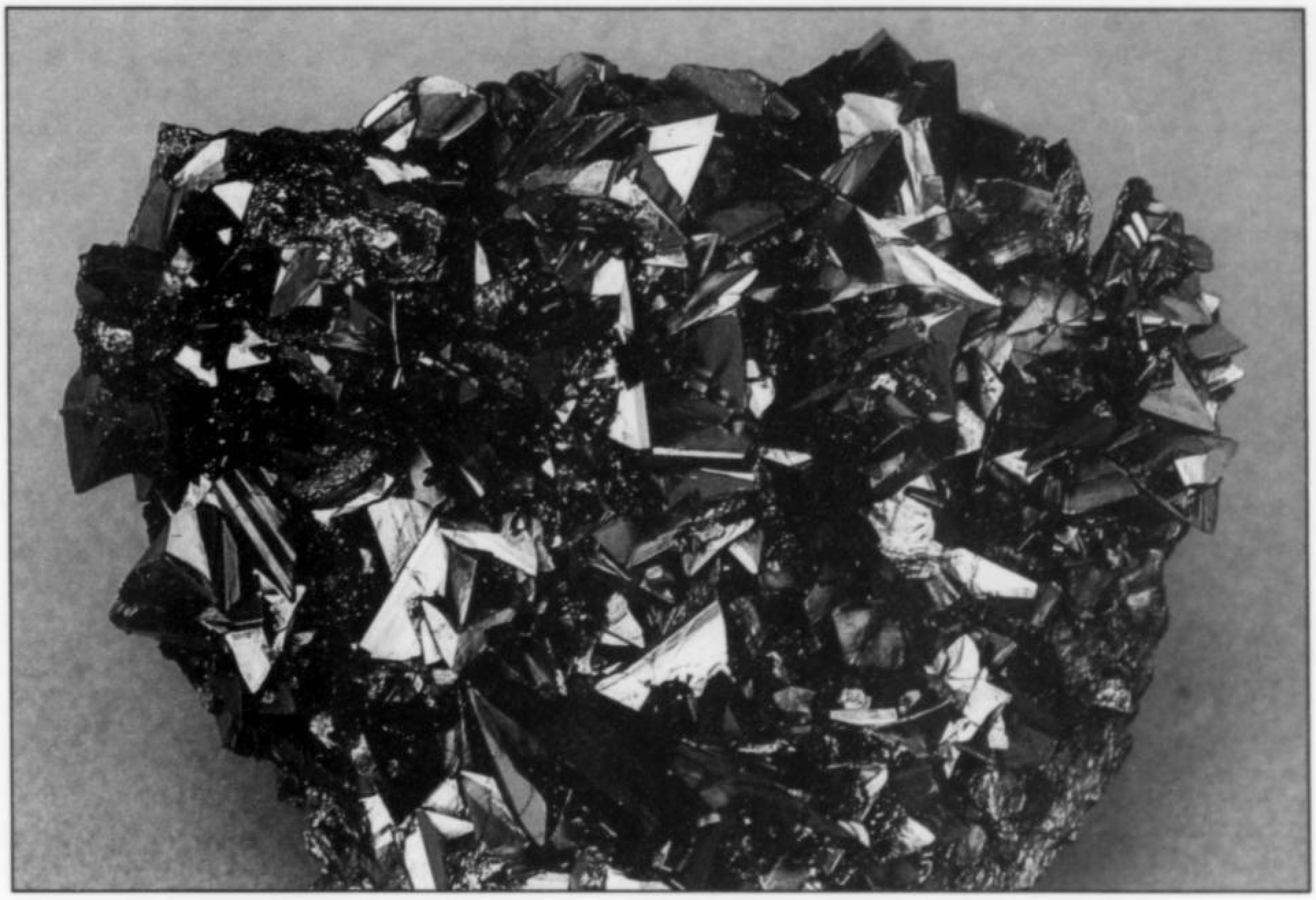


Figure 51. **Tetrahedrite crystal group, 7.5 cm, from Pachapaqui. Jack Crowley specimen and photo.**

Rhodonite $(Mn^{+2},Fe^{+2},Mg,Ca)SiO_3$

Rhodonite is found in thick masses of deep pink microcrystals that sometimes solidly coat the massive rhodonite matrix. Both manganaxinite and helvite have been reported to occur on these rhodonite specimens. Massive rhodonite is common on the dumps of some of the mines. Some of this massive material is quite attractive, especially when spotted with galena and sphalerite impurities, and it has been sold as a lapidary material.

Sphalerite $(Zn,Fe)S$

Dull to lustrous dark brown to near black sphalerite is actually a transparent dark straw-yellow to dark amber to deep orange red color in transmitted light. Sphalerite is one of the earlier formed minerals, occurring with quartz, pyrite and rhodochrosite. It often forms the matrix on which the other minerals have crystallized.

Tetrahedrite $(Cu,Fe)_{12}Sb_4S_{13}$

Some of the tetrahedrite specimens from Pachapaqui are stunning: highly lustrous crystals up to 2.5 cm on edge in brilliant black to silvery-black groups. The tetrahedrite usually occurs as simple tetrahedrons with minor modifications. Tetrahedrite crystals are sometimes markedly modified to form complex crystals. Tetrahedrite occurs both by itself and with pyrite, chalcopyrite, bournonite and sphalerite. In 1990–1991 miners collected tetrahedrite in geode-like masses that made splendent, top-quality specimens (Dan Belsher, personal communication, 1992). Tetrahedrite may have coatings of pale pink to pink, crudely formed scalenohedral to bladed manganoan calcite crystals.

Some tetrahedrite has a later deposit of tetrahedrite crystals implanted on the earlier-formed crystals. These second-generation crystals resemble little pyramids that form tooth-like spikes on the first-generation tetrahedrite; they have no preferred orientation. Many tetrahedrite specimens appear to have been replaced by a very fine-grained pyrite, which in turn has been partially replaced by a new generation of splendent tetrahedrite crystals. Where replacement(?) has occurred this second-generation tetrahedrite frequently has a parallel growth habit that looks ribbed.

Tetrahedrite from Pachapaqui can generally be differentiated from other Peruvian localities by its simple form, smooth crystal faces and brilliant luster. In 1986 some of the tetrahedrite specimens that were recovered had the appearance of a birthday cake: a quartz crystal matrix with 1.25-cm tetrahedrite crystals scattered on the quartz, and associated bright pyrite crystals and pink manganoan calcite crystals scattered over the entire surface.

Huanzala Mine, Huallanca District

Dos de Mayo Province
Huanuco Department

LOCATION and HISTORY

The Huanzala mine is about 250 km north of Lima in the northwest corner of the Huallanca district about 11 km by road from Huallanca. Discovered in 1721 and later abandoned, the San Jose De Huanzala mine was largely ignored until around 1964. In that year the Mitsui Mining and Smelting Corporation founded the Compania Minera Santa Luisa S.A. and began intensive work in the Huallanca district. Underground mining began in 1968. By 1981, the mine, now called the Huanzala, was producing 900 metric tons of ore per day. As of January 1991 the remaining life of the Huanzala mine was estimated at 13 years (Cavanagh, 1993?).

GEOLOGY

Imai *et al.* (1985), studied the area and much of the following geologic data is abstracted from their paper.

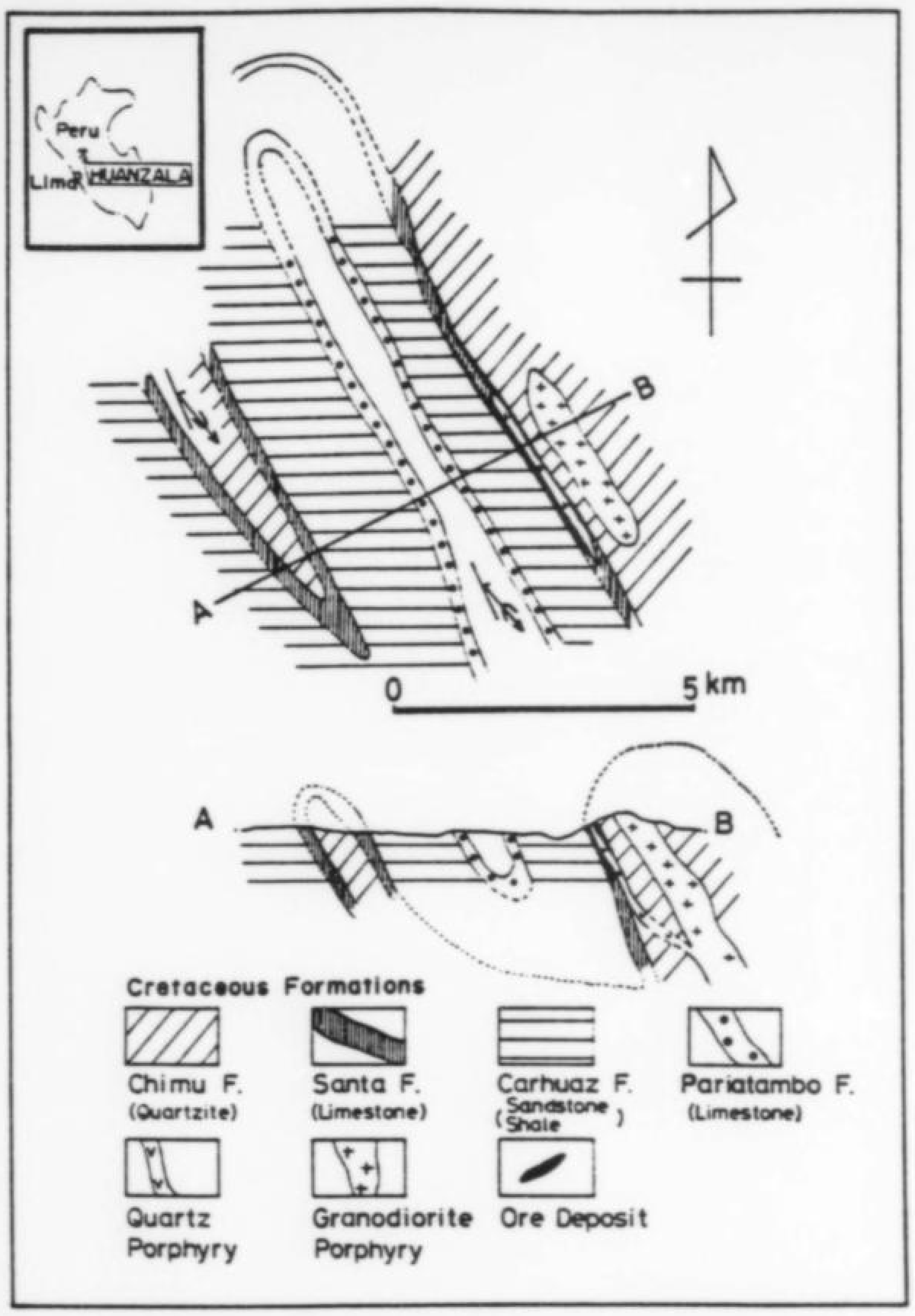


Figure 52. **Geology of the Huanzala mine (from Imai *et al.*, 1985).**

The region is underlain by Lower Cretaceous sedimentary rocks that are correlative with the Goyllarisquizga Group. In the area of the mine, the sedimentary rocks, from bottom to top, are cherts of the Chimu Formation, limestone of the Santa Formation, and interbedded sandstone and slate of the Carhuaz Formation.

The Huanzala deposit occurs in the limestone of the Santa Formation, which is 150–200 meters thick, on the eastern arm of an overturned syncline. A quartz porphyry dike intrudes the limestone and is directly related to the ore deposition. The Huanzala deposit was emplaced with attendant skarn formation and hydrothermal alteration on both sides of the quartz porphyry dike. This mineralized zone extends for more than 6 km along strike.

The orebodies contain pyrite, lead-zinc minerals and copper minerals accompanied by silver-tin-tungsten minerals with sporadic occurrence of bismuth and tellurium minerals. Non-metallic gangue minerals include quartz, fluorite, calcite, dolomite, rhodonite, rhodochrosite, various skarn minerals and alteration products such as sericite and kaolinite. Noteworthy is the sparsity of barite, which may help in differentiating Quiruvilca specimens from Huanzala specimens.

PARAGENESIS

The zinc and lead minerals form the primary ores at Huanzala. Frequently they are accompanied by pyrite, and in some cases the zinc and lead minerals have replaced pyrite. There are two types of zinc ores, one consisting of an Fe-rich, brown to reddish brown sphalerite and the other an Fe-poor sphalerite. The Fe-poor sphalerite is nearly colorless in thin section but black in hand specimens due to an abundance of microscopic blebby inclusions of chalcopyrite and bornite. The Fe-rich sphalerite generally occurs with skarn minerals while the Fe-poor sphalerite occurs in the hydrothermally altered rocks associated with sericitic muscovite, quartz and calcite.

Pyrite followed by zinc and lead deposition constitutes the first stage of mineralization. The zinc and lead was then followed by a middle stage of copper mineralization, accompanied by small quantities of silver-tin-tungsten minerals and other minor accessory species.

As part of the middle stage mineralization in the northern periphery of the ore deposit, canfieldite, hocartite, stannite, hessite, argentite, pyrargyrite, stephanite, polybasite and native silver were deposited, characteristically accompanied by minor cassiterite, arsenopyrite and chlorite. Pyrrhotite and Fe-rich sphalerite are rarely associated with these minerals.

Late-stage mineralization on the northern margin of the deposit is represented by Fe-Mn-rich sphalerite, wurtzite (both the sphalerite and the wurtzite are deep brown in color), alabandite, rhodochrosite and rhodonite.

Pyrite occurs as both fine-grained (generally massive) and loose coarse-grained (often crystalline) material. The coarse-grained pyrite is frequently associated with sericitic muscovite.

The copper minerals chalcopyrite, bornite, enargite, tennantite, stannite, chalcocite and digenite generally occur in association with the zinc and lead and usually also with pyrite. Chalcopyrite formed prior to bornite; tennantite is usually associated with chalcopyrite and bornite; and enargite formed at the same time as the bornite. Copper-bismuth minerals such as emplectite and wittichenite have also been identified as occurring with bornite. Scheelite, tungstenite and cassiterite preceded or accompanied the copper minerals. The copper minerals are always surrounded by, and may be associated with, the alteration minerals sericite, chlorite, quartz, calcite, dolomite, fluorite, sellaite, talc, gypsum and montmorillonite.

Enargite is usually associated with pyrite and is sporadically associated with bornite, chalcocite and digenite. Tennantite is commonly associated with simultaneously deposited chalcopyrite and bornite, whereas enargite usually is not. As a general rule, the most common assemblages are pyrite plus or minus enargite, followed by tennantite plus or minus chalcopyrite, plus or minus bornite. Bournonite and orpiment have not been recorded at Huanzala (in contrast to Quiruvilca). The matrix rock, for those specimens that have retained a rock matrix, is generally quartzitic and sericitic with a light color; for example, some of the pink fluorite found in 1980 was on this type of matrix, which superficially resembles quartzite.

THE RELIQUIA MINE

Like most mining areas in Peru, the Huanzala mine is actually a composite of several mines and related workings in the immediate area. One of these mines, the Reliquia (meaning "relict" in Spanish), is on the northern periphery of the main Huanzala mine. Its workings produced some of the more interesting Huanzala minerals, such as arsenopyrite, arsenopyrite after pyrrhotite, and pyrite after pyrrhotite. It produced attractive pale green, pastel pink, and colorless fluorite, with a variety of associate minerals. It also produced fine specimens of pearly gray dolomite, with a curled or curved appearance to the crystals, which is found on black sphalerite and is frequently associated with arsenopyrite. It is one of the few localities in Peru that produced a small amount of crystallized pyrrhotite in the mid-1980's.

Table 5. **Minerals reported from the Huanzala mine.**

	Common or Abundant	
***Chalcopyrite**	***Sphalerite**	***Calcite**
***Enargite**	***Tennantite**	***Dolomite**
***Galena**	***Quartz**	***Fluorite**
***Pyrite**	Sericite	
	Rare or Locally Abundant	
Alabandite	Emplectite	***Pyrrhotite**
***Apatite**	Hessite	Rhodochrosite
Argentite	Hocartite	Rhodonite
***Arsenopyrite**	***Hübnerite**	***Scheelite**
***Barite**	Lillianite	Stannite
Bornite	Native silver	Stephanite
Canfieldite	Natrolite	Tungstenite
Cassiterite	Polybasite	Wittichenite
Chalcocite/digenite	Pyrargyrite	***Wurtzite**
Cosalite		

*Collector-quality specimens

MINERALS

Huanzala undoubtedly will be known in the future as one of the world's greatest mineral localities. Though not famous for a wide diversity of minerals, it will certainly be remembered for its sheer volume of specimens, particularly pyrites, in spectacular crystals and clusters that rank among the world's best. In terms of tonnage of pyrite, plus other mineral specimens, Huanzala has been the number one specimen producer in Peru. In addition, the spectacular pink fluorites must also rank with the world's best. As at so many localities in Peru, if carbonates were present in fairly large amounts as late-formed minerals on sulfides and other good crystals, the Peruvian dealers have dissolved them off with HCl.

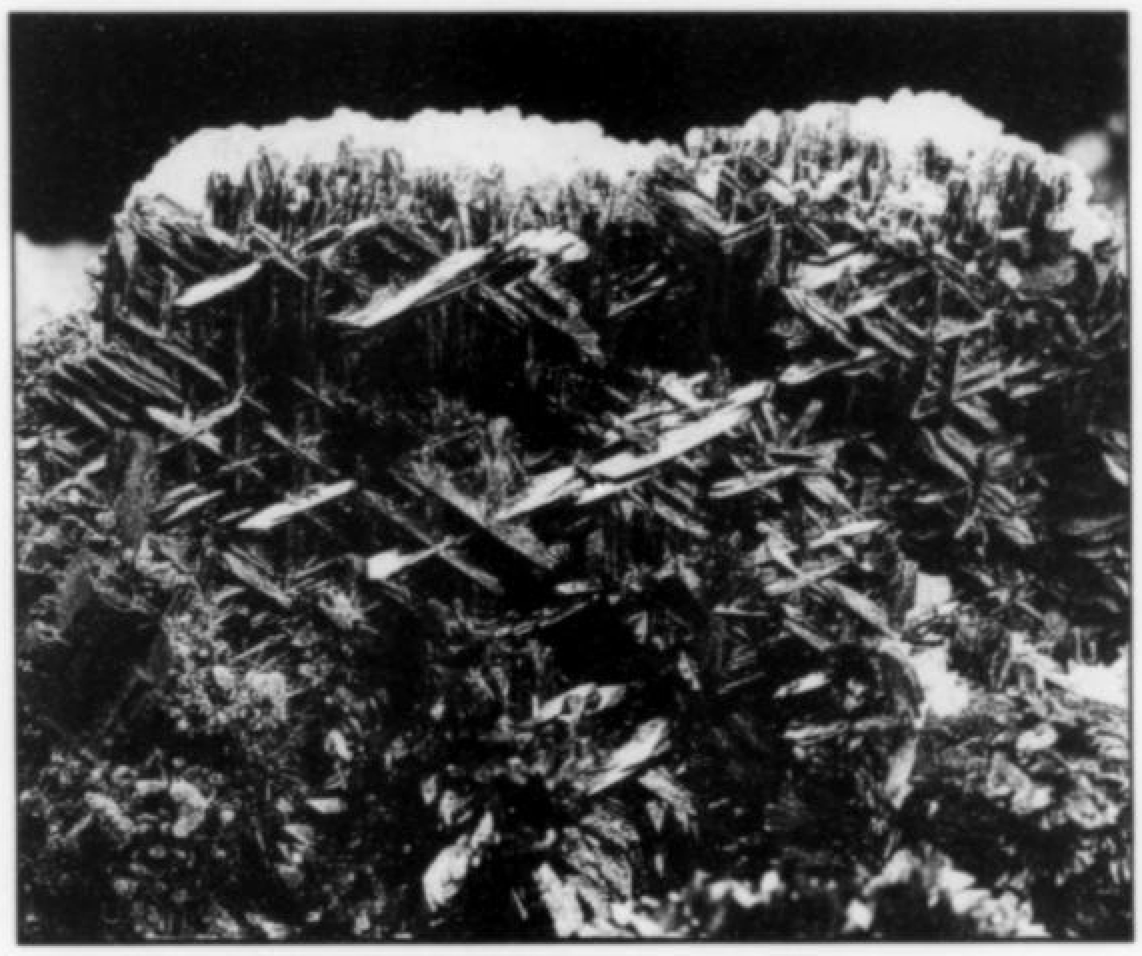


Figure 53. **Reticulated arsenopyrite crystals, 3 cm across, from Huanzala. Gene Schlepp collection; Wendell Wilson photo.**

Arsenopyrite FeAsS

Arsenopyrite occurs as individual crystals, as partial coatings on mixed sulfides, particularly black sphalerite, and as nearly monomineralic masses of crystals. Typical crystals vary from long thin prisms with dull terminations and bright silvery sides, to slightly more stout prismatic crystals with the typical diamond-shaped termination. Crystals exceeding 2 cm in length are rare. Arsenopyrite also replaces rose-like bladed masses and barrel-shaped crystals of pyrrhotite, thus creating beautiful sparkling pseudomorphs; apatite and fluorite are sometimes associated.

Barite $BaSO_4$

Barite is uncommon at Huanzala. However, when found it usually occurs in specimen quality, associated with pyrite or other sulfides. Crystals are not large, rarely exceeding a few centimeters in height, and are usually white to chalky white with a simple bladed habit. In 1980 barite was found associated with cuboctahedral galena crystals, with both minerals coated by calcite. One of us (TS) found that by dissolving off the overlying calcite with dilute phosphoric acid, outstanding specimens resulted which show crystals of white barite growing on masses of bright metallic cuboctahedral galena crystals. The dilute phosphoric acid (H_3PO_4) did not harm the underlying galena crystals.

Figure 54. **Barite crystal cluster with pyrite, 6.5 cm, from Huanzala. Rock Currier collection; Jack Crowley photo.**

Bornite Cu_5FeS_4

Bornite is a common ore mineral found infrequently as crystals on crystallized specimens of other minerals, particularly pyrite. It is worth noting as an accessory mineral, and is usually present in crudely formed microcrystals with a dull purplish to blackish appearance. Huanzala is one of the few mines in Peru producing bornite crystals, and this can aid in determining a specimen's locality if such crystals are present.

Calcite $CaCO_3$

Calcite occurs as white, flattened rhombs with a distinctive (sometimes curved) discoidal appearance. The size of the crystals rarely exceeds 3 cm on the better specimens. Calcite also occurs as scalenohedrons, frequently showing some degree of alteration or corrosion. Crystals are usually small to microscopic. Some of the calcite fluoresces a weak pink under longwave ultraviolet light, but exhibits no response to shortwave radiation. Calcite with a "Granny Smith" apple-green color was reported from here in 1986 by Siber (1987). Dan Belsher (personal communication, 1992) recounts that an unnamed location near Huanzala has on occasion produced green calcite crystals with a modified scalenohedral habit. These crystals come from an area situated between the town of Huallanca and the Chuiricu mine. This is most likely the location listed in *Lapis* (1987) as the "Huanzala mine."

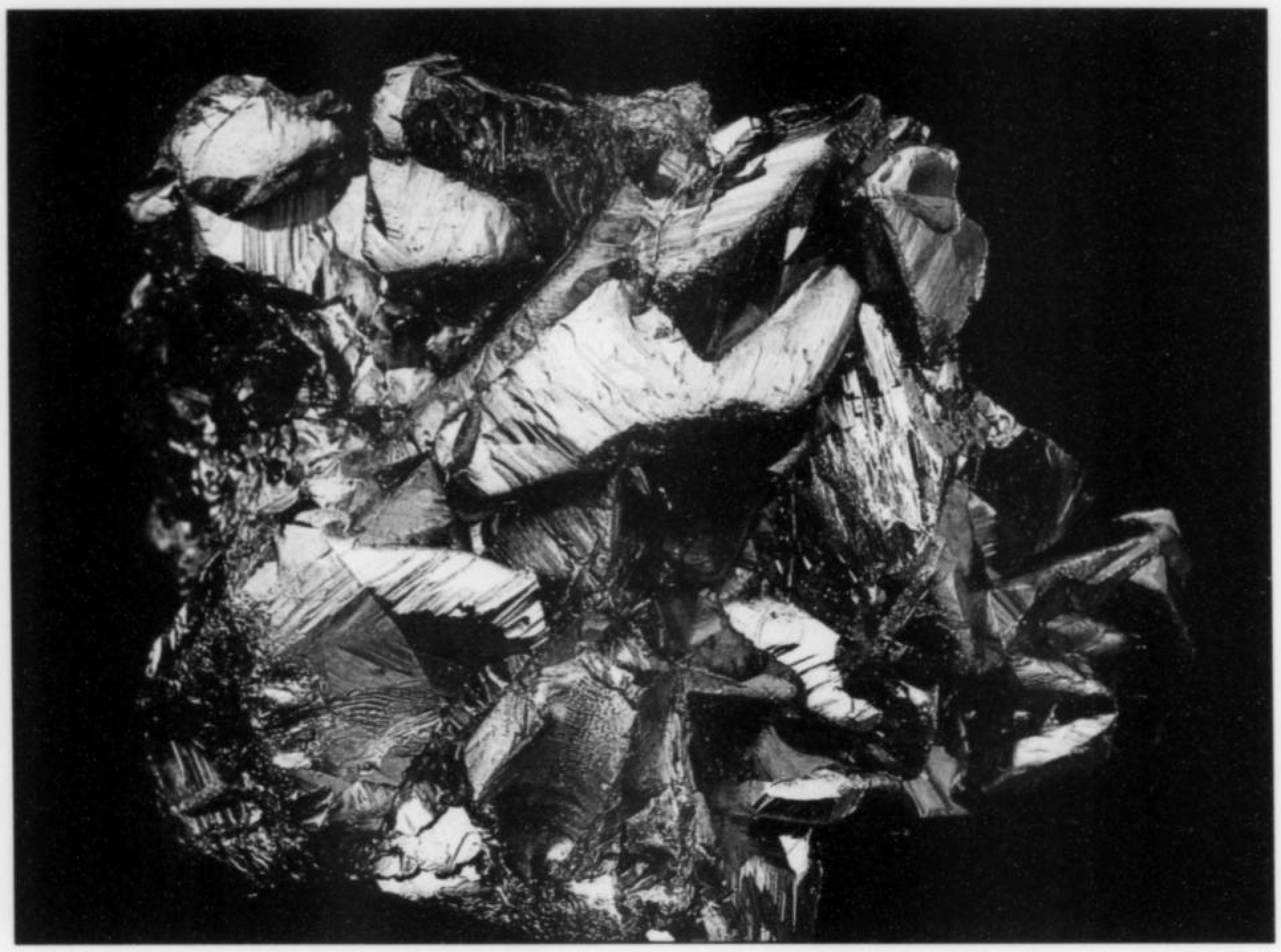


Figure 55. **Chalcopyrite crystal group, 8.2 cm, from Huanzala. Jack Crowley collection and photo.**

Chalcopyrite $CuFeS_2$

Chalcopyrite is relatively common and frequently occurs on or with pyrite specimens. Crystals are occasionally large, sometimes reaching 5 cm or more in size, and tending toward pseudotetrahedrons in shape. Chalcopyrite is a common accessory mineral, particularly on pyrite specimens, and may be coated with a bright gun-metal blue iridescence which gives the superficial appearance of another mineral. Brilliant chalcopyrite crystals as large as 2 cm have been found on pale green, usually somewhat crudely formed, octahedral fluorite on or with drusy aggregates of small quartz crystals that may form large specimens. Fine specimens with bright, deep golden yellow chalcopyrite crystals exceeding 4 cm across, on quartz, pyrite and other minerals, came on the market in 1989 through 1991. The pyrite on these particular specimens is dominantly cubic, the cubes generally substantially smaller than the chalcopyrite crystals.

Dolomite $CaMg(CO_3)_2$

Dolomite occurs as grayish white to white, curved "saddle-shaped" crystals and as bladed crystals which exhibit an extreme modification of the rhombic form. Crystals are usually less than 1 cm in size but can exceed 3 cm in the "saddle-shaped" crystals. Dolomite usually occurs as a later-formed mineral on pyrite and other minerals. Zoning commonly makes the edges of the flattened rhombs clear and colorless, while the interior of the rhombs are milky white. Some of the dolomite specimens effervesce more strongly in acid than others. Both dolomite and calcite can have a discoidal appearance, although the calcite, as mentioned before, also occurs in scalenohedral and typical hexagonal dipyramidal crystals.

Enargite Cu_3AsS_4

Enargite from Huanzala has never been common, but when it is found it can be very attractive. It occurs in crystals and masses of crystals with a dark blue-black color and a brilliant metallic luster. The best of these have individual crystals exceeding 1.5 cm in length, in spectacular hand-size and larger groups. Colorless fluorite, pyritohedral pyrite, and arsenopyrite may occur with the enargite.

Fluorapatite (?) $Ca_5(PO_4)_3F$

Apatite crystals are commonly microscopic in size. They are frequently found on pyrite or in association with galena. Better specimens consist of colorless to whitish gray, lustrous simple hexagonal prisms to about 2 cm in length. They fluoresce a cream color under shortwave ultraviolet light, and a yellow color at the terminations and prism edges. This variation in color probably reflects a compositional change. The effect is much weaker under longwave ultraviolet light.

Fluorite CaF_2

Fluorite is a relatively common mineral at Huanzala, and its presence helps to identify specimens originating there. The most spectacular specimens have pink octahedral crystals, some with greenish cores, occurring with pyrite, galena and sphalerite. There were only about 100 good specimens from this find. The largest crystals are about 5 cm in diameter. Belsher (1982) documented this November 1980 discovery. Most fluorite from Huanzala is colorless to green, and more rarely it is found in shades of purple to pink. Crystals may be totally clear and flawless and are usually crudely octahedral in form with stepped growth, although good cubic specimens have also been collected. Common associated minerals are pyrite, sphalerite, galena and chalcopyrite. The majority of the high-quality specimens recovered were the result of a series of finds in 1981 and 1982.

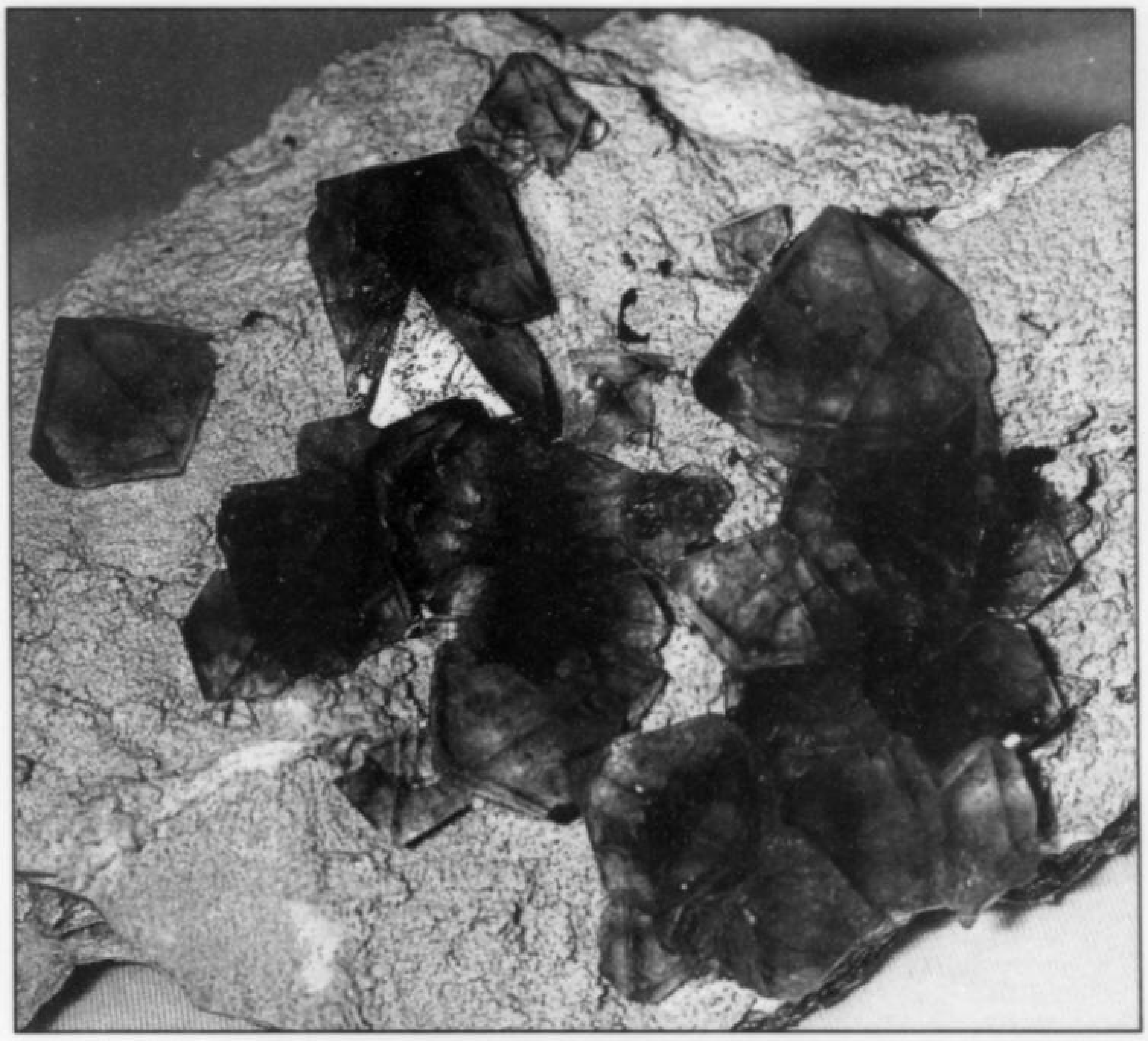


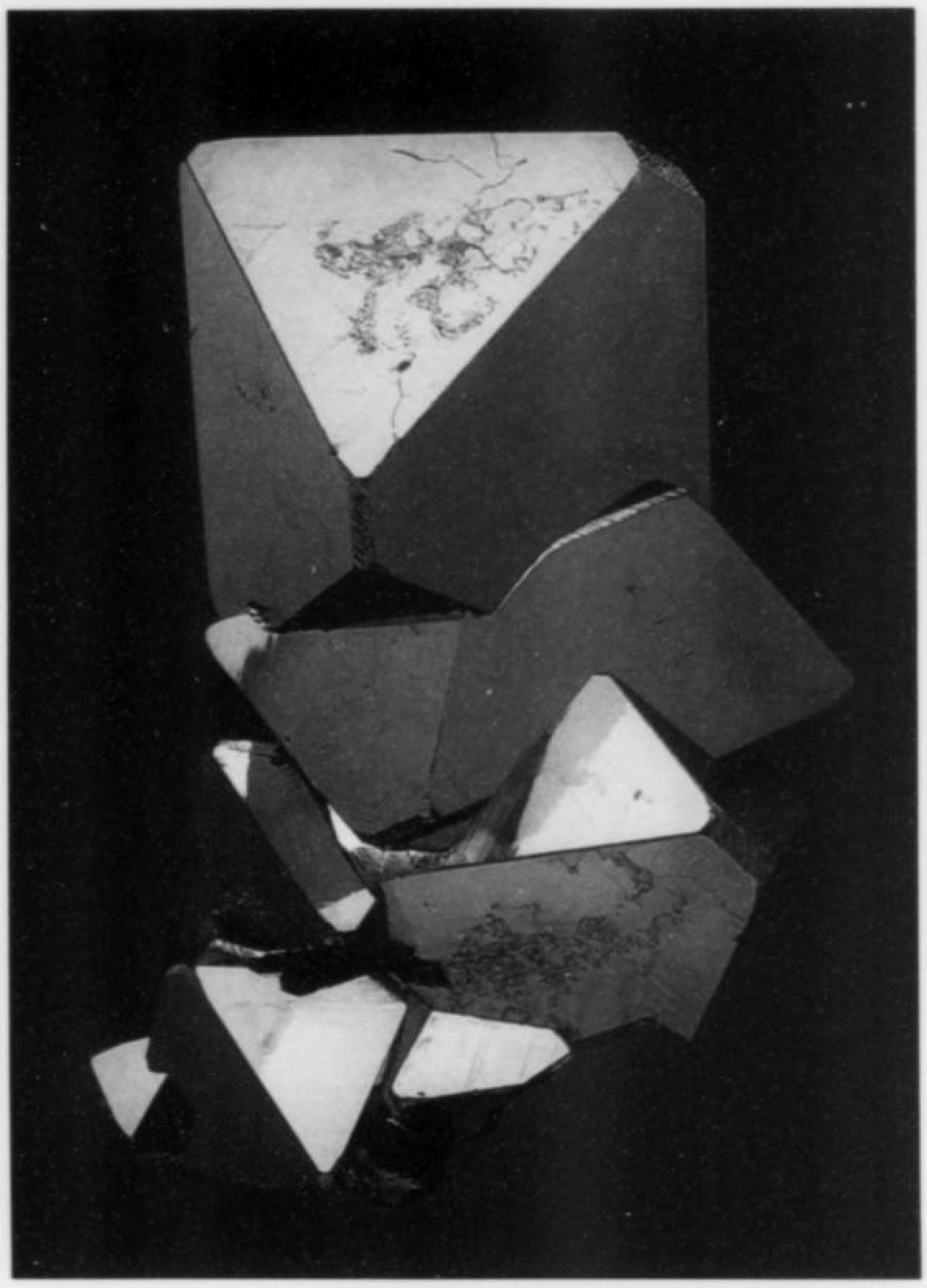
Figure 56. **Fluorite crystal group, 3.2 cm, from Huanzala. Jonathan Weiss collection; Wendell Wilson photo.**

Figure 57. **Fluorite crystals to 3 cm from Huanzala. Rock Currier specimen; Wendell Wilson photo.**

Figure 58. **Fluorite crystals to 3 cm from Huanzala. Rock Currier specimen; Wendell Wilson photo.**

Galena PbS

Galena varies from very bright, highly lustrous crystals to dull, gray-white, highly altered and corroded crystals (probably acid etched by Peruvian collectors). Cubic, cuboctahedral and dodecahedral forms are common, and occur frequently in combination. Many specimens display some degree of apparent "melting," as if they had begun to soften and flow, losing the distinctness of their form, and yet staying bright and lustrous (probably the result of natural partial dissolution). Some specimens exhibit spinel-law twinning. Maximum crystal size is about 2.5 cm. In 1980 and 1981 a small number of galena specimens with associated white barite crystals were produced which are quite attractive.



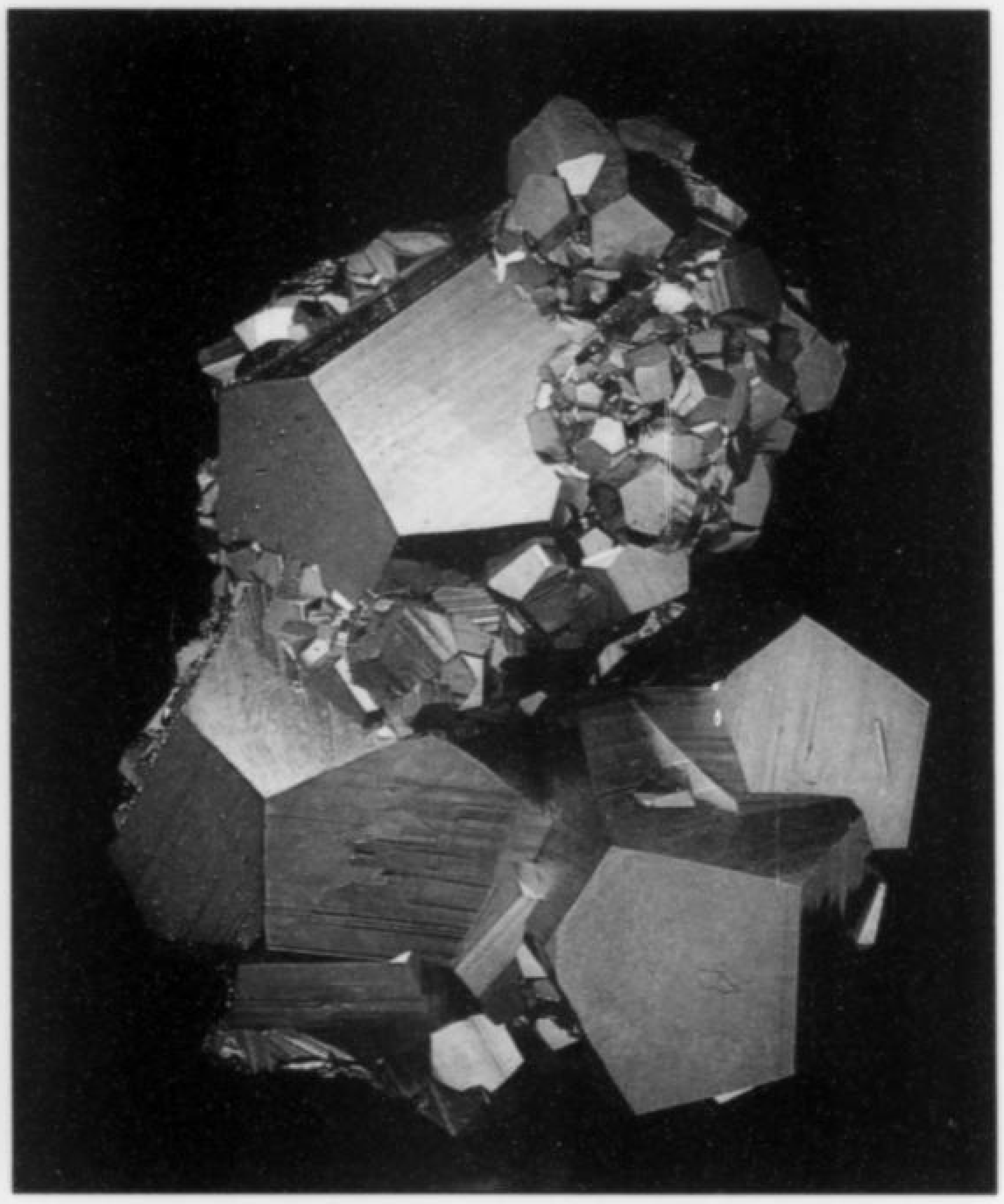


Figure 60. Pyrite crystal group, 5.8 cm, from Huanzala. Jack Halpern collection; Jeff Scovil photo.

Figure 59. Pyrite crystal group, 9.7 cm, from Huanzala. Steven Neely collection; Jeff Scovil photo.

Figure 61. Pyrite crystal group, 15 cm, from Huanzala. Gene Schlepp specimen; Wendell Wilson photo.

Hübnerite $MnWO_4$

Although a rare constituent of the ores, a few minor lots of beautiful, small, brilliant black crystals of hübnerite were recovered in the mid-1980's. Although nice, they are not up to the quality standards of the Pasto Bueno material.

Muscovite $KAl_2(Si_3Al)O_{10}(OH,F)_2$

Muscovite (sericite) is a common associated phase on pyrite specimens, usually in minor to trace amounts. On most specimens it is present as botryoidal to slightly tufted groups of microcrystals that are less than 1 mm long. Its color varies from pale beige to pale pink. Some specimens have a pale to light ice-green color. Sericite is usually found around the base of pyrite crystals, in crevices between pyrite crystals, and on the backs of mineral specimens. Other minerals are rarely present on the sericite; one notable exception is natrolite in white, acicular, brittle crystals. If the locality on a specimen's label is in doubt, and sericite is present without any other distinguishing minerals, then the sericite from Huanzala is distinctive enough to help differentiate the specimen from other Peruvian localities.

Pyrite FeS_2

Pyrite has been removed by the ton from the Huanzala mine. It must rank as the largest producer of pyrite specimens in the world. Pyrite occurs in cubic, pyritohedral, and octahedral forms, frequently with many modifications. All three forms are common, with the pyritohedral form somewhat dominant over the others. Crystals vary from mirror-bright to satiny in luster. Sericitic muscovite is commonly an associate mineral, but in minor amounts. Cubic crystals are usually striated, which sometimes gives a rib-like appearance to the crystal faces. Pyritohedrons are commonly modified by other forms, and their faces are lightly striated to mirror bright with no striations.

The most recent find of pyrite from Huanzala was reported by one of us (RHC) in the *Mineralogical Record* (1989). This 1988 find consisted of octahedral crystals averaging 8–10 cm in size, with large crystals to 25 cm on an edge. This find produced over 5 tons of specimens! Specimens exceeding 100 kg in weight were imported into the United States; some of these were so heavy that they had to be moved around on a "dolly." Miniatures were in short supply. At the Tucson shows in 1991 and 1992, RHC had a large lot of pyrite for sale that he obtained in 1990. This one lot weighed in at about 1000 kg. The pyrite included octahedral, cubic and pyritohedral forms in splendent groups, some of which were large enough to be a bit difficult to lift.

A magnificent pyrite specimen came out in 1982. It was part of a large lot of cubic pyrite. The specimen is composed of clusters of large pyrite cubes on a sericitic matrix, similar to the matrix supporting the pink fluorites. Large, clear octahedrons of fluorite are perched on one side of this specimen; the other side has large white calcite crystals, and the entire specimen is dusted with tiny bright sphalerite crystals.

One of the best Huanzala pyrite specimens, collected in 1989 or 1990, is now in the U.S. National Museum (Smithsonian). It is a "floater" group with octahedral crystals 25 cm on edge, weighing 63 kg (Dan Belsher, personal communication, 1992).

One of the more interesting types of pyrite from Huanzala is the *chispas* (meaning "sparkling") pyrite. *Chispas* pyrite has been exported by the ton for the decorator market. The authors estimate that over 1000 tons of this material have been collected and sold from this mine. It has been used as a base for countless thousands of pewter figurines that are set on the crystal masses. In 1987–1988 good specimens of *chispas* pyrite with small green octahedra of fluorite resting on the pyrite, were fairly common on the streets of Lima (Dan Belsher, personal communication, 1992).

Pyrite also occurs as replacements of other minerals; particularly notable are the attractive pseudomorphs of pyrite after bladed pyrrhotite in compact, parallel-stacked pseudohexagonal crystals. Pyrite after pyrrhotite may be associated with fluorite, quartz, arsenopyrite and other minerals.

Quartz SiO_2

Quartz can be one of the definitive minerals characterizing specimens from Huanzala. It is relatively common in trace amounts as small (usually 1–5 mm) crystals that occur in layers of almost drusy, white, waxy to satiny crystals. Although tiny, these quartz crystals are usually long and prismatic, and frequently occur in interlocking groups. Japan-Law twinning is present, but rare, and doubly terminated crystals are common. Quartz also occurs as scattered small patches or tiny clusters of white crystals which are nestled among the other mineral species. Although uncommon, larger crystals up to several cm long also occur, and resemble quartz crystal specimens from Huaron. The size and occurrence of quartz at Huanzala is distinctive; quartz crystals from other well-known Peruvian mineral localities are commonly much larger and showier, and generally just look different. Quiruvilca quartz is somewhat similar, but these crystals are generally stubby microcrystals rather than the more slender prismatic crystals found at Huanzala.

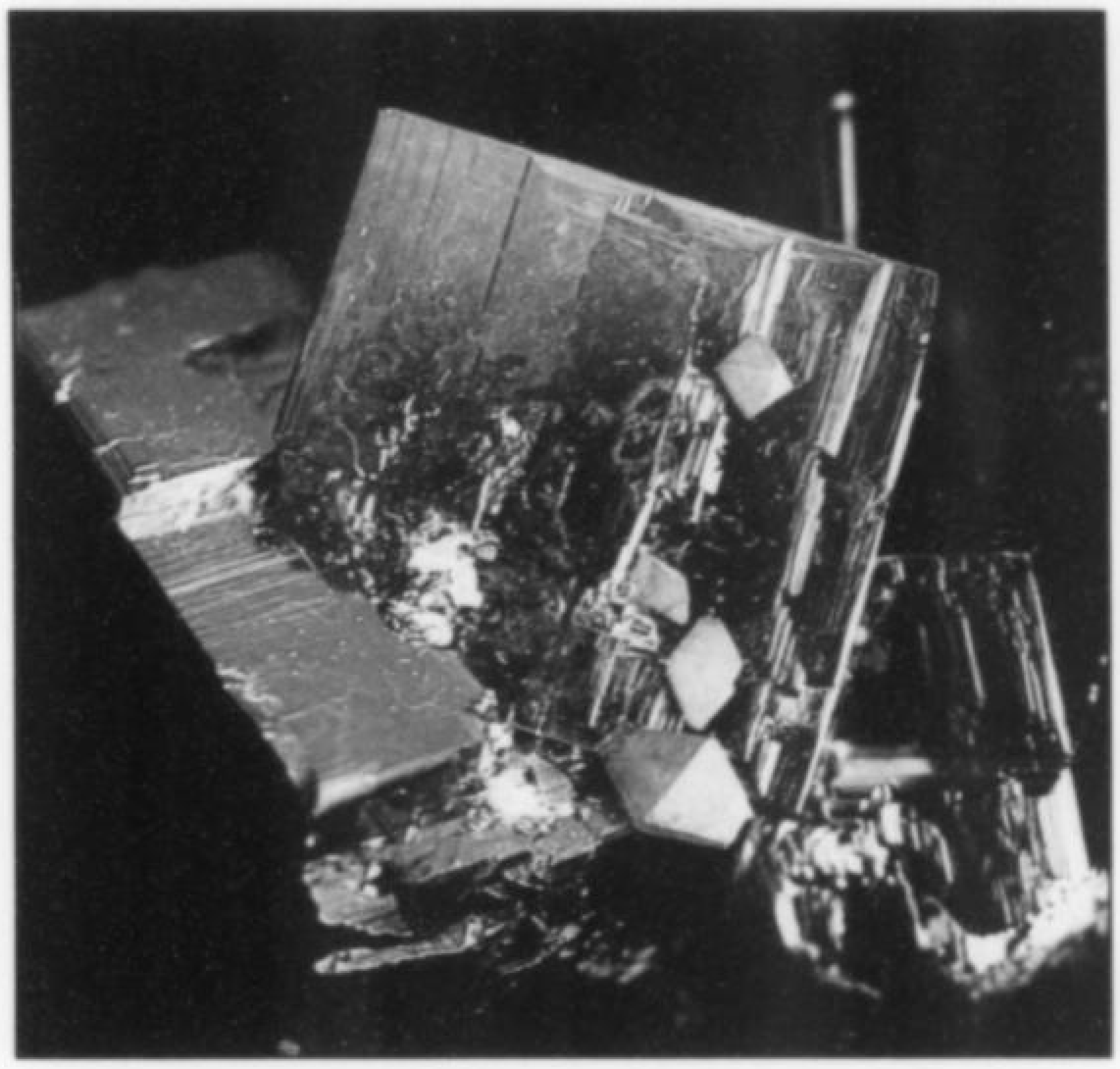


Figure 62. **Scheelite crystals to 6 mm on pyrite, from Huanzala. Jack Crowley specimen and photo.**

Scheelite $CaWO_4$

Scheelite, although uncommon, is an accessory mineral worth watching for. It usually occurs on or with pyrite or fluorite, and the crystals are normally microscopic, but they may reach up to 1 cm in size. The dominant form is an equant to slightly stretched pseudo-octahedron with blunt ends. The color of the crystals varies from beige to honey-yellow. These crystals are very rare in macroscopic specimens. One small lot of the larger crystals was recovered about 1982; we have not seen crystals larger than 6 mm.

Siderite (?) $Fe^{+2}CO_3$

Siderite(?) occurs as tan, saddle-shaped rhombic microcrystals which have a pinkish interior. These crystals may just be stained dolomite, but are different in form from the discoidal dolomite.

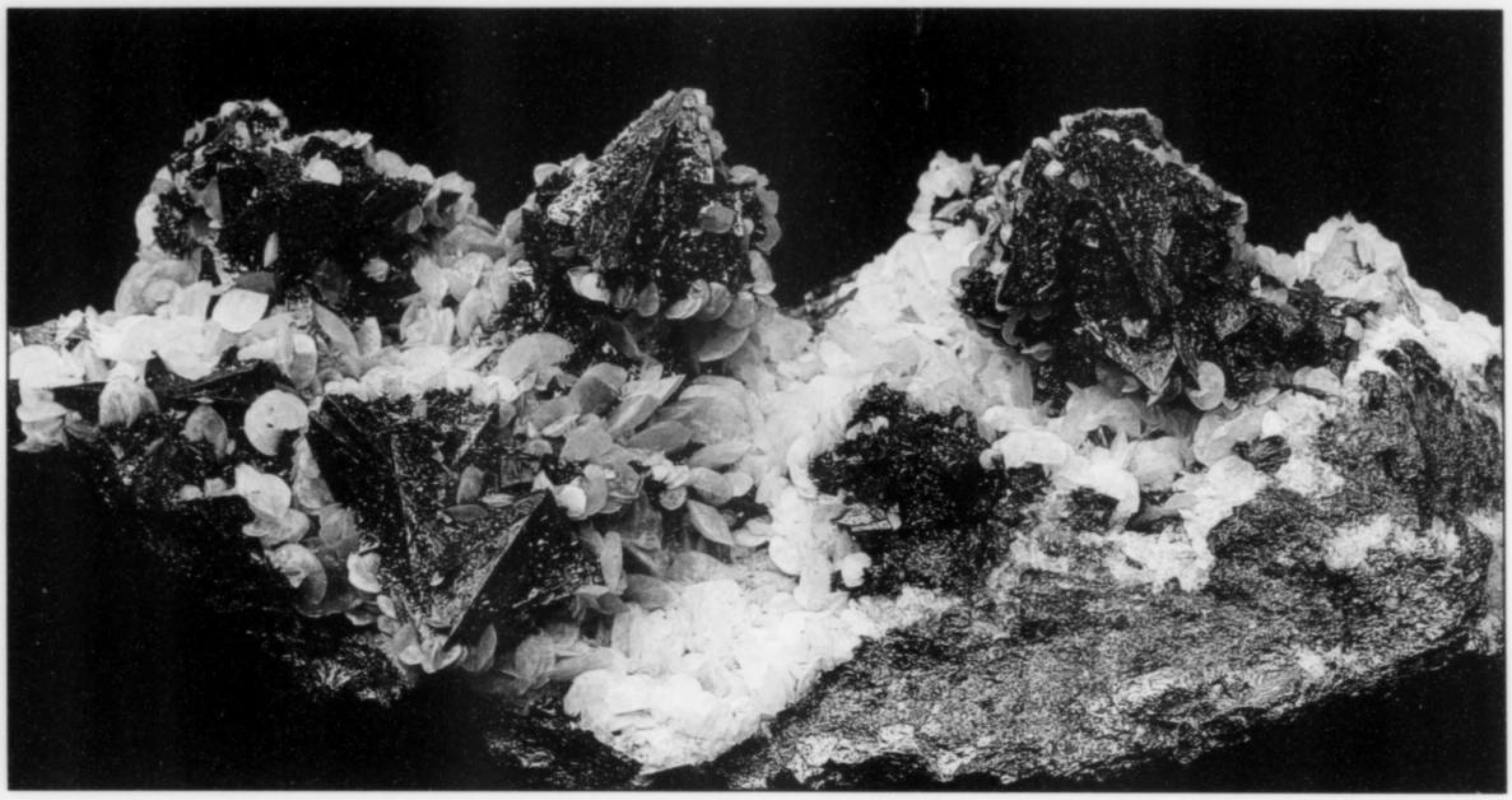


Figure 63. **Tetrahedrite crystals with calcite on matrix, 22 cm, from Huanzala. Rock Currier collection; Jack Crowley photo.**

Siderite(?) has been observed on arsenopyrite, sphalerite and pyrite.

Sphalerite (Zn,Fe)S

Huanzala is not noted for producing outstanding sphalerite specimens. The mineral usually occurs in blackish brown to black crystals that are a dark ruby-red to brownish red in transmitted light. Tetrahedrons are common and are frequently striated. Crystal faces vary from very bright and shiny to satiny in luster. Spinel-law twinning is relatively common. Tetrahedrons frequently tend towards a stepped or stacked pyramid appearance, due to deeply inset striations. The tetrahedrons are commonly modified by cube faces. The black shiny sphalerite crystals elicit no response under either shortwave or longwave ultraviolet light. A heavily ribbed, duller-luster "sphalerite" fluoresces a weak brick-red color under shortwave ultraviolet light, and elicits a much more pronounced brick-red color under longwave ultraviolet; this material may be wurtzite, but its identity has yet to be confirmed.

Tetrahedrite-tennantite $(Cu,Fe)_{12}Sb_4S_{13}$ - $(Cu,Fe)_{12}As_4S_{13}$

Imai *et al.* (1985) states that tennantite is the dominant member of the tetrahedrite group at Huanzala. Tennantite usually occurs in bright, lustrous, simple tetrahedrons with the "*o*" {111} face frequently modified by the dodecahedron and positive tristetrahedron. These modifications give the crystal faces a slightly curved look. Twinning is common. Large, highly modified, brilliant silvery-black tennantite crystals, associated with stubby white quartz crystals and tiny pyritohedral pyrite crystals, were collected during the late 1980's. Tetrahedrite on pyrite is one of the more common mineral combinations from Huanzala. The tennantite crystals may reach 4 cm in size in the best specimens.

BUYING PYRITE AT HUANZALA

When the miners and their lady-folk knew there was a mineral buyer in residence, it was not uncommon for the buyer to be surrounded by women calling out, "I have good *Chispas* today," "I have *cocos* (pyritohedral pyrite) today," "I have *cuadros* (cubic pyrite) today," or "I have *triangulos* (meaning "triangles"—octahedral pyrite) today." It would sound almost like the stock market, what individual stocks were doing that day. Of course the selling and buying of pyrite is illegal at the mine, but this only adds to the interest of the goings on.

Most miners live in dirt-floored houses. They bury the very best pyrite specimens in the dirt floors, and then dig them up when a trusted buyer appears. On one occasion in 1991 one of us (TS), a buyer, showed up at one of these miner's houses about 2 a.m. to purchase pyrite, an unlikely hour but a common practice due to the illegality of selling minerals. The miner was considerably inebriated, but still he proceeded to dig up the pyrite specimens. The shovel would go "ting" when it hit the specimens, but luckily, when the dirt was brushed off, all the important areas on the pyrite specimens were undamaged. Three large pieces were unearthed, the biggest weighing in at about 30 kg. A quick deal was struck, before the police might arrive, but then the buyer was faced with the problem of how to get all this weight of pyrite out of Huanzala. A storekeeper with a 3-wheeled bicycle (one wheel in back, two in front) was found, the pyrite was loaded into the basket on the front end, covered with burlap, and this "arrangement" was hand-wheeled up the road in the dead of night for a safe getaway.

When the *chispas* pyrite was coming out in such abundance, it was not uncommon for a buyer to wait at the mine to buy the material. At shift changes the miners would emerge carrying specially sewn knapsacks that were full of these *chispas* pyrite specimens. They would carry approximately 50 kg of pyrite in each knapsack. When they emerged, the miners were totally and completely coated with black pyrite dust; this made them look more like coal-miners. They were apparently working, at the time, in a totally pyritic environment. As the saying goes, "there are no old miners in Peru"; understandably so considering working conditions like these. Each shift would bring out a ton or more of specimen pyrite. Some miners would break the pyrite down by size, and price it accordingly. These specimens would all quickly be absorbed into the world marketplace. Demand has far exceeded the supply of this material, and since about 1989 the volume of *chispas* pyrite coming out of Huanzala has declined dramatically.

TS

AT HUANZALA IN 1988

During my trip to Lima in August of 1988, I bought a few specimens of what I thought was the tail end of a rather outstanding find of octahedral pyrite crystal clusters. As it turned out, however, these were just the leading edge of the find. The mine, Huanzala, soon went on strike and the stuff started to pour out, and continued to do so until about the middle of December.

According to the *pyriteros* (the guys who run back and forth from Lima to the mines, buying specimens, mostly pyrite, at the mines and selling it in Lima), the strike provided an ideal opportunity for the miners and a number of local men to spend full time collecting in the mine. During normal operations, only the miners have access to the mine, and their collecting of specimens is limited because they must attend to mining ore. They usually find a little time to collect specimens during lunch, between shifts, on Sundays, etc.

It was the kind of find that did not lend itself well to the production of small, choice specimens because individual crystals are so large . . . 8–10 cm on the average. I personally laid a ruler along the edge of the largest crystal I saw in Lima, and it measured 20 cm. The specimen that includes this crystal probably weighs at least 45 kg (100 pounds), but cannot be considered choice because of the amount of damage it has.

Ferdinand Zatch, a German dealer who has made Lima his home for the last few years, agreed that 20 cm is about the maximum crystal size for this find. He reported seeing one specimen of about 150 kg, but didn't buy it because the quality wasn't good enough. He estimates that the find may have produced as many as 100 specimens weighing 50 kg or more, and that 40 of these may have gone to Europe. From what I saw on the streets (in the homes and storerooms of the *pyriteros*), he is probably right. As in many big finds, however, the top specimens represent only a small percentage of the total.

In the entire find there is probably no such thing as a thumbnail or miniature-size specimen, and even good small cabinet pieces are rare. Because of the large average crystal size, the specimens will undoubtedly find their way into institutional collections as classics of their species.

The crystals have points truncated by small cube faces and other small forms; the octahedral edges are also modified to a small degree. The large crystal faces have small, angular, lustrous growth pits concentrated near the center. Some crystals are a bit dull, and some have a crust of drusy quartz centered on the growth pits. A few pyrite crystals are completely covered with gray drusy quartz, and one I saw is partially covered with black microcrystals of tetrahedrite. Some specimens show fractured and rehealed pyrite.

Judging from the configurations of some specimens, the vein must have had at least a meter of clearance in places, and must have run for many meters to yield so many pieces.

The prices for these pyrites ranged all over the map, depending more or less on the seller's perception of the buyer's wealth and experience. I saw one lot of perhaps 15 large specimens (which included some okay ones and a number of pigs) priced at $20 per kilogram. Other poor specimens went for as little as $2/kg; I got the impression that, had I pushed it, I could have bought the rubbish for $1/kg. One dollar per kilogram seems to be a sort of base price, at least for massive pyrite suitable for lapidary purposes. The cost of exporting specimens from Peru, because of government taxes and government manipulation of the exchange rate, is in excess of $1/kg, excluding the cost of shipping.

RHC
1989

THE MERCEDES MINE, HUALLANCA DISTRICT

Dos de Mayo Province
Huanuco Department

LOCATION

The Mercedes mine is another one of those locations that is surrounded by considerable mystery and confusion. This is partly due to the existence of several *Merced* or *Mercedes* mines in the central Peruvian mining belt. Little written information is available on the location.

Moore (1990a), erroneously lists the Mercedes mine location in the Department of Huancavelica but correctly lists the mine as the source of brilliant, large (up to 4 cm single crystals), metallic black tetrahedrite groups in flat plates to 15 cm on quartz-pyrite matrix.

Located high in the Andes above Huallanca and the Huanzala mine, the Mercedes mine is a small family-owned mine, that has been run at a marginal profit. Bodenlos and Ericksen (1955) list the mine as the "Merced" mine "about 5 km west of Huallanca" in the Huallanca district. The mine is located between the Huanzala mine and the town of Huallanca below, some distance off the main highway on the south side of a steep mountain. The country rock is pale gray coarse-grained sandstone overlain by dark gray metamorphosed shale. In the mine area the rock resembles the quartzitic matrix rock found at the Huanzala mine.

MINERALS

Tetrahedrite $(Cu,Fe)_{12}Sb_4S_{13}$

Tetrahedrite occurs in large, splendent crystals exceeding 7 cm in width. It is usually associated with near-microscopic pyritohedral pyrite and tiny, wart-like to drusy quartz crystals. Some tetrahedrite

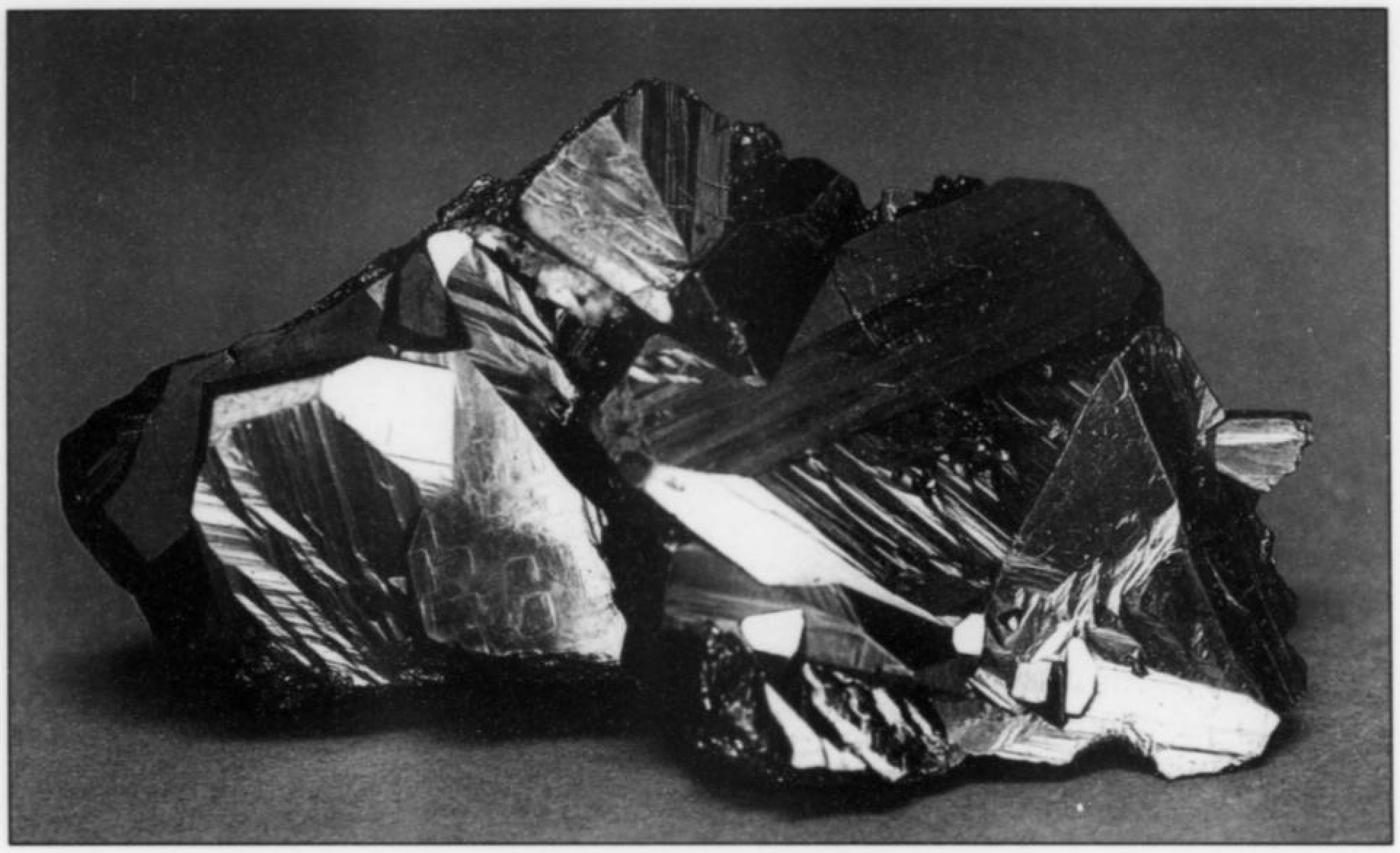


Figure 64. **Tetrahedrite crystal group, 9 cm, from the Mercedes mine. Jack Crowley specimen and photo.**

specimens are associated with, and partly coated by, a thin layer of pale green microcrystalline scorodite. The scorodite also coats the quartz and other associated minerals.

The tetrahedrite crystal habit is a simple tetrahedron with some modification. One of the better specimens from the Mercedes mine is in the U.S. National Museum (Smithsonian). It is a geode-like specimen approximately 18 cm across by 13 cm deep; it contains good size, highly lustrous simple tetrahedra of tetrahedrite (Dan Belsher, personal communication, 1992). Another fine specimen collected and sold from this mine is a flat plate about 25 cm across, covered with small milky drusy quartz, with large bright tetrahedrite crystals and crystal groups scattered across it. The only Peruvian location that has produced larger tetrahedrite crystals of this quality is Casapalca.

Chiurucu Mine

Dos de Mayo Province
Huanuco Department

LOCATION and HISTORY

Made famous by the discovery of fine rhodonite, the Chiurucu "mine" is actually just an exploration prospect. The prospect is to the east of Huanzala and was being developed by the Milpo Company, which was testing the deposit for minable reserves of base metals, when the rhodonite was discovered in April 1989. The prospect has been abandoned since 1990.

MINERALS

Rhodonite $(Mn^{2+},Fe^{2+},Mg,Ca)SiO_3$

The Chiurucu "mine" is noted for its fine-quality, intense reddish pink rhodonite, some of which grades to a very pale-pink to near-white color. This color variation probably reflects differences in chemical composition. The matrix is quartzitic and is similar to that from Huanzala, with mixed sulfides, quartz, and tiny cubic pyrite crystals. Only a few hundred rhodonite-bearing specimens were recovered, and none have been forthcoming since 1990. The best rhodonites gravitated to the town of Huallanca, where some of the miners and mining staff were housed. The rhodonite crystals must have been in flat plates in the vugs, as the specimens look uniformly the same, with their axe-blade-like terminations. Little information is available about the locality, and the prospect for further production of rhodonite specimens is unknown at this time.

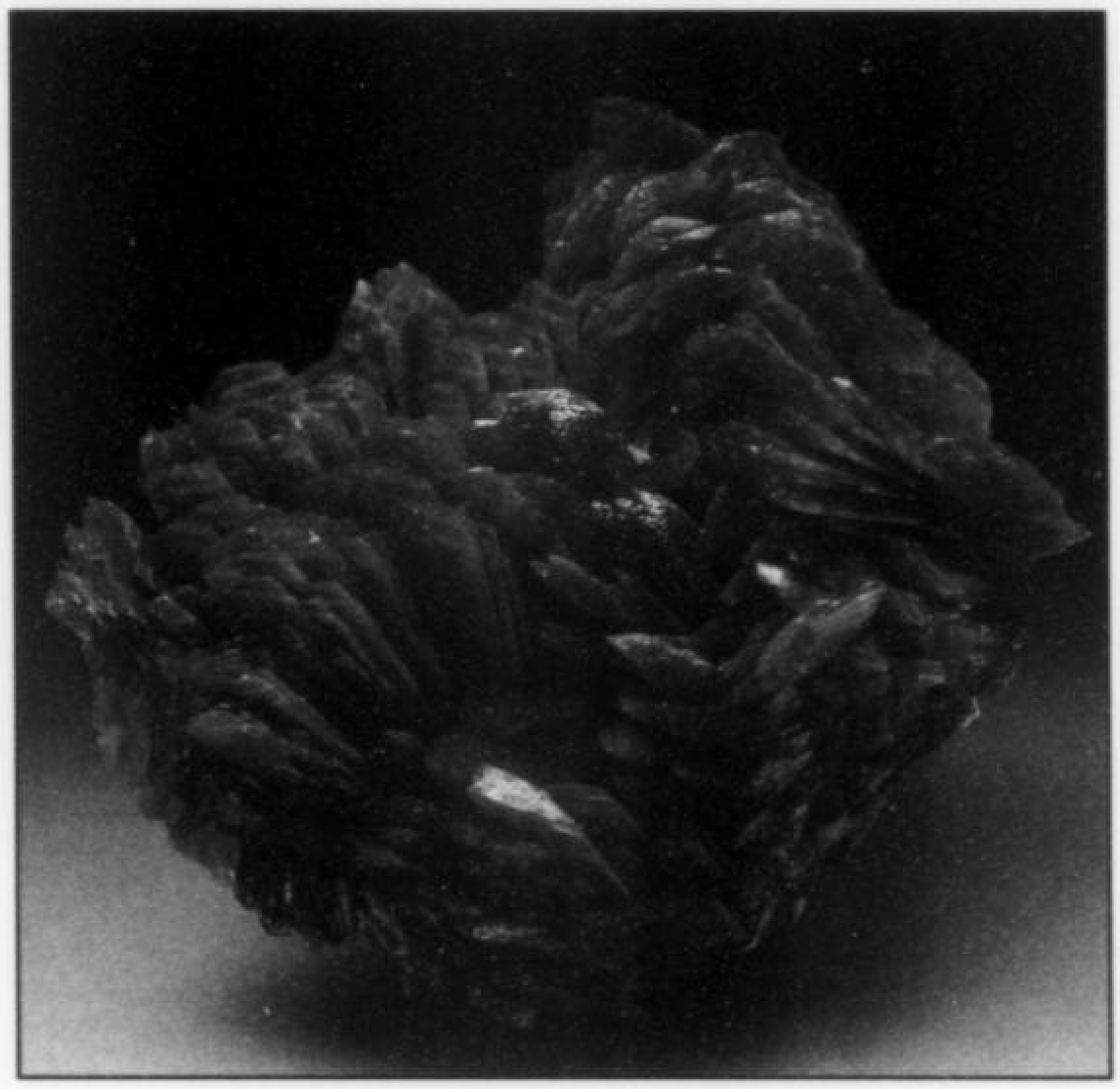


Figure 65. **Rhodonite crystal cluster, 6.7 cm, from the Chiurucu prospect. Betty Llewellyn collection; Jeff Scovil photo.**

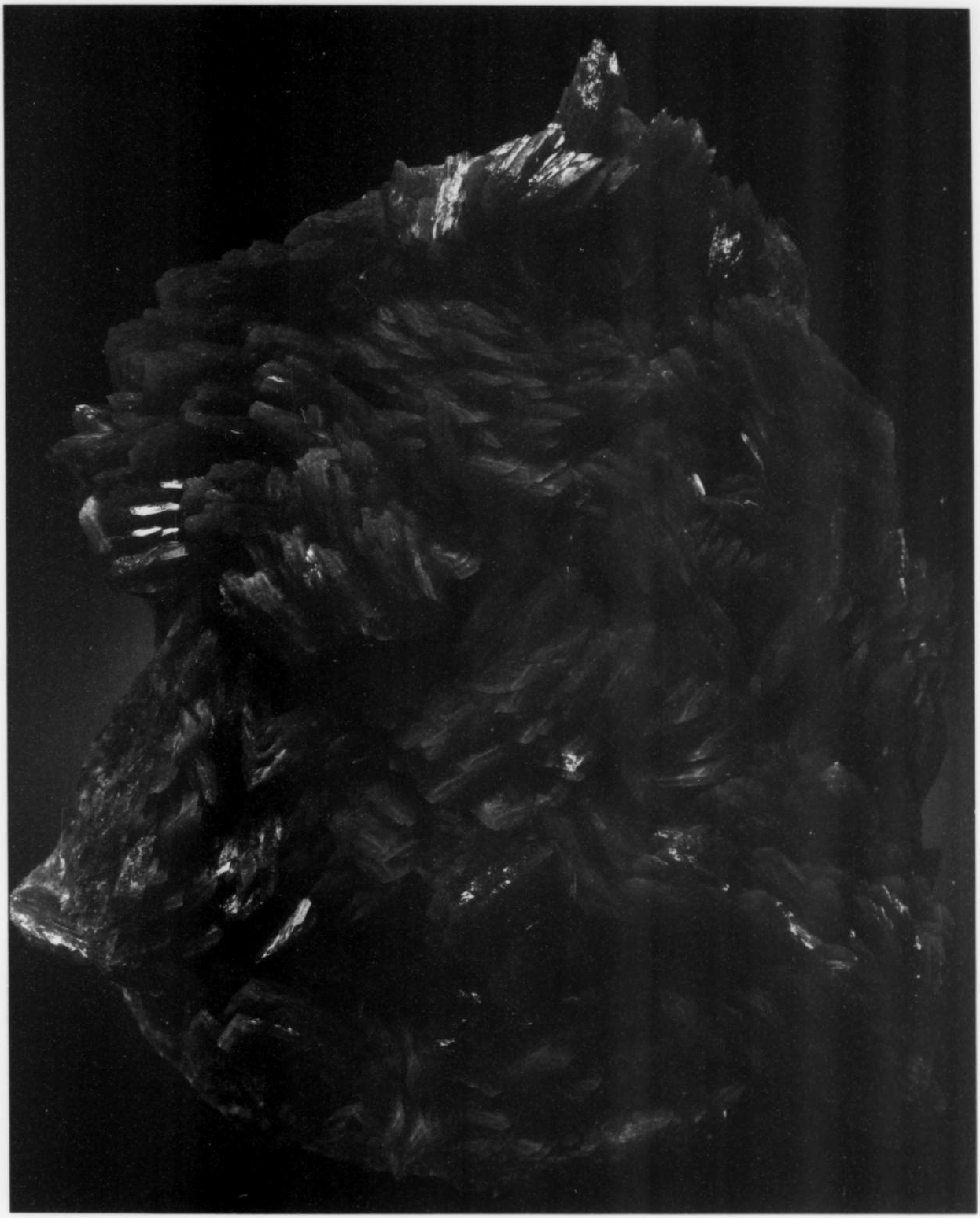


Figure 66. **Rhodonite crystal cluster, 11 cm across, from the Chiurucu prospect. Hyman and Beverly Savinar collection; Harold and Erica Van Pelt photo.**

The Uchucchacua Mine

Oyon Province
Lima Department

LOCATION

Uchucchacua is a silver-manganese-lead-zinc replacement vein and skarn district located about 20 km south of the Raura mine (Fig. 68). It lies very near the border with the Department of Junin. Elevations range from 4,500 meters to above 5,100 meters for the higher peaks.

HISTORY

Mining activity at Uchucchacua (originally known as Uchuc-Chacua) dates from colonial times. This is shown by the presence of abundant scattered workings almost entirely in the oxidized zone. Bussel *et al.* (1990) reported on the district, and much of the geologic data given below is from their paper. Regarding recent history they write:

> Noble visited and reported negatively on the district for the Cerro de Pasco Corporation, but the Compania de Minas Buenaventura . . . acquired options on the property and began exploration in 1960. Following promising results from preliminary mapping and drilling programs, a pilot plant with a capacity of 150 tons/day was constructed in 1975.

In the late 1970's exploration activities focused on the Carmen and Socorro mine areas (Fig. 67). This was followed in 1981 by the discovery of three large high-grade orebodies associated with the Rosa vein in the Carmen area. Vigorous expansion followed and production was increased to 500 short tons/day at an average grade of about 16 ounces of silver per ton. Uchucchacua became the third largest silver producer in Peru, with an annual production of 3 million ounces of silver and a subordinate but significant production of lead and zinc (Benavides, 1984). Discovery of the Claudia and Victoria orebodies, which lie to the south of the Rosa vein, has added further reserves. Mining levels range from 4,360 to 4,730 meters elevation, and the mine plant facilities are located at 4,500 meters.

GEOLOGY

Sedimentary rocks consist mainly of limestone and less commonly marl of the Cretaceous Jumasha Formation (Wilson, 1963; Cobbing, 1973; Romani, 1982). Major orebodies and mineral veins are all located in fractured rocks with gently inclined bedding which lie within the middle member of the Jumasha Formation. A variety of Ag, Mn, Pb and Zn-bearing minerals are associated with veins and skarn zones located around small intrusions of dacite. Ore occurs in veins and massive orebodies that formed in faults and wall rocks by a combination of fissure-filling and replacement.

Veins are common in the district, especially in the Carmen, Casualidad, Plomopampa, Mercedes, and Huantajalla-Candelaria areas. The Carmen area also contains several very important sheet-like replacement orebodies that are closely associated with the Rosa vein. There are several large replacement orebodies which are economically significant. Three of these orebodies, the Irma, Rosa Norte and Viviana, have been extensively mined; the others constitute potential reserves.

The orebodies occupy zones of brecciated limestone which contain high concentrations of sulfides and sulfosalts that occur as

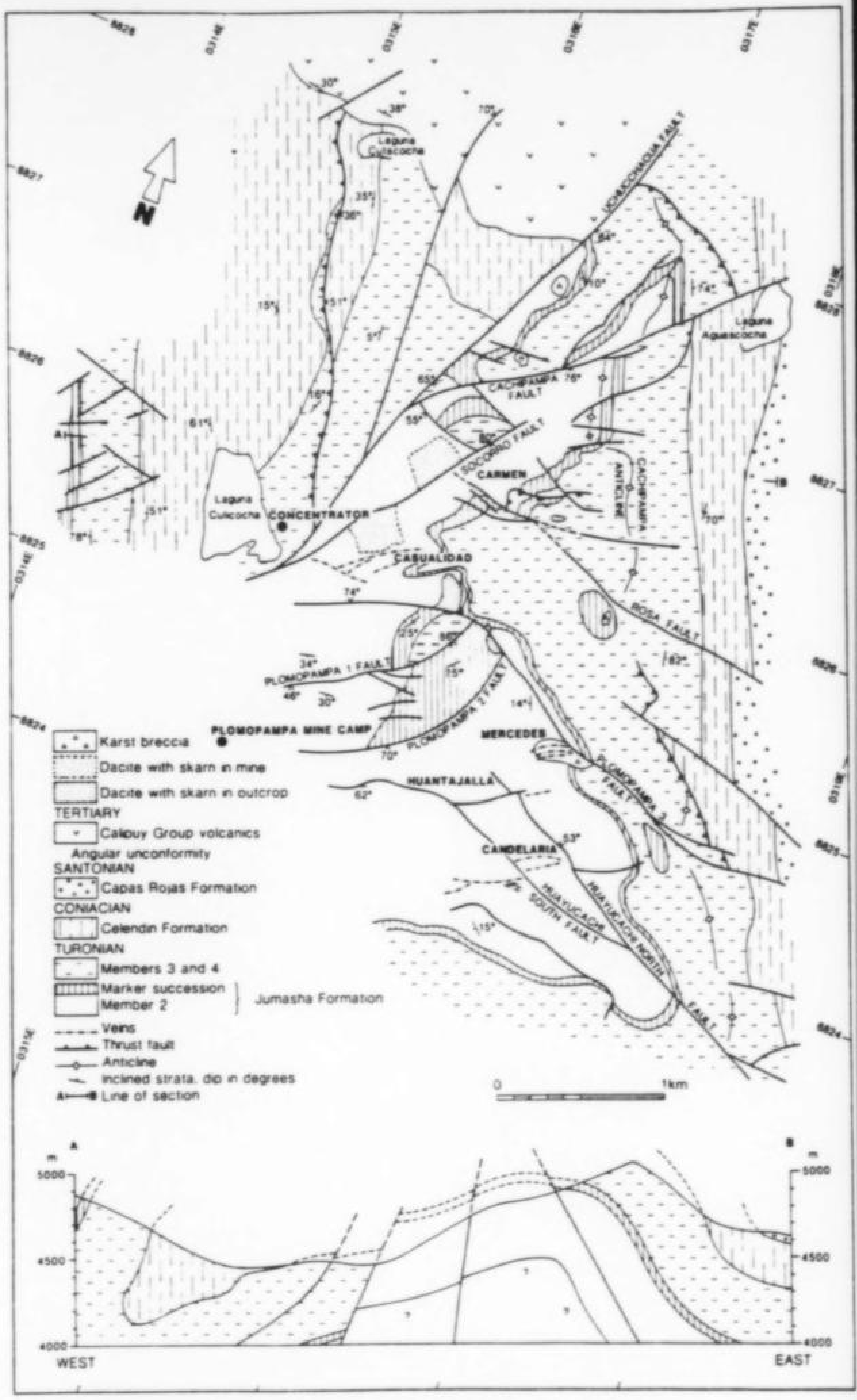


***Figure 67.* Geology of the Uchucchacua district (from Bussel *et al.*, 1990).**

replacement masses and veinlets. Hypogene mineralization has been broken into 3 stages: *Stage I*, skarn formation; *Stage II*, main mineralization; *Stage III*, late mineralization. Metals introduced in Stage I were manganese and iron. Metals introduced in Stage II were zinc, lead, iron, copper, boron and manganese. Metals introduced in Stage III were silver, arsenic, antimony, manganese, zinc, lead and iron.

Carbonates and sulfides occur along reaction fronts replacing the Mn-Fe-silicates. Sulfide and sulfosalt minerals include galena, wurtzite, alabandite, arsenopyrite, pyrite, pyrargyrite and tetrahedrite. Carbonate minerals include calcite, rhodochrosite, and kutnohorite. Elsewhere in the orebodies, fluorite, rhodochrosite and quartz are found crustified in vugs. They apparently formed at the end of the Stage II mineralization or during Stage III. Pyrargyrite and calcite can occur as overgrowths on the vuggy rhodochrosite. Rhodonite and bustamite are the principal gangue minerals for a significant tonnage of the manganese-calcium-silicate-bearing ore taken from stopes in the Luz vein, which is immediately west of the Rosa vein. This rhodonite-bustamite gangue is well-banded with alternating pink rhodonite and white or cream bustamite separated by thin bands of fine-grained sulfides. These thin sulfide

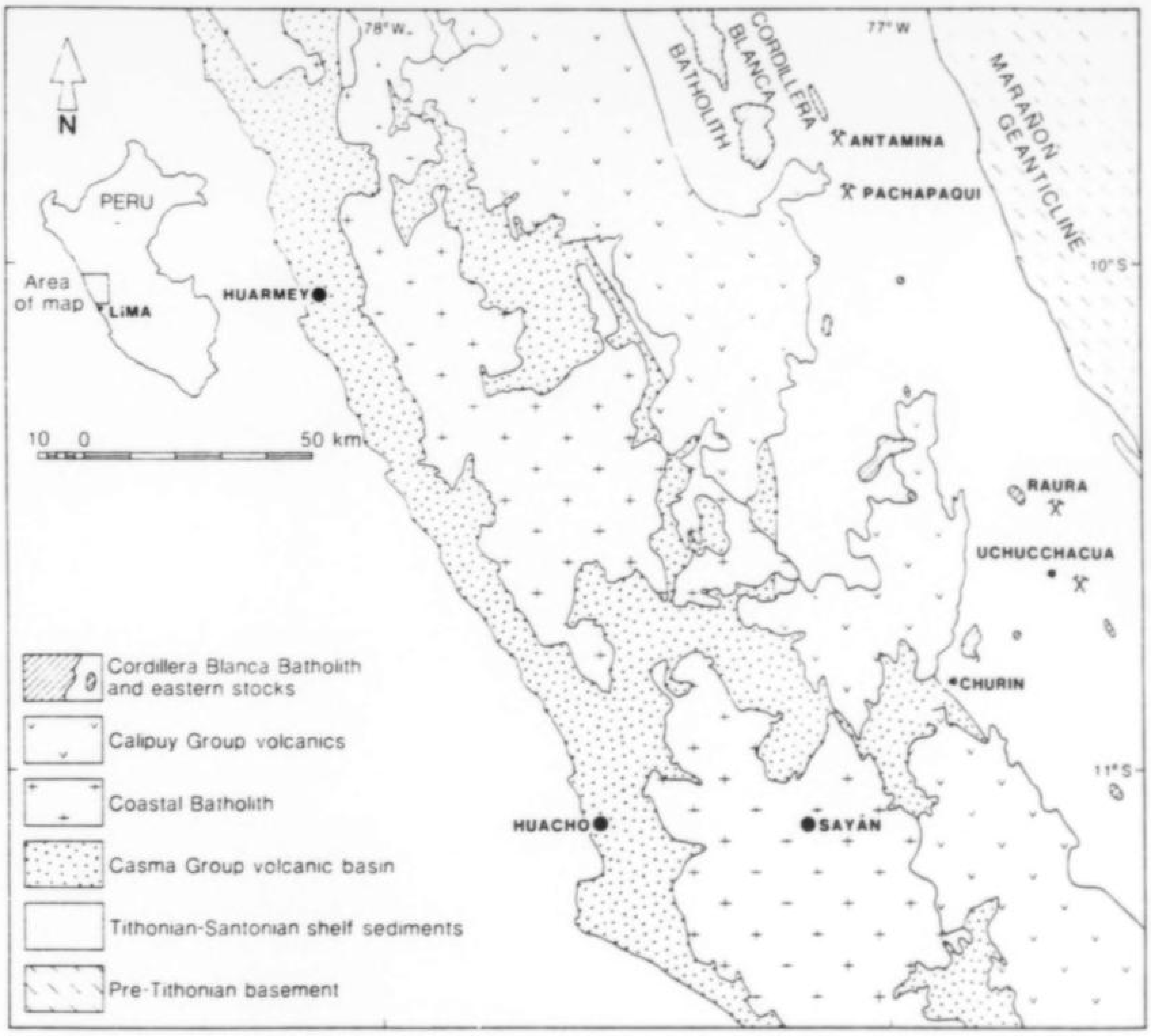


***Figure 68*. Geology of central Peru, showing the location of the Uchucchacua district in relation to the Raura and Pachapaqui districts (after Bussel *et al.*, 1990).**

***Table 6*. Minerals reported from the Uchucchacua district.**

	Common or Abundant	
Alabandite	Manganoan calcite	Sphalerite
Chalcopyrite	***Pyrrhotite**	Tetrahedrite
Galena	Quartz	Wurtzite
***Kutnohorite**	***Rhodochrosite**	
	Rare or Locally Abundant	
Andradite	Grossular	***Proustite**
***Acanthite**	Jamesonite	***Pyrargyrite**
Arsenopyrite	Johannsenite	***Pyrite**
Benavidesite	Magnetite	Realgar
Bournonite	Manganaxinite	Rhodonite
Bustamite	Mangan-pyrosmalite	Siderite
Cerussite		***Silver**
Enargite	Marcasite	Stibnite
Ferroan tephroite	Miargyrite	Uchucchacuaite
***Fluorite**	Orpiment	Wollastonite
Friedelite	Polybasite	

*Collector-quality specimens

bands are composed of alabandite, wurtzite, galena, arsenopyrite and pyrite.

Calcite is the dominant gangue mineral in the district. Minor amounts of quartz occur as stringers and irregular patches with the carbonates.

MINERALS

Specimens from Uchucchacua first came on the mineral market in 1983, with the appearance of raspberry-red to strawberry-red rhodochrosite. Also finding their way onto the market at about this same time were mineral specimens of fluorite, pyrrhotite, pyrite, proustite and pyrargyrite (in crystals up to 3 cm in size, averaging 1–2 cm). Kutnohorite was found in light to medium-pink, stalactitic aggregates.

Rhodochrosite $MnCO_3$

Rhodochrosite forms include scalenohedrons, rhombohedrons and hexagonal prismatic crystals. It occurs in translucent to transparent pink crusts of small-to medium-sized, rhombic crystals, frequently associated with small, white quartz crystals. It also occurs in deep raspberry-pink and strawberry-red translucent to transparent crystals to over 1 cm in size, with a modified scalenohedral to prismatic habit, and as gemmy rhombohedral crystals. Beautiful transparent to translucent crystals up to 2.5 cm in size have recently been collected. These began coming out in 1985 and are continuing to be recovered from the mine.

Uchucchacua rhodochrosite usually occurs on a dark manganese-rich matrix that is sometimes splotchy with light and dark patches; this matrix is distinctive for the locality. It has a tendency to break perpendicular to the face on which the crystals grow; as a result many specimens have a blocky matrix with a small amount of rhodochrosite crystals on one end. Better specimens usually have excess matrix removed by diamond saw. Quartz is often found with the rhodochrosite crystals. Another fairly common associate mineral is colorless, water-clear fluorite, which is found as bright cubic to cuboctahedral crystals to about 1 cm in size.

Much confusion surrounds Uchucchacua rhodochrosite because specimens are often mislabeled as coming from Pachapaqui, Raura, Casapalca or other Peruvian locations. Dan Belsher (personal communication, 1992) warns that, because of the tendency for crystals to pop off the matrix during trimming, a significant number of specimens may be repaired or manufactured. Specimens should be examined closely, particularly where only a few nice rhodochrosite crystals are involved.

Figure 69. **Rhodochrosite crystal, 2.8 cm, on matrix, from Uchucchacua. Bryan Lees specimen; Wendell Wilson photo.**

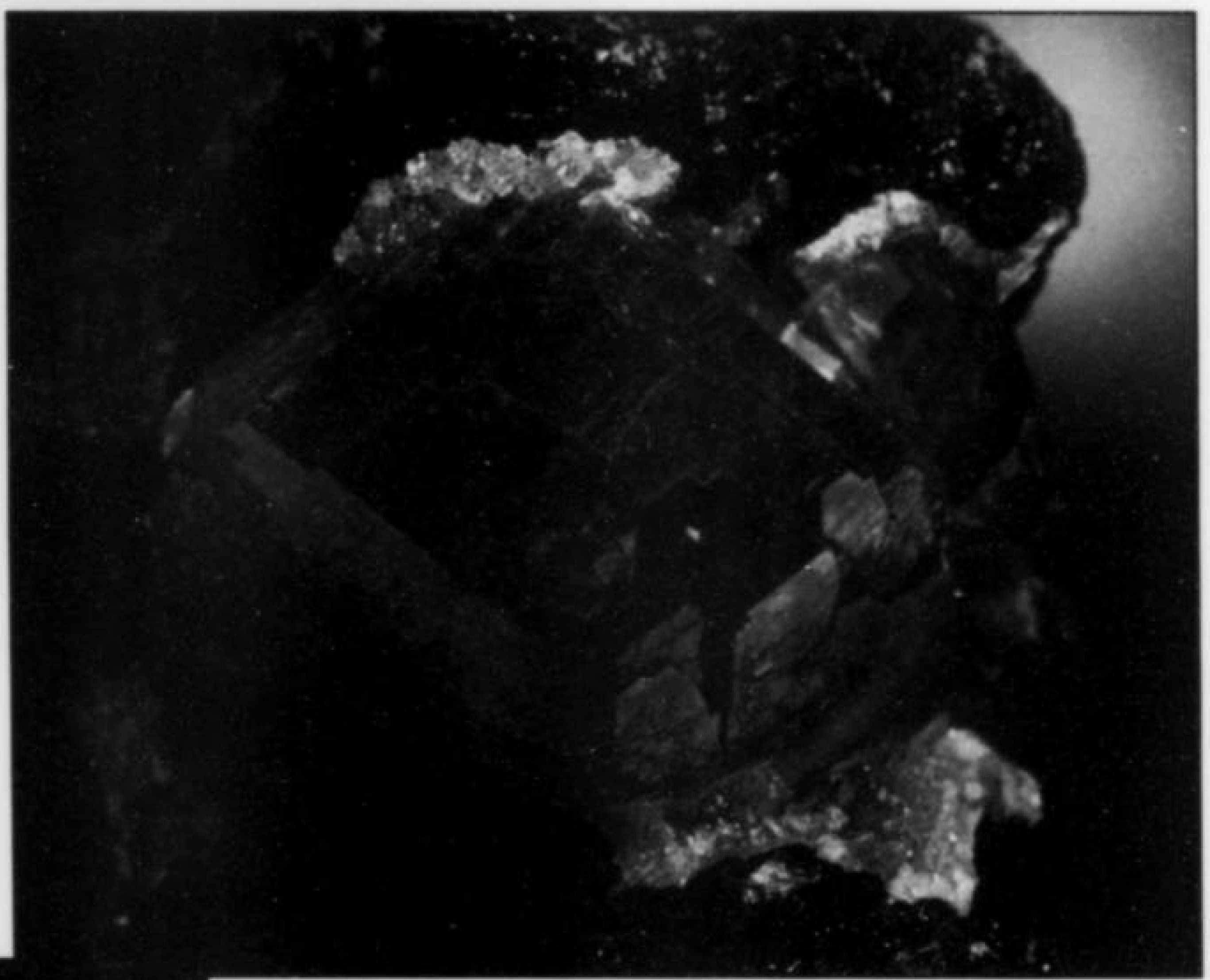


Figure 70. **Rhodochrosite crystal, 3.3 cm, from Uchucchacua. *International Mineral Exchange* specimen; Jeff Scovil photo.**

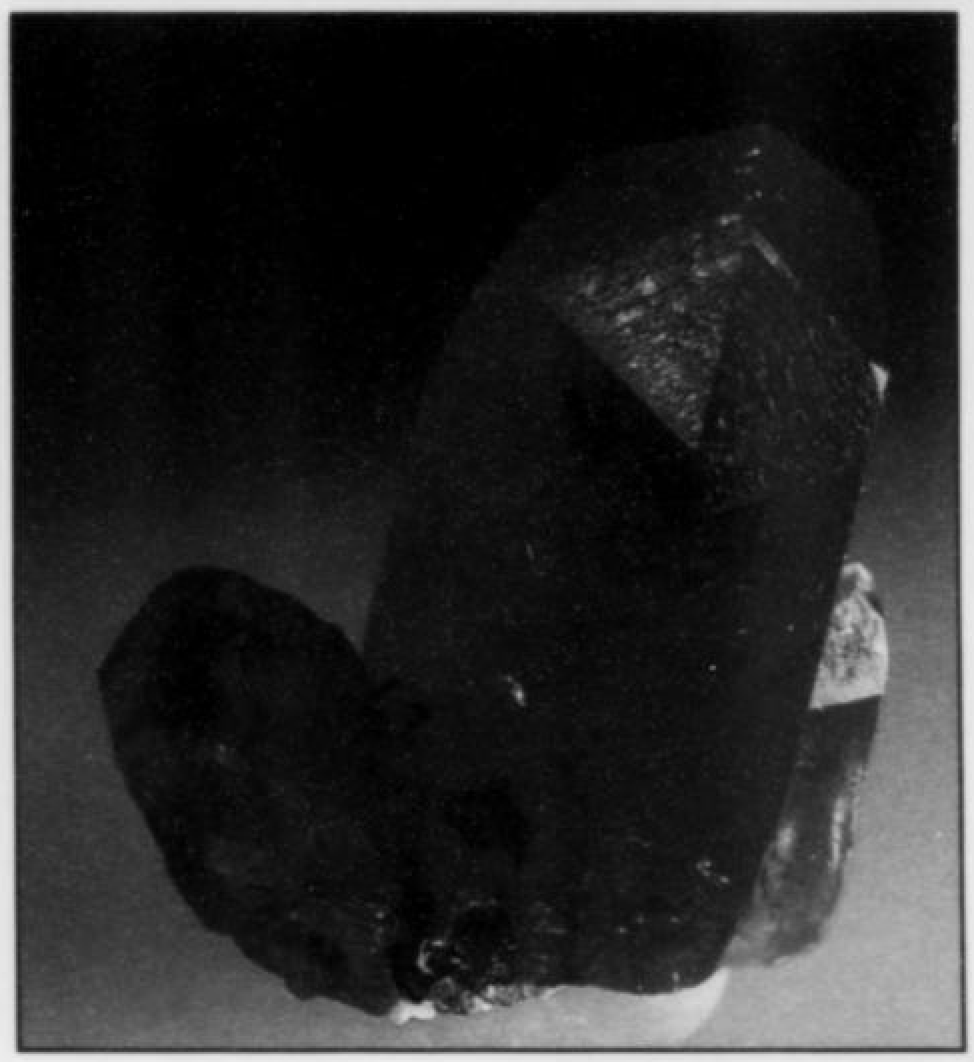


Figure 71. **Rhodochrosite crystal group, 2 cm, from Uchucchacua. Ralph Clark collection; Wendell Wilson photo.**

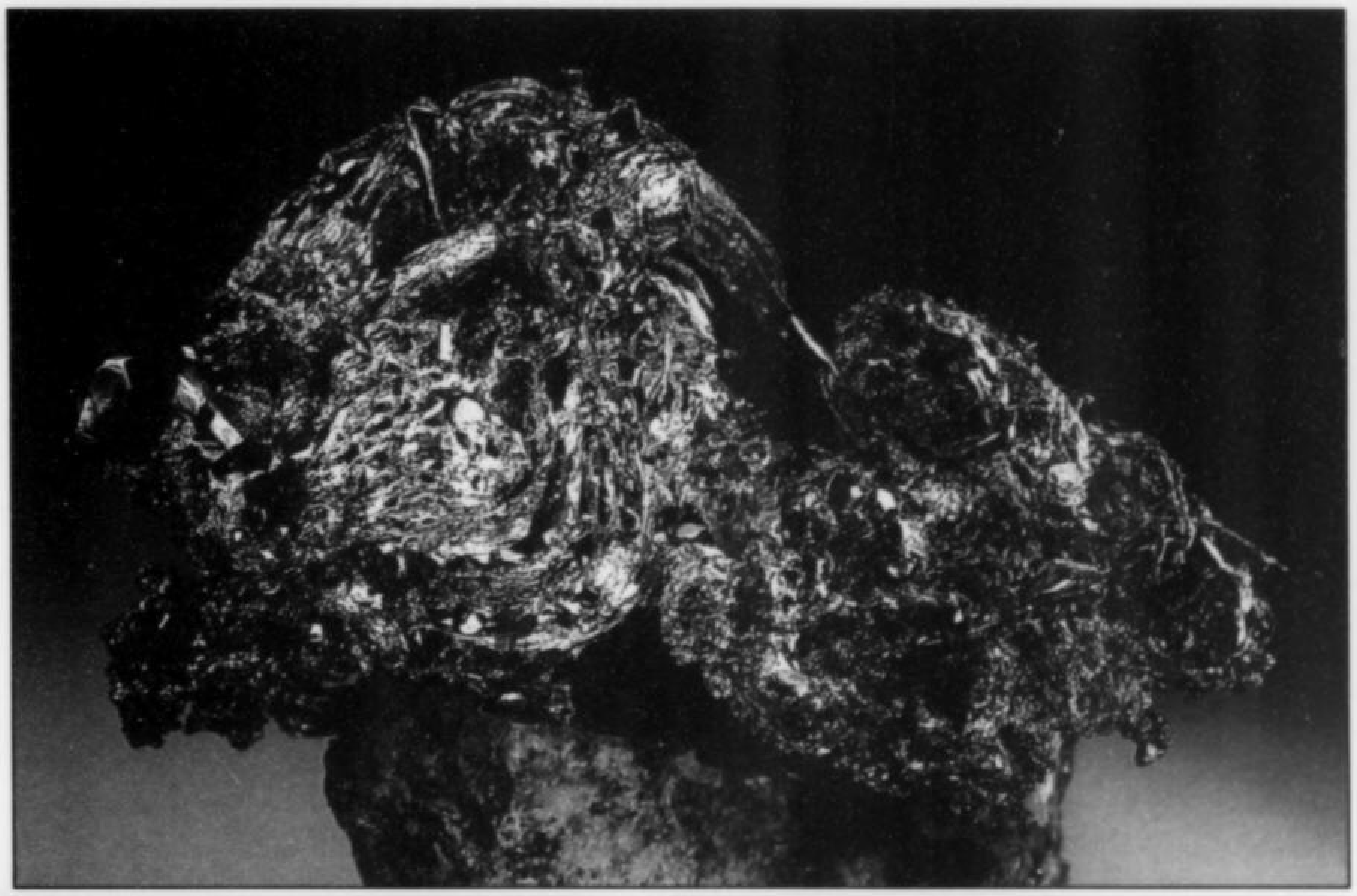
Figure 72. **Rhodochrosite crystal, 2.3 cm, from Uchucchacua. *Iteco* specimen; Jeff Scovil photo.**

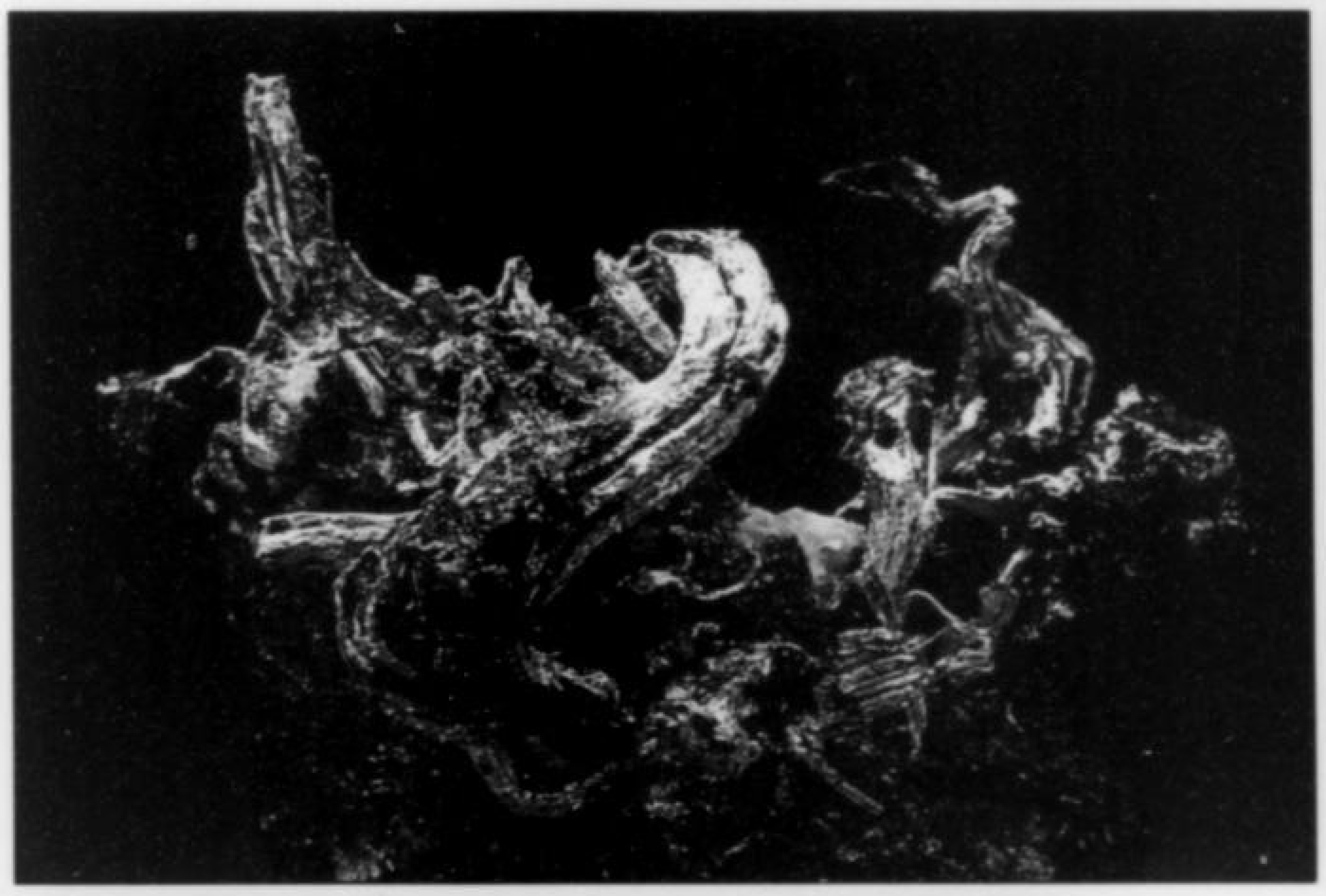
Figure 73. (right) **Rhodochrosite crystal, 1.3 cm, on matrix, from Uchucchacua. Wendell Wilson collection and photo.**

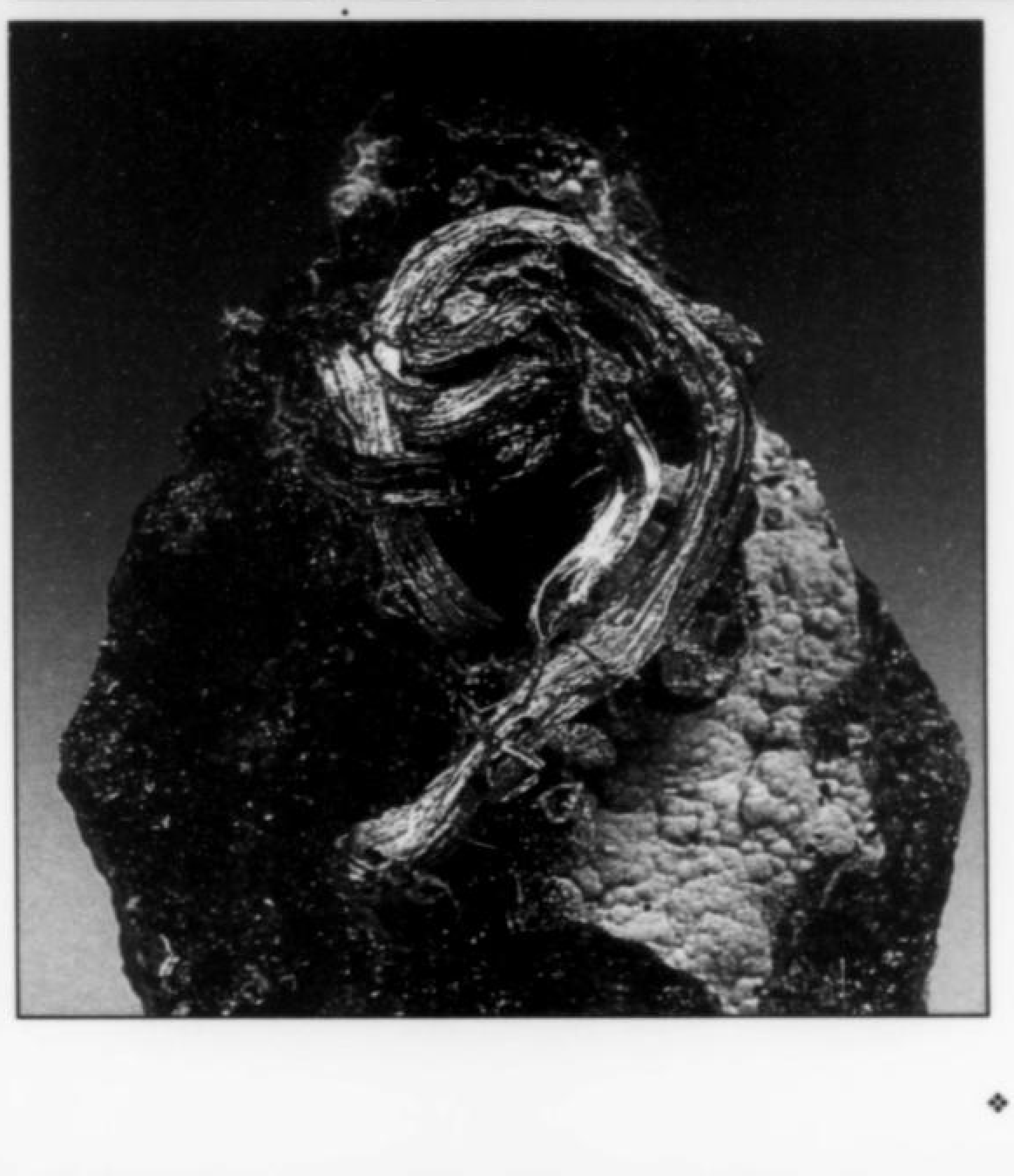
Figure 74. **Silver with black acanthite crystals, 4 cm, from Uchucchacua.** ***Tyson's Minerals*** **specimen; Wendell Wilson photo.**

Figure 75. (below) **Silver, 5.5 cm, from Uchucchacua.** ***International Mineral Exchange*** **specimen; Jeff Scovil photo.**

Figure 76. (bottom) **Silver on matrix, 7.4 cm, from Uchucchacua. Mike Bergmann specimen; Wendell Wilson photo.**







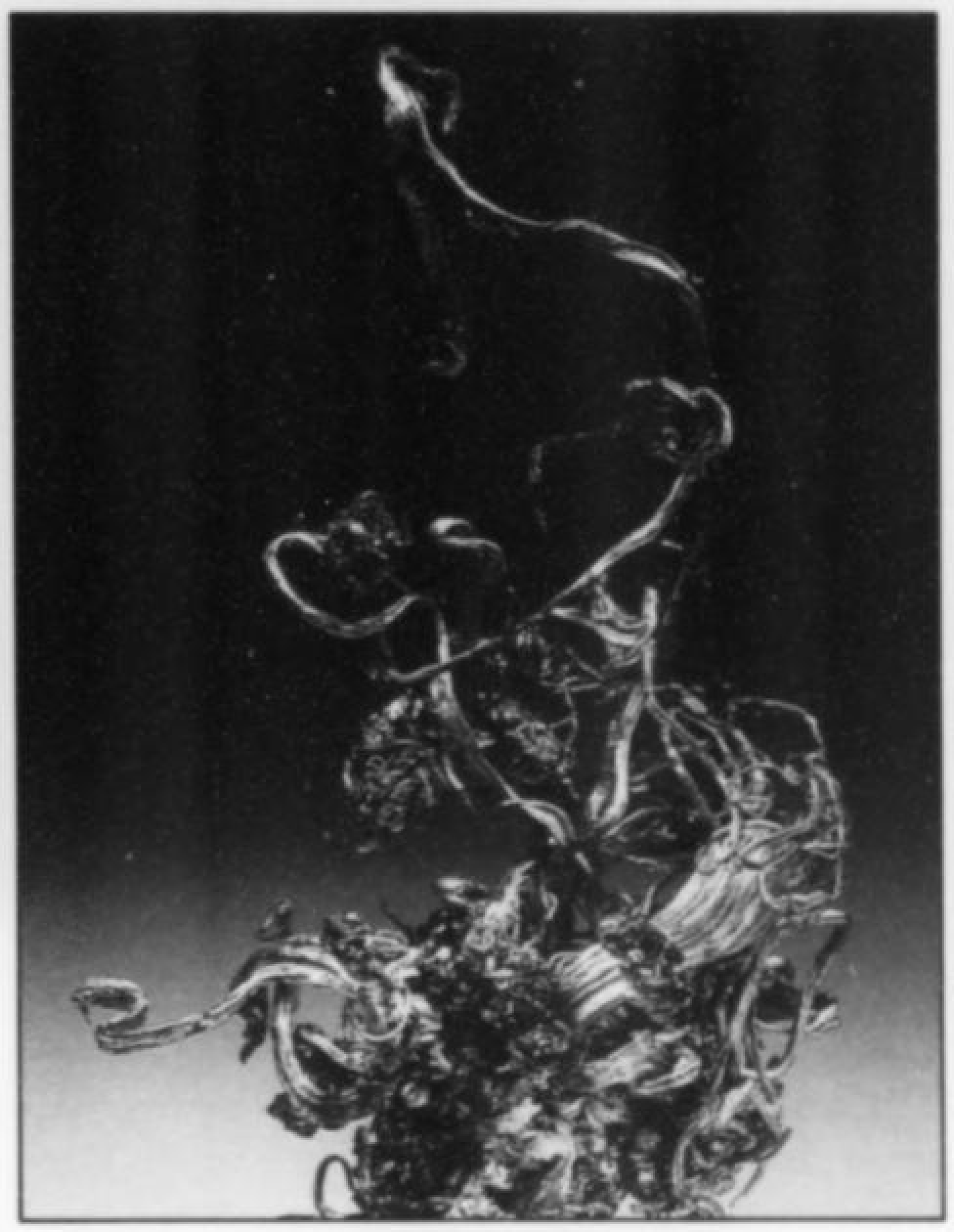


Figure 77. **Silver with black acanthite, 2.7 cm, from Uchucchacua. Terry Wallace collection; Wendell Wilson photo.**

Silver Ag

Native silver occurs as excellent examples of wire silver in vugs within massive galena, and on or in a grayish, altered rock. According to Dan Belsher (personal communication, 1992), the better silver specimens occur as "birds' nest" masses of wire silver, some of the best silver specimens to come from Peru in the past five to ten years. One miniature specimen he described, would have a wire of silver "8 to 9 inches long, if unraveled." Another specimen (in the Wendell Wilson collection) shows sharp, lustrous, black acanthite crystals of complex habit, to about 3 mm each, abundantly disseminated over thick wire silver on a quartz and galena matrix.

The Hercules Mine Area, Ticapampa District

Recuay and Aija Provinces
Ancash Department

LOCATION

The local area is known as the Callejon de Huaylas, and is considered one of the most beautiful regions of Peru. The district is divided into three parts geographically. The central area, trending northwest, is composed of high, very steep mountains of the Cordillera Negra, with elevations reaching over 4,600 meters. The other two areas are the less steep slopes to the west and east of this mountain chain. The west and east parts are less than 4,600 meters in elevation and are generally covered with glacial debris. Bedrock, where exposed from beneath the glacial debris, often shows extensive hydrothermal alteration. The district is approximately 18 km long by 17 km wide. Much of the following discussion is abstracted from Cabos and Tumialan (1975).

The main mines in the district are the Alianza, Hercules, Coturcan and Collaracra; other smaller mines are the Huran (also called Huaron), Huancapeti, Tarugo, Belota, Lorena, Coturcan, Dos Obreros, Gioconda, Florida, Estremadoyro, Maguina, Atahualpa, Carpa, Hinchis and Santa Rita. The Alianza mine is on the banks of the Santa River, and the Hercules mine is on the crest of the Cordillera Negra due west of Ticapampa (Purser, 1971). Siber (1987) lists the Hercules mine and the Alianza mine as the main sources of mineral specimens from the district. In 1991 all production from the Alianza, Hercules, Coturcan, and Collaracra mines was "temporarily" shut down except for "casual labor" production (Cavanagh, 1993?). The owner of the main mines in 1991 was the Compania Minera Alianza S.A.

GEOLOGY

The northwestern part of the district, near the Hercules, Huancapeti, and Tarugo mines, is mantled by volcanic rocks of the Tertiary Calipuy Formation. Underlying the volcanic rocks are Lower Cretaceous carbonaceous shales. The entire sequence has been penetrated by a series of porphyry intrusives.

There are three major epigenetic vein structures or systems—the Huancapeti, the Tarugo, and the Collaracra—and several minor ones. Most of the mines in the district are working these vein structures.

The Huancapeti and Tarugo vein systems are exploited by the Tarugo, Huancapeti and Hercules mines, which are the largest ones operating in this district. The veins show a variable temperature of deposition; the Hercules mine veins range from epithermal to mesothermal, the Tarugo mine veins are mesothermal, and the Huancapeti mine veins are epithermal. The Coturcan mines are physiographically higher than the Hercules mine, but are in the same general vein structure.

The Hercules mine is operating on at least eight different veins. These veins occur along fractures in Calipuy volcanics of early Tertiary age. The mineralization has in some cases replaced portions of the andesite walls of the veins, and in the main productive vein at the Hercules mine, mineralization falls off sharply when the vein passes into metamorphosed shales. The Hercules mine veins show three temperature-dependent pulses of depositional mineralization, the third stage being of lowest-temperature, and the second stage of highest temperature. The veins have a tendency to coalesce at depth. Metallic minerals found in the Hercules mine are pyrite, chalcopyrite, arsenopyrite, tetrahedrite-tennantite, pyrrhotite, sphalerite, jamesonite, bournonite and chalcocite. Many veins in the Hercules mine area have been prospected but not extensively developed. Minerals found in these veins, where they outcrop, are quartz, tourmaline, rhodochrosite, calcite, pyrite, marcasite, galena, sphalerite, chalcopyrite, argentite, pyrolusite and psilomelane. These veins, which number over a dozen, vary from 30 cm to 2 meters thick.

The Collaracra vein system contains pyrite, tetrahedrite, acanthite, sphalerite, arsenopyrite, chalcopyrite, jamesonite, boulangerite, bournonite, seligmanite, quartz, calcite and rhodochrosite. Arsenopyrite increases while pyrite and calcite decrease with depth. In the Huran vein (and mine) of this system, stibnite is present in the upper part of the vein. The Dos de Mayo (Alianza) mine is included within the Collaracra vein system.

Prior to metallic mineralization the area was subjected to a high-temperature alteration episode as evidenced by the presence of tourmaline. Many of the deposits have undergone more than one phase of mineralization; for example, as mentioned earlier, the Hercules mine shows three pulses of mineralization.

Table 7. **Minerals reported from the Hercules mine area.**

Acanthite	***Galena**	Rhodochrosite
***Arsenopyrite**	***Jamesonite**	Seligmanite
Boulangerite	***Pyrite** (pseudo -pyrrhotite)	***Sphalerite**
Bournonite		***Stibnite**
***Chalcopyrite**	***Quartz**	Tetrahedrite

*Collector-quality specimens

MINERALS

The district has never been a prolific producer of mineral specimens, but some material is occasionally offered on the market.

Octahedral galena, quartz, sphalerite, chalcopyrite, hair-like jamesonite, arsenopyrite, stibnite and calcite are all reported to occur in specimen quality. Quartz occurs with pyrite after pyrrhotite or with pyrite after chalcopyrite. In 1986 the Alianza mine furnished good sphalerite, galena, jamesonite and quartz specimens.

Arsenopyrite FeAsS

Arsenopyrite occurs most often as nearly acicular prismatic crystals up to about 1 cm in length. Some arsenopyrite crystals have odd, flattened, "waffle-like" terminations with an over-all diamond shape. It is also present as a metallic silvery replacement of pyrrhotite on a pyritic matrix. These can be bright and attractive specimens. Arsenopyrite specimens from this area can be very difficult to distinguish from those found at Huanzala.

Jamesonite $Pb_4FeSb_6S_{14}$

Jamesonite has been found in specimens that megascopically appear similar to the below-mentioned stibnite. Any specimens with bright sprays of acicular crystals should be examined closely to determine whether they are jamesonite or stibnite.

Stibnite Sb_2S_3

Nice specimens of stibnite were produced around 1984. The crystals are not large, and occur as bright acicular sprays in fist-sized vugs in the matrix.

The Cerro de Pasco Group

The Cerro de Pasco District

Alcides Carrion Province
Pasco Department

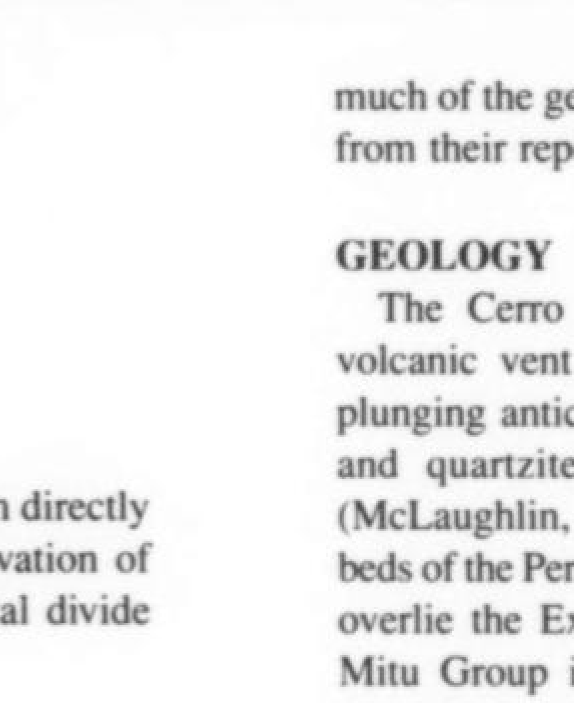
LOCATION

The Cerro de Pasco district is located about 190 km directly northeast of Lima on the Andean plateau at an elevation of 4,300 meters. The district lies east of the continental divide and west of the Cordillera Oriental.

HISTORY

Cerro de Pasco is one of the most extensively worked districts in Peru; discovered in 1630, it has been active for more than 300 years. Some 558 mines and another 1,000 small excavations were active in 1828. Many of the mine openings were located in peoples' houses for security reasons (Purser, 1971). By the 1840's, the town of Cerro de Pasco had 18,000 people.

In 1901 the Cerro de Pasco Mining Company was formed, and the railway from Lima to the Cerro (as the district was commonly abbreviated) was completed in 1904. The Cerro de Pasco Corporation became formal owners of the district mines in 1902.



Peru

Today the major mining at Cerro de Pasco is by open pit methods. The orebody at the Cerro de Pasco mine is estimated to have contained a total of 100 million tons of pyrite, 4 million tons of zinc, 2 million tons of lead (Petersen, 1965), in excess of 1 million tons of copper, 10 thousand tons of silver, and lesser amounts of gold and bismuth.

Cerro de Pasco has been extensively studied, and numerous papers have been written about its geology and ore deposits (McCutchan, 1945; McLaughlin, 1945; Parsons, 1945; Ward, 1961; Petersen, 1965; Purser, 1971; Silberman and Noble, 1977; and Einaudi, 1977). Einaudi (1977) and Ward (1961) did detailed studies of the Cerro, and much of the geologic and orebody data presented here is abstracted from their reports, as well as from the other authors listed above.

GEOLOGY

The Cerro de Pasco orebody is associated with a Tertiary volcanic vent which is located in the core of a broad, north-plunging anticline composed of highly contorted shales, phyllites and quartzites belonging to the Devonian Excelsior Group (McLaughlin, 1924; Jenks, 1951). On the surface, continental red beds of the Permian Mitu Group (Newell *et al.*, 1953) unconformably overlie the Excelsior Group on both limbs of the anticline. The Mitu Group is, however, absent or unrecognized in the underground mine workings. Underground, the Triassic-Jurassic Pucara Limestone appears to overlie the Excelsior Group shales. The Pucara Group, the main lead-zinc ore host rock, consists of thick-bedded, dark colored limestone and dolomite with infrequent cherty shale interbeds (Jenks, 1951).

A volcanic vent 2.5 km in diameter is filled with pyroclastic breccia that has been intruded by multiple plugs and dikes of quartz monzonite porphyry. Subsequent hydrothermal fluids associated with the volcanic activity deposited massive replacement and fissure-vein sulfides that formed a steep, funnel-shaped, massive pyrite-quartz body in the limestone wall rocks (Ward, 1961).

Lead-zinc ore is depositionally associated with pyrrhotite and is composed of pyrite, sphalerite, galena and quartz, with minor pyrrhotite, arsenopyrite, marcasite, tennantite, chalcopyrite, chlorite, sericite, siderite and calcite.

Enargite and enargite-tennantite ore occurs in steep veins in the vent and in a pyrite-quartz body, and also occurs in steep pipes associated with the veins in the northern portion of the pyrite-quartz body (Ward, 1961). The vein minerals are pyrite-enargite, with minor quartz, barite and epidote. Zoning in the veins is symmetrically developed relative to the contact between the vein and the pyrite-quartz body (Ward, 1961).

The last hydrothermal activity at Cerro de Pasco caused local leaching of previously deposited sulfides, the formation of collapse breccias, and the open-space deposition of a host of rare

Figure 78. **Silver mines of Cerro de Pasco (Simonin, 1869).**

minerals. Assemblages include: pyrite-hematite-realgar associated with high-silver mineralization consisting of a complex association which includes gratonite, baumhauerite, aramayoite, "waxy" sphalerite, and galena (Ward, 1961); and alunite-native sulfur vug fillings in enargite-pyrite pipes (Cerro de Pasco Corporation, 1950). Barite is common near enargite-tennantite pipes in the northern portion of the pyrite-quartz body.

According to Ward (1961), enargite is the principal hypogene mineral, other than pyrite, in many of the primary copper orebodies. Enargite has been found as large, bladed crystals nearly 20 cm long in cavities in pyrite. It is replaced by, or intergrown with, tennantite, chalcopyrite, primary and secondary chalcocite, and pyrite, which it in turn replaces. Enargite predominantly occurs as an open-space filling throughout the mine. Luzonite, which differs in color from enargite, is found in the Cleopatra vein and in orebodies with a high gold content. One of the very rare "minerals" reported from Cerro de Pasco is "revoredoite" which is actually not a true mineral but an amorphous As-S glass. Chalcocite replaces enargite and pyrite on the margins of some primary copper orebodies. Covellite, malachite and native copper are minor minerals.

Table 8. **Minerals reported from Cerro de Pasco.**

	Common or Abundant	
***Barite**	***Pyrite**	***Sphalerite**
***Enargite**	Pyrrhotite	***Tennantite**
***Galena**	Quartz	
	Rare or Locally Abundant	
Aramayoite	Covellite	Marcasite
Arsenopyrite	Freibergite	Native Copper
Baumhauerite	***Gratonite**	Realgar
Bismuthinite	Hematite	Siderite
Bornite	Jamesonite	Stannite
Calcite	Luzonite	Vivianite
Chalcocite	Magnetite	Wolframite
Chalcopyrite	Malachite	

*Collector-quality specimens

MINERALS

Cerro de Pasco was noted for having fine specimens during the first half of this century, but only a few of them made their way into museums and private collections. Not many specimens have come out in the past 30 years, partly due to the advent of extensive open-pit mining. During the late 1960's and into the early 1970's, many of the specimens coming from Peru were labeled as coming from Cerro de Pasco. This was just an expedient for the Peruvian dealers; knowing that the mineral market required a locality for specimens, they labeled almost everything as coming from Cerro de Pasco. Except for specimens definitely collected prior to the 1970's, many of those labeled Cerro de Pasco are suspect.

Enargite Cu_3AsS_4

Attractive, large sprays of enargite were reported from Cerro de Pasco prior to 1970.

Gratonite $Pb_9As_4S_{15}$

Cerro de Pasco is the type locality for gratonite (Palache and Fisher, 1940), and has produced the world's best specimens. Examples first came to the attention of mineralogists in 1938,

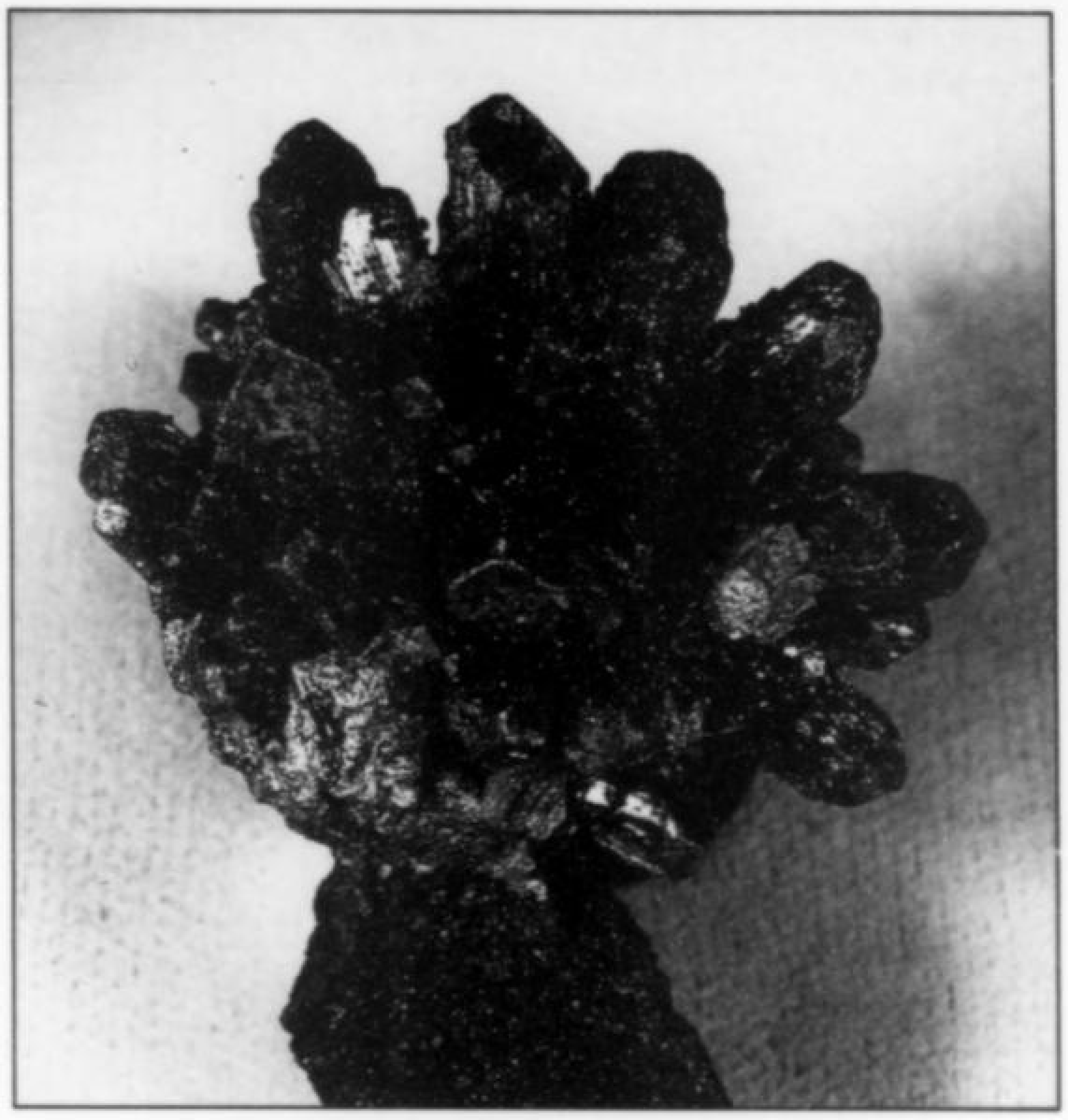


Figure 79. **Gratonite crystal cluster, 2.5 cm, from Cerro de Pasco. Smithsonian Institution specimen C-6683; Rock Currier photo.**

when Ward's Natural Science Establishment sent specimens to Harvard for identification, and at the same time George Rust of the geological staff at Cerro de Pasco sent specimens to the University of Chicago for identification. Charles Palache (at Harvard) and D. Jerome Fisher (in Chicago) collaborated on the formal description.

Crystals of gratonite on the type specimens are dark lead-gray and up to 1 x 1.5 cm in size, in stout to elongated hexagonal prisms with trigonal pyramid terminations, and in some cases with small modifications. They are typically in radiated groups to 5 cm on gray siliceous matrix. The stubby crystals can easily be mistaken for dodecahedrons. Rare examples show probable contact twinning at 30° to the *c* axes.

Rust (1940) described the original occurrence as a small, high-grade orebody situated below a flat-lying dike on the 1400-foot level of the mine. The first gratonite specimens were recovered from the outer fringes of this orebody, in fractures and solution cavities in a heavily leached and altered igneous rock. This extreme vugginess of the host rock accounts for the high quality and large crystal size exhibited by the specimens. More specimens were then found nearby; Rust described the subsequent find as follows:

> So extreme was this dissolution [causing the alteration and vugginess of the host rock] that a few feet to the north of the loose material in which the gratonite [first found] was deposited, the ground has collapsed leaving a large cave. This opening is about 40 feet across and averages about 15 feet in height. Its floor is covered with an unknown thickness of loose material which has caved from the roof. Three sides of this cave are composed of the same porous siliceous rock, which also carries some gratonite. Locally the host rock has broken down into a loose sandy mass of quartz grains. Much gratonite [also] occurs in this sandy material, as isolated clusters of crystals.

Rust reports that gratonite is found replacing galena along cleavage planes and fractures, and as well-formed crystals growing in open fractures in galena. Other minerals that appear to be part of the same stage of mineralization as gratonite include pyrite, freibergite, chalcocite, bornite and lesser amounts of bismuthinite, chalcopyrite, covellite and possibly arsenopyrite. Realgar also appears locally. None of these species occur in actual contact with gratonite except galena.

Gratonite was also found at two other locations within the mine: a stope 150 feet above the main occurrence on the 1400 level, and on the A level 300 feet below the surface, where it was found associated with high-grade Cu-Pb-Zn ore. Gratonite has therefore been found over a range in depth of at least 1100 feet, and may well have subsequently been found at other locations within the mine. One of us (RHC) visited the mine in 1974 and was surprised to be offered about two dozen thumbnail-size gratonite specimens, so there is no telling where and for how long specimens continued to be found after the initial discovery in 1938.

Colquijirca Mine

Cerro de Pasco Province
Pasco Department

LOCATION

Colquijirca is located 10 km south of Cerro de Pasco, at an elevation of 4,500 meters, and is one of the old Colonial mines that has been intermittently worked for rich near-surface ores for hundreds of years. The Colquijirca mine, now called the El Brocal mine, is one of Peru's oldest continuously operated mines.

GEOLOGY

Colquijirca is described as a lead-zinc-silver mine. The area of mineralization measures about 1 x 3 km. The mineralization is related to a dacite porphyry located about 1 km south of the mine. Colquijirca and Cerro de Pasco are both situated on the same longitudinal fault system. At Colquijirca, the predominant mineralization is in the carbonate portions of the Casapalca Formation. At Cerro de Pasco the predominant mineralization in the sedimentary series is in the Pucara Group limestones and related rocks.

Two main orebodies occur at Colquijirca; a stratigraphically lower pyrite-enargite zone, and a stratigraphically higher lead-zinc-silver zone. The lead-zinc-silver zone is separated from the pyrite-enargite zone by an unmineralized sandstone layer. Both orebodies occur as a series of replacement beds (or *mantos*). Several *mantos* were encountered over a stratigraphic distance of 50 meters. The lead and zinc beds form the middle members of the deposit, with the copper-rich enargite zone below them and the silver-rich sulfosalt zone above them. Lindgren (1935) felt this rapid change of mineralization was due to very rapid cooling of the mineralizing fluids over this short vertical distance, rather than a telescoping of the ore deposit.

Table 9. **Minerals reported from the Colquijirca mine.**

	Common or Abundant	
Barite	Galena	Sphalerite
***Chalcopyrite**	Marcasite	Tennantite
***Enargite**	Pyrite	
	Uncommon or Locally Abundant	
Ankerite	Hematite	Stromeyerite
Dolomite	***Native silver**	Wittichenite

*Collector-quality specimens

Brown-colored chert is the dominant matrix material for the ore minerals, particularly the lead-zinc-silver species. Kaolinite, dolomite and ankerite are less common as gangue minerals. Barite is ubiquitous, particularly in the enargite ore. The order of deposition for the sulfide minerals is: Ag-poor pyrite, sphalerite, enargite, tennantite, galena, and chalcopyrite. Bismuth-bearing minerals occasionally partially replace the tennantite. The last ore mineral to form was stromeyerite.

Although the deposit is no longer mined, rich wire-silver-bearing ores were frequently encountered in the upper, older reaches of the mine during the 1920's. Silver, in particular, is strongly associated with the barite-tennantite-stromeyerite-bearing portions of the veins.

MINERALS

Colquijirca produced a few nice mineral specimens in the early to mid-1900's. However virtually nothing has come out in the past 25 years. Enargite, chalcopyrite and native silver have been recovered as specimens. Very fine wire silver specimens were frequently collected.

Enargite Cu_3AsS_4

A limited number of specimens of enargite have been produced. Crystals are typical for the species, forming crusts and mounded groupings. Crystals rarely exceed 1 cm or so in length and several millimeters in width, with flat, often rather dull terminations and bright shiny prism faces. Microcrystalline pyrite in pyritohedrons is a common associated mineral.

ATACOCHA DISTRICT

Cerro de Pasco Province
Pasco Department

LOCATION

The Atacocha mines are located about 12 km northeast of Cerro de Pasco on the Amazon basin side of the Andes. There are two main mines, the Atacocha and the Milpo. The elevations of the workings for the mines vary from 3,600 to 4,300 meters. The workings are in very rugged country, with slopes of 30–35 degrees. Johnson (1955) and Peterson (1962) have described the area and their observations are summarized below.

GEOLOGY

Sedimentary rocks in the area are dominated by the Permian Mitu Formation, the Triassic Pucara Formation, the Cretaceous Goyllarisquizga Formation and the Tertiary Casapalca Formation. Intrusive rocks consist of stocks, dikes and sills of dacite, dacite porphyry, diorite porphyry and andesite.

***Table 10.* Minerals reported from the Atacocha district.**

Common or Abundant			
Calcite	Galena	Pyrite	Rhodochrosite
Sphalerite			
Rare or Locally Abundant			
Alabandite	Fluorite	***Orpiment**	Tennantite/
Arsenopyrite	Jamesonite	Quartz	Tetrahedrite
Chalcopyrite	Marcasite	Realgar	

*Collector-quality specimens

The ore deposits consist of veins and irregular replacement bodies, mostly in the Pucara Formation limestones and, to a much lesser extent, in the Goyllarisquizga Formation and in the intrusions. Veins average 1 meter in width, but may be up to 4 meters thick. Typical sulfide mineral associations are galena, sphalerite and pyrite, with minor second-generation pyrite and jamesonite. Non-sulfide gangue minerals are calcite, rhodochrosite and minor fluorite. Arsenopyrite occurs intergrown with pyrite and frequently replaces it. Realgar and orpiment are closely associated within the veins in the upper parts of the Atacocha mine. These realgar and orpiment-bearing veins cut the main ore mineral veins, but are not directly associated with the lead-zinc orebodies and veins.

MINERALS

Orpiment As_2S_3

The only important collector-quality mineral from Atacocha is orpiment, which occurs in fine crystals and crystal masses. Individual crystals are a deep orange to red-orange color, and over 2.5 cm in length on the best specimens. Most crystals average 1 cm or less in length. They are more prismatic than Quiruvilca orpiment.

***Figure 80.* A geologist offering orpiment specimens at Atacocha. Rock Currier photo.**

ON A TRIP TO ATACOCHA, 1974

Atacocha is another high Andean mining camp similar to many others. After a while, all mining camps start looking the same. We did not find many specimens when we visited there, and the miners gave us strange looks. "Who in the world are these strange foreigners who want to buy rocks from the mine? It must be a joke. No one pays money for rocks."

We got a nice tour of the surface facilities and were told how many tons a day of copper, lead and zinc ores are mined and put through the concentrator, how many hundreds of men work underground and how many above ground, etc. I vividly remember a giant 20-foot pile of broken rusty wheelbarrows that were being accumulated for sale to a scrap metal dealer. This spoke volumes about the lack of modern mining methods.

We located a geologist who was interested in minerals and had a small collection of specimens from the mine. The outstanding things in his collection were some orpiment crystals that he had collected. They were rather prismatic and totally unlike any we had ever seen. He gave me two specimens but did not want to trade or sell any others from his collection. He promised to try to get more, but said they were from an area of the mine that was partially caved in, and he did not want to crawl through the partially collapsed tunnels if he could avoid it. We never saw any more of these specimens. Again we thought about the many good specimens that must have been destroyed. RHC

Huaron Group

THE HUARON MINES

Cerro de Pasco Province
Pasco Department

LOCATION

Huaron lies 40 km south-southwest of Cerro de Pasco, on the road from Canta, near Huayllay. The district is about 14–15 km due west of the northwest shore of Lake Junin, and lies next to Lake Huaron. The mines are located on the east flank of the Western Cordillera of the Andes, at elevations ranging from 4,300 to 4,800 meters; the district is small, measuring about 3 km by 4 km (Fig. 81).

HISTORY

Pasco Department was originally part of Junin Department; they were divided after 1919 into the current configuration. Initially the Huaron area was known as the Huancavelica District of Junin Department (Miller and Singewald, 1919). This led to confusion as to precise mineral locations. The mine was referred to as the San Jose mine in the 1920's, and is now considered to be in the San Jose de Huayllay district. The Compagnie des Mines de Huaron has been active at Huaron since 1912, and in continuous production since 1914. Ownership of the mines was partially sold off in 1987 to several other companies. Peak output was reached in the 1970's, but fell off in the 1980's as ore grades declined and costs increased. The low price of silver hurt the company also, as it has so many Peruvian mining companies. In 1991 the Compania Minera Huaron S.A., as the company is titled, filed for temporary closure and reduction of personnel. As of April 1991, ore production was 40% of normal (Cavanagh, 1993?). Production today is predominantly lead and zinc (approximately 96%), with lesser copper and minor silver.

Peru

GEOLOGY

The Cretaceous Machay Group limestones and Tertiary Pocobamba (Casapalca Red Beds) continental sedimentary rocks are the dominant sedimentary rocks in the area. The Huaron anticline is the dominant structural feature of the area. The Machay Group limestones and Pocobamba sedimentary rocks are strongly folded, and are intruded by quartz monzonites and quartz monzonite dikes, with accompanying fracturing. This fracturing was followed by alteration and mineral deposition by hydrothermal fluids. Following the intrusion of the dikes, the sedimentary rocks were further compressed and fractured, and the fractures were subsequently mineralized by hydrothermal fluids. These fractures frequently attain considerable width, and persist to great depth. The dikes have undergone extensive hydrothermal alteration, typified by sericitization, kaolinization and pyritization. Post-mineralization Huayllay pyroclastic volcanics have mantled the region.

The area has been glaciated, and surface oxidation is minimal. The ore is described by Petersen (1965) as similar to that found at Morococha. The deposits are composed of veins, shoots and *mantos* (blanket like orebodies); general zoning occurs from the center of the district outward in an asymmetrical pattern.

Huaron is described as a complex copper-lead-zinc-silver deposit; distinct zonation exists from the center zone where copper ores predominate, to an outer lead-rich zone. Five major east-west-striking lead-zinc ore veins are distributed over 3 or 4 km, along with two northeast striking copper-ore veins. Ore-bearing veins vary from a few dozen centimeters to 10 meters wide, and may extend, in the larger veins, over 1,800 meters horizontally. Ore veins have been traced to depths exceeding 500 meters.

Three major periods of mineralization occurred in the fracture zones. The initial mineralization consists of relatively high-temperature minerals deposited in the following order: milky quartz, pyrite, enargite, and tetrahedrite. Enargite dominates the mineralization in the central part of the district, while tetrahedrite dominates the outer part of the enargite zone. Reopening of the fractures caused the initial mineralization to be brecciated, and the breccia was subsequently cemented together by the next, second-period generation of medium-temperature minerals: milky quartz, brown sphalerite, and galena. Crystals of large size were deposited during this period, usually on a botryoidal gangue of siderite, dolomite and rhodochrosite. A final, third period re-fracturing, followed by a

Figure 81. **Geology of the Huaron district (from Boggio, 1985).**

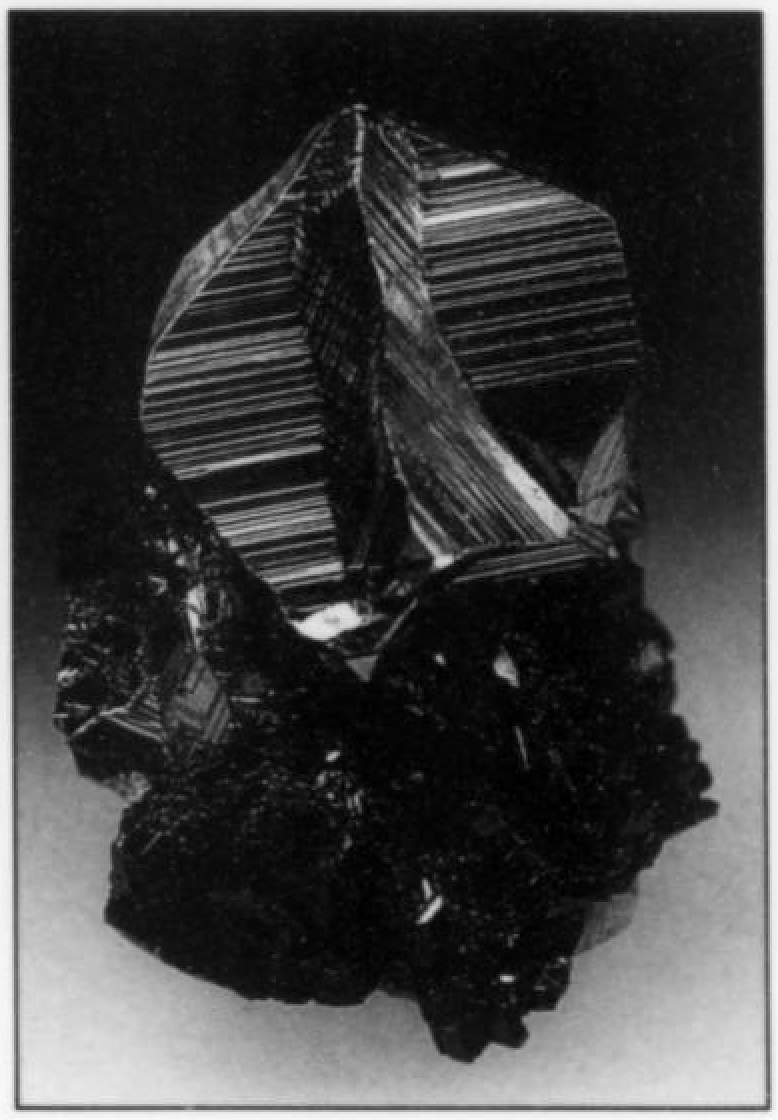


Figure 82. **Chalcopyrite twin on sphalerite, 2.6 cm, from Huaron. Cal Graeber specimen now in the Tom Gressman collection; Wendell Wilson photo.**

rapid deposition of hydrothermal minerals, resulted initially in the formation of minerals with colloform and botryoidal textures. This rapid deposition continued with fine-grained crystallization and continuous late precipitation of the carbonates, beginning with siderite and gradually changing to dolomite, rhodochrosite, and calcite. As a final pulse during this late-stage deposition, barite, pale to reddish amber-colored sphalerite, galena, tetrahedrite, polybasite and chalcopyrite were deposited.

Most of the ore being mined today is from veins in the second stage lead-zinc mineralization zones. There are about 20 mines in the Huaron district; in the south and middle part of the district are the Andalucia, Restauradora, Cometa, Elena, Yanamina, Travieso, Alianza, and Yanacreston mines; in the north part of the district are the Shiusha, Mechita, and Patrick mines; and in the western part of the district are the Fastidiosa, San Narcisco, and Constancia mines. The Alimon mine, a source of specimens, is not mentioned in the literature.

Table 11. **Minerals reported from the Huaron mines.**

Ankerite	Enargite	***Quartz**
Barite	***Galena**	***Rhodochrosite**
Calcite	Polybasite	***Sphalerite**
***Chalcopyrite**	***Pyrite**	Tetrahedrite
***Dolomite**		

*Collector-quality specimens

MINERALS

Through the early 1990's Huaron continued to furnish to the mineral market a large percentage of mixed-sulfide mineral specimens, many of which are mislabeled as coming from other Peruvian areas.

The Alimon mine is a small mine contributing the bulk of the Huaron specimens. Most of the specimens are from just one or two levels within the mine. It became a major supplier in about 1985 of "textbook-perfect" chalcopyrite, sphalerite, pyrite and other attractive minerals. These minerals are often nestled in groups of needle-shaped quartz prisms, some of which show delicate Japan-law twins.

Ankerite $Ca(Fe^{+2},Mg,Mn)(CO_3)_2$

Ankerite occurs as a relatively common minor accessory mineral, usually as small (about 1-mm), beige to pinkish colored rhombic crystals. Some curving of the crystal faces results in saddle-shaped crystals. Visually distinguishing between ankerite and dolomite is difficult.

Barite $BaSO_4$

Crystals are zoned (white in the center, clear and colorless on the edges) and are simple flattened tablets about 1 cm on edge.

Chalcopyrite $CuFeS_2$

Chalcopyrite usually occurs as disphenoids, giving the crystals a pseudo-tetrahedral crystal shape. Twinning is common. Chalcopyrite crystals are frequently coated by later, often microscopic, chalcopyrite, sphalerite, tetrahedrite, marcasite (?) and enargite (?). When not coated by these other minerals, chalcopyrite crystals can be sharp and clean, with a lustrous dark golden yellow color containing just a hint of greenish yellow overtone. When coated by later-growth chalcopyrite, the chalcopyrite crystals are a dull, dark golden yellow in color. Tarnished crystals are not uncommon. Pyrite crystals are often seen embedded in the chalcopyrite crystals

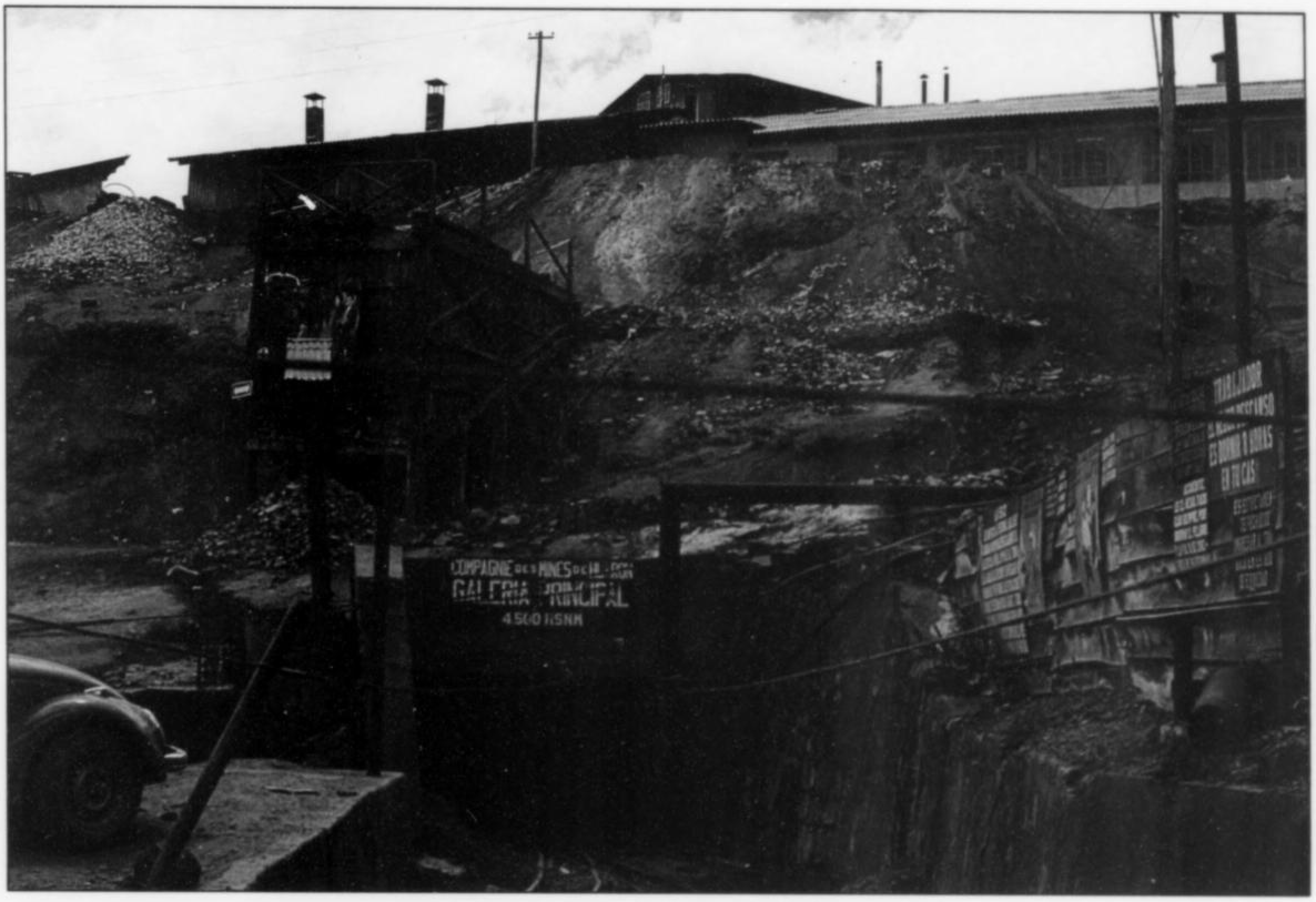


Figure 83. **Mine entrance at Huaron. Rock Currier photo.**

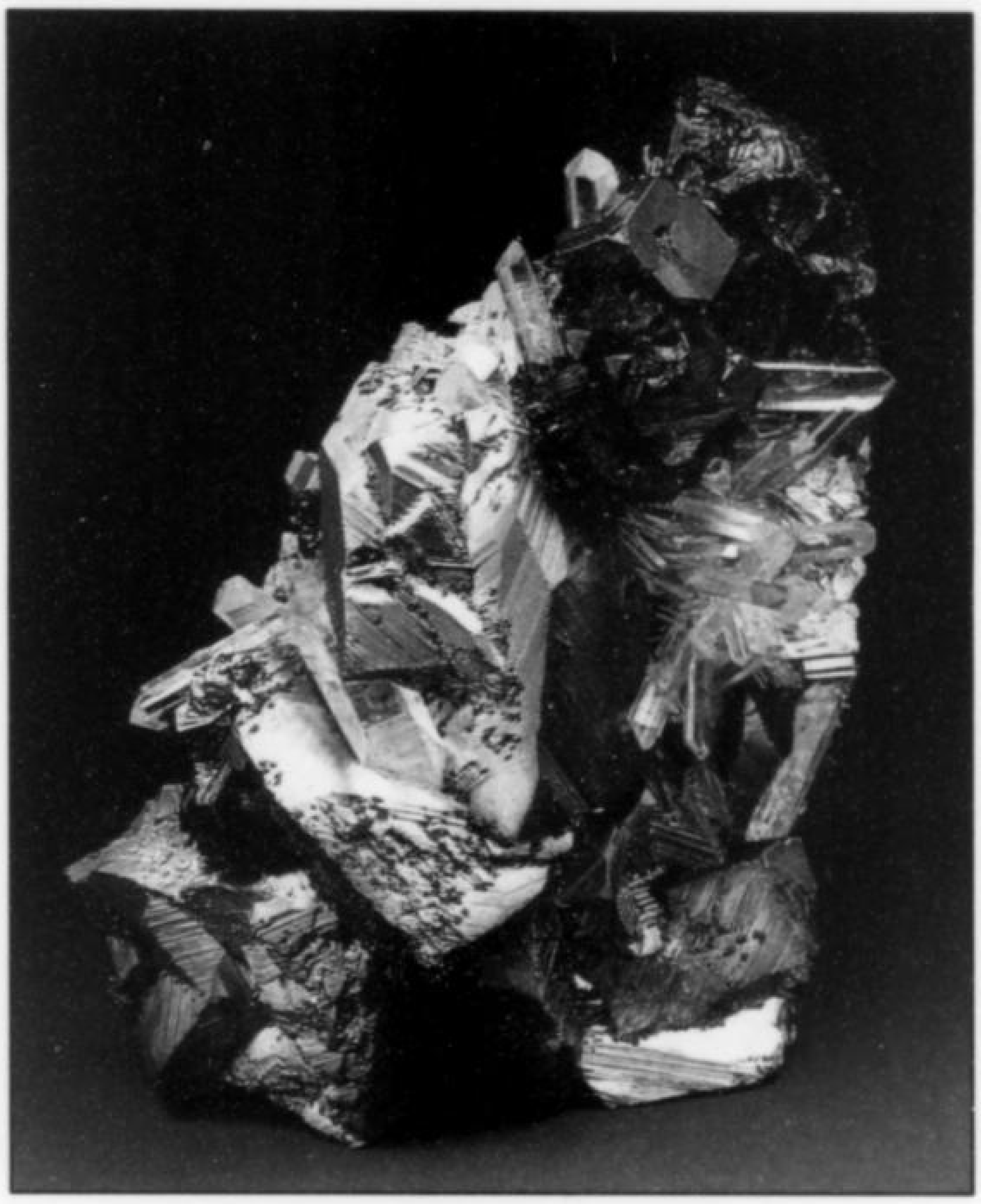


Figure 84. **Chalcopyrite with quartz and sphalerite, 8 cm, from Huaron. Private collection; Jeff Scovil photo.**

like raisins in a cookie. Coatings of gray tetrahedrite on chalcopyrite usually have a preferred orientation; on twinned crystals this is readily apparent, with each twin having a different reflectivity due to the reflection of light off the microscopic tetrahedrite crystal faces. Chalcopyrite crystals often exceed 5 cm in size, and aggregates of crystals can be considerably larger. In many specimens the chalcopyrite crystals are scattered on and amongst the usually white to gray prismatic quartz crystals that are typical of the locality. Others are interspersed with complex black sphalerite crystals.

Dolomite $CaMg(CO_3)_2$

Dolomite occurs as beige to pinkish colored saddle-shaped crystals that make attractive specimens. Dolomite also occurs as replacements after calcite. These dolomite pseudomorphs after rhombohedral calcite are a pale beige-pink in color with a pearly luster. Quartz is the most common associated mineral.

Galena PbS

Galena from the Alimon mine usually occurs as lustrous, dark gray cubes having a slight bluish tint, and is commonly associated with chalcopyrite. Some of the galena cubes are corroded, giving them a skeletal appearance. The only distinctive feature of the non-corroded galena is a tendency toward wavy, ripple-like lines crossing the cube faces; these lines resemble wavy strand lines on a beach. The crystals routinely average 2.5 cm in size.

Pyrite FeS_2

Pyrite is a very common associated mineral on specimens from Huaron. The crystals are usually very bright, with the cube form dominant. The cubes are often slightly modified by pyritohedral and octahedral forms that add extra, albeit small, faces to the edges

***Figure 85.* Chalcopyrite crystal, 2 cm, with tetrahedrite coating, on quartz, from Huaron. Wendell Wilson specimen and photo.**

and corners. Cube faces are generally striated to some degree, whereas the modifying faces are usually mirror-bright and non-striated. Cubes commonly range in size from 1 to 2 cm, with exceptional crystals reaching 5 cm in size. Quartz is commonly associated with the pyrite. An attractive and common specimen combination from Huaron is long, tapered quartz crystals with lustrous pyrite cubes nestled among them.

Quartz SiO_2

The quartz from the Alimon mine makes very attractive specimens, particularly when combined with other minerals. The quartz is distinctive, with a large aspect ratio (1:8 approximately), and is commonly slightly tapered, giving crystals a quill-like appearance. The crystals are generally oriented perpendicular to the matrix and occur frequently in divergent sprays. They vary in color from white to colorless and are usually transparent, or nearly so. Prism faces vary from smooth, with a glassy to brilliant luster and very fine striations, to ribbed or bumpy, with a dull to satiny luster. The basal areas of quartz clusters usually have many smaller, long, thin, hair-like quartz crystals growing randomly around the larger ones. The initial impression one gets of quartz specimens from Huaron is of white to colorless, porcupine-like aggregates of long, thin, tapered crystals projecting out from the matrix, frequently with a divergent habit. Japan-law twinning is occasionally present, particularly in the denser clusters of small crystals that grow around the bases of the larger crystals. Japan-law twins to at least 5 cm in size have been collected.

An additional relatively common attribute of Huaron quartz is the presence of dark, blood-red inclusions of hematite. This feature can help distinguish some Huaron quartz from other Peruvian localities. The hematite occurs as minute flakes, shreds and freckle-like stains, almost always with a distinctive hematite-red color. The concentrations of hematite inclusions vary from moderately heavy and obvious to the naked eye, to infrequent microscopic shreds that are only observed under magnification. The hematite inclusions generally occur on the same side of all the quartz crystals in any given group. Bright cubic pyrite crystals are commonly implanted among the quartz crystals, creating aesthetic specimens. Sphalerite is frequently the major matrix mineral for the quartz.

Sphalerite (Zn,Fe)S

Sphalerite is thus far ubiquitous in the specimens marketed from Huaron. It is usually present as blackish brown crystals with a satiny to glassy luster. Crystal sizes to 5 cm are common. The most abundant crystal forms are the tetrahedron, octahedron and tristetrahedron. These forms are combined in crystals with a flat, triangular octahedron face that is distinctive. Triangular growth lines are common on crystals, as well as striations from repeated twinning of the crystals. Sphalerite is frequently the matrix mineral for the other mineral species.

Sphalerite occurs in two generations of crystals. The first, and most abundant generation is blackish brown in reflected light, with an amber to brownish red color in transmitted light. The less common, second-generation sphalerite crystals usually occur as tetrahedral to warty-looking rounded crystals that rarely exceed a few millimeters in size, on pyrite and chalcopyrite. These second-generation sphalerites are usually lemon-yellow to pale amber in transmitted light, with a silvery reflectance. Spectacular clusters of sphalerite with associated pyrite, quartz and chalcopyrite dominate the specimen supply coming from Huaron.

The Carhuacayan District

Carhuacayan Province
Junin Department

LOCATION

The Carhuacayan district and mines are located approximately 25 km south-southwest of the Huaron district and about 55 km northwest of La Oroya. Information on the district is limited.

The Carhuacayan deposit is related to a quartz-andesite stock intruded into limestone. Cobbing *et al.* (1981) briefly describe the district: "Complex lead-zinc-silver-copper mineralization occurs in radiating veins within the stock, in replacement bodies within megaxenoliths of limestone and in contact-metasomatised tectonic breccias surrounding the intrusion."

MINERALS

Specimens of galena with pyrite and sphalerite have been produced in limited amounts during the recent past but the mines seem to have ceased producing specimens around 1984. Specimens from Carhuacayan are frequently mislabeled as to locality.

Bournonite $PbCuSbS_3$

Bournonite occurs as shiny, 1 to 2-cm, barrel-shaped, metallic black crystals. They are usually untwinned and striated.

Pyrite FeS_2

Pyrite occurs at Carhuacayan in fine pyritohedral and modified pyritohedral crystals to at least 5 cm in diameter. They are very difficult to distinguish from the pyrite of other Peruvian locations such as Huanzala. A large find was made in the early 1980's; the pyrites occurred as "floater" groups that were encased in a whitish clay, and were collected from a clay-filled vein in the mine. This clay coating was easily cleaned off. The pyrite crystals are generally modified pyritohedrons, with one crystal attached to another in a habit somewhat reminiscent of that of the Spanish pyrites. Carhuacayan pyrites are generally near perfect in form, with a brilliant luster; the crystal faces may have small pits, which is an aid in distinguishing the locality.

Sphalerite (Zn,Fe)S

A significant find of sphalerite in good specimens was made in early 1983. The splendent crystals are a very dark blackish brown, frequently twinned on the Spinel law, up to 4 cm in size, and associated with cream to tan-colored, stalactitic, botryoidal dolomite.

Morococha-Casapalca Group

MOROCOCHA DISTRICT

Yauli Province
Junin Department

LOCATION

The Morococha district is at about 4400 meters elevation and is located roughly 17 km east-northeast of Casapalca and about 25 km west-southwest of La Oroya.

The Morococha district is a spectacular region of high glacier-clad peaks and lakes close to the crest of the western Andean range. It lies in a nearly east-west trending valley with its outlet to the east. Three lakes occupy the valley, at elevations ranging from 4,350 to 4,600 meters. The Quechua name *Morococha* means "painted lake," because of the brilliant coloring of the altered rocks surrounding the area (McLaughlin, 1945).

HISTORY

Deposits around Morococha were worked for a time by the Portuguese prior to 1634. Mining was again active in 1760, since in that year applications were submitted to the viceroy for the right to construct metallurgical plants. In 1915 the Cerro de Pasco Corporation bought most of the mining concessions from C. R. Pflucker, who had been the owner for a number of years. As of 1970 the district had seven major mines, three of which were active, and had some 560 km of tunnels, of which about 80 km were being used (Purser, 1971). In 1984 the new Huacracocha mine was placed in operation. In 1989 the Morococha complex suffered a devastating attack by "Shining Path" guerrillas, who destroyed the compressed air plant and other surface installations. In 1990 the mines were again operating, at 63% of capacity (Cavanagh, 1993?).

Peru

GEOLOGY

Morococha is considered to be part of the Central Peru metallogenic sub-province, which includes the Cerro de Pasco District, the Casapalca District, and the nearby area of Yauli. Much of the geologic and orebody data presented here are abstracted from Nagell (1960) and Petersen (1965).

The stratigraphy consists of Permian Catalina volcanics and the Jurassic Potosi Formation limestone. The main geologic feature of Morococha is a gently northwest-plunging anticline with intrusions cutting the anticline on the southwest flank. A large portion of the principal mine area is occupied by limestone and dolomite of the Pucara Formation, locally known as the Potosi Formation (Peterson, 1965).

Two main phases of igneous activity have been identified. The first is the Anticona quartz diorite, which bounds the western portion of the district. The second is the younger cross-cutting quartz-monzonite porphyry of the Morococha Series. Alteration by the Morococha intrusions is extensive and pronounced, especially around the San Francisco stock, and has created the colorful alteration assemblage characteristic of the area. Contact metamorphism extends as much as 1.6 km from the intrusives.

Nagell (1960) divided the district into eastern and western portions based on the orebody types. Vein structures from the dominant orebodies in the eastern part of the district, whereas pipe and *manto* (blanket-like) orebodies predominate in the western part of the district. Mineralization occurs over approximately 50 square kilometers.

The Catalina volcanics, host for the ore deposits, and the San Francisco stock are the principal rock types in the eastern part of the Morococha district. The veins are open-space fillings with well-developed euhedral crystals of enargite, tennantite-tetrahedrite, chalcopyrite, sphalerite, galena, pyrite, quartz and barite in open vugs. The ore minerals generally break cleanly from sharply defined vein walls, allowing easy collecting of specimens.

Alteration products of the Potosi Formation and the Gertrudis stock are the major rock types in the western part of the Morococha district. The pipe and *manto* replacement orebodies are of primary importance. Open space-filling textures, such as vugs lined with crystals of sulfide minerals, are abundantly distributed in the *manto* and replacement bodies.

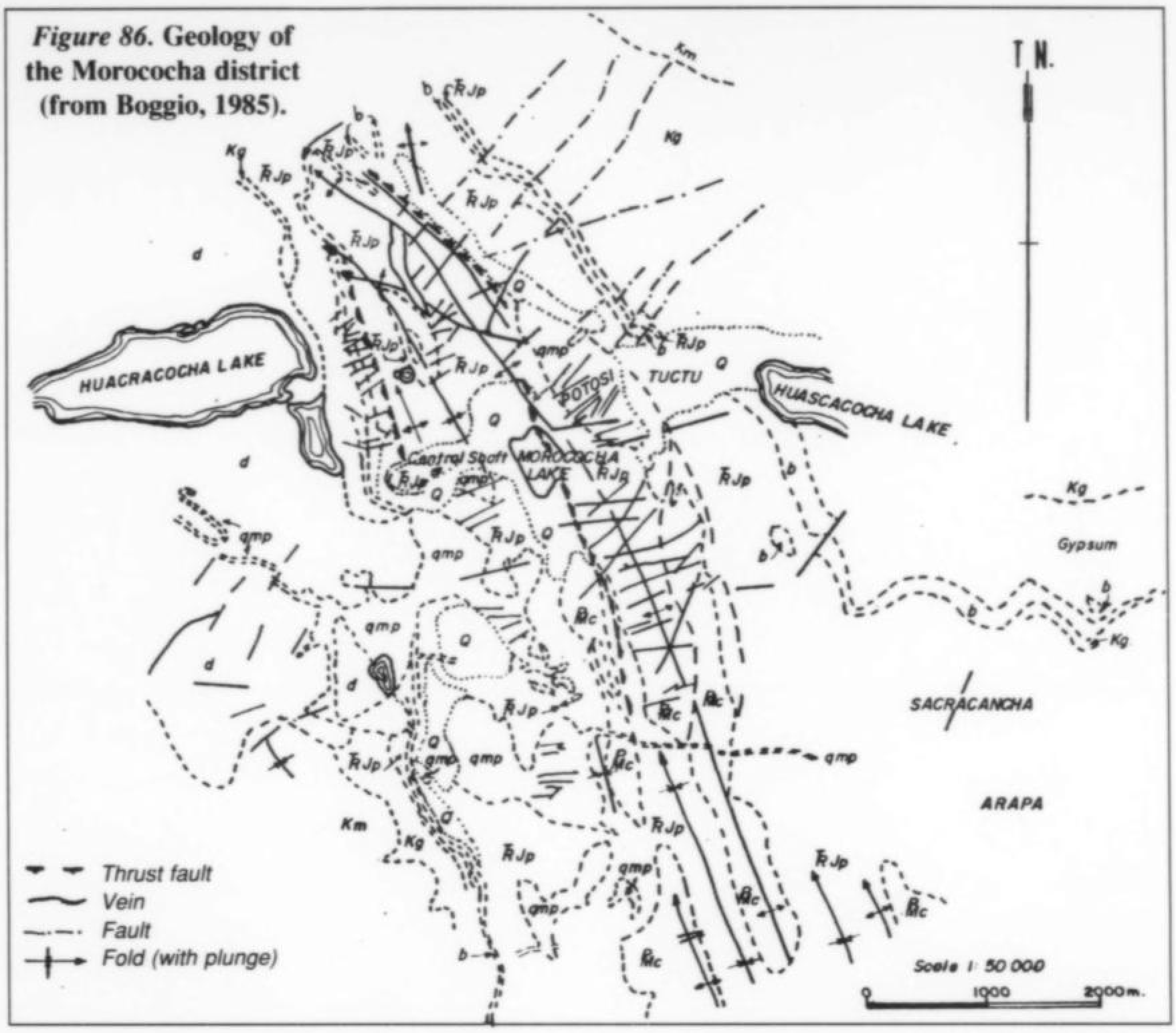


Figure 86. **Geology of the Morococha district (from Boggio, 1985).**

Table 12. **Minerals reported from the Morococha district.**

	Common or Abundant	
Anhydrite	Fluorite	Rhodochrosite
Barite	Galena	Rhodonite
Bornite	Gypsum	Scheelite
Calcite	Magnetite	Sphalerite
Chalcocite	Molybdenite	***Tetrahedrite/ tennantite**
Chalcopyrite	***Pyrite**	
Covellite	***Quartz**	Wolframite
***Enargite**		
	Rare or Locally Abundant	
Aikinite	Emplectite	Native arsenic
Alabandite	Famatinite	Proustite
Ankerite	Greenockite	Pyrrhotite
Arsenopyrite	Gypsum	***Siderite**
Bournonite	Luzonite	Stromeyerite
Djurleite	Marcasite	***Vivianite**
Dolomite	Matildite	

*Collector-quality specimens

MINERALS

Both arsenic and antimony are present in the ores, and their proportion varies throughout the district, yielding a range of tennantite-tetrahedrite compositions. Regional zoning is distinct, with the center in the area of the San Francisco and Gertrudis stocks, where quartz-molybdenite veins occur. Enargite occurs mainly within, and immediately adjacent to, the intrusive rocks and is commonly associated with tennantite-tetrahedrite, which is found throughout the district. In the central or core zone, chalcopyrite is common, sphalerite rare, and galena practically absent, with quartz and pyrite the main gangue minerals. The predominant ore minerals in the intermediate zone are tennantite-tetrahedrite, sphalerite and chalcopyrite; galena is common and rhodochrosite, ankerite, and calcite are the gangue mineral assemblage, which may be locally abundant at the expense of quartz and pyrite. The dominant mineral assemblage at the margins of the district is sphalerite, galena, calcite and Ag-bearing tetrahedrite. Generally the arsenic content of the ores decreases away from the central part of the district.

Next to pyrite, sphalerite is the most widespread and plentiful sulfide in the district. Where enargite is plentiful, sphalerite is rare or absent.

Pyrite is abundant both in cubic and pyritohedral habits. For example in the Ombla orebody, vugs in the central part of the orebody are typically lined with pyritohedral crystals, while vugs near the margins of the orebody are lined with cubic crystals. The cubes and pyritohedrons are up to 15 cm in diameter, and are accompanied by well-formed quartz crystals. Quartz is common in the Ombla orebody vugs and, near the margins of the orebody, sphalerite occurs on or with the pyrite, or it occurs as the dominant mineral in the vugs, occasionally associated with some galena. The upper part of the Ombla *manto* is especially vuggy.

Bornite is found in small amounts throughout the intermediate zones of Morococha district orebodies. Barite is sparsely distributed in the central part of the district, but has a tendency to be more abundant at the fringes. Pyrrhotite and arsenopyrite are rare and have been found at only one locality in the Morococha mine. Bournonite occurs associated with aikinite and tennantite-tetrahedrite.

In the copper-lead-zinc-silver veins that cut the Catalina volcanics, quartz, pyrite and sphalerite are the most abundant minerals and were deposited early in the mineralization phase. They are followed by smaller amounts of chalcopyrite and enargite which are intergrown with tennantite-tetrahedrite. Dolomite, ankerite, siderite, calcite and rhodochrosite were the last to form. The association galena-tennantite-tetrahedrite-rhodochrosite has not been observed with enargite or bornite. In the orebodies which occur in the altered limestones, pyrite is the dominant gangue mineral, and quartz is subordinate. Fluorite is reported to occur along the edges of some of the orebodies.

Common mineral specimen associations are chalcopyrite-pyrite, tennantite-tetrahedrite-chalcopyrite-sphalerite, and sphalerite-galena; these associations commonly occur on a pyrite matrix and are associated with variable amounts of enargite and quartz. Chalcopyrite frequently was deposited on dark brown sphalerite. Much less common is the red sphalerite (in transmitted light) in vugs in chalcopyrite or other minerals, with tiny chalcopyrite crystals perched on the sphalerite.

The results of leaching by later fluids are observed in several veins of the district. The first mineral leached is barite, then galena, sphalerite, pyrite, tennantite-tetrahedrite, and finally the carbonates, in that order. Quartz does not seem to be attacked.

The generalized paragenetic sequence is: hematite, magnetite; quartz, molybdenite; pyrite; brown sphalerite, (arsenopyrite); enargite; bornite, chalcopyrite, tennantite-tetrahedrite; galena, carbonates; barite; red sphalerite, galena.

Today Morococha is not an abundant source of specimens. Occasional specimens seen for sale are usually (but not always) recycled from pre-existing collections.

Pyrite FeS_2

Once abundant, pyrite specimens from Morococha are now rarely seen. Crystals are usually pyritohedrons in sizes up to several centimeters. Good typical specimens from here are about 6 x 7 cm, and are composed of bright pyritohedrons about 1 cm across partly coated with small white drusy quartz crystals. Pyrite, partly coating stout gypsum crystals, was recovered in abundance in the early 1970's; the appearance of these particular specimens on the world market signaled the start of serious interest by mineral dealers in the Peruvian mineral market.

Sphalerite (Zn,Fe)S

Sphalerite has been collected in red-brown translucent crystals to at least 1 cm on pyrite.

Tennantite-tetrahedrite $(Cu,Fe)_{12}As_4S_{13}$ - $(Cu,Fe)_{12}Sb_4S_{13}$

Tennantite-tetrahedrite can occur on enargite and on other minerals. Crystals are black and are usually of simple tetrahedral habit. Common associated minerals include pyrite in pyritohedrons, rhombohedral calcite and white gypsum.

Vivianite $Fe_3^{+2}(PO_4)_2 \cdot 8H_2O$

Dan Belsher (personal communication, 1992) reports that vivianite in little sprays of attractive bladed crystals has been found at Morococha. The specimens look totally different from the large, stout crystals collected from Bolivia.

Figure 87. **Rhodochrosite crystal group, 9 cm, from the Manualita mine near Morococha. Rock Currier collection; Jack Crowley photo.**

Beginning in 1991, a large amount of rhodochrosite, in bright pink solid coatings of rhombs on matrix came on the market. These rhodochrosites are attributed to the Manuelita mine, "near Morococha." These same specimens have also been labeled as having been collected from Casapalca, and from the "Santa Rita" mine, "near Morococha" or "near Casapalca." These particular rhodochrosite specimens are discussed in more detail in the section on the Santa Rita mine, Morococha district.

Enargite Cu_3AsS_4

Abundant specimens of enargite were produced from Morococha at one time, but never in the quality associated with other enargite specimen-producing districts, at least not within the last 30 years.

COLQUI DISTRICT

Huarochiri Province
Lima Department

LOCATION

The Colqui district is situated at the headwaters of the Santa Eulalia River and river valley 75 km northeast of Lima and 27 km northwest of Casapalca. Elevations of the workings range from 4,200 to 5,000 meters. The district measures about 16 km north-to-south and about the same dimensions east-to-west. The district has also been referred to as the "Huampar" district on the *Mining Map of Peru* (Boggio, 1985), and as the "Venturosa" district (Boggio, 1985, p. 18). The name *Colqui* comes from the Quechua word for "silver."

HISTORY

The district has been intermittently worked since Spanish colonial times. Between 1924 and 1929 the Colqui vein was mined for silver. In 1958 the Colqui mines were acquired and operated by the Compania Minera Huampar, S.A. Operations switched to the Finlandia vein in 1958. The Finlandia mine produced mostly lead and zinc, however, several ore shoots along the vein contained high-grade silver-gold ore. Mines within the district include the Aurelio, Colqui, Condor Pasa, Felicidad, Finlandia, Pio Pio, and Venturosa.

GEOLOGY

Petersen and Diaz (1972) and Kamilli and Ohmoto (1977) described the district and the following geologic data are abstracted from their papers.

The Colqui district lies within the Tertiary volcanic belt of Peru. In the district, the volcanic rocks are composed of andesite, andesite tuffs and basalts. A number of stocks are found in the district. The volcanic rocks cannot be directly correlated with other volcanic rock sequences such as those at Casapalca. The volcanic rock has been extensively altered, particularly near the ore veins. The tuffs have undergone the most intense alteration.

The Colqui district exhibits a mineralogical zoning that is centered in the area of the Cobre vein; this is a small chalcopyrite-rich vein situated northeast of the Colqui mine. Westward from the Cobre vein the mineralization grades from copper to lead-zinc, then silver, and finally mercury. The Finlandia, San Juan-Lourdes and Vermouth veins are located between the Colqui mine and the Cobre vein. These veins are principally sphalerite-bearing and galena-bearing.

In the western part of the district, the Colqui and Maria Teresa veins have been mined principally for silver. The Colqui mine and vein has argentiferous tetrahedrite as its principal ore mineral, and it also contains sphalerite, galena, rhodochrosite, realgar and quartz. The Maria Teresa vein contains silver-bearing minerals with abundant pyrite and some stibnite (Petersen and Diaz, 1972). At Pariamina, in the southwestern margin of the district are several small fractures which contain cinnabar. To the east of the Cobre vein is the Pio-Pio vein. This vein contains galena, pyrite, tetrahedrite and sphalerite, and appears to be transitional between the lead-zinc and the silver zones. The silver-gold ore shoots of the Finlandia vein are an obvious exception to this zoning pattern.

Table 13. **Minerals reported from the Colqui district.**

	Common or Abundant	
***Barite**	Pyrite	Rhodonite
Chalcopyrite	***Quartz**	Sphalerite
Galena	Rhodochrosite	***Tetrahedrite**
Marcasite		
	Locally Abundant or Rare	
Acanthite	Native gold	Pyrargyrite
Bornite	Pearceite	Realgar
Cinnabar	Polybasite	Native silver
Famatinite	Proustite	Stibnite

*Collector-quality specimens

MINERALS

Specimens from the Colqui district are frequently labeled as coming from the "Huampar" mine; this is the name of the company that operates the mines. The Colqui district produced attractive barite for a short time. These include honey-colored crystals about 2.5 cm in size, and also delicate white crystals that are slightly smaller in size. Tetrahedrite occurred as large, bright crystals on a microcrystalline drusy quartz and pyrite matrix. The Colqui district has also produced a little amethyst quartz. The mines are currently idle.

The San Cristobal District

Yauli Province
Junin Department

LOCATION

The San Cristobal district was once considered part of the Yauli district; it is located a few kilometers south-southeast of Morococha. The Yauli district proper occupies the Yauli Valley, about 10 km north of the San Cristobal area. The principal San Cristobal mines are the San Cristobal, Huaripampa, Carahuacra, Santa Rita and Andaychagua. The San Cristobal mine, however, is actually considered to be the southernmost mine of the Yauli district. The Carahuacra mine, located in the south-central part of the original Yauli district, lies midway between Yauli and San Cristobal. The San Cristobal mine is 19 km southeast from Morococha, just south of Yauli (Fig. 88).

HISTORY

The San Cristobal mine has been worked since the early 1900's. The camp and principal adit lie at an elevation of about 4,700 meters. Most of the mining activity has taken place between that level and the surface outcrops at 5,000 meters. Glaciers occupy the valleys high above the camp.

During the early decades, small-scale mining for silver was carried out at shallow depths, below the vein outcrops, near the snow line. Small-scale mining was also done during this same time period in the Carahuacra section, which is the northwestward extension of the San Cristobal district. In 1929, the Cerro de Pasco Corporation began exploitation of the principal vein, known as the Siberia. The mines, as of 1991, were owned by Centromin.

GEOLOGY

The principal structure in the district is the northwest-trending Chumpe anticline. Monzonite porphyry stocks and dikes intrude Excelsior phyllite and overlying Catalina volcanics in the core of the Chumpe anticline. The two most important intrusions are the Carahuacra and Chumpe stocks. The Carahuacra stock crops out 2 km north of San Cristobal. The Chumpe stock crops out near the San Cristobal vein, but is not well mapped as it is partially covered by a glacier. The Carahuacra mine replacement body *manto* extends for 3 km in the Potosi (Pucara) limestone along the western flank of the Chumpe anticline. The dominant minerals in this deposit are sphalerite and pyrite with a gangue of quartz and manganiferous siderite.

Ore occurs in veins that cut the Excelsior phyllite and the Catalina volcanics, as well as in breccias and replacement *mantos*

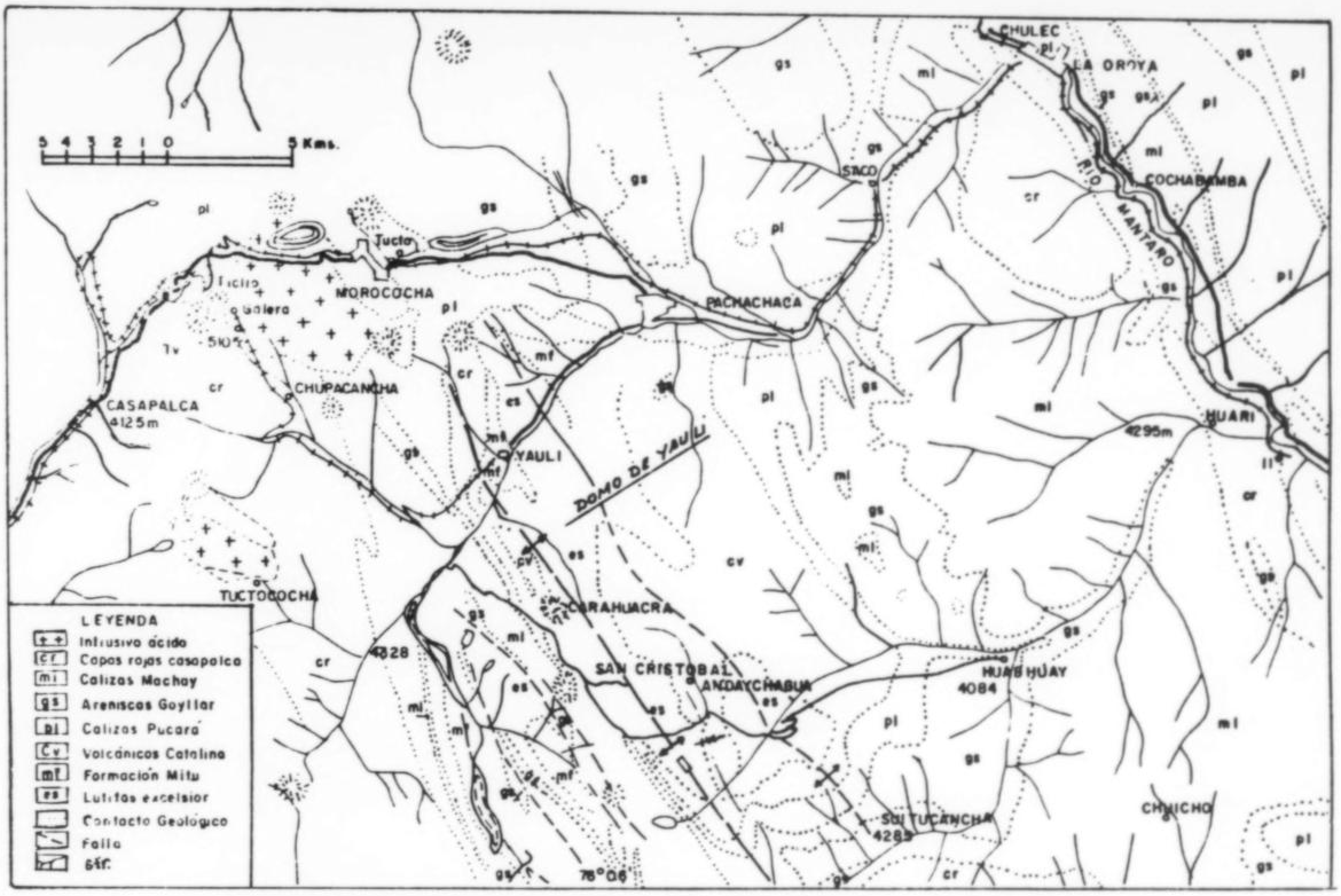


Figure 88. **Geology of the San Cristobal-Yauli-Casapalca region (from Boggio, 1985).**

along the contact between Catalina volcanics and Pucara limestone. The major vein at San Cristobal is 1 to 8 meters wide. Sphalerite and pyrite are the most abundant minerals, followed by galena, chalcopyrite, tetrahedrite-tennantite, wolframite (hubnerite), calcite, siderite, quartz and marcasite. Hematite, acanthite, pyrargyrite and barite occur rarely. To the northwest, the adjacent Carahuacra mine has been reported to contain native silver and proustite in its upper levels.

The general sequence of crystallization shows a strong zonation from the center of the Chumpe anticline outward. The sequence of deposition is pyrite, wolframite, quartz, chalcopyrite, sphalerite, galena, barite, and carbonates. At any given location, only a few of these minerals are present, and their relative concentrations vary from one area to another. In general, the San Cristobal ores are higher in arsenic than antimony, whereas the Carahuacra ores are higher in antimony than arsenic.

San Cristobal has two major veins, the Main vein and the Siberia 1 vein. As of 1984, the Main vein and its branches have been mined for a horizontal distance of 2.5 km and to a depth of 500 meters.

The mineralization is subdivided into three stages. The first was a tungsten stage, consisting of pyrite, wolframite and quartz with trace amounts of sericite and augelite. The second stage was the base-metal phase, consisting of pyrite, chalcopyrite, sphalerite, galena and barite. The third and final stage was mainly carbonate with small amounts of sphalerite and galena.

In the first stage, pyrite, wolframite and quartz occur together; pyrite was deposited first, followed by wolframite, and then by quartz. The wolframite occurs in crystals up to 8 cm across, which are commonly twinned. The majority of the chalcopyrite mineralization occurred in the second stage, and was followed by the deposition of sphalerite and galena. Pyrite occurs as euhedral crystals on or in the chalcopyrite. This suggests that it was deposited shortly before and through the chalcopyrite crystallization phase. Although uncommon, barite is found in crystals up to several centimeters long, which are usually associated with the base metal phase (second stage).

Table 14. **Minerals reported from the San Cristobal district.**

	Common or Abundant	
Chalcopyrite	***Quartz**	***Wolframite**
Galena	***Siderite**	(Hübnerite)
***Pyrite**	Sphalerite	
	Uncommon or Locally Abundant	
***Barite**	***Pyrargyrite**	***Stephanite**
***Native Silver**		

*Collector-quality specimens

MINERALS

Barite $BaSO_4$

A small number of barite specimens, in large plates with bladed pale blue-gray crystals to over 2.5 cm in size, were collected in the late 1980's and into the early 1990's. Many of these specimens are labeled as having originated from San Cristobal, but may be from other Peruvian localities.

Calcite $CaCO_3$

Calcite is associated with the sulfosalts.

Pyrargyrite Ag_3SbS_3

Pyrargyrite occurs as dark red-black crystals that are up to at least 2 cm across.

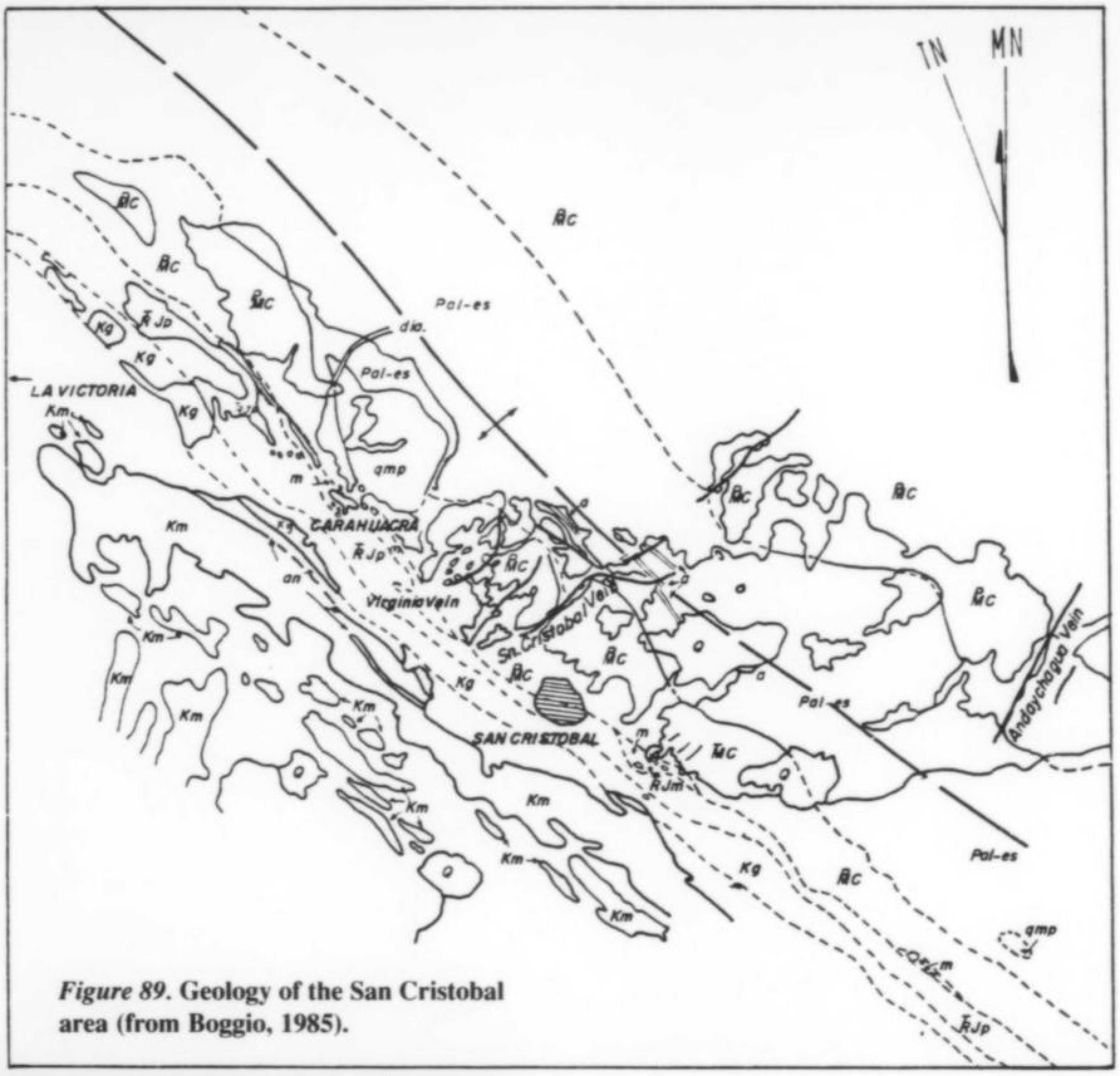


Figure 89. **Geology of the San Cristobal area (from Boggio, 1985).**

Figure 90. **Pyrargyrite crystal cluster, 2.8 cm, from San Cristobal. Terry Wallace collection; Wendell Wilson photo.**

Pyrite FeS_2

Pyrite occurs as large, shiny, pyritohedral to cubic crystals perched on slightly stubby quartz crystals. San Cristobal is best known for its shiny pyrite crystals that are "outlined" or rimmed with quartz crystals. These pyrite crystals are distinctive; the cubes are commonly modified by other forms which causes a rounding of the cube edges. Very typical of the San Cristobal pyrite-quartz combination is that many of the pyrite crystals show severe fracturing. These fractures are filled with crystallized white drusy quartz. This "healing" of the fractures with quartz is a striking and possibly unique aspect. Pyrites from San Cristobal also typically show parallel growth on crystal faces, in "step-up" formation, and this helps distinguish them from other Peruvian locations. These pyrite specimens can be very attractive, and very large; the best crystals are brilliant pyritohedra exceeding 6 cm across. Although eclipsed by the Huanzala specimens (by sheer volume if nothing else), the San Cristobal crystals still rank as some of Peru's finest pyrite.

Quartz SiO_2

White to colorless quartz crystals, with pyritohedrons of pyrite resting on the quartz, are distinctive for San Cristobal. The crystals have a good glassy luster and typical quartz terminations. The quartz has a moderate aspect ratio, and there is nothing definitive about the form or habit to distinguish it from other Peruvian localities such as Pachapaqui.

Siderite $FeCO_3$

Siderite, although not a glamorous mineral, does occur in fair-quality mineral specimens for the species. The crystals are usually dull to satiny in luster, in tan-colored discoids. Crystals exceed 1 cm across in the better specimens. From 1978 to 1980 siderite was commonly collected at the mine as large botryoidal masses up to several kg in weight. When cut open these siderites display a concentric pattern similar to that of Argentine rhodochrosite. Siderite is also a common matrix mineral for the superb pyrites found at San Cristobal.

Silver Ag

Fine specimens of coarse, steel-wool-like to crystalline aggregates of native silver on fine-grained galena and other sulfides have been recovered. Native silver also occurs with pyrargyrite and other sulfosalts in this same wiry habit.

Stephanite Ag_5SbS_4

A few specimens of stephanite have appeared on the market since 1977.

Wolframite-Ferberite $(Mn,Fe)WO_4$ - $Fe^{+2}WO_4$

San Cristobal has produced very good, distinctive wolframite-ferberite. Crystals are usually twinned, thin, broad-bladed and spear-shaped, pseudo-hexagonal, black in color, strongly striated and standing on edge. Most specimens have been dissolved out of quartz with hydrofluoric acid (HF), the net result being that no quality quartz exists on these specimens. Many, in fact, have a quartz matrix that is badly etched and corroded. The best wolframite-ferberite specimens have individual crystal blades that exceed 2.5 cm in diameter, and are at most a few millimeters thick.

Wolframite-ferberite also occurs in stubby crystals associated with pyrite; these are totally different in appearance from the bladed crystals. Although unlike the bladed habit, these stubby crystals are also completely different in appearance from hübnerite-wolframite-ferberite crystals collected from Mundo Nuevo, Pasto Bueno, and Julcani, which are the other major hübnerite-wolframite-ferberite sources in Peru. Chemically the wolframite-ferberite from San Cristobal ranges in composition from 27 to 94% $FeWO_4$. Many of these specimens were originally mislabeled as from Casapalca, probably due to the proximity of the two localities.

REMINISCENCES ON A TRIP TO SAN CRISTOBAL, 1974

The road up to San Cristobal led past the tungsten concentrator at the Mar Tunnel. We were given an extensive tour of the concentrator and told more about the concentration of tungsten ores than we ever wanted to know. In back of the compound against a hill was an old fashioned cement portal, inscribed "The Kingsmill Tunnel," which had a real ripping small river coming out of a cement channel in its floor. I asked what it was. "That is the drainage for the lower level of Morococha," they said. I protested, "But that's about 60 miles away." I was told something like "No, in a straight line it is only about 23 miles." Mr. Kingsmill was one of the former directors of the Cerro Corporation before Peru nationalized the mines, and this amazing, mostly forgotten and now taken for granted engineering feat was named after him.

San Cristobal, like many other high mining camps, is ringed with yet higher mountains, their slopes dotted with mine dumps and tunnels. Its production was mostly wolframite and other tungsten minerals. It occasionally produced fabulous pyrite and quartz specimens of a distinctive nature, and sometimes small blocky wolframite crystals associated with pyrite.

We arrived just after a snowstorm and the camp was paved with three inches of partially frozen slush covering a layer of mud; just the thing to make walking around a real misery. The pavilions where the miners lived also had three inches of partially frozen slush on their corrugated iron roofs, which overhung the walls by about a foot. The slush was melting fast and brisk rivulets of ice water were cascading off the roofs. Every time we would knock on a door we tried to avoid getting a pint of ice water down the back of our necks; we were not always successful.

Mineral specimens were scarce, but two or three of the miners had quartz specimens that consisted of beautiful, thin, 2.5-cm butterfly bladed twins of some black mineral that was thinly coated with tiny quartz crystals. I thought, correctly as it turned out, that I might be able to etch them off with hydrofluoric acid (HF) and produce spectacular specimens. This mineral turned out to be almost pure iron tungstate (ferberite). Some of the specimens we got later, however, were more heavily covered with quartz crystals, and we discovered that, when the ferberite was exposed by etching with HF, they were etched and not-well formed. We only got about two dozen of these specimens, and wondered how many more had been ground into dust when run through the mill.

RHC

THE CASAPALCA DISTRICT

Huarochiri Province
Lima Department

LOCATION

The town of Casapalca and Centromin's Casapalca mines are about a four-hour drive east from Lima. The town is at an elevation of 4,200 meters; mining in Casapalca centers on the Cerro Casapalca (later named Cerro Carlos Francisco), a mountain rising to over 5,200 meters east of town.

A second Casapalca mine was established by Compania Minera Casapalca S.A., in 1987. The mine is at 4,700 meters and is only 7 km from Centromin's original Casapalca mine. Operations at this new underground mine began in 1987, and by January 1991 it was producing 400 metric tons per day of copper-lead-zinc-silver ore.

HISTORY

Early mining for silver started on the high outcrops where scattered deposits of rich ore were found. The Backus and Johnston Company began systematic exploration and development of the area in the late 1800's, and were subsequently bought out by the Cerro de Pasco Corporation. In 1919 the most important producer was the Carlos Francisco mine, followed by the Aguas Calientes, Carmen, San Antonio, and Chuquichuccho mines. As of 1991, Casapalca was owned by Peru's Centromin; the mine was operating at 61% of capacity at that time, a reflection of the low prices for silver during the past several years.

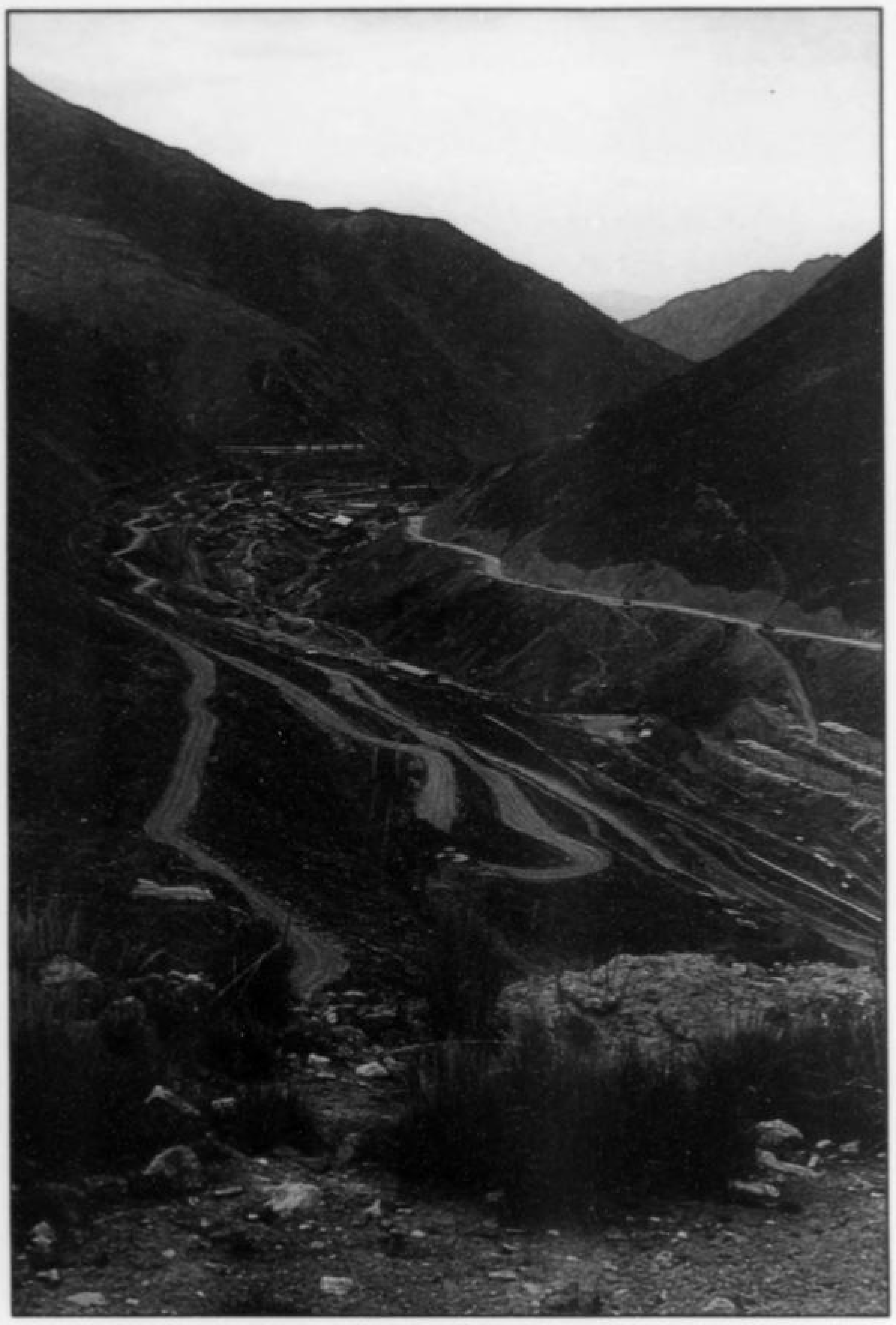
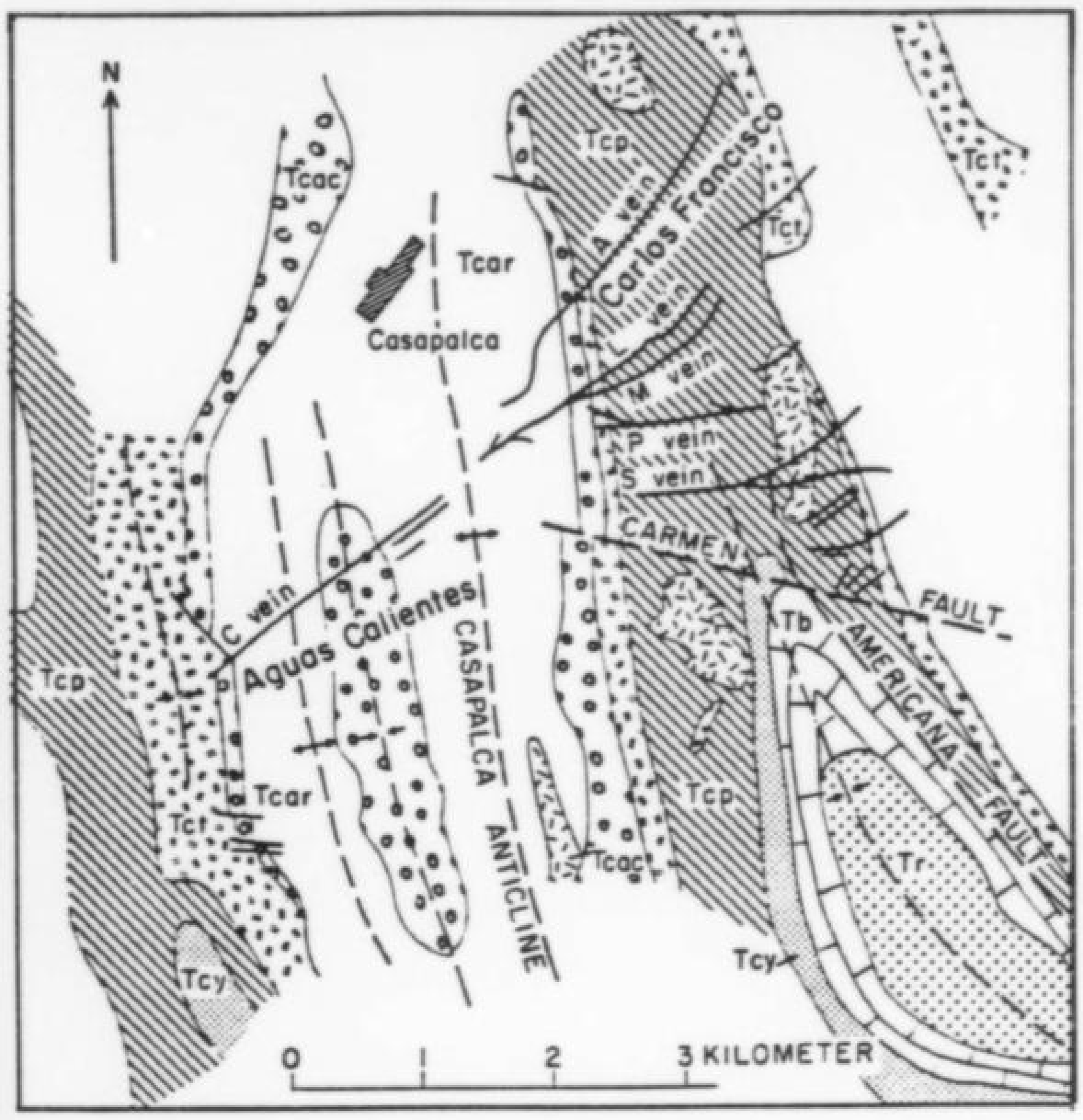


Figure 91. **The Casapalca mining camp, at an elevation of 15,000 feet. Rock Currier photo.**



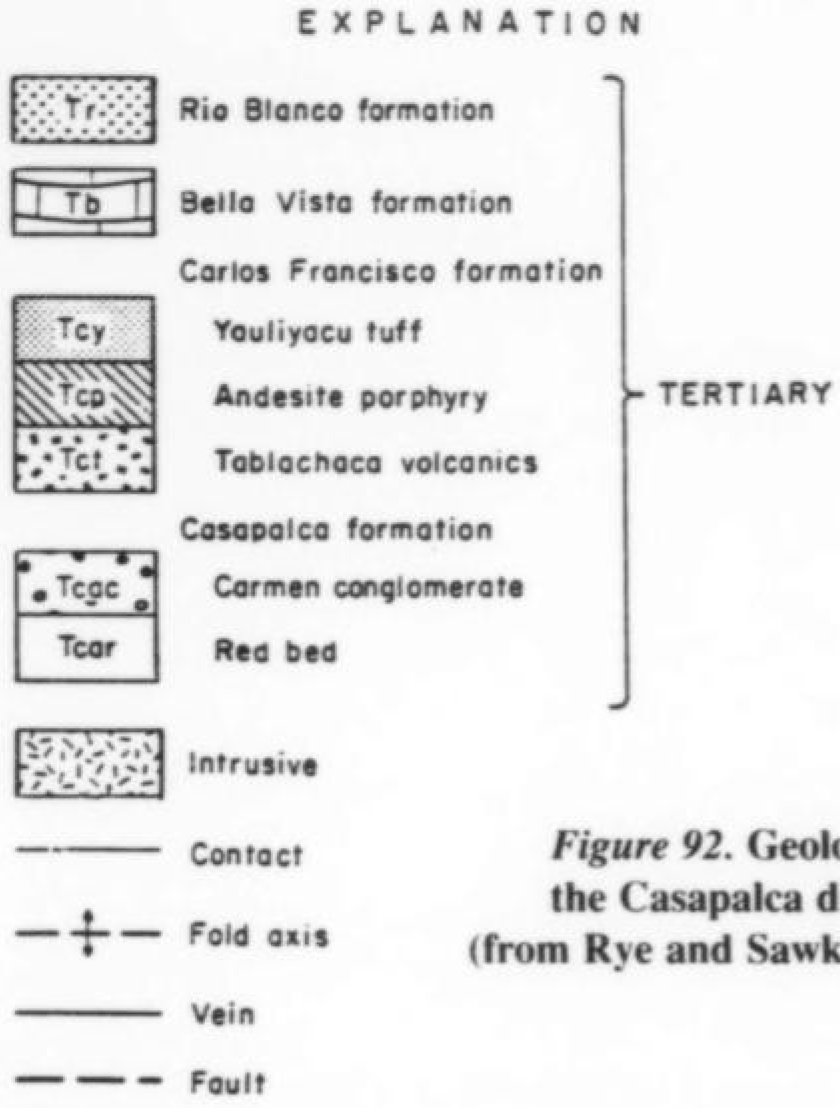


Figure 92. **Geology of the Casapalca district (from Rye and Sawkins, 1974).**

GEOLOGY

Epithermal silver ores which contain acanthite, proustite, pyrargyrite and miargyrite were found with pyrite in a siliceous and pyritic gangue. These silver-rich ores were the original targets of the early development work, and existed only in the highest part of the veins; they did not last long. Deeper exploration of the mineralized zones located silver-bearing veins which contain pyrite, galena, sphalerite, chalcopyrite, tetrahedrite-tennantite and bournonite in a gangue composed of quartz, calcite and rhodochrosite.

The stratigraphy of the district is as follows: limestone of the Upper Cretaceous Machay Formation is overlain by shale, sandstone, redbeds and conglomerates of the early Tertiary Casapalca Formation; the Casapalca Formation is, in turn, overlain by andesitic tuffs and flows of the Tertiary Carlos Francisco Formation. Intrusive rocks in the Casapalca area consist of diorite and syenite of unknown age. Some of the intrusions predate the mineralization, and none of the intrusions appear to be directly related to the mineralization found at Casapalca. However, skarn zones encountered at depth in the Cretaceous Jumasha Formation limestones (which do not crop out), coupled with hot water encountered at depth in the mines, strongly suggests a nearby heat source driving the mineralization.

The principal veins of the district are part of a northeast-striking fracture zone which is about 5 km long. Most of this fracture zone has been explored for potential ore. Wu and Peterson (1977) describe the fracture system of the veins at Casapalca as follows:

> One significant feature of the fracture system is the continuity of open spaces along the veins. This is especially demonstrated by the 241 and 242 veins where a single fracture with an open space up to 2 cm can often be traced for over 100 meters.

According to Rye and Sawkins (1974) the fracture zone has been divided into two main ore-bearing sections, the Aguas Caliente in the southwest portion of the deposit, and the Carlos Francisco in the northeast portion of the deposit.

Casapalca ores show a gradual lateral zonation. The paragenesis of different major veins can be correlated, and four stages of mineralization, without obvious time breaks, have been identified.

Three main zones of mineralization have been defined which are based on alteration, metal content, and mineral type (Centromin, 1977), as modified by Wu and Petersen (1977): ***Zone I*** is intensely silicified, with no carbonates in the central part and pure calcite at the edges of the zone. Arsenopyrite and hubnerite occur in this zone. Pyrite is predominantly cubic rather than pyritohedral. Sphalerite is abundant, chalcopyrite is common, galena is minor, and tetrahedrite is rare and As-rich. ***Zone II*** contains abundant carbonate and sericite, and the sphalerite is usually dark in appearance due to chalcopyrite inclusions. Sphalerite, galena and tetrahedrite are the dominant ore minerals, chalcopyrite is rare, and pyrite occurs as pyritohedrons. Bournonite is also present. The tetrahedrite in Zone II is Sb-rich. Zone II has a subzone where chalcopyrite is relatively common in association with pyrite. ***Zone III*** (peripheral zone) has dolomite, siderite and rhodochrosite as the dominant carbonates, and they are all very common. Sericite is ubiquitous and common. Bournonite, geocronite, stibnite, orpiment and realgar are typical of this zone. Tetrahedrite is usually associated with galena, and sphalerite is much less common. Pyrite is predominantly pyritohedral.

Wu and Petersen (1977) have divided the mineralization into four stages based on temperature of deposition and the type of mineralization. ***Stage I*** is the zinc-lead stage, ***Stage II*** is the copper stage, ***Stage III*** is the copper-silver stage, and ***Stage IV*** is the gangue stage (quartz and carbonates). The beginning of chalcopyrite crystallization was later than that of sphalerite, galena and pyrite within stage I, and tetrahedrite deposition corresponds mainly to a single well-defined event within stage III. Minerals formed in stage I are abundant in most of the vein system and often continued to crystallize within stages II and III. Chalcopyrite and tetrahedrite characterize stages II and III, respectively. Stage IV is rather distinct in most of the veins. Carbonate deposition in this stage may be divided into two periods: calcite I; pearly-white carbonates (calcite and/or dolomite); and calcite II. Large rounded balls of dolomite crystals with a very pale pinkish tint, resting on the sulfides, are one of the habits that the pearly white carbonates stage takes.

The general order of crystallization in the veins appears to have been quartz, manganoan calcite, rhodochrosite, quartz (II), pyrite, sphalerite, galena, chalcopyrite, tetrahedrite, quartz (III), chalcopyrite (II), jamesonite and bournonite, and pyrite (II), sometimes followed by a late crusting of thin layers of quartz, calcite and pyrite. Chalcopyrite is common in the deeper workings of the central or Consuelo vein located in the Carlos Francisco section. Sparse chalcopyrite occurs throughout the ore zone and has been observed in small lenses at surface outcrops. The Aguas Calientes section contains more calcite and rhodochrosite, commonly with tetrahedrite, whereas the Carlos Francisco section contains more quartz and tends to have more vugs. The dominant sulfide is sphalerite with lesser quantities of chalcopyrite, galena, tetrahedrite and pyrite.

The most abundant and widespread vein minerals are sphalerite, galena and pyrite. Still widespread, but of lesser importance, are quartz, chalcopyrite, tetrahedrite and the carbonates. Bournonite can be fairly common in places, but is always present in small quantities relative to the other ore minerals. Late-stage realgar and orpiment are reported from the upper levels, and are recorded as common in the peripheral zone where they occur with stibnite and Pb-Ag sulfosalts (McKinstry, 1927; McKinstry and Noble, 1932). Arsenopyrite, geocronite and hübnerite have also been reported, but are quite rare.

Quartz and calcite are commonly associated in the majority of the veins. Sphalerite can be light or dark in color; the dark-colored sphalerite contains numerous blebs of chalcopyrite, while the light-colored sphalerite is free of them. The tetrahedrite is Sb-rich and As-poor. According to McKinstry and Noble (1932), the tetrahedrite crystals are commonly replaced by chalcopyrite in ores from the Aguas Calientes section. This usually occurs on the outer margins of the crystals. Specimens of tetrahedrite from this area are frequently coated by a golden layer of chalcopyrite or are variably replaced by chalcopyrite. McKinstry and Noble (1932) also mention that bournonite is a common associate of the tetrahedrite, and is usually found in a band of irregular width which lies between the galena and the tetrahedrite. There is also some late-stage bournonite which grew as independent crystals interspersed with the other minerals.

Hypogene leaching was recognized by McKinstry and Noble (1932) in veins from both the Carlos Francisco and the Aguas Calientes sections. Galena and sphalerite are usually etched, whereas the late-stage sulfides are not. Barite is the first mineral to be leached, then the sulfides (in the order tetrahedrite-galena-sphalerite, pyrite, and chalcopyrite), and finally the carbonates with deposition of new sulfides terminating the process.

Table 15. **Minerals reported from the Casapalca district.**

	Abundant	
***Calcite**	***Dolomite**	***Rhodochrosite**
***Manganoan calcite**	***Galena**	***Sphalerite**
	***Pyrite**	***Tetrahedrite**
***Chalcopyrite**	***Quartz**	
	Locally abundant or rare	
Acanthite	Diaphorite	Orpiment
***Anhydrite**	***Geocronite**	Polybasite
Arsenopyrite	***Gypsum**	Pyrargyrite
***Barite**	Hübnerite	Realgar
Bornite	Jamesonite	Rhodonite
Boulangerite	Miargyrite	Stibnite
***Bournonite**		

*Collector-quality specimens

MINERALS

McKinstry (1927) described Casapalca as a great specimen-producing source, particularly for bournonite. Vugs were reported as very common; he described them as follows:

> Vugs are first lined with sphalerite crystals, some of which are a centimeter or more in diameter. Upon the sphalerite is bournonite and around the latter crystals, and frequently upon them, quartz prisms attached by their bases form radiating groups. Perched upon all of these minerals are tufts of calcite scalenohedra. Galena and tetrahedrite are usually not well crystallized; occasionally galena crystals are intergrown with the bournonite as though the two minerals had started crystallizing from different centers and interfered with each other during growth. Tetrahedrite is commonly pitted as though by etching and is sometimes covered by a film of chalcopyrite. The pyrite, where it has had an opportunity to crystallize in open vugs, is usually in quite perfect pyritohedrons. Where replacing wallrock it is usually in cubes, while octahedrons of pyrite are unknown at this locality. Bournonite . . . crystals are splendent and some are nearly a centimeter in diameter. Usually the basal and prism forms dominate. In portions of the veins, pink cleavable rhodochrosite is abundant; in others the carbonates take the form of manganiferous calcite and dolomite. Rhodonite occurs sparingly in grains up to 1 cm.

McKinstry in a later article (McKinstry and Noble, 1932) describes the Carlos Francisco vein:

> Some of the open cavities in the Carlos Francisco mine are a foot or more wide and measure ten feet or more lengthwise. They are lined with quartz, calcite, sphalerite and bournonite,

Figure 93. **Tetrahedrite crystal group, 12 cm, from Casapalca. Rock Currier collection; Jack Crowley photo.**

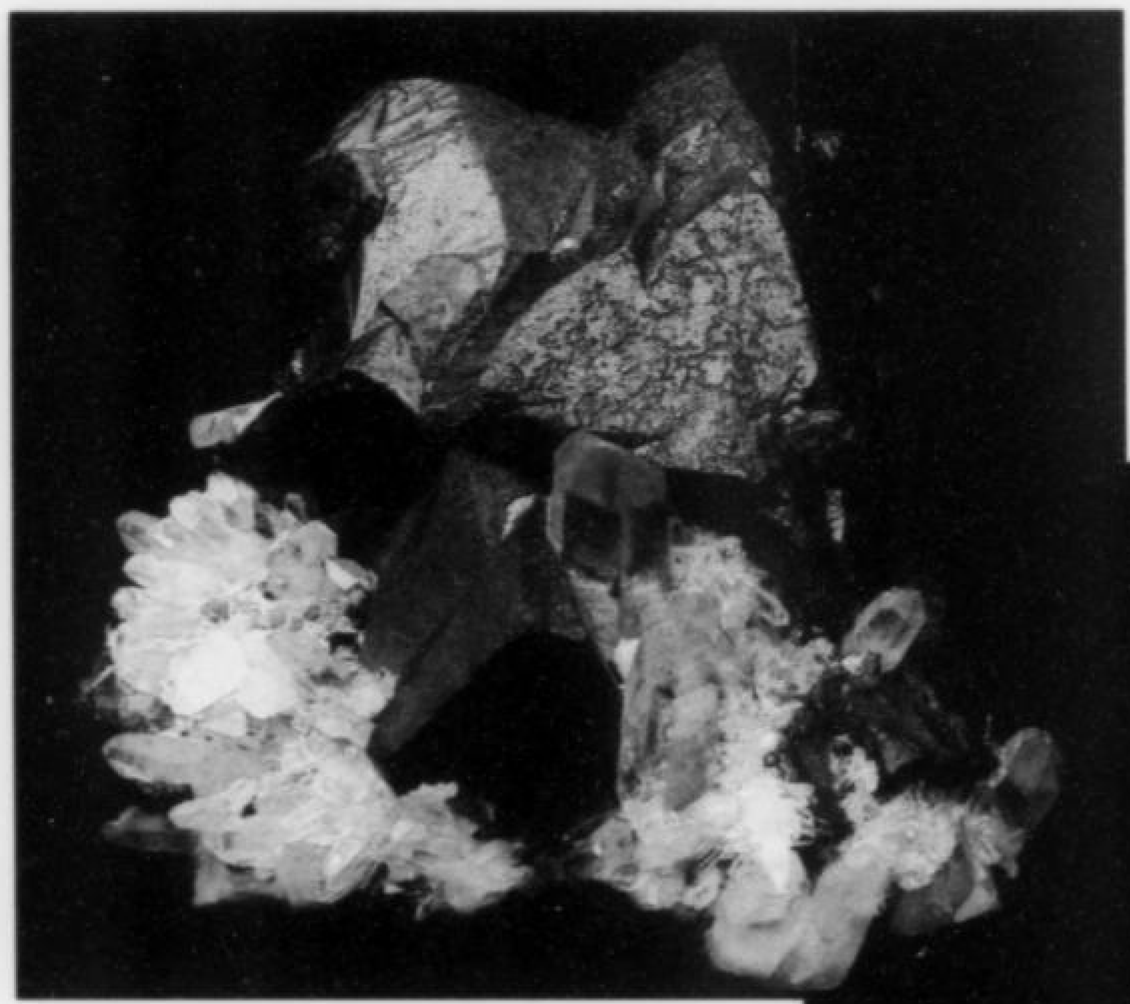


Figure 94. **Tetrahedrite crystals with quartz, 12.5 cm, from Casapalca. Rock Currier collection; Jack Crowley photo.**

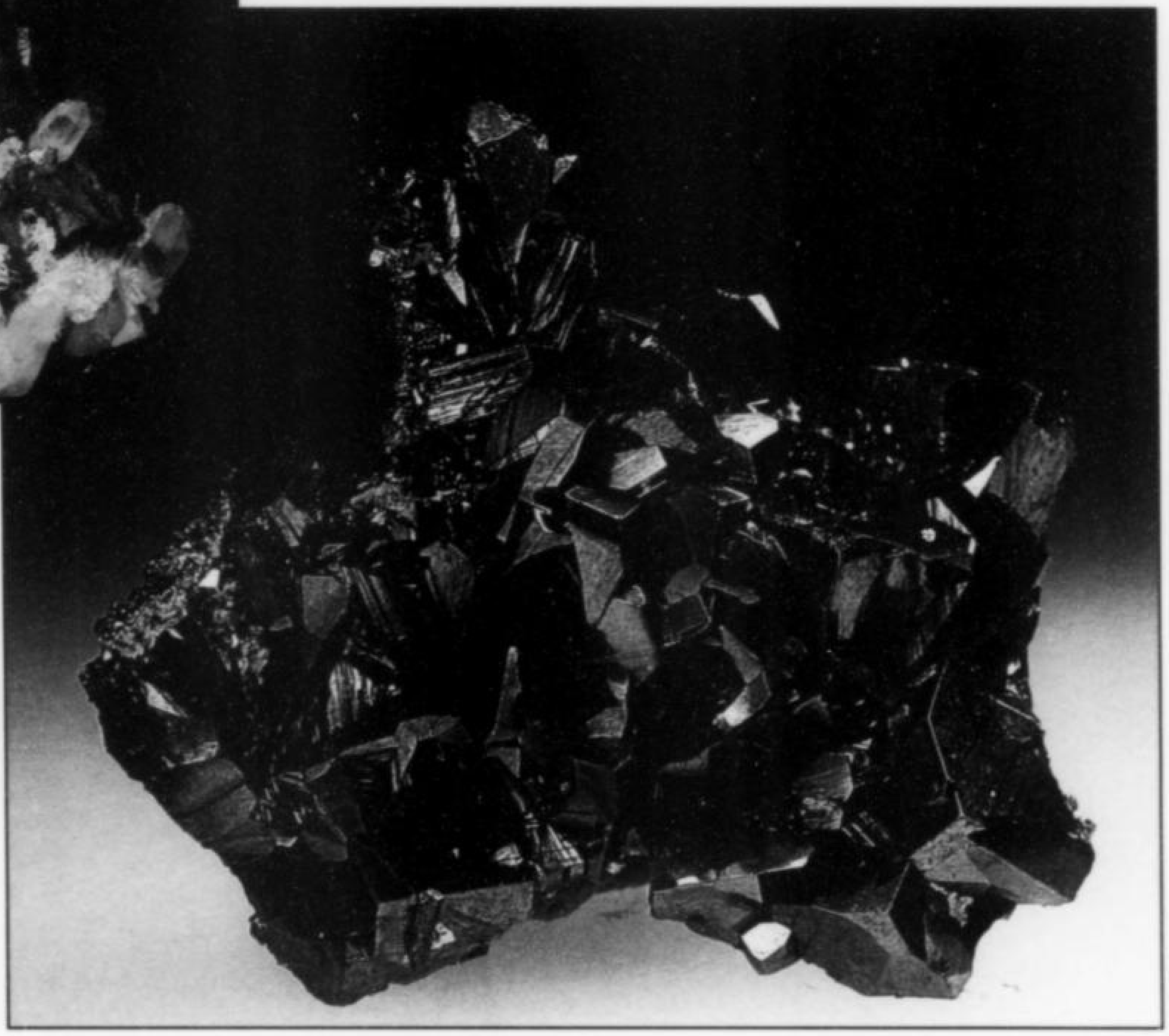


Figure 95. **Tetrahedrite crystal group, 8.1 cm, from Casapalca. Terry Wallace collection; Wendell Wilson photo.**

all well crystallized. . . . In some vugs the early sulfides, galena and sphalerite, are pitted and etched, but the tetrahedrite and bournonite are fresh. Occasional pyritohedrons of a late generation of pyrite rest on the sphalerite. Vugs from the Aguas Caliente mine, showing similar etching of galena and sphalerite, contain tetrahedrite crystals entirely coated by chalcopyrite. Bournonite in these specimens is unetched but bears a dusting of minute pyrite crystals. Tiny quartz crystals rest on the coated tetrahedrite but not on the bournonite; in fact one bournonite crystal clearly grew around one of the quartz crystals.

Specimens collected from Casapalca today are essentially identical to those described by McKinstry over 60 years ago. Beautiful examples of tetrahedrite, bournonite and mixed sulfide specimens are still occasionally available on the mineral market. Casapalca has been notable for its lack of enargite, a definite distinction when one tries to identify mineral specimens from here. However, in 1992 some enargite supposedly from Casapalca appeared on the market.

The main Casapalca mine has furnished good to excellent specimens of quartz, bournonite, galena, sphalerite, pyrite, calcite, manganoan calcite and tetrahedrite. The tetrahedrites occur in crystals to over 8 cm in size; they are some of Peru's largest and, it can be argued, some of Peru's best. Most of the minerals seen for sale today are from the main Casapalca mine.

Anhydrite $CaSO_4$

A few specimens of massive purple anhydrite with some accompanying pyrite were found in the 1970's.

Barite $BaSO_4$

Barite is an uncommon mineral in collector-quality specimens from Casapalca. It tends to be colorless, clear to white, and in thick, distinctly bladed, crystals. Quartz casts after bladed barite are often found; the quartz forms drusy coatings over the barite, which has in some cases been leached away.

Bournonite $PbCuSbS_3$

Bournonite is a relatively common associated mineral at Casapalca, usually crystallized on galena, and less commonly on sphalerite and tetrahedrite. It rarely occurs by itself as quality specimens. Crystals are often only partially formed and are usually bright in luster, commonly with a bluish tint. Forms are complex to relatively simple barrel-shapes with distinct striations. Flattened, more discoidal-looking crystals also occur, and these can be difficult to differentiate from the more complex forms of tetrahedrite-tennantite.

Calcite $CaCO_3$

Calcite, when present, can be one of the more distinctive minerals that help to differentiate Casapalca specimens from those of other Peruvian localities. It typically occurs as opaque white to cream-colored, rather narrow scalenohedrons that frequently occur in little bundles and sprays. It is generally one of the last minerals to crystallize when in this habit, and this, in combination with the distinctive quartz crystals from Casapalca, is most helpful in identifying specimens. In addition, this habit of calcite fluoresces a bright orange under shortwave ultraviolet and an even brighter intense orange with a hint of pink under longwave ultraviolet. This colorful fluorescence is distinctive and can be a real aid in identifying Casapalca specimens when this type of calcite is present.

Calcite also occurs in flattened rhombohedral discoids of the type referred to as "nail-head" calcite, as well as being present in the typical rhombohedral form. One type of calcite occurrence is the small (up to 5 mm) white crystals sprinkled randomly on quartz crystal plates. This gives the quartz the appearance of having been sprinkled with "rice grains." Calcite also occurs as coatings on quartz crystal plates, with the calcite occurring preferentially on one side only of each crystal, or sometimes on two or three surfaces; this makes it look as if "snow" has fallen on the quartz specimens. It is also common for specimens that have had a heavy coating of calcite over the other minerals to have had this calcite dissolved off in acid by the *piriteros*.

Manganoan calcite crystals generally have a bladed habit, with skewed saddle-shaped rhombs as the common form. Other habits are also present, including long thin bundle-like masses of crystals with a stretched scalenohedral habit. Crystals up to 3 cm in size have been recovered on matrix specimens that are over 25 cm across. These crystals have an attractive pale pink color.

Although they are not common, some of the finest Peruvian manganoan calcite specimens have come from Casapalca. From 1978 to 1984 manganoan calcite was relatively abundant, predominantly as scalenohedrons. Some specimens have crystals as large as 10 cm in size on matrix associated with quartz and sphalerite. Although the scalenohedrons are generally not lustrous they still make attractive specimens. The combination of pink manganoan calcite scalenohedrons and brown, twinned sphalerite, both on quartz crystals, is a most attractive association and is quite typical of Casapalca.

Chalcopyrite $CuFeS_2$

Chalcopyrite is a common mineral at Casapalca, particularly as coatings on, and as a replacement of, tetrahedrite. It also occurs as excellent euhedral to poorly-formed crystals and crystal masses having an intense deep yellow color and bright satiny or dull luster. The best specimens, which often occur with sphalerite, have lustrous, golden yellow sphenoidal crystals which are commonly twinned. The individual crystals often exceed 4.5 cm in size, and occur in groups over 9 cm across.

Dolomite $CaMg(CO_3)_2$

The most attractive dolomite at Casapalca is from the "pearly-white carbonate stage," where it is found as large globular, ball-shaped aggregates of tiny, cream to pale pink, rhombohedral crystals. These ball-shaped aggregates can be many centimeters across. Dolomite is also found as small to microscopic-size rhombic and saddle-shaped rhombic crystals. The microscopic crystals are among the last minerals to crystallize. The dolomite does not fluoresce.

Enargite Cu_3AsS_4

First reported from Casapalca in 1992, enargite in various-sized plates up to about 25 cm across has been offered for sale by the *piriteros*, who insist the location is Casapalca. These specimens may be from the nearby "new" Casapalca mine mentioned above.

The matrix for the specimens is quartz, in white to transparent, non-tapered crystals which come in various lengths up to about 5 cm long. Small enargite crystals are scattered on the quartz. The quartz, in turn, is coated by chalky, beige to cream-colored dolomite or calcite; these carbonates occur as small, crude rhombic crystals. Implanted on the carbonate is more enargite in single crystals (frequently doubly terminated) and small crystal groups up to about 3.5 cm. Some enargite crystals appear to be coated with micro-drusy enargite, and others appear to be coated with micro-crystalline pyrite. The enargite crystals are not lustrous.

Galena PbS

Galena occurs most often at Casapalca as cubes and cuboctahedrons; in some cases this combination is more octahedral than cubic. Crystals can be corroded, with a satiny luster, or very bright and mirror-like in their reflectance. Bright, lustrous crystals are uncommon. Some galena crystals have a melted appearance that tends to obscure the original form, and these "melted" crystals may have a bluish, somewhat iridescent tarnish or a satiny luster. Galena is frequently found intimately associated with bournonite, with the galena acting as the host mineral on which the bournonite has crystallized.

Geocronite $Pb_{14}(Sb,As)_6S_{23}$

Geocronite is a very rare mineral at Casapalca in specimen quality. A few small specimens having twinned, steel-gray, 1-cm crystals were recovered in 1981.

Gypsum $CaSO_4 \cdot 2H_2O$

Dan Belsher (personal communication, 1992) reports that gypsum "occurs in crystals up to 18 inches long, similar to those found at Naica, Mexico."

Muscovite $KAl_2(Si_3Al)O_{10}(OH,F)_2$

Muscovite (sericitic) is common as a minor late-stage associated mineral. It is usually present as near-microscopic, wispy, flaky, delicate masses which possess a white to cream color.

Pyrite FeS_2

Although pyrite is usually associated with many other minerals at Casapalca, it generally does not occur as large groups of solid pyrite like those so common at Quiruvilca and Huanzala. Pyrite, as bright, unstriated to lightly striated pyritohedrons and cubes of small size, is a common minor associate with other sulfides and sulfosalts. Some of the best pyrite specimens from Casapalca are pyritohedrons over 2.5 cm across. These pyrite crystals are commonly associated with lustrous quartz crystals; this combination makes for aesthetic crystal groups. Pyrite is often the matrix mineral on which the other minerals are deposited; it is not usually found in cubes, and not in exceptional specimens when it is. Of the good crystals the cubic pyrite specimens, due to their rarity at Casapalca, tend to be prized by collectors specializing in Peruvian mineral specimens. Cubic pyrite crystals rarely exceed 5 mm in diameter. Octahedral pyrite does not occur at Casapalca.

Quartz SiO_2

Quartz is usually found in association with the other minerals from Casapalca. Quartz has had a long period of deposition at Casapalca, so it is not uncommon to find it as the matrix (often with pyrite) for the various sulfides and sulfosalts or to find it as one of the last minerals to crystallize on the other minerals. On some specimens quartz shows two generations of crystallization: the first generation is a drusy coating of small crystals, with no distinctive individuals; the second generation is less drusy-like, with more individuality to the crystals and with larger crystal sizes. However, this demarcation can be obscure. Early-formed (first generation) crystals appear to be more milky white in color, usually with a satiny luster, while later (second generation) crystals vary in color from translucent milky white to bright, gemmy, clear, colorless crystals.

It is common for quartz from Casapalca to have a satiny luster on the prism faces and a bright-glassy luster on the pinacoid faces. Crystals are frequently opaque or translucent at the base and near water-clear at the termination. As seen when viewed vertically, these quartz crystals tend to have a strong triangular rather than hexagonal development due to the dominant growth of alternating prism faces. Casapalca quartz also has a tendency toward sceptering of the crystals. Sometimes this sceptering is very pronounced and thus, beautiful quartz specimens can result. Casapalca quartz occasionally may show a tapering habit, but this is uncommon. Those tapered quartz crystals form individuals with a wide center which tapers toward the top and the bottom of the crystal in what is known as a "Tessin" habit. Generally these crystals are somewhat frosty in luster, with bright terminal faces, and they occur in groups or small clusters of crystals that are up to several cm in size.

Casapalca quartz is usually not striated on the prism faces, but instead has a series of small vertical growth marks which give a parallel growth appearance to the prism faces. The quartz from Casapalca is usually distinctive enough that it helps to identify Casapalca specimens. When quartz and calcite occur together, they form a characteristic combination of color, habit and form which distinguishes Casapalca specimens from those of other Peruvian localities.

Sphalerite $(Zn,Fe)S$

Sphalerite is commonly found on specimens from Casapalca. The luster varies from very bright to dull; most sphalerite specimens collected recently have bright faces. It is frequently transparent to translucent with the transparent crystals often quite gemmy. Sphalerite in transmitted light varies from pale straw-yellow, through yellow, to a deep reddish amber (almost ruby-red), and dark brown. Crystals in reflected light are silvery to blackish brown in color, and sometimes exhibit a bright, dark bluish black tarnish or a golden-yellow chalcopyrite film that looks like golden spray-paint. Crystal size is variable, and usually parallels that of the other cogenetic minerals, rarely exceeding 5 cm. Rye and Sawkins (1974), however, report that sphalerite crystals in vugs in the Carlos Francisco section exceed 10 cm in size. Crystal forms are often complex with a tendency toward modified octahedrons or positive and negative tetrahedron giving the crystals an octahedral appearance. Spinel-law twins are not common. Casapalca sphalerite generally is not striated; this fact differentiates it from both Huanzala and Quiruvilca sphalerites. The best sphalerite specimens from Casapalca are the gemmy dark amber to reddish crystals over 3 cm in size associated with bright colorless quartz crystals and bright golden pyrite and chalcopyrite.

Tetrahedrite $(Cu,Fe)_{12}Sb_4S_{13}$

Tetrahedrite is a common mineral in specimens from Casapalca. Crystals can be very large for the species, to more than 8 cm on edge, and range in habit from simple tetrahedrons to the more complex habits usually associated with tennantite. These more complex habits may reflect an increase in arsenic relative to antimony within the structure of the mineral. Luster varies from dull (in corroded crystals) to brilliantly metallic. Some crystals have an iridescent tarnish, although they still maintain a high luster.

The majority of tetrahedrite crystals from Casapalca are simple tetrahedrons with minor modifications by other forms and are satiny to brilliant in luster. Chalcopyrite is common as both a coating on and a replacement of the tetrahedrite. Commonly associated are quartz and sphalerite. It is interesting to note that on some specimens with well-developed {111} faces and small {211} faces, chalcopyrite preferentially coats only the octahedral faces; this leaves a bright shiny silvery-black reflectance on the other faces contrasted by a deep golden yellow reflectance on the octahedron faces. It is not uncommon to find microscopic pyrite crystals on the tetrahedrite crystals.

Most of the good tetrahedrite in recent times came out in the very early 1970's. Since 1980 Casapalca tetrahedrite has virtually disappeared from the specimen market, except as recycled specimens.

THE SANTA RITA MINE, MOROCOCHA DISTRICT

Yauli Province
Lima Department

LOCATION

The Santa Rita Pb-Zn-Ag-Cu mine is located a few km east of and above Casapalca, high in the Ticlio pass at 4,800 meters elevation. The entrance to the mine is right in the pass. Although a part of the Morococha district, it is treated here as a separate mine.

The Santa Rita and nearby Huacracocha mines were producing approximately 600 metric tons per day of ore in 1991. The Santa Rita mine has been providing fine specimens of galena, sphalerite, rhodochrosite and quartz in fine scepter crystals, since about 1987. Nothing, however, has been published on its geology.

MINERALS

Many fine Peruvian rhodochrosite specimens were offered for sale in 1991. Most of these consisted of simple, lustrous, rhombic, deep pink crystals over 2.5 cm in size. There is some confusion about whether these specimens originated from the Santa Rita locality; the Manuelita mine, Morococha district, also produced fine rhodochrosite specimens, at about the same time as the Santa Rita mine. Some of the specimens were listed as "near Morococha" by one of us (RHC) at the 1991 Tucson mineral show. Actually these rhodochrosites were mostly from the Manuelita mine, which is east of the Ticlio pass and down near Morococha, along the road to the La Oroya smelter complex. Labels on the rhodochrosite specimens gave their various locations as Santa Rita mine, Casapalca; Santa Rita mine, near Morococha; Casapalca; and occasionally San Cristobal, Yauli district, because the Santa Rita mine has also been considered as part of the Yauli district, which is not too far from Casapalca. A few rhodochrosite specimens were also labeled as from the Manuelita mine. Very little has been published about the ore deposits and minerals of the Manuelita mine.

Distinguishing between rhodochrosite specimens from the Santa Rita mine and the Manuelita mine is very difficult. Rhodochrosite from the Santa Rita mine tends to be on, or associated with, quartz; the rhodochrosite crystal size is up to at least 2.5 cm on edge; and the rhombohedrons are frequently curved on the larger specimens. These can look similar to the rhodochrosite collected from Silverton, Colorado. The Manuelita mine rhodochrosite, on the other hand, is generally in smaller crystals, may be attached directly to the rock matrix without the quartz crystal substrate, and tends to form drusy crusts. Centromin's Casapalca mine has not produced any rhodochrosite, so it can be eliminated as the source.

The confusion is partly due to the way the mines are laid out. A *piritero* going out to get specimens in this area will normally first stop at Casapalca, then go on to the Santa Rita mine, then go over the top of the pass, and then down the other side to the Manuelita mine. Quite often the *piritero* will acquire a few or a lot of specimens from each location. Whichever location has the largest amount of material from a particular trip will usually end up carrying the label for the entire amount. These specimens are usually then offered for sale as all from the same mine. To further confuse things, along with these particular rhodochrosite specimens were a number of similar rhodochrosite specimens from Uchucchacua. These occur in both the scalenohedral and rhombohedral forms, came out in the same time frame, and some of these are mislabeled as Casapalca or Santa Rita. A further complication with this locality is the large number of "Santa Rita" mines in the big mining districts of Peru; it is a very common mine name.

Rhodochrosites from Uchucchacua are, for the most part, distinctly different and are discussed in detail in the section dealing with the Uchucchacua district.

In 1992, along with the rhodochrosite specimens, many interesting specimens of drusy quartz were brought out from the Santa Rita mine. Some of these quartz specimens are colored pink by underlying rhodochrosite. At times the quartz is dusted with a late-stage coating of dark, botryoidal pyrite which makes for attractive specimens.

Sphalerite from Santa Rita is frequently gemmy, with a bright luster and a yellowish green color. Crystals may exceed 2 cm on the better specimens. Microcrystalline, pale pink rhodochrosite is the matrix on some specimens.

THE PACOCOCHA DISTRICT

Huarochiri Province
Lima Department

LOCATION

The Pacococha district is located 4 km southwest of Millotingo, on the banks of Pacococha Lake about 20 km nearly due southwest of Casapalca, and about 35 km southwest of Yauli. Elevations range between 4,600 and 5,200 meters; the district covers an area of about 4 x 6 km. Pacococha is one of the highest mining camps in the world, with some adits located at 5,100 meters (over 16,500 feet) elevation. Pacococha is situated among the mining districts of Viso-Aruri, Millotingo, Pucacorral and Chanape. Millotingo is considered to be part of the Pacococha district by Ly and Arce (1965). Petersen (1962) and Ly and Arce (1965) briefly describe the district, and much of the data given here is abstracted from their reports.

HISTORY

Scattered workings suggest some mining was going on during the Colonial period.. Modern development began in 1950 with the building of a 27-km road from the Central Highway to the district. The main mine in the 1970's was the Purisima, followed in order of size by the San Alejandro, Incataycuna, San David, Reserva, Carolina, Colquechaca, Santiago Mayor, and Santiago Menor. As of the mid-1970's, approximately 42,000 meters of drifts had been completed on 24 veins in the various mines. In late 1991, unless further reserves were discovered, the life for the district's mines was estimated at four years (Cavanagh, 1993?). The formal name for the company mining the district is the Sindicato Minero Pacococha S.A.

GEOLOGY

The predominant rock types at Pacococha are Cenozoic andesitic volcanic flows which have a composite thickness of 700–1000 meters. These flows are interlayered with tuffs and rhyolites. The volcanic rocks have been intruded by several fine-grained diabase or diorite porphyry stocks, which have pyritized, silicified, kaolinized, and otherwise altered adjacent volcanics.

Mineralization is by fracture filling, with the larger veins having lengths of 500 to 1000 meters and thicknesses of 1 to 1.5 meters. Outcrops of these veins are composed of quartz with a boxwork structure caused by weathered-out sulfides. Veins are discontinuous and new reserves must be continuously sought.

***Table 16.* Minerals reported from the Pacococha district.**

	Common or Abundant	
Chalcopyrite	Galena	Quartz
***Dolomite**	Pyrite	Sphalerite
	Rare or Locally Abundant	
Acanthite	***Calcite**	Pyrargyrite
Arsenopyrite	Fluorite	Rhodochrosite
Barite	***Marcasite**	Tetrahedrite
Bornite	Orpiment	

*Collector-quality specimens

MINERALS

Vein mineralization is predominantly chalcopyrite, galena, dark sphalerite, and quartz, with lesser pyrite. Tetrahedrite, silver sulfosalts, acanthite, marcasite, fluorite, barite, calcite and rhodochrosite are minor constituents. Pyrite is usually present as stringers in the veins and is also disseminated in the wall of the veins as small cubes. High-grade veins have almost no quartz. Quartz is usually found in the sub-economic portions of the veins or where the veins narrow and pinch-out.

Some veins are located in the upper parts of the diabase stocks; these have a more complex mineralogy than do the veins in the tuffs and andesites. Typical minerals in these upper portion veins are pyrite, sphalerite, chalcopyrite, arsenopyrite, galena, bornite, pyrargyrite, tetrahedrite, trace gold, calcite, and quartz.

The Pacococha district is often confused with the Castrovirreyna district because of the presence of Pacococha Lake and an adjacent settlement, informally called Pacococha, within the Castrovirreyna district. Specimens from mines near this lake are frequently labeled as from Pacococha.

Calcite $CaCO_3$

Calcite is found at Pacococha in long, colorless crystals showing both the hexagonal prism and the scalenohedral forms. Calcite is often found with rhombohedral dolomite.

Dolomite $CaMg(CO_3)_2$

Dolomite occurs as colorless to translucent white rhombohedra implanted on other minerals.

Marcasite FeS_2

Marcasite occurs on flat plates, as bright six-sided crystals. These specimens are attractive but not outstanding. Marcasite from Pacococha has often been mislabeled as from Casapalca.

Pyrite FeS_2

Pyrite is usually the matrix material at Pacococha, but is also rarely found in specimens with crude pyritohedrons and striated cubes.

Quartz SiO_2

Quartz occurs as colorless, non-tapered crystals with a moderate aspect ratio. Quartz is also present as small crystals and drusy coatings.

Sphalerite (Zn,Fe)S

Sphalerite at Pacococha is the very dark, nearly black variety. This is an aid in differentiating specimens from this locality from sphalerite specimens originating from the Castrovirreyna district, which are lighter in color.

The Millotingo Mine

Huarochiri Province
Lima Department

LOCATION

The Millotingo mine is located a few kilometers southwest of Casapalca, midway between the Pacococha mines and the Casapalca mines. The Pacococha Cu-Pb-Zn district is a short distance to the southwest . Millotingo is considered by Ly and Arce (1965) to be part of the Pacococha district.

HISTORY

In production since about 1958, the Millotingo mine is a rich but small silver mine whose ore is largely composed of silver-bearing sulfosalts. In recent years ore grades have dropped substantially, and since 1987 the company has been operating at a loss. In March of 1991 the phone lines to the mine were out, workers were being paid late, and morale was low. The mine was expected to be shut down before the end of 1991, as the mine could not operate at a profit unless the price of silver rose to over $5.21/ounce (Cavanagh, 1993?). Owned primarily by the Zacarias family, the company's formal name is Compania Minera Millotingo S.A.

GEOLOGY

The main veins at the Millotingo mine have a northeast strike, and in the past have averaged 30 to 40 ounces of silver per ton. Current ore grades in the veins are averaging 9 ounces/ton silver. The two main veins run into the southwest side of a very steep *quebrada* (valley) which, in turn, runs northwest into the Rimac Gorge. Workings follow these southwest-trending veins and also extend under the *quebrada* to the northeast. The veins are nearly vertical with silicified andesite as the wall rocks.

Table 17. **Minerals reported from the Millotingo mine.**

Chalcopyrite	Orpiment	***Pyrargyrite**
Miargyrite	***Proustite**	Quartz

*Collector-quality specimens

MINERALS

The minerals mined are mainly proustite and pyrargyrite. Pyrargyrite has been collected in crystal sizes to over 3 cm. Good mineral specimens from here occasionally appear on the market. It is common for specimens from the Millotingo mine to be labeled as collected from Pacococha district, as this district is only a few km away.

Proustite As_3AsS_3

A very few proustite microcrystals were found during the 1980's, and a few specimens were found in 1981 amid one or two small lots of other minerals. The proustite is mostly in microcrystals 3 to 4 mm long, with beautifully formed scalenohedra, a bright luster and a transparent red color. A few specimens were collected that have microcrystals of proustite nestled in a quartz crystal matrix, associated with orange microcrystalline orpiment crystals.

Pyrargyrite Ag_3SbS_3

Pyrargyrite is rare in good crystals at Millotingo. It usually occurs as 4-mm or less sized crystals with a prismatic habit and a deep red color. These specimens can make excellent micromounts. Associated minerals can include quartz, chalcopyrite, orpiment and other sulfides.

Pyrargyrite has been collected from Millotingo in fairly good-sized crystals for the species, but the quality is not as good as those collected from San Genaro in the Castrovirreyna district. Crystals exceed 5 cm in size, but are satiny or etched-looking, and do not possess the desirable bright luster. In 1980–1981, a number of specimens came out with large crystals, up to 3 cm long, on matrix. They are well-formed, with typical pyrargyrite habit and good dark red color, but with a dull luster.

The Yauricocha District

Yauyos Province
Lima Department

LOCATION

The Yauricocha district is situated about midway between Julcani and Casapalca, 16 km west of the divide between Lima Department and Junin Department and a short distance west of the small town of Huachucmillo. Three glacially carved lakes, Yauricocha, Onacocha, and Acococha, lie southeast of the mines. The Spanish colonialists first worked the district for gold and silver to a depth of 250 meters. Today the district produces copper, lead, zinc and silver (Fig. 96).

GEOLOGY

Much of the geologic data presented here are from Petersen (1965). The Yauricocha orebodies are closely associated with a granodiorite stock located on the limb of a major anticline of Cretaceous Machay Limestone to the west and a syncline of Tertiary Casapalca Red Beds to the east. Two granodiorite stocks crop out in the mine area, and several others have been encountered in underground workings. The contacts between the stocks and the country rock are sharp. These stocks generally exhibit a cylindrical shape that extends over considerable vertical distances (at least 300 meters in one case).

The Casapalca Red Beds show bleaching for a considerable distance from the contacts with the stocks. Alteration of the red beds has caused hematite to turn to pyrite, sandstones to quartzite, and shales to hornfels. The Machay Limestone, in the immediate area of the intrusions, is altered to thin zones of skarn. Farther away from the contacts with the intrusions, it is bleached or recrystallized.

There are two types of orebodies being mined: one is copper-rich and the other is lead-zinc rich. The copper orebodies occur only in altered rock, whereas the lead-zinc orebodies may be found in nearly unaltered limestone. The copper orebodies, which sustained production through the 1960's, are located within pipe-like pyrite-rich bodies close to the granodiorite stocks. Most copper orebodies are elongated in an east-west or north-northwest direction.

Pyrite composes 60–80% of the sulfide orebodies. In general, cubes formed first and pyritohedrons and octahedrons formed later. The pyritohedrons and octahedrons are more abundant toward the centers of the orebodies.

In the copper-rich orebodies, the most important Cu-bearing mineral is enargite, which is commonly associated with quartz and pyrite. Small amounts of late-formed chalcopyrite, bornite and covellite may occur on the enargite in vugs. Empty casts with the morphology of barite or gypsum crystals are relatively common in the massive enargite ores.

Chalcopyrite is the second most abundant Cu-bearing mineral. Bornite is generally associated with chalcopyrite and also with enargite, but less frequently. Digenite, djurleite, chalcocite, covellite, idaite and tennantite-tetrahedrite occur mainly in the bornite-rich ores. Bornite has been replaced by chalcopyrite, covellite, digenite, chalcocite and sphalerite.

The edges of enargite-bearing orebodies are characterized by the presence of tennantite, which may be replaced by enargite. Tennantite is also found in small amounts within massive chal-

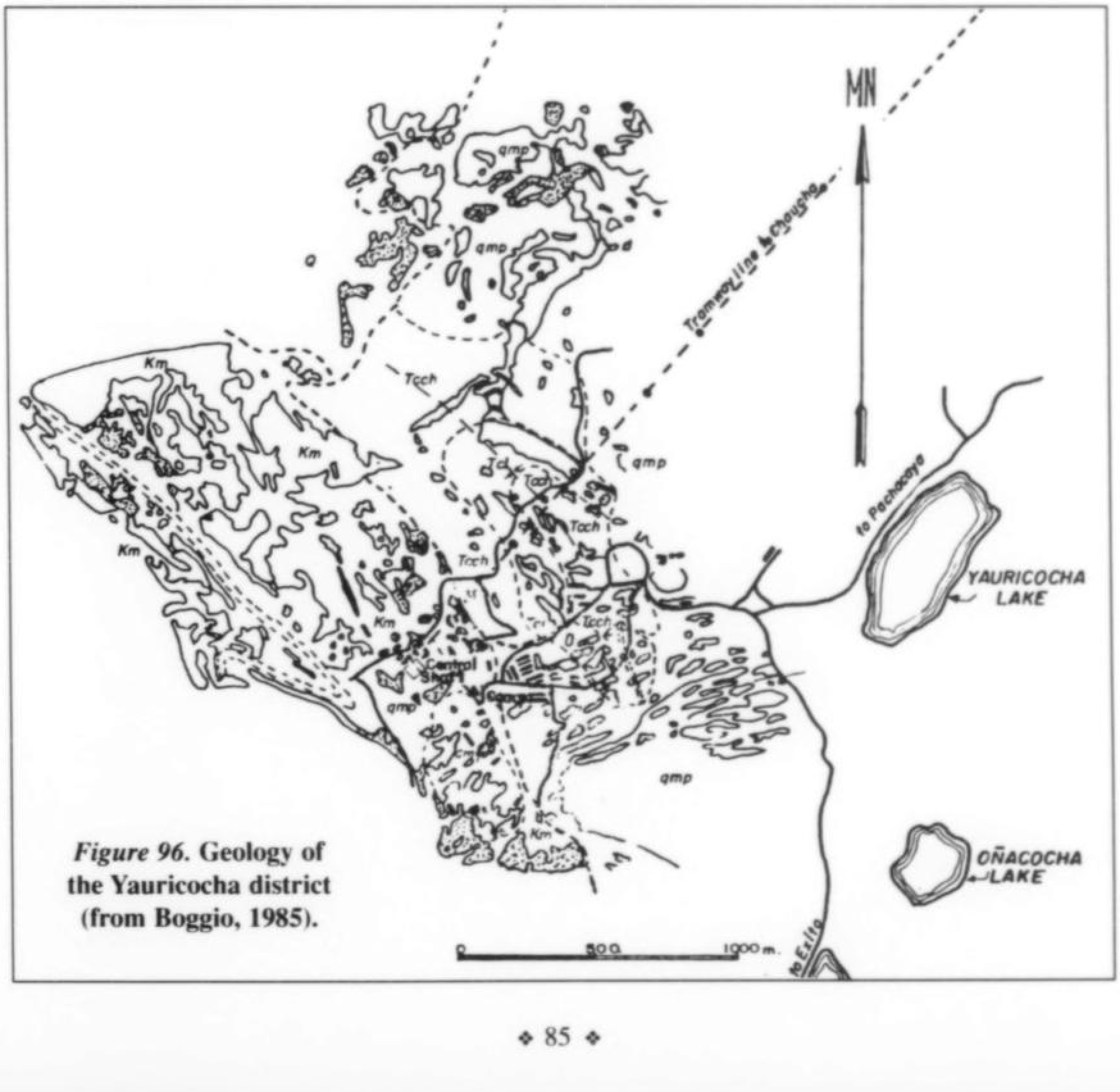


Figure 96. **Geology of the Yauricocha district (from Boggio, 1985).**

copyrite ores. Bismuthinite, stannite (?), emplectite and gallite (?) occur mainly with the enargite-pyrite ore. Realgar and orpiment occur in very small amounts on the margins of the upper level orebodies.

In the lead-zinc rich orebodies, chalcopyrite is the Cu-bearing mineral usually associated with galena and sphalerite. Tennantite-tetrahedrite is a less common associated mineral in these orebodies. Most sphalerite is the dark, Fe-bearing variety, except for late-generation sphalerite, which is lighter in color. Fluorite and arsenopyrite are occasionally found in the lead-zinc ores.

Bournonite is not common in the lead-zinc orebodies and, where found, is usually associated with galena. It may be partially replaced or overlayered by tetrahedrite-tennantite. Enargite rarely replaces bournonite. In the Purisima Concepcion West section of the lead-zinc orebody, plagionite occurs with galena, pyrite and arsenopyrite. In the San Jose de Alis prospect, north of Yauricocha, geocronite occurs intergrown with galena.

Barite is uncommon and, like quartz, appears to have crystallized earlier than the sulfides. Hydrothermal solutions depositing either copper or lead-zinc appear to have leached the early-formed barite. A late generation of calcite is found associated with quartz and sphalerite, peripheral to the main orebodies. Quartz is ubiquitous throughout the orebodies and seems to have crystallized during several pulses of mineralization. Thomson (1960) has identified four generations of quartz deposition.

Oxidation and supergene enrichment extend from the surface to the deepest levels in some orebodies, whereas other orebodies display almost no oxidation or supergene enrichment. Supergene sulfides include covellite, chalcocite and digenite.

MINERALS

Although Yauricocha has good potential for producing mineral specimens, very few have been recovered for the mineral market.

Table 18. **Minerals reported from the Yauricocha district.**

	Common or Abundant		
Bornite	Enargite	Pyrite	Sphalerite
Chalcopyrite	Galena	Quartz	Tennantite-tetrahedrite
	Uncommon or Locally Abundant		
Arsenopyrite	Chalcocite	Geocronite	Polybasite
Azurite	Covellite	Hematite	Realgar
Barite	Digenite	Idaite	Siderite
Bismuthinite	Djurleite	***Malachite**	
Bournonite	Emplectite	Orpiment	
Calcite	Fluorite	Plagionite	

*Collector-quality specimens

Trips to the locality by Peruvian dealers in the 1980's were generally fruitless, other than the acquisition of some low-luster, poor-quality pyrite.

Azurite $Cu_3(CO_3)_2(OH)_2$

Although not mentioned in the literature, azurite has been found as tiny crystals on dull, slightly corroded pyrite, and as below.

Malachite $Cu_2(CO_3)(OH)_2$

Yauricocha is one of the few mineral localities in Peru that actually has an oxide zone. Although malachite is not officially reported from Yauricocha, it is present in the oxide zone. The malachite in the best specimens, which are now rare, occurs as botryoidal aggregates, sometimes with minute azurite crystals nestled in the crevices. A specimen acquired by one of us (TS) in the late 1970's had been used as an ash-tray by one of the mining engineers before it was rescued, cleaned and sold. It is reminiscent of malachite from Bisbee, Arizona, and measures about 15 cm across.

Huancavelica Group

The Julcani District

Angaraes Province
Huancavelica Department

LOCATION and HISTORY

The Julcani district is located about 65 km by road southeast of the city of Huancavelica, at an elevation of 4,200 meters. The district has been mined discontinuously since Spanish colonial times. Serious mining has been conducted since about 1907, and large-scale mining commenced in 1936. The present operator is Alberto Benavides Q., who founded the Compania de Minas Buenaventura S.A. in 1953. Julcani is one of Peru's largest producers of silver and bismuth.

GEOLOGY

Goodell and Petersen (1974) and Petersen *et al.* (1977) have described the geology and mineralogy of the Julcani area. The mineralogy in these papers, as well as one published by Goodell (1974), is used as background for the following synopsis of the district geology and ore deposits.

The Julcani district is dominated by a series of rhyodacitic to dacitic dikes, volcanic domes with related eruptive rocks, and pyroclastic material described as the Julcani volcanic center. There were three phases of activity. The first or main stage activity is characterized by explosive pyroclastic eruptions. The second stage resulted in the formation of a series of domes, and the third and final stage consisted of recurrent doming and dike formation. Hydrothermal alteration and mineralization occurred more or less simultaneously with the intrusion of the third stage volcanic domes and dikes.

Peru

Ore mineralization is generally confined to fracture filling, with limited replacement of the country rock within the vein structures. The mineralized area, containing the major mines of the district, measures approximately 3 x 5 km. Ore solutions appear to have spread upward and outward from several centers. This resulted in clearly defined zoning patterns. These centers are also the location of the major mines today. Some of the more important mines are the Herminia (in the south) and Mimosa (in the north), followed by the Estela, Tentadora, Lucrecia, Rita, Sacramento (Sacramento Otoni), Acchilla, and Manto mines.

Generally, as the ore-bearing solutions moved upward and outward from the innermost centers of the Herminia vein system, they first deposited pyrite-wolframite-enargite-barite, then enargite-pyrite-tennantite/tetrahedrite, then a zone of complex silver and bismuth sulfosalts with bismuthinite (Robinson *et al.*, 1997; Vajdak, 1995), and at a greater distance they deposited galena, followed by lead sulfosalts, orpiment, and realgar. Pyrite was deposited first throughout the vein system, particularly in association with enargite; smaller amounts of pyrite also crystallized later. Barite commonly crystallized with, or slightly after, enargite and extends beyond the area of enargite deposition. In the outermost fringes of the zoning sequence, barite precipitated with tennantite/tetrahedrite, followed by bismuth sulfides and sulfosalts, then galena, followed by orpiment, realgar, and lead sulfosalts. Galena is the main ore mineral in the distal parts of the zoning sequence.

Pyrite-gold-tungsten mineralization is the dominant mineralization in the Tentadora mine, which is thought to be in the innermost zone of the Herminia vein system.

The Mimosa vein system is in the northern part of the district. In this vein system, tennantite/tetrahedrite is the dominant mineral in the innermost assemblage, with galena being the dominant mineral in the outer zones. The Mimosa system is similar to, and somewhat simpler than, the Herminia system. Pyrite was the first mineral to crystallize, followed, in order, by tennantite/tetrahedrite, sphalerite with chalcopyrite, and siderite. This first stage of mineralization was followed by crystallization of bismuth-bearing minerals, followed by galena, then lead sulfosalt-bearing mineral assemblages. In both the Herminia and the Mimosa vein systems, the final mineralization phase was a crystallization of sphalerite and siderite.

Southwest of the Mimosa mine is the Estela vein system. The inner zone of this system is dominated by pyrite-wolframite mineralization, followed by tennantite/tetrahedrite-chalcopyrite-arsenopyrite-bismuthinite, and finally by galena-sphalerite mineralization.

Figure 97. **Geology of the Julcani district (from Boggio, 1985).**

Table 19. **Minerals reported from the Julcani district.**

Major Mines and Common to Locally Abundant Minerals		
	Herminia Mine	
Andorite	*Chalcopyrite	Sphalerite
Aramayoite	*Enargite	*Stibnite
Arsenopyrite	Galena	*Tennantite-tetrahedrite
*Barite	*Pyrite	
*Bismuthinite	Semseyite	Wolframite
*Bournonite	*Siderite	
	Lucrecia Mine	
*Barite	*Tennantite-tetrahedrite	
Galena		
	Tentadora Mine	
Galena	Quartz	Wolframite
Pyrite	Sphalerite	
	Estela Mine	
*Apatite	Galena	Tennantite-tetrahedrite
*Arsenopyrite	Pyrite	
*Bismuthinite	Sphalerite	Wolframite
Chalcopyrite		
	Mimosa Mine	
*Bismuthinite	Galena	Tennantite-tetrahedrite
*Boulangerite	Siderite	
Chalcopyrite	Sphalerite	
	Sacramento Mine	
*Orpiment	Realgar	
Minerals reported with no specific mine listed		
*Aikinite	Friedrichite	Krupkaite
Bornite	Gustavite	Marcasite
Calcite	Hammarite	Pavonite
*Cosalite (?)	Hodrushite	Scheelite

*Collector-quality specimens

MINERALS

The reader is referred to Goodell (1974) for an excellent short description of the minerals reported from Julcani.

A help in distinguishing mineral specimens from Julcani is the matrix rock. If the matrix is country rock, it will be an altered, siliceous volcanic rock, usually with anhedral quartz phenocrysts, originally rhyolitic to dacitic in composition.

Aikinite $PbCuBiS_3$

Aikinite has been identified by one of us (JAC) in two specimens provided by two individuals, both specimens attributed to Julcani. It occurs as coatings of tiny, acicular, steel-blue, metallic-lustered crystals up to 3 mm long associated with chalcopyrite, tetrahedrite and enargite. It could easily be mistaken for boulangerite or bismuthinite. Identification was made by X-ray powder diffraction analysis.

Arsenopyrite FeAsS

Arsenopyrite occurs as brilliant, silvery, prismatic crystals with flat, triangular or wedge-shaped terminations. The crystals are usually on the order of a few centimeters in maximum dimension. According to Goodell (1974), arsenopyrite is restricted to the Estela mine. In 1993 a small find of arsenopyrite was made at Julcani, presumably from the Estela mine. The specimens are in flat to mounded plates composed of near-solid coatings of bright, silvery, simple prismatic crystals up to 6 mm diameter and about 1 cm long. Colorless or very pale yellow to yellowish green apatite crystals up to 2 cm long are frequently implanted on the arsenopyrite.

Barite $BaSO_4$

Barite is relatively common at Julcani as bladed crystals and mound-like crystal aggregates. This latter habit is similar in shape to barite from the Mibladen, Morocco vanadinite area. Barite is frequently associated with the sulfides and sulfosalts. Crystals may exceed 5 cm in size and, according to Goodell (1974), have been recorded up to 25 cm in size from the Herminia mine.

Commonly white, barite can also be gray-blue, pinkish or colorless. Julcani produced some quite attractive thin, flake-like or wafer-like barite in 1987. A substantial amount of very pretty and choice barite, covered with siderite and associated with galena crystals, was produced in 1988. In the early 1990's, Julcani produced a small amount of attractive yellow barite which is associated with siderite.

Bismuthinite Bi_2S_3

Bismuthinite is found as lustrous, steel-gray, needle-shaped prismatic crystals that superficially resemble stibnite. Bismuthinite can achieve crystal lengths up to several cm, which make excellent specimens for the species. White bladed barite is a common associated mineral.

Boulangerite $Pb_5Sb_4S_{11}$

Boulangerite occurs in hair-like, sometimes matted, crystals.

Bournonite $PbCuSbS_3$

Bournonite usually occurs as splendent black to steel-gray crystals up to 2.5 cm across. It frequently occurs with bladed barite, bismuthinite, boulangerite and jamesonite (these last three identifications are questionable as they are visual observation only).

Cosalite (?) $Pb_2Bi_2S_5$

Cosalite (?) has been tentatively identified by one of us (JAC) in one specimen attributed to Julcani. It occurs as long, thin, prismatic crystals with metallic luster and typical arsenopyrite-gray color where crystals have been broken; the cosalite (?) is partially covered with drusy quartz. It is also associated with tetrahedrite and chalcopyrite. Identification was made by X-ray powder diffraction analysis.

Fluorapatite (?) $Ca_5(PO_4)_3F$

Apatite occurs in sharp crystals, usually as simple hexagonal prisms with flat terminations. They are near-colorless to a pale yellow, greenish yellow, or yellowish green color. Larger crystals are frequently zoned. In the case of single-terminated crystals, the base is white or colorless and the termination may be greenish in color. In the case of doubly terminated crystals, the midpoint is white or colorless and both terminations may be greenish in color. Julcani apatite fluoresces a cream-yellow color that varies in intensity due to zoning within the crystals. Rarely, apatite crystals may exceed 2.5 cm in length. Associated minerals are usually white to near colorless, tapered crystals of quartz and small crystals of siderite and pyrite. Arsenopyrite, frequently found in drusy crusts, often forms the matrix mineral for the apatite crystals.

Galena PbS

Galena occurs as shiny gray crystals. These are usually highly modified cubes tending toward the octahedron or dodecahedron forms, sometimes to the degree that the cube is no longer distinguishable. Some galena has a "crinkly" surface, possibly due to etching.

Jamesonite $Pb_4FeSb_6S_{14}$

Jamesonite is megascopically indistinguishable from boulangerite and bismuthinite.

Orpiment As_2S_3

Orpiment occurs in bright orange, glassy, lustrous, pencil-shaped crystals that are up to at least 2.5 cm in length. They are distinctly different in appearance from the orpiment crystals found at Quiruvilca.

Pyrite FeS_2

Pyrite, commonly in pyritohedrons, is usually a minor constituent on most mineral specimens. Where present, crystals may reach 1 cm across. During the past several years botryoidal pyrite specimens, typical for Julcani, have been produced in small numbers in handsized specimens.

Quartz SiO_2

Quartz is usually present on Julcani mineral specimens, commonly as very small, white to colorless drusy crystal coatings and as the matrix for other minerals. Quartz also occurs as milky white, nearly opaque crystals which have a strong triangular development when viewed along the *c*-axis. Crystals can also be slightly barrel-shaped and at least 2 cm long.

Siderite $Fe^{+2}CO_3$

Siderite is common as a minor accessory mineral and also as good specimens in its own right. It is beige to brownish in color, and is usually found in flattened rhombohedral crystals that are quite discoidal in appearance. Siderite commonly occurs on barite, sometimes with galena. Very nice stalactites and "worms" of siderite up to 15 cm long were recovered from 1988 to 1990. These make rather interesting specimens.

Stibnite Sb_2S_3

Stibnite in the specimens seen occurs as typical, acicular, metallic luster crystals up to several mm in length. Barite is a common associated mineral.

Tennantite/Tetrahedrite $(Cu,Fe)_{12}As_4S_{13}$ - $(Cu,Fe)_{12}Sb_4S_{13}$

Tennantite/tetrahedrite crystals are usually complex in form, though such complexity is more typical of the As-rich end member, tennantite. It rarely occurs in simple tetrahedrons. Crystals are usually lustrous and black to silvery black in color. It also occurs as casts after enargite.

THE CASTROVIRREYNA DISTRICT

Castrovirreyna Province
Huancavelica Department

LOCATION

The Castrovirreyna district (Fig. 105) is located along the road which leads from the city of Huancavelica to Pisco on the Pacific coast. The district is named for the town of Castrovirreyna.

The Castrovirreyna district is composed of a series of volcanic peaks that average about 5,000 meters in elevation. There are 18 peaks exceeding 4,700 meters in the district . Snow in the winter months is common. The Western Cordillera divides the district into two halves. Many large glacial lakes are present. Orcococha, one of the largest, is in the Atlantic watershed and Pacococha, about 7 km to the west over the divide, is in the Pacific watershed. The terrain is strongly glaciated, which creates sharp angular relief. The dark volcanic rocks are colored by areas of manganiferous and limonitic alteration and weathering. Masias (1924) described the area from atop 5,000-meter Monserrate Chico hill:

> As no wind blew, the lakes appeared as extensive surfaces of lead. To the front, the snowed-under ribbon of the cordillera peaks extended like a rampart, an immense wall with its scarps and parapets. It seemed like a cyclopean fortress placed by God to defend our native soil. Above the level of the lakes the different mineralized hills rise to a great elevation, some forming great masses and others, volcanic cones or needles of varied forms.

HISTORY

The district's mineral deposits were discovered in 1590, but the mines closed a short time later in response to the occurrence (according to legend) of various supernatural events (Purser, 1971). Serious mining operations began again in 1946.

GEOLOGY

The Castrovirreyna district is briefly described by Masias (1924) and Purser (1971) and the following geological discussion is abstracted from their papers. Very little other information on the district is available.

Rocks in the district are flat-lying Cenozoic andesitic volcanics with some dacite and rhyolite present. A buried intrusion is inferred from the mine geology.

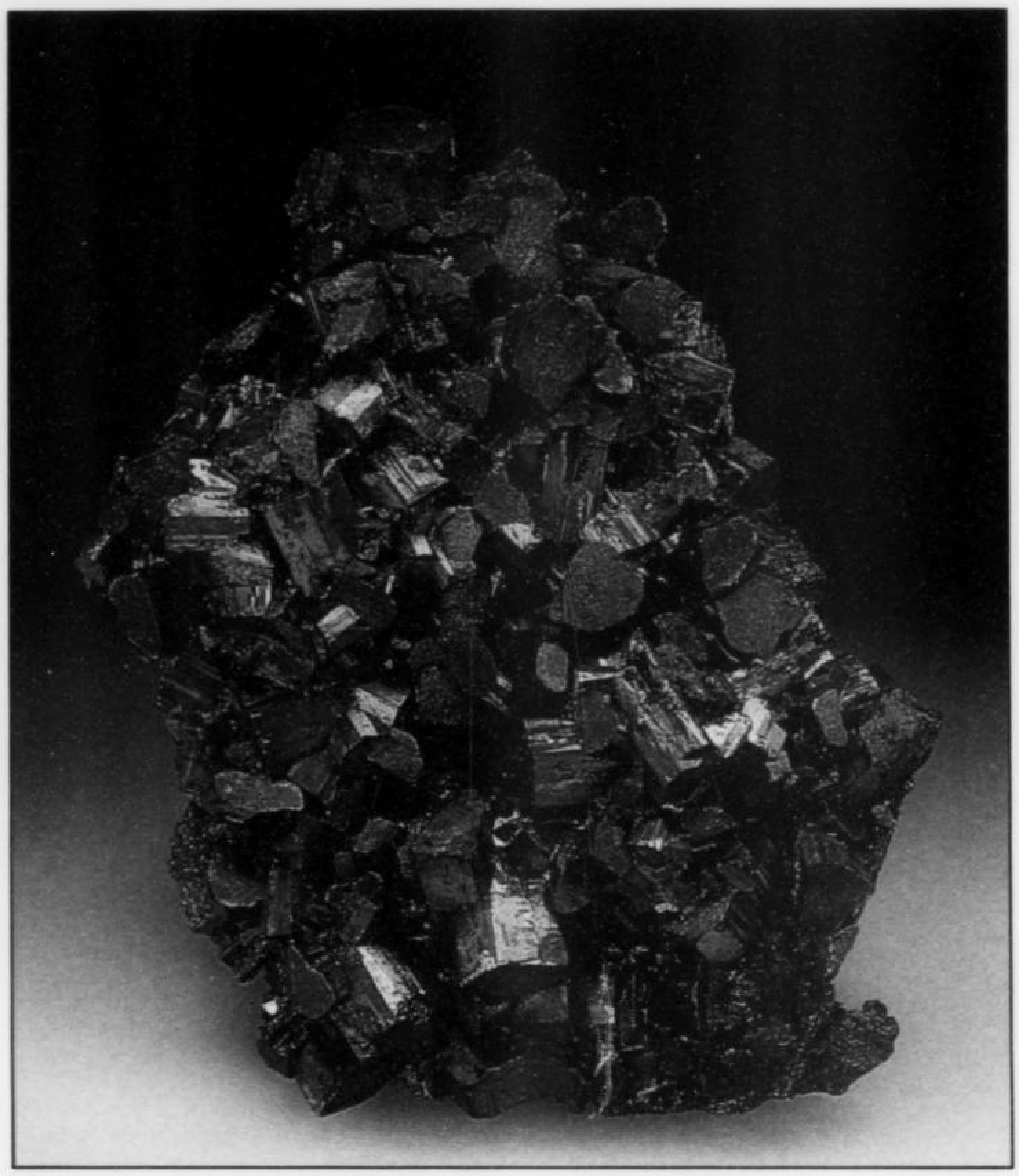


Figure 98. **Enargite crystals partially coated by chalcopyrite on the prism faces, 12 cm, from Julcani. Galena Rock Shop specimen; Jeff Scovil photo.**

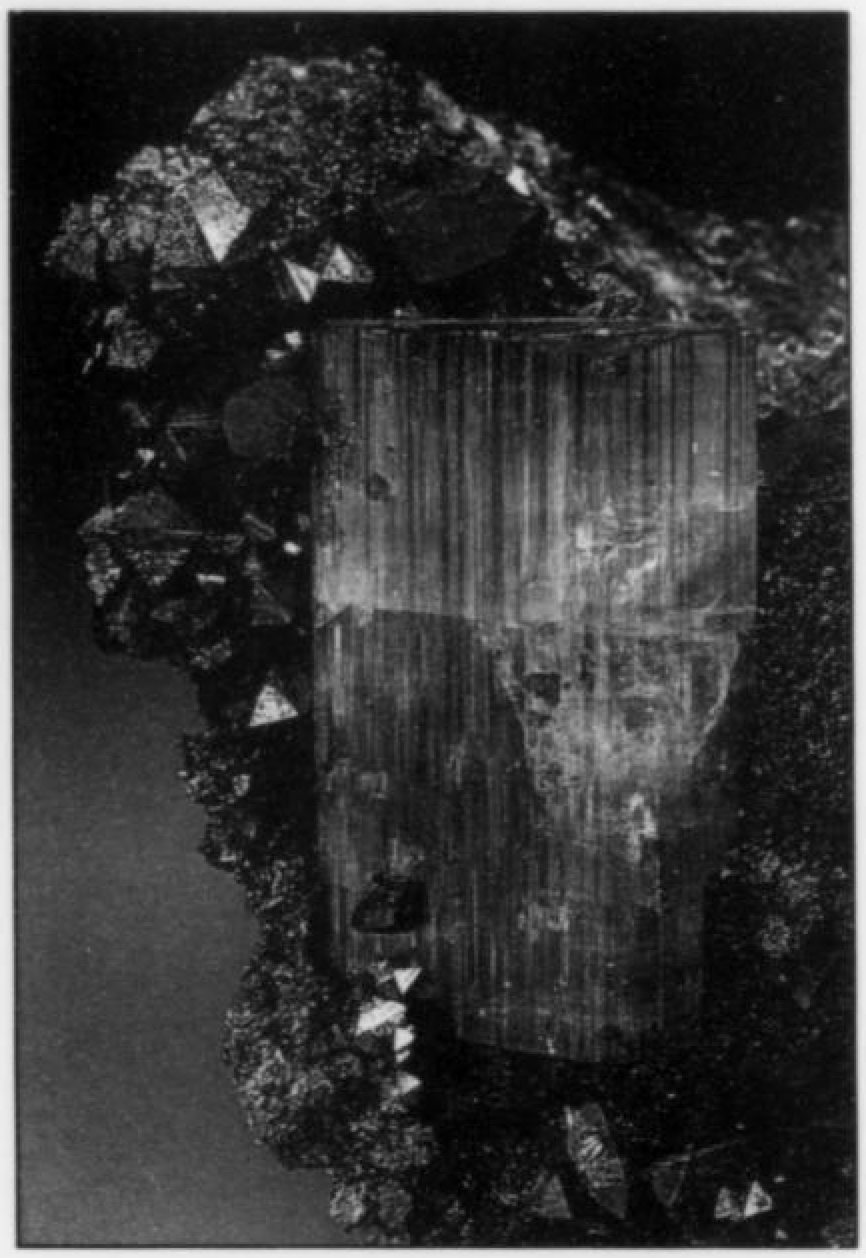


Figure 99. **Fluorapatite crystal, 2.8 cm, on arsenopyrite, from Julcani. Harvey Gordon specimen; Jeff Scovil photo.**

Figure 100. **Bournonite crystal on pyrite, 3 cm, from Julcani. Philip Goodell collection; Rock Currier photo.**

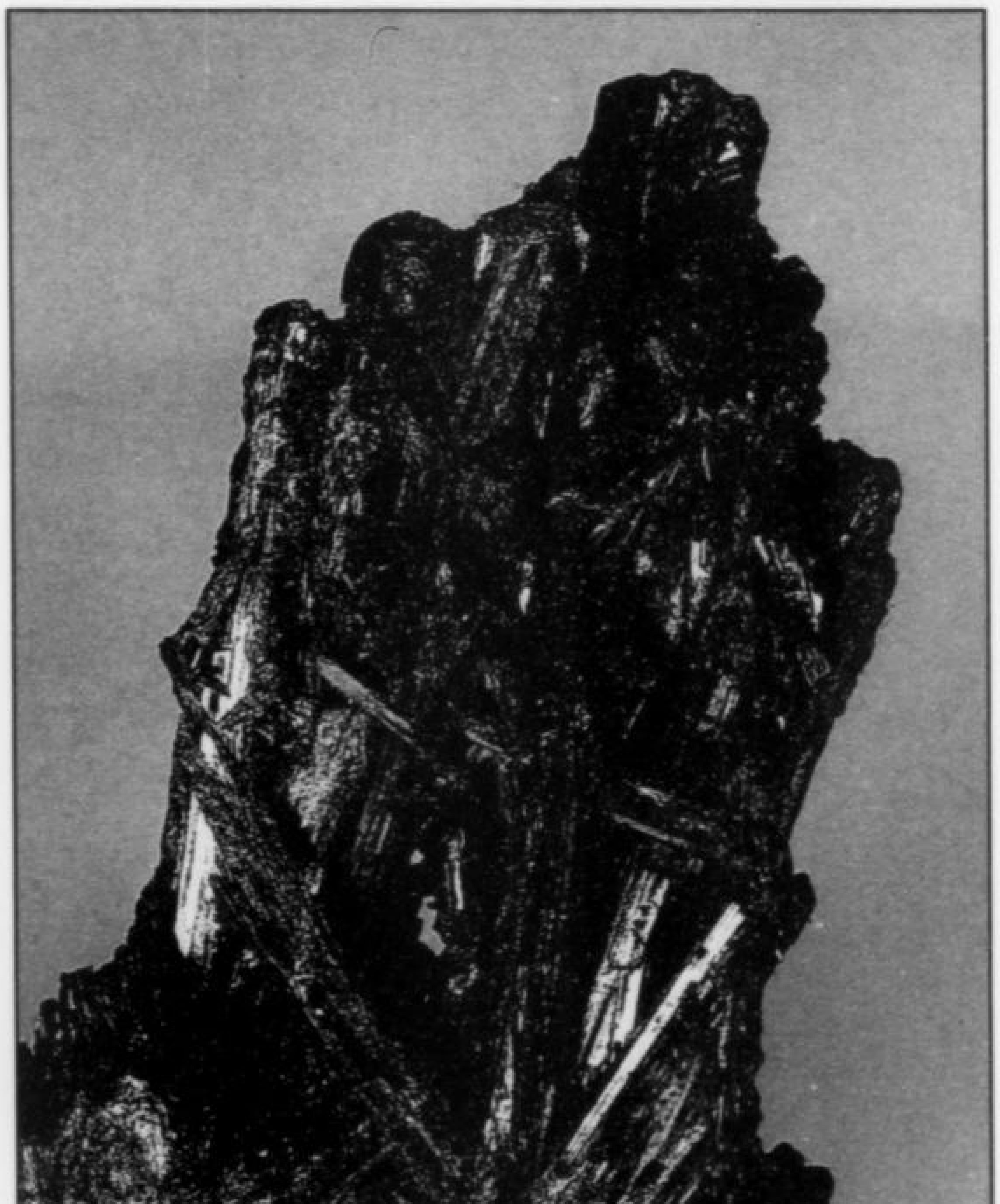


Figure 101. **Bismuthinite crystal group, 6.5 cm, from Julcani. Philip Goodell collection; Rock Currier photo.**

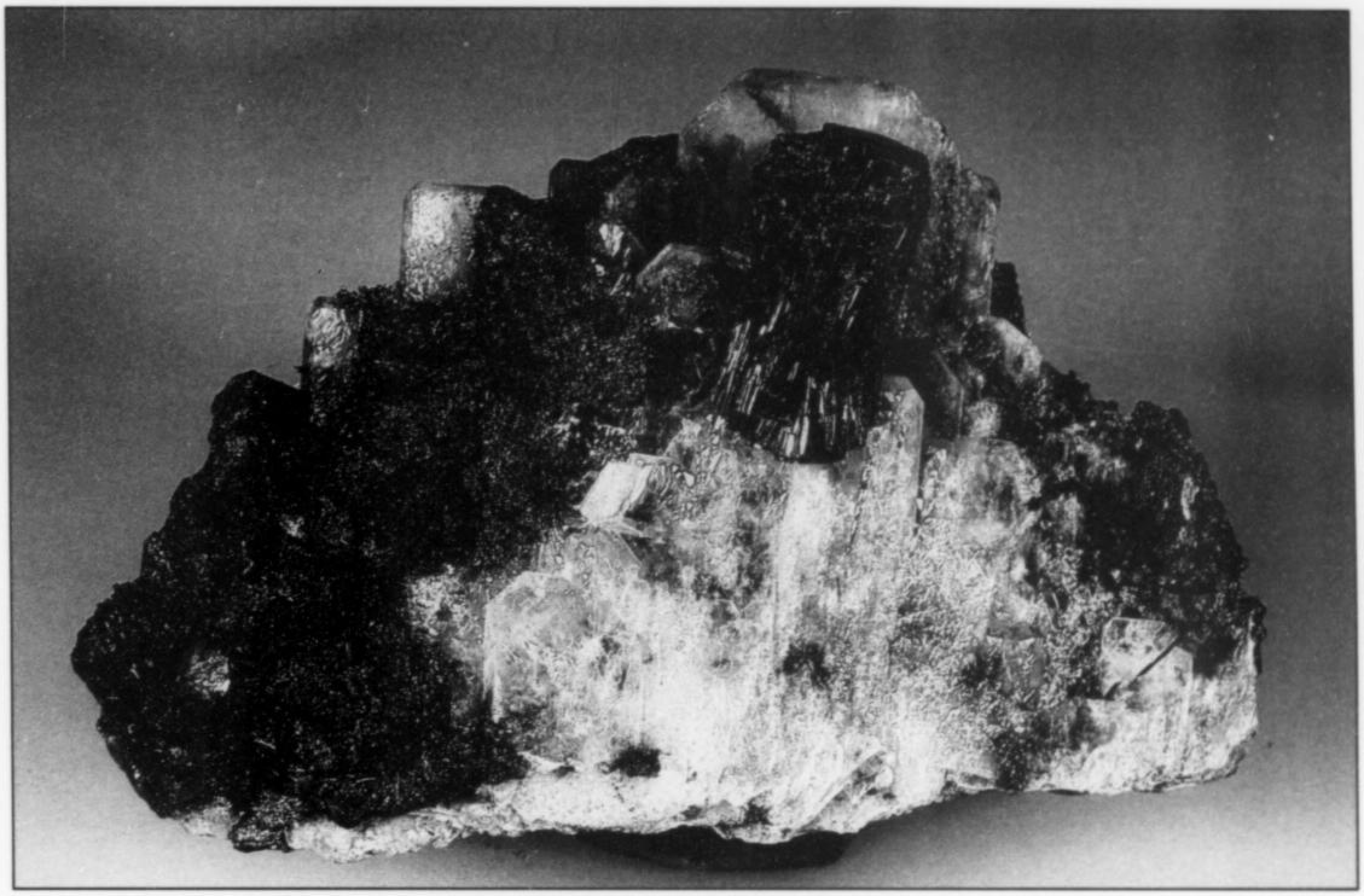


Figure 102. **Bournonite crystal with black semseyite on barite, 7 cm, from Julcani. Philip Goodell collection; Rock Currier photo.**

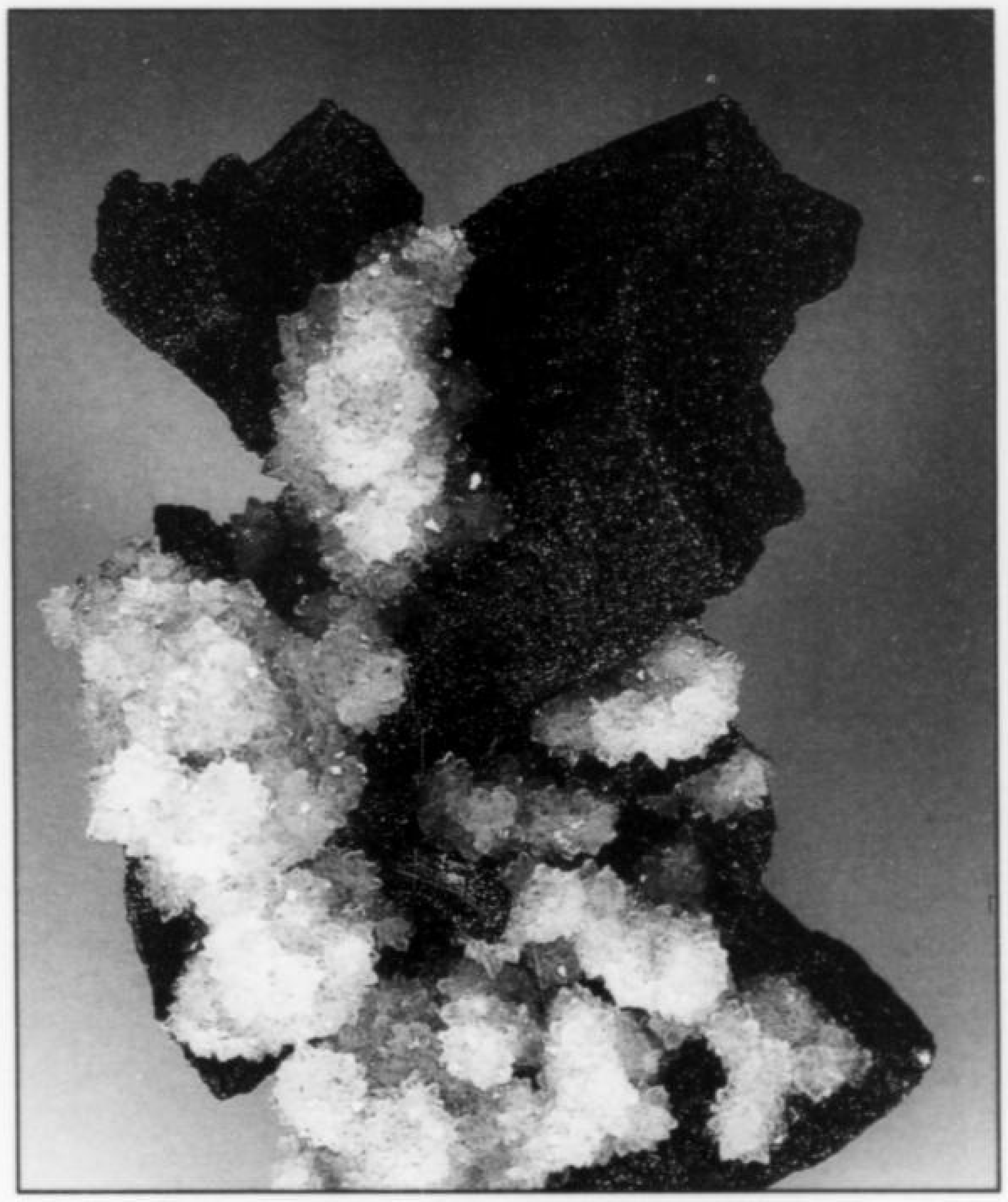


Figure 103. **Enargite crystals coated by chalcopyrite, 7.6 cm, from Julcani. Philip Goodell collection; Rock Currier photo.**

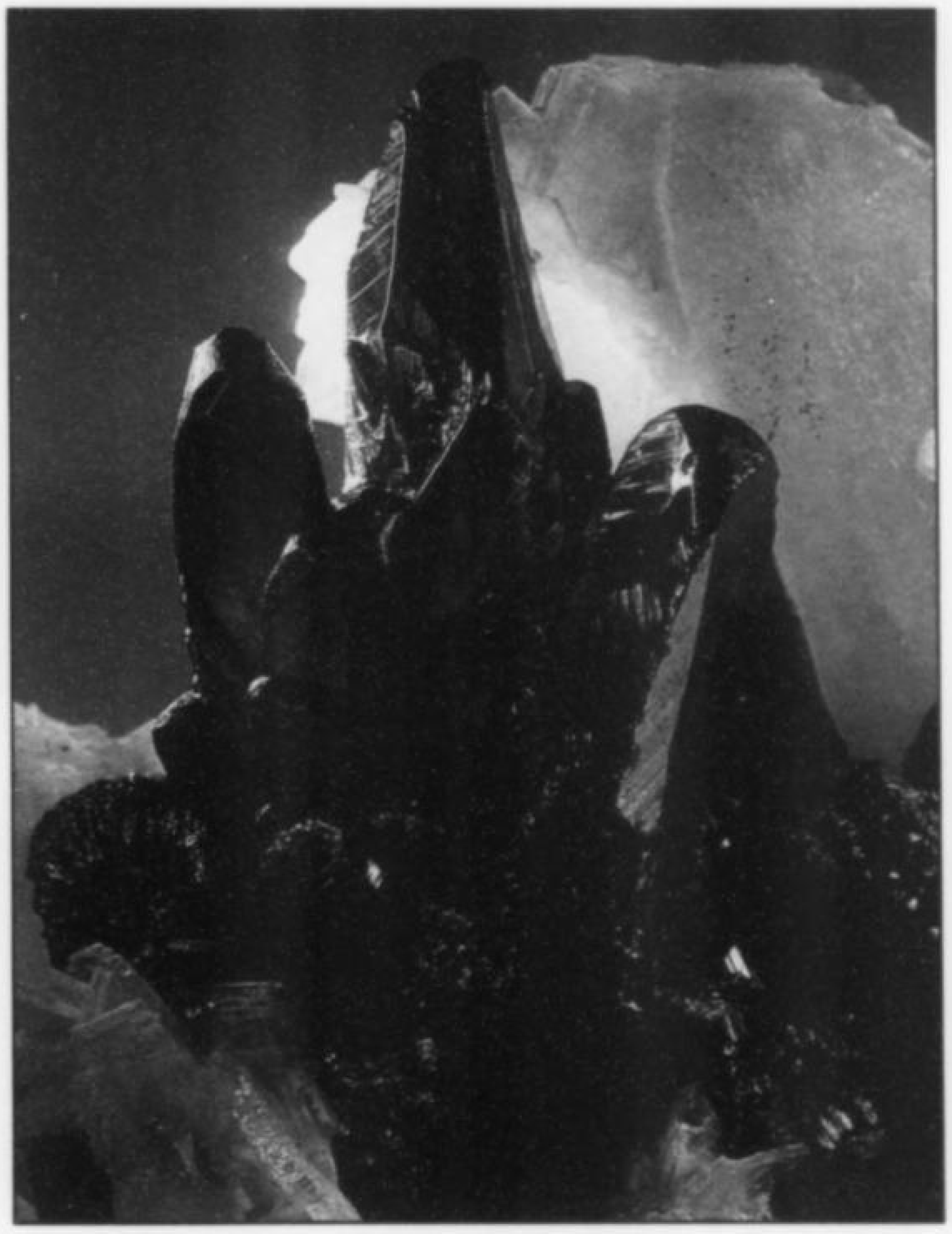


Figure 104. **Pyrargyrite crystal cluster, 2 cm, with calcite, from San Genaro. Cal Graeber specimen now in the Frank Knechtel collection; Wendell Wilson photo.**

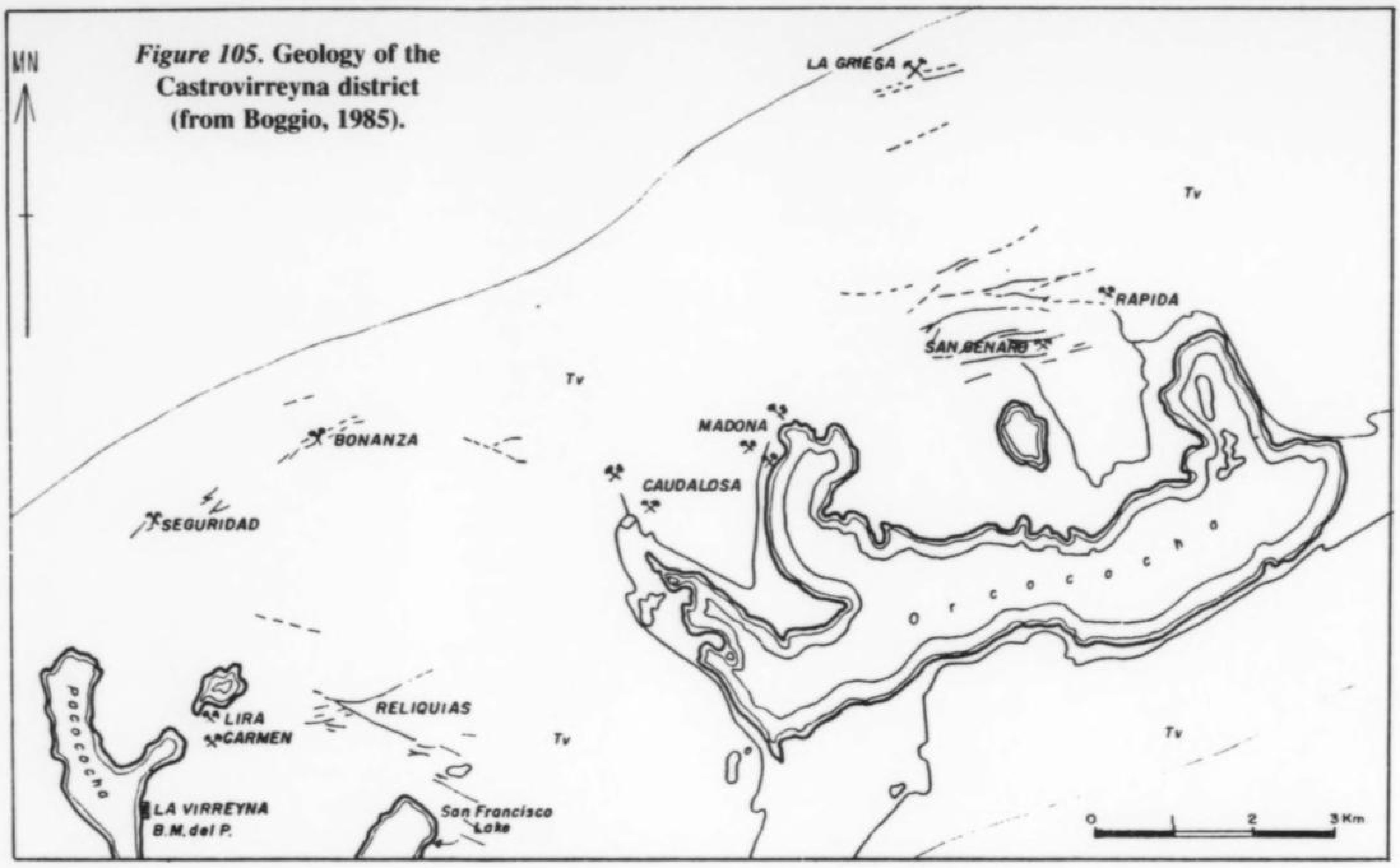


Figure 105. **Geology of the Castrovirreyna district (from Boggio, 1985).**

There are four major mines in the district. The largest are the Caudalosa and Candelaria mines, which are found in the Caudalosa vein-group. Another major mine is the San Genaro mine, east of the Caudalosa mine near the village of Choclococha, in the San Genaro vein-group area. The third is the Carmen-Lira mine in the La Virreyna vein-group. The Carmen-Lira mine is the source for most of the sulfide-bearing mineral specimens from the district. Near the Caudalosa mine are several smaller mines including the Reliquias, Dorito, San Pablo and Madona. The Reliquias is the largest of these.

The Pb-Cu-Zn-Ag veins in the district run more or less east-west in the andesite-to-rhyolite country rock. They frequently contain proustite, pyrargyrite and other rarer silver sulfosalts. Silver content of the ores from the district increases from west to east. There are three main groups of veins; the La Virreyna group, just east of Pacococha Lake, the Caudalosa group, at the northwest end of Orcococha lake, and the San Genaro group, a few km north of the eastern part of Orcococha Lake. Veins vary from 30 cm to 3 meters wide, with quartz usually the dominant gangue mineral. The Caudalosa mine veins have been traced a horizontal distance of 1,500 meters. In the La Virreyna group, the Carmen-Lira veins usually contain tetrahedrite, chalcopyrite, galena, sphalerite, pyrite and quartz. The Huachacolpa district, several km to the northeast, is considered to be an extension of the Castrovirreyna district by Masias (1924).

The Caudalosa mine ores are composed of Ag-rich galena, sphalerite and pyrite, plus or minus stibnite. Gangue minerals are quartz, manganoan calcite and rhodochrosite. Deposition in the Caudalosa mine occurred in four stages. In the first stage, pyrite, galena, sphalerite and enargite were deposited. In the second stage, pyrite, sphalerite and chalcopyrite were deposited, galena was replaced by boulangerite and bournonite, and enargite was replaced by famatinite. In the third stage, conversion of lead-bearing minerals to jordanite, replacement of copper-bearing minerals by tetrahedrite, and deposition of pearceite and proustite took place. In the fourth stage, deposition of stibnite, rhodochrosite, pyrargyrite and polybasite occurred.

At San Genaro, on the east side of the divide, there are three stages of mineralization. The first stage is marked by the deposition of pyrite, sphalerite, galena and chalcopyrite. The second stage is marked by proustite. The third stage is marked by pyrargyrite, polybasite and other sulfide/sulfosalts in small amounts.

Neither Masias (1924) nor Purser (1971) discuss the Carmen-Lira mine.

Table 20. **Minerals reported from the Castrovirreyna district.**

	Common or Abundant	
***Barite**	Jordanite	***Pyrite**
***Boulangerite**	***Miargyrite**	***Quartz**
***Bournonite**	Pearceite	***Rhodochrosite**
***Chalcopyrite**	***Polybasite**	***Native silver**
Enargite	***Proustite**	***Sphalerite**
Famatinite	***Pyrargyrite**	***Stibnite**
***Galena**		
	Rare or Locally Abundant	
***Aramayoite**	Calcite	Realgar
Acanthite	Hematite	***Tetrahedrite**
Arsenopyrite	Marcasite	

*Collector-quality specimens

MINERALS

Most mineral specimens from the Castrovirreyna district are simply labeled "Castrovirreyna," with no specification as to which mine they came from. Confusion also exists regarding mineral specimens collected from the Castrovirreyna vs. the Pacococha mining district. This confusion, related to geographic location, is the result of there being a Pacococha district and mine near Millotingo; in the Castrovirreyna district, there is a Pacococha Lake, and hill, with mines adjacent to both, located in the western part of the district. Specimens from the Carmen-Lira mines are frequently labeled as "Pacococha, Huancavelica." To add to the location problems for the district, there is another large, operating, Caudalosa mine in the Huachacolpa district, just north of the Castrovirreyna district. The majority of good specimens of chalcopyrite, sphalerite, galena and tetrahedrite labeled "Pacococha" are actually from the Castrovirreyna district. A help in differentiating the two locations labeled as "Pacococha" is that the Pacococha mines near Millotingo have produced (in comparison to the Castrovirreyna district) very few mineral specimens. Generally, the Caudalosa and Carmen-Lira mines produce mixed sulfide specimens, and the San Genaro mines produce silver and silver-sulfosalt minerals. The San Genaro mines produced a significant number of very fine-quality sulfosalt specimens, primarily miargyrite and pyrargyrite associated with aramayoite, native silver, proustite and barite, in the mid-1970's through the middle 1980's.

Ankerite $Ca(Fe^{+2},Mg,Mn)(CO_3)_2$

Ankerite is a common accessory mineral in the west side of the district, and is one of the last minerals to have formed. Ankerite crystals occur as poorly formed rhombohedra usually having a dull beige or tan color and a chalky appearance. It is present as small crystals and aggregates which coat the other minerals. Larger ankerite crystals commonly have pinkish cores; this may reflect a change from kutnohorite(?) to ankerite as the crystals grew. Ankerite from the Pacococha area of Castrovirreyna is distinctive enough to help identify specimens from there. Specimens from the Pacococha district near Millotingo do not have this distinctive-appearing ankerite.

Aramayoite $Ag(Sb,Bi)S_2$

Aramayoite is a relatively common but minor accessory mineral on specimens of miargyrite and pyrargyrite. It occurs as iron-black, crystalline, platy masses on the sulfosalts. It can be easily overlooked as it resembles miargyrite.

Barite $BaSO_4$

San Genaro is the most prolific location for barite in Peru. Barite occurs in the San Genaro mine as translucent to opaque, white to off-white bladed crystals in good and sometimes large groups associated with sulfides and quartz. These groups are often damaged. The barite crystals may have white centers which are less transparent when compared to the white edges; this creates a two-tone effect on the crystals. The barite crystals average about 2 cm in size, but may be up to 10 cm long, and occur in plates up to about 22 cm across, associated with milky quartz. These large barite specimens may weigh up to several kilograms. Most of these specimens have been purchased by European mineral dealers. Barite also occurs at the Caudalosa mine.

Calcite $CaCO_3$

Pink manganoan calcite has been visually identified as fine-grained pink coatings on stibnite and other sulfides from the Caudalosa mines.

Chalcopyrite $CuFeS_2$

Chalcopyrite at Castrovirreyna is dark yellow-gold in color, with a bright and shiny luster. It occurs in the better specimens as sharp crystals over 2 cm across. Some crystal faces are mirror-bright with no striations, while opposing faces are striated and very slightly etched. The crystals are frequently twinned. Tetrahedrite may occur on the chalcopyrite. In the Carmen-Lira mines, chalcopyrite crystals may exceed 2 cm in size. The crystals have a bright luster, sometimes with an iridescent tarnish. One Carmen-Lira specimen, about 5 x 6.5 cm in size, has very sharp, bright, gold-colored chalcopyrite crystals 2 cm across on a bed of clear glassy quartz crystals which average about 2.5 cm long.

Galena PbS

Galena occurs both as dull, etched-looking crystals and as lustrous bluish-silvery cubes and cubes modified by the octahedron. It occurs both on and with sphalerite or chalcopyrite. Galena frequently has triangular surface growth features on some faces. It also occurs as crystals with a "melted" look. The melted-appearing galena has considerably brighter luster than the etched-looking galena.

Kutnohorite $Ca(Mn,Mg,Fe)(CO_3)_2$

Kutnohorite has been tentatively identified in pale pink rhombic crystals with a satiny to dull luster. They have also been found at the core of ankerite crystals.

Miargyrite $AgSbS_2$

Miargyrite occurs at Castrovirreyna in crystals up to 3 cm in size. Most specimens, however, consist of botryoidal miargyrite coated with microscopic to small red-black miargyrite crystals with other minor associated minerals.

Pyrargyrite Ag_3SbS_3

Found at Castrovirreyna in magnificent crystals to over 4 cm in size, pyrargyrite is more common as microscopic crystals up to a few millimeters in size. The best pyrargyrite specimens have 2 x 4-cm crystals. San Genaro has produced some of the largest pyrargyrite crystals in the world. The best specimens are described as "golfball"-sized crystals which are lustrous and deep ruby-red to red-black in color. Perhaps the best specimen of pyrargyrite collected from San Genaro is now in the Houston Museum of Natural Science.

Pyrite FeS_2

Pyrite occurs at Castrovirreyna as lustrous pyritohedrons up to 1 cm in size, frequently associated with tetrahedrite in the Caudalosa mine. The Carmen-Lira mines commonly produce pyrite associated with various ore minerals, but it does not generally form good specimens there by itself.

Quartz SiO_2

Quartz from the district is usually opaque milky white in color. Other than the strong milky-white color, they are typical in crystal appearance. Quartz has been collected from the Caudalosa mine as drusy quartz which forms molds of now-absent tabular barite. The Carmen-Lira mine has quartz that occurs both as drusy coatings and as individual crystals exceeding a few centimeters in length. These crystals are typically clear to colorless, with a very slight taper and somewhat triangular cross-sections. The San Genaro mine produces milky quartz crystals which typically exceed 1 cm in length.

According to Dan Belsher (personal communication, 1992), amethyst occurs in fairly nice specimens from the San Genaro mine, as "milky amethyst which looks like Guanajuato, Mexico amethyst, with some occurring in plates to 9 inches square with crystals to 5 or 6 inches long, fairly lustrous, sometimes sceptered, and very pretty."

Silver Ag

In the San Genaro mine native silver occurs as wiry aggregates mixed with the silver sulfosalts.

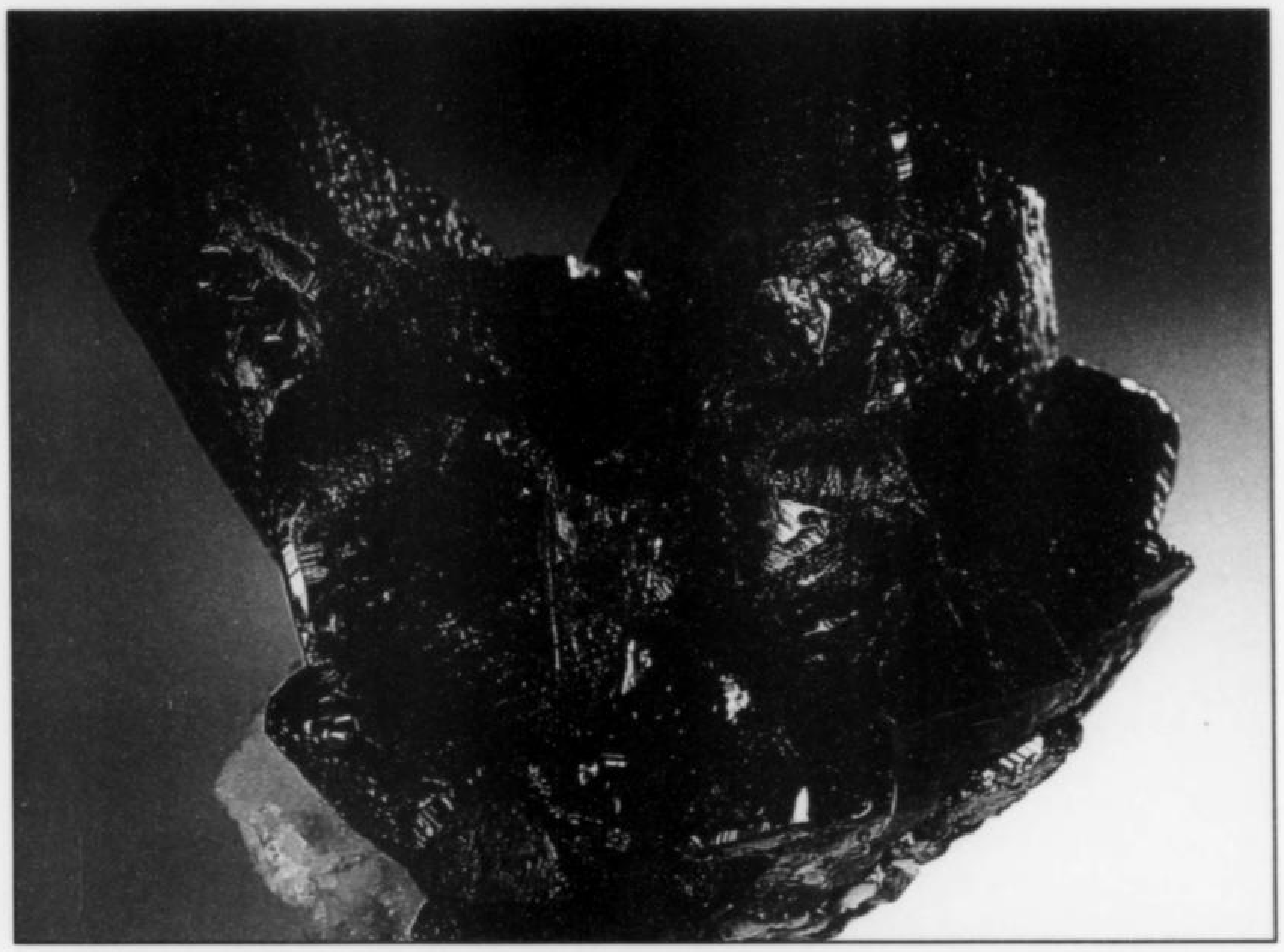
Sphalerite (Zn,Fe)S

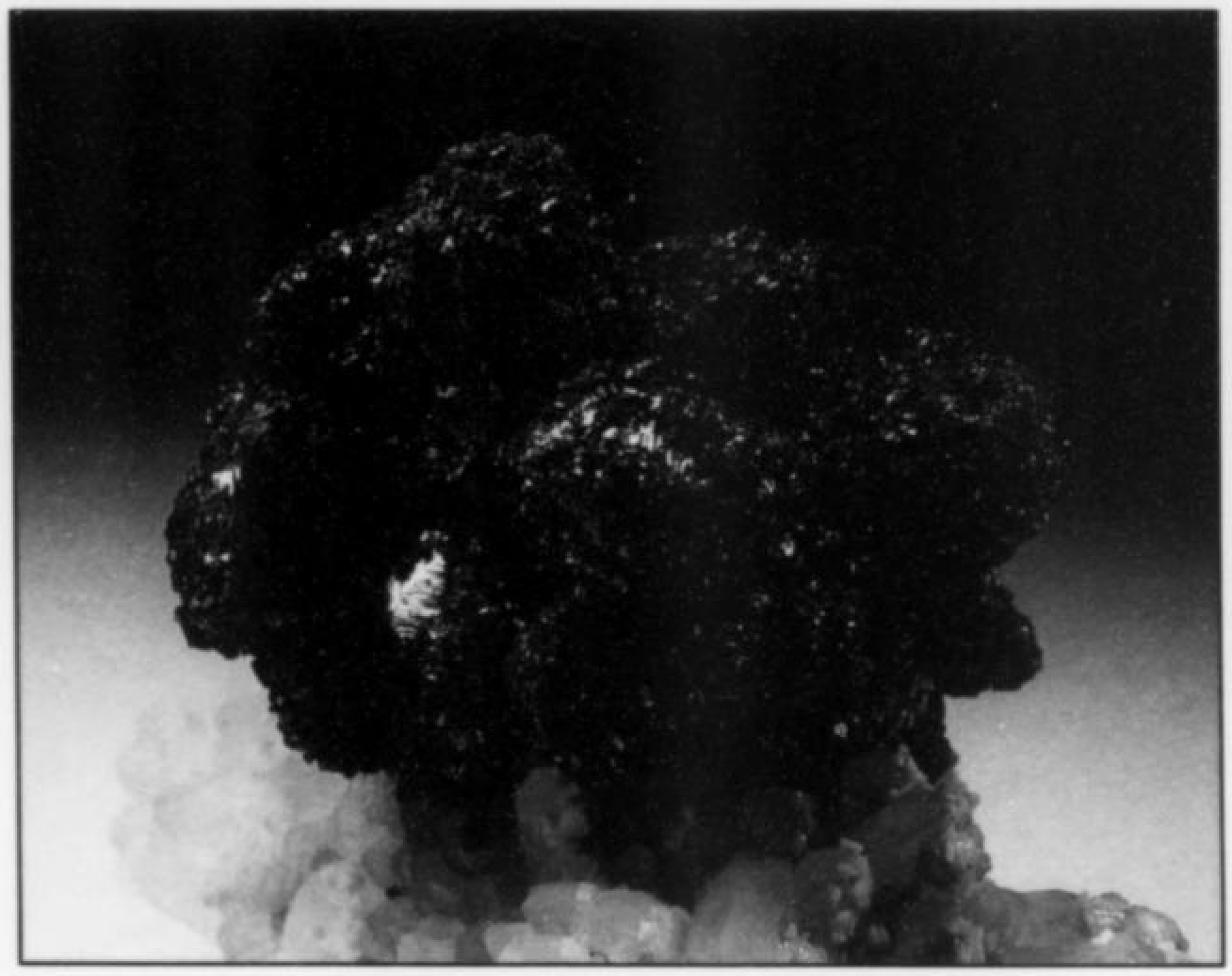
In splendent dark brown to light yellow crystals, sphalerite in reflected light often has a silvery look, particularly in the lighter colored crystals. Crystals vary from well-formed to subhedral cubic shapes, and to poorly formed tetrahedrons. The best of these crystals can be up to about 2 cm across, associated most commonly

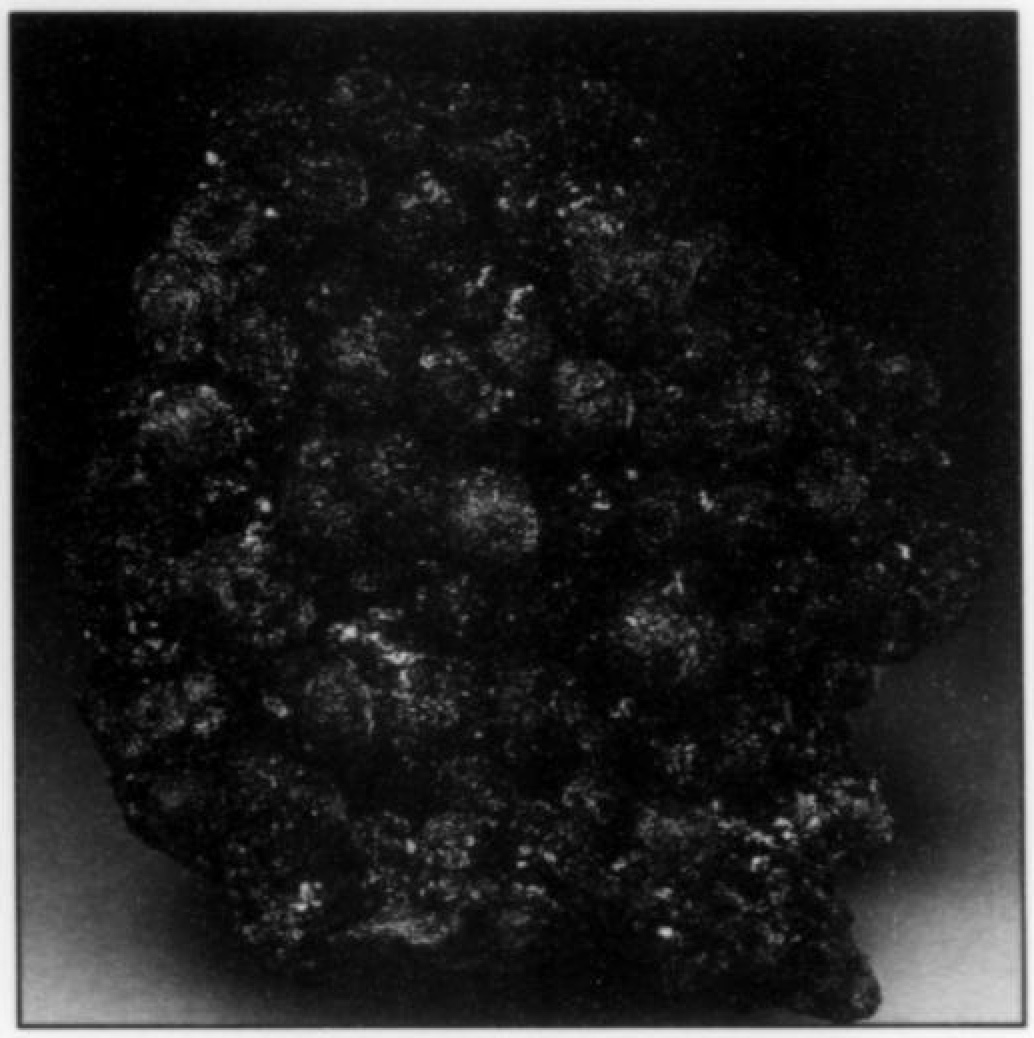
Figure 106. (right) **Pyrargyite crystal group, 5.2 cm, from the San Genaro mine. Terry Wallace collection; Wendell Wilson photo.**

Figure 107. (below) **Miargyrite crystals coating a pyrargyrite crystal group, 4.2 cm, from the San Genaro mine. Terry Wallace collection; Wendell Wilson photo.**

Figure 108. (below right) **Miargyrite crystal cluster, 11 cm, from the San Genaro mine. Bill Smith collection; Jeff Scovil photo.**







with quartz and galena. Sphalerite tends to be gemmy in the pale straw-yellow, yellow-green or dark reddish-amber colored crystals. Sphalerite from the Carmen-Lira mines occurs in good crystals; these vary from a dark brown to amber-yellow color in transmitted light, and possess a silvery to iridescent luster. Crystals generally do not exceed 2.5 cm in size, even in the best specimens. In the Carmen-Lira mine, the sphalerite crystal habits are complex, giving rise to rather rounded crystals. Better specimens are usually dominated by orange to amber-yellow crystals about 1 cm in size, associated with white quartz, galena, chalcopyrite and siderite.

Stibnite Sb_2S_3

Stibnite occurs as needle-like crystals in fan-shaped sprays on milky quartz crystals. The crystals are generally on the order of 7 cm or less in length, with the sprays at least 7 cm across. In rare cases the stibnite has been replaced by finely crystalline galena; this creates unusual and pretty specimens. Probably erroneously labeled as from the San Genaro mine, the stibnites are most likely from the Caudalosa mines. Stibnites from the Caudalosa mine are sometimes coated with tiny, pale pink crystals of manganoan calcite forming a solid covering over the stibnite. The underlying stibnite has a frayed look to it. Stibnite crystals from the Caudalosa mine can reach several centimeters long.

Tetrahedrite $(Cu,Fe)_{12}Sb_4S_{13}$

Tetrahedrite in good specimens is not common in the Castrovirreyna district. The Carmen-Lira mines have produced simple tetrahedrons, 1 cm or so in size, with dark gray color and a satiny to bright metallic luster. Tetrahedrite crystals are usually slightly modified by other forms. The satiny crystals are usually slightly etched and pitted when viewed under the microscope. Tetrahedrite comes with a variety of associated minerals including chalcopyrite, sphalerite, quartz, siderite and dolomite.

Conclusions

Mining in Peru has been going on for more than four centuries. During most of this long period of time, the bonanza years for many of the mines, virtually no mineral specimens were saved. It is only since the 1970's that any serious effort toward saving specimens has been expended. Literally thousands, possibly millions of tons of specimens have been crushed and run through the mills or discarded onto the mine dumps. The wonderful specimen production from Peru during the past 20 or 30 years is only a small window into what must have been mined over the centuries.

Mineral specimen production from Peru has been in a slump since 1989 due to low metal prices and political problems. However, with the on-going privatization of Peru's mines, specimen production can be expected to improve in the future. Peru is still considered by mining companies to have a tremendous potential for additional ore deposit discoveries. With this potential, exploration and development can also be expected to increase in the near future, opening up new sources for mineral specimen production. Due to the discouragement of mineral collecting practices at the mines by management, specimen production may never achieve the volumes seen in the late 1970's and early 1980's.

Still, with the ingenuity of the miners and the lure of additional income to supplement their low wages, specimens will surely be collected and offered for sale. We can be optimistic about Peru's future as a continuing source of fine mineral specimens.

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Most of all, we want to acknowledge the miners of Peru. Without their procurement of thousands of beautiful mineral specimens, the mineral world would indeed be a poorer place.

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The Editor

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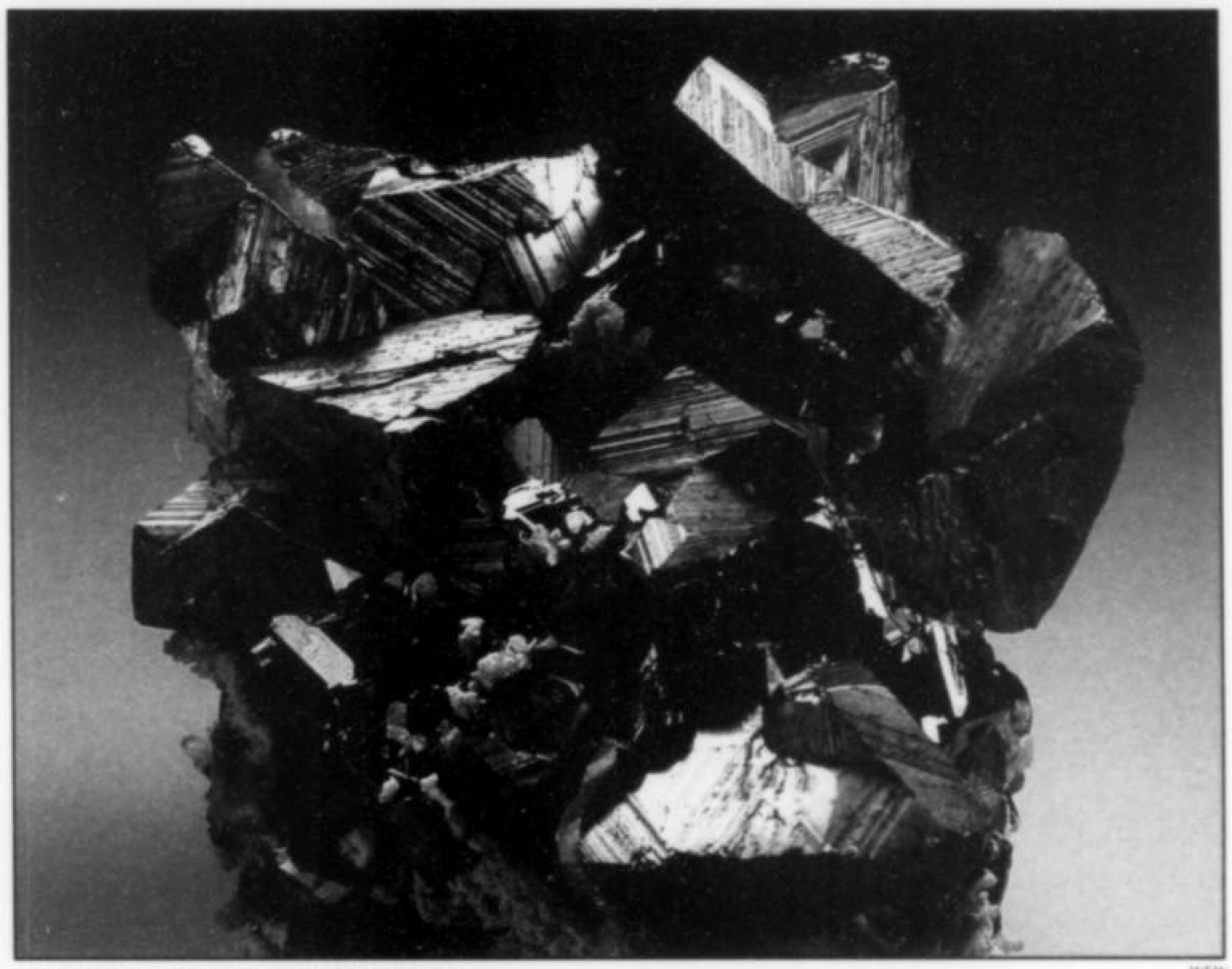

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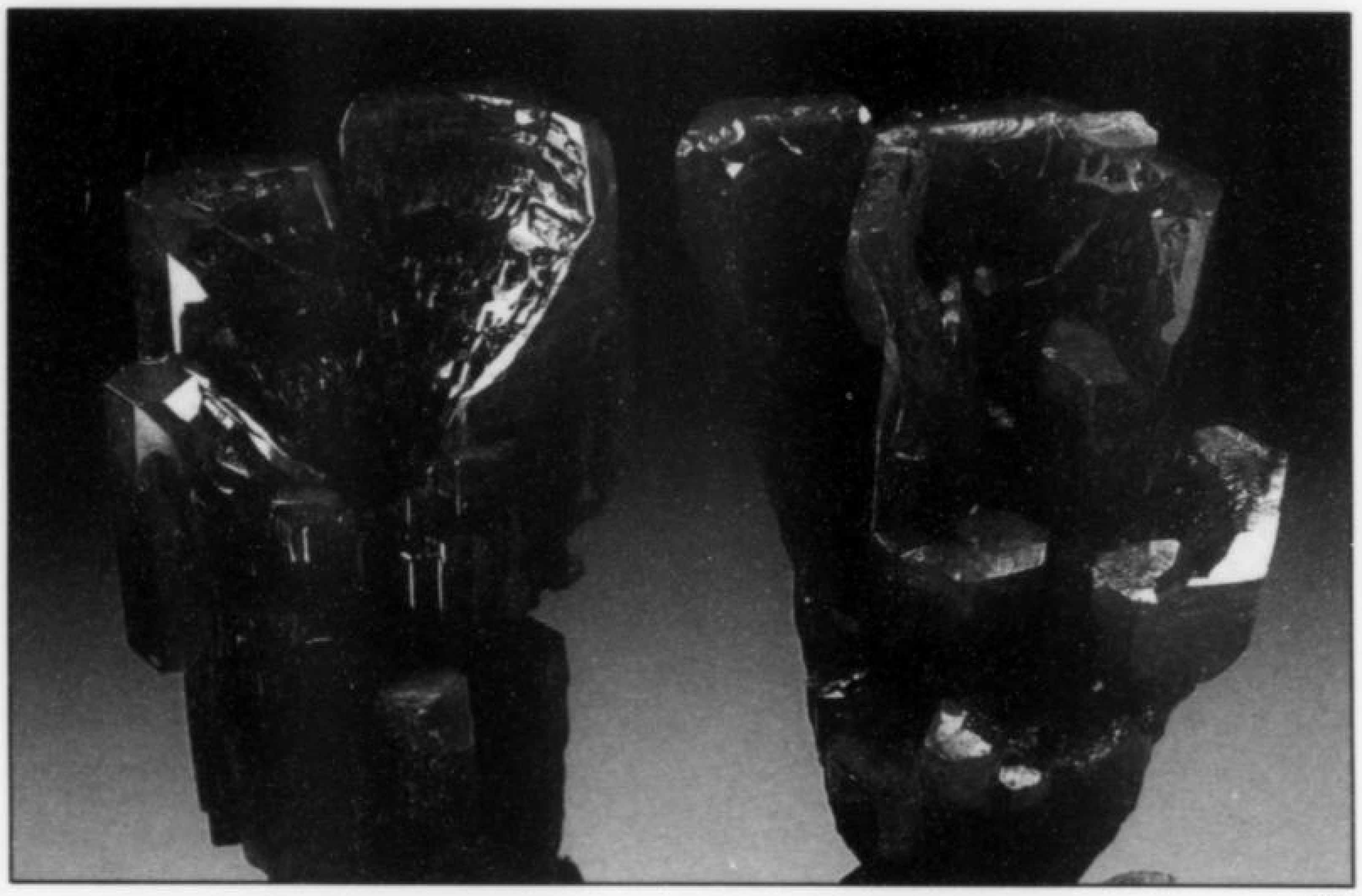

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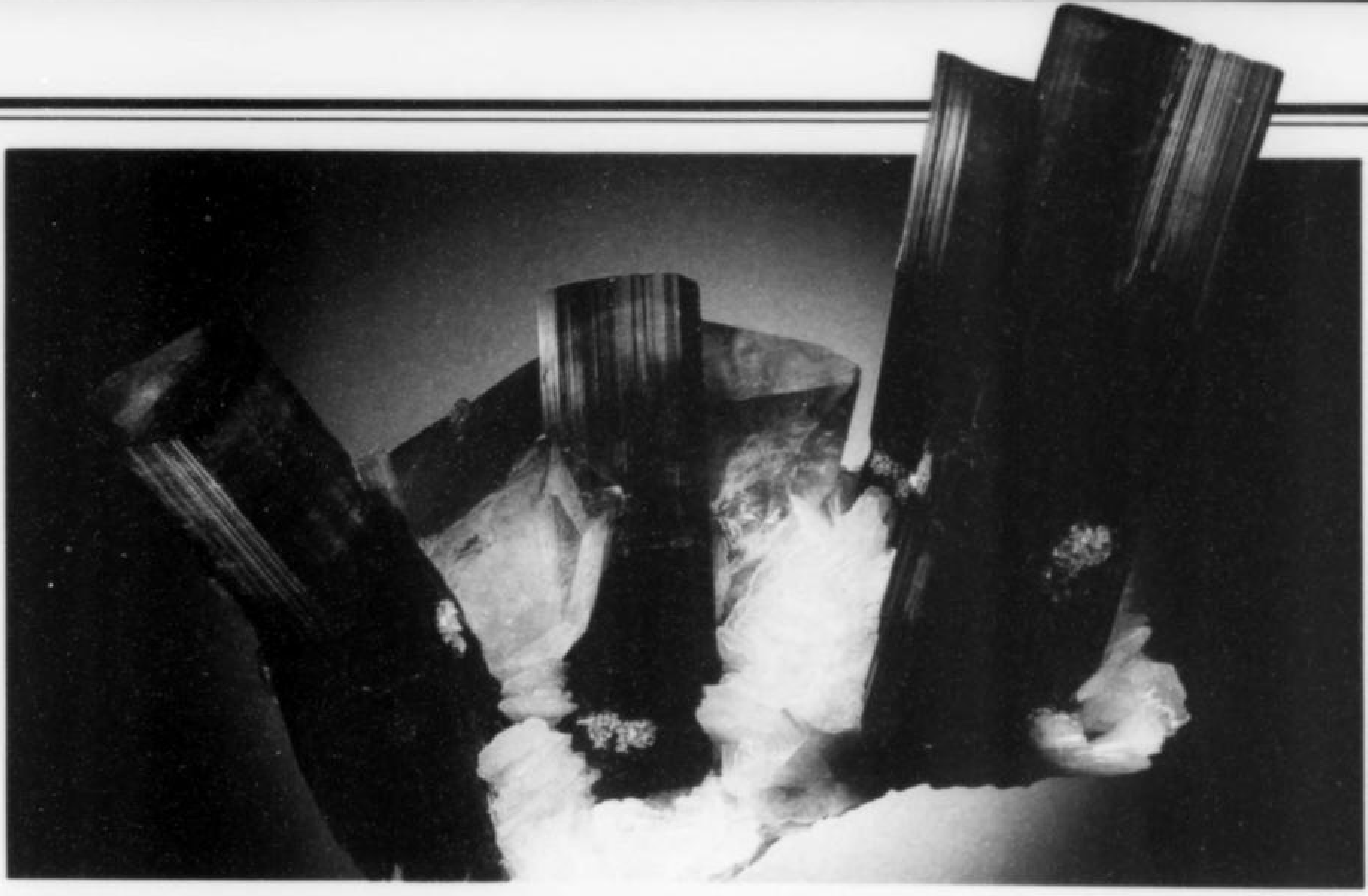
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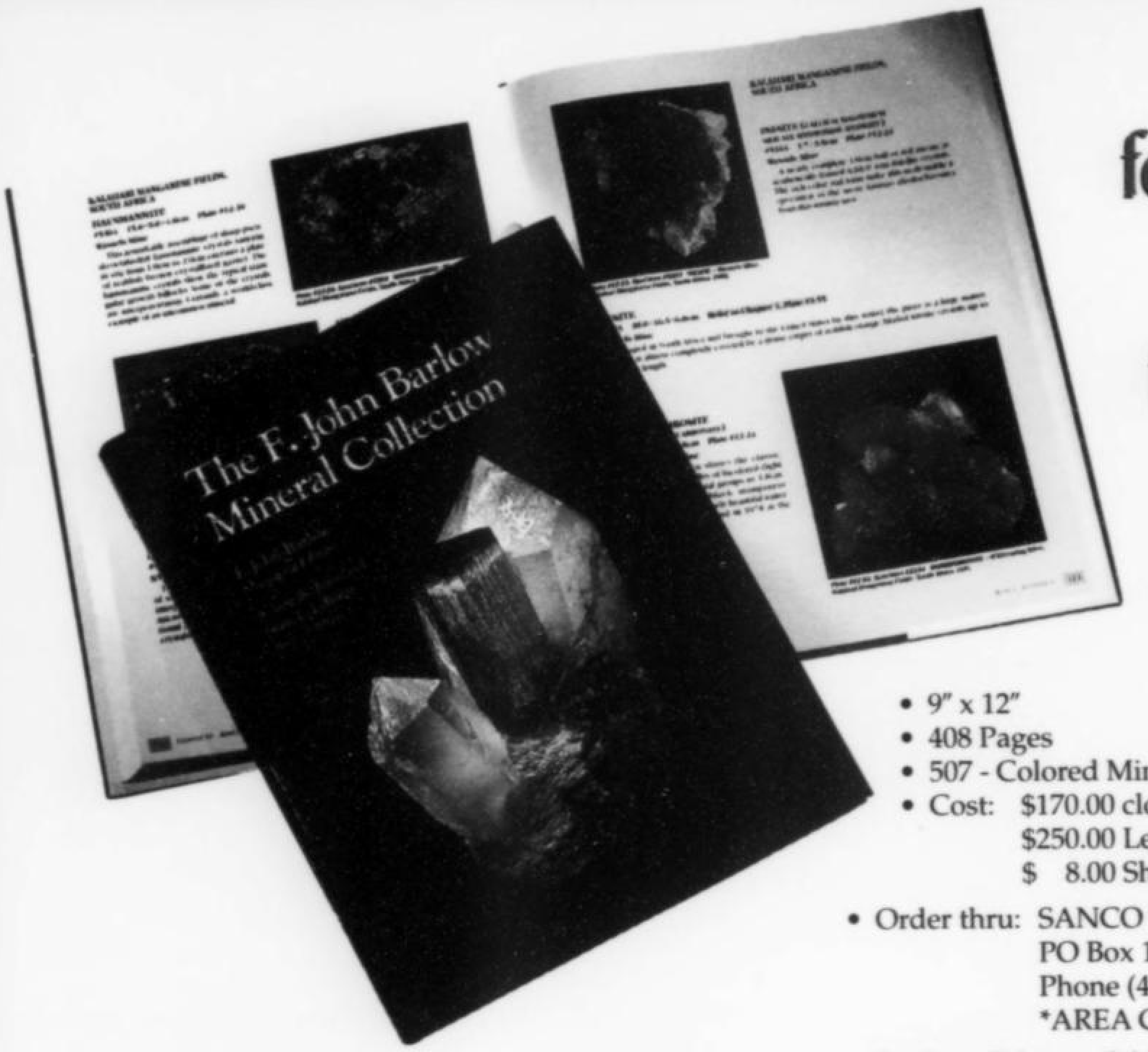

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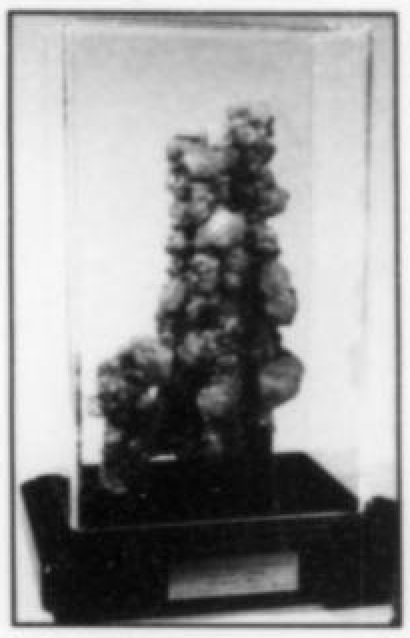

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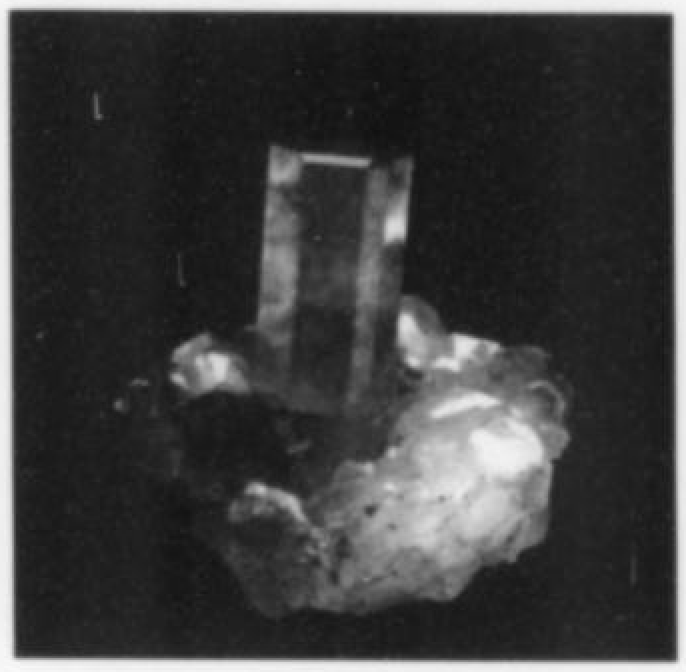

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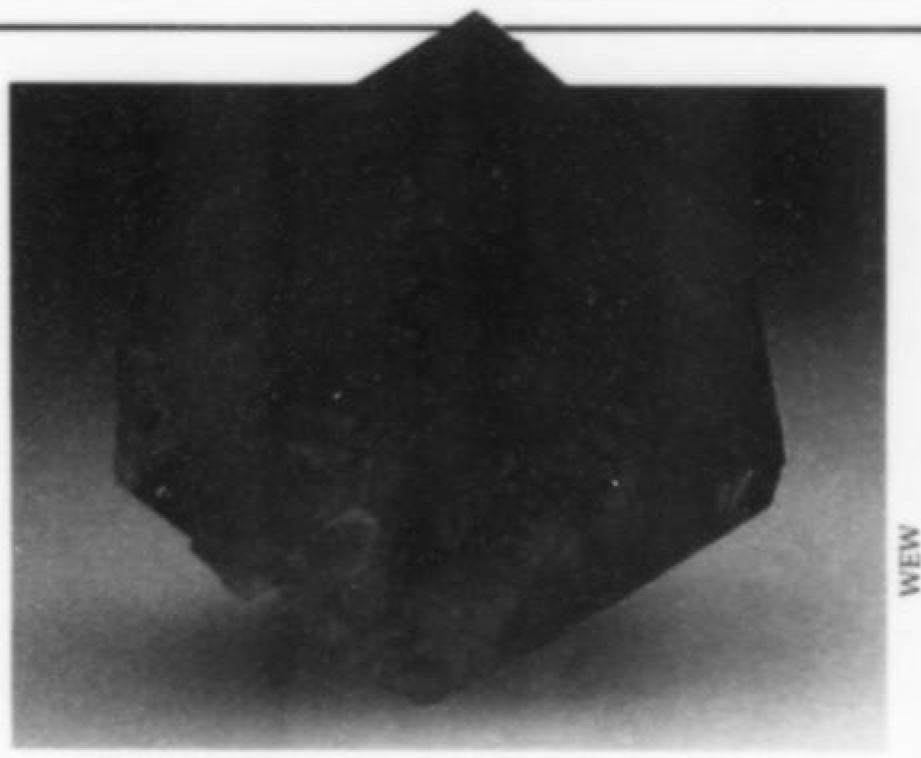

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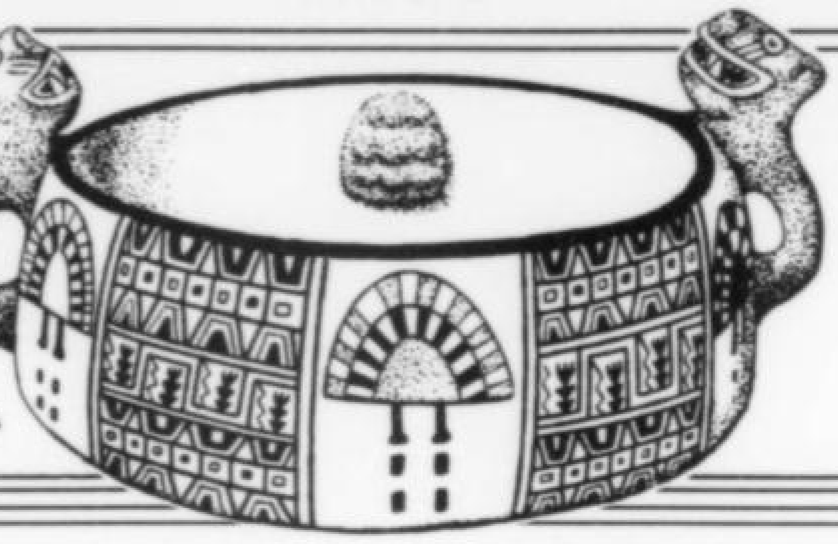

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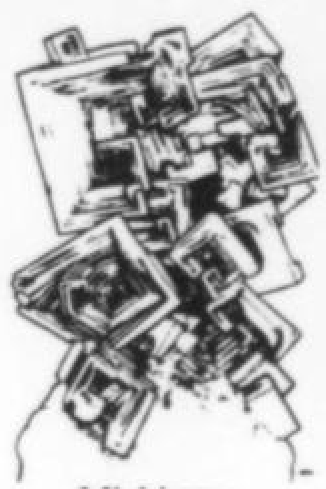

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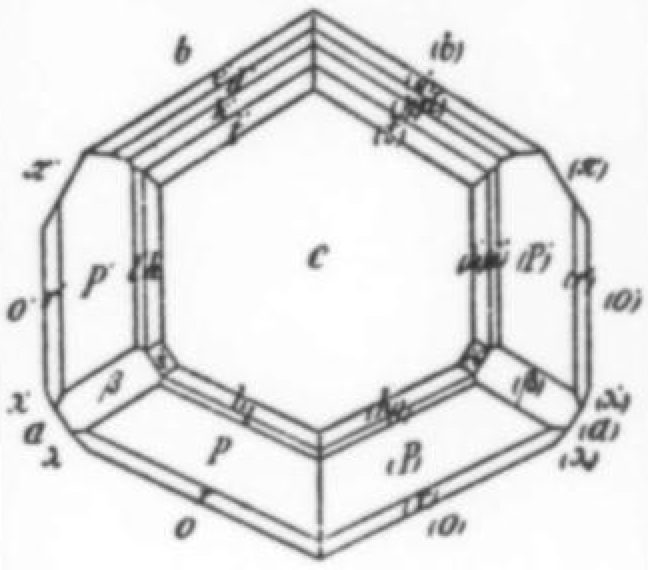

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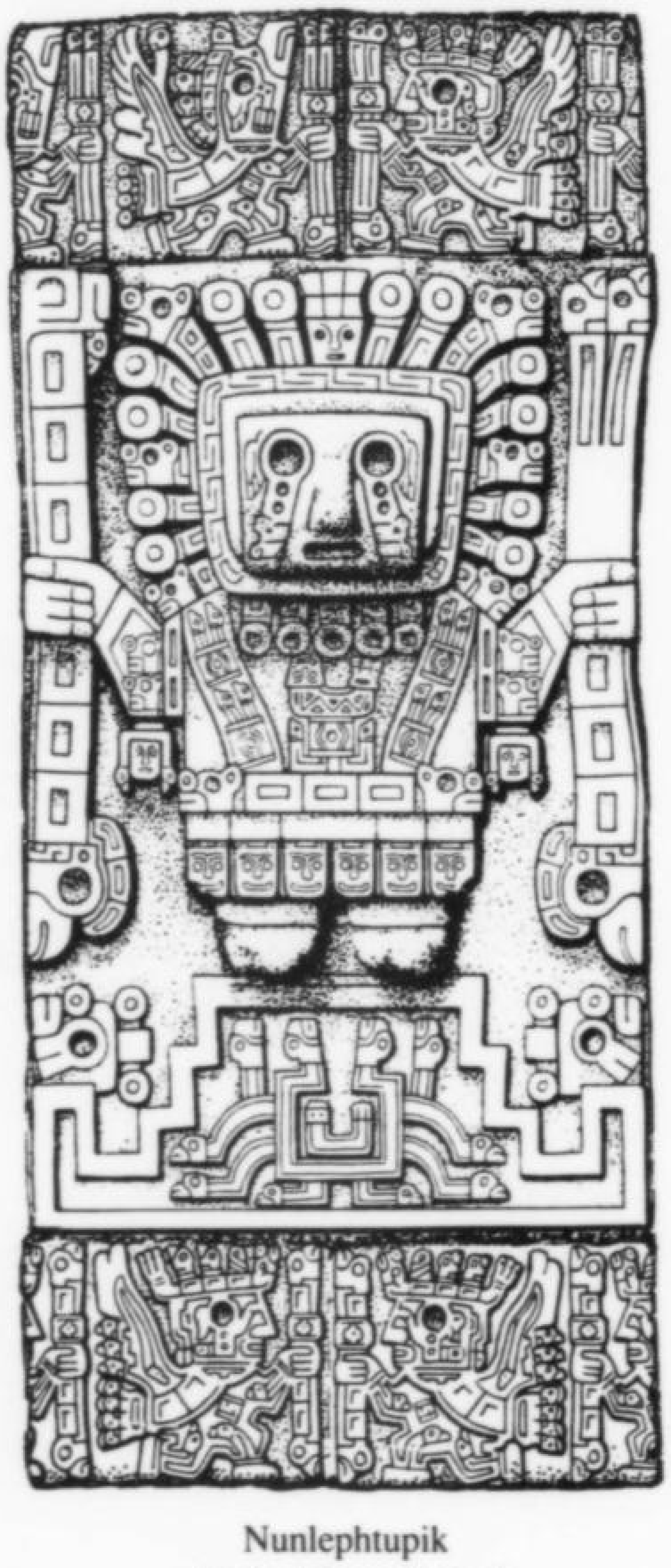

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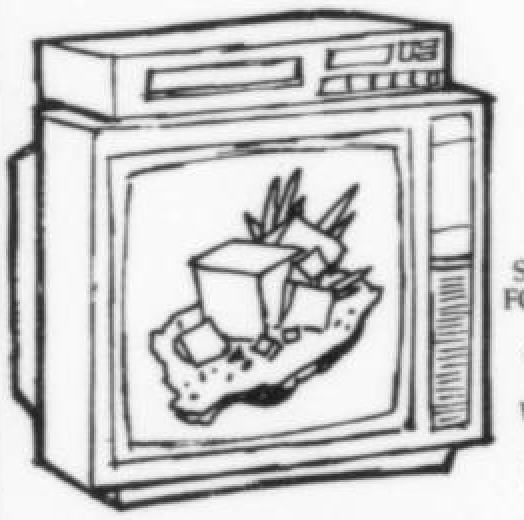

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Vol 1, No 1, Mineralogical Record, Spring 1970
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* Compiling and publishing information on mineral localities, and important mineral collections.
* Encouraging improved educational use of mineral specimens, collections, and localities.
* Support a semi-professional journal of high excellence and interest designed to appeal to mineral amateurs and professionals, through which *FM* activities may be circulated.
* Operating informally in behalf of minerals, mineral collecting, and descriptive mineralogy, with voluntary support by members.

The Mineralogical Record has agreed to an affiliation with the Friends of Mineralogy whereby it will publish its written material and news of its activities. The *Friends of Mineralogy* will support the *Mineralogical Record*, since the aims of both are similarly educational and directed toward better coordination of the interest and efforts of amateurs and professionals.

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