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THE MINERALS OF CASAPALCA, PERU[1]

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INTRODUCTION

Since the days of the Spanish conquerors the mineral wealth of the Andes, and the even more fabulous reports of it, have made the name of Peru synonymous with untold riches and have attracted mining ventures, first on the part of daring colonial prospectors and later of substantial modern companies, into the rugged peaks and high treeless plateaus of the cordillera. The mineralogist, however greatly intrigued by the glamor of romance, finds much of a purely scientific nature to claim his interest.

Viewing Central Peru as a whole, one is impressed by the manner in which the mineralogy of each particular district, while having its individual peculiarities, accords with the general characteristics of the region. There is, throughout, a general abundance of arsenic and antimony, richness in silver and, in spite of the tales of Inca treasure, poverty in gold. Thus, the mines of Morococha are famous for their large and brilliant crystals of tetrahedrite and those of Cerro de Pasco for their famatinite and enargite, particularly the rare variety luzonite.

At Casapalca, enargite is unknown, and while tetrahedrite of the silver-bearing variety is abundant as are a number of more common minerals, beautifully crystallized, the most spectacular specimens are those of bournonite.

LOCATION

The Central Railway of Peru climbs nearly 16,000 feet in the course of an eight-hour journey from the Pacific coast at Callao to the continental divide. Just below the summit, deep in the valley of the Rimac River, are the station and camp of Casapalca at an elevation of about 13,700 feet. The mine workings are in the mountains to the east which rise more than 3,000 feet higher.

[1] The writer is indebted to Professors L. C. Graton and D. H. McLaughlin for much assistance during geological work on the ore deposits and to Mr. L. W. Lewis for cooperation in the mineralogical study. For permission to publish the present paper thanks are due to the officers of the Cerro de Pasco Copper Corporation.

General Geology

The river has carved its valley through a thick series of redbeds—sandstone and shale—affording ideal exposures of the sedimentary series and of the andesitic flows which overly it. These formations, which are presumed to be of Tertiary age,[2] are folded along the northwest-trending axes of Andean structure and are intruded by stocks and sills of albite-diorite porphyry.

Veins. The veins, which cut both the redbeds and the extrusives, are of the type deposited at intermediate to shallow depths. The gangue consists of quartz, calcite and rhodochrosite; the metallic minerals are chiefly pyrite, sphalerite, galena and tetrahedrite. To the geologist, an interesting feature of the vein system is the definite zonal arrangement of mineralization, both laterally and vertically from what is believed to be the center of deposition. In those portions of the veins which were supposedly formed under more intense conditions of heat and pressure, the sulphides are coarse-grained, chalcopyrite is common, tetrahedrite occurs sparingly and carbonates are nearly absent. Away from the center, tetrahedrite and carbonates become more abundant, and chalcopyrite is very rare. With the coolest phases of mineralization, botryoidal carbonates and stibnite begin to appear, and in the outlying mines of the district, barite becomes important.

Another interesting geological feature is the change in proportion of minerals with different types of wall-rock. The redbeds contain some calcite and where they form the vein-walls, the gangue in general abounds in carbonates, while in the porphyry quartz is the principal non-metallic mineral.

Mineralogy

The veins are in many places open in texture and contain large crystal-lined vugs. During the summer of 1923 a great vug was opened up which was lined with crystals of quartz, sphalerite, calcite and bournonite, and from it many beautiful specimens were taken.

Throughout the Casapalca district the minerals both in the vugs and in the massive ore show a definite order of deposition. Polished sections of the massive vein matter studied under the microscope show this to be as follows: quartz, pyrite, sphalerite,

[2] McLaughlin, D. H.; *Bull. Geol. Soc. Am.* **35**, pp. 591-632 (1924).

galena, tetrahedrite, and bournonite. Veins of quartz and calcite appear at a number of points throughout the sequence and pyrite also appears at various stages.

In the vugs the order is similar. Adjoining the massive ore which contains quartz and pyrite the 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

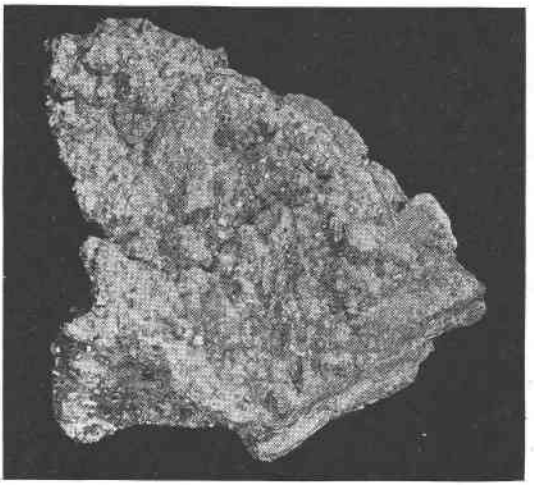

Fig. 1. Bournonite Crystals on Quartz and Sphalerite. (Photo. by E. B. Dane, Jr.)

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 wall-rock it is usually in cubes, while octahedrons of pyrite are unknown at this locality.

The bournonite crystals have been described by Gordon.[3]

[3] Gordon, Samuel G.; Crystallographic Notes on Six Minerals from Peru and Bolivia: *Proc. Acad. Nat. Sci. Phila.*, vol. **76**, 336, (1924).

Measurements made by Mr. L. W. Lewis of Harvard University showed the same forms as those which Gordon described, namely: *a* (100), *c* (001), *m* (110), *o* (101), *n* (001) and *u* (112). The 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. in diameter in veins with quartz.

Within the main veins a type of vein matter of a late generation consisting of botryoidal carbonates, with quartz-lined vugs, carries realgar in grains a centimeter or more in width. The contrast of this red mineral against white quartz gives some of the specimens a strikingly beautiful appearance. In the same type of vein matter are blades of stibnite, sometimes in radiating aggregates up to two centimeters in length. Stibnite occurs also toward the edges of the strongly mineralized zone in masses of tiny hair-like needles occupying vug-spaces.

One very interesting outlying mine, the Corina, apparently on a continuation of the main vein system, shows mineralization of a somewhat different sort. The gangue, subordinate in amount, consists of quartz and calcite; the reddish porphyry wall-rock is cut by a network of stringers which consist of sphalerite grains surrounded by a felt-like mass of boulangerite. The ore, examined microscopically, shows tiny crystals of arsenopyrite replacing quartz of the gangue. Sphalerite in part corrodes the arsenopyrite and contains needles of boulangerite.

Near the surface the veins show the usual alteration products; limonite, psilomelane, sparing amounts of malachite, azurite, chrysocolla and smithsonite. In the mine workings descending waters have deposited kaolin, allophane, and the sulphates gypsum, chalcanthite and melanterite. The primary sulphides are slightly enriched near the surface by chalcocite and covellite.

Apart from the veins, intrusives in the district have developed alteration minerals in the rocks. A little tourmaline is developed in the shale around bodies of andesite, and in other places veinlets of epidote and specularite appear. To the west of Casapalca, at the head of Tablachaca Quebrada, contact minerals in limestone, including garnet and axinite, have been found.