GEOLOGIC OCCURRENCE OF GRATONITE AT CERRO DE PASCO, PERU*

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General Geology

The copper-silver-gold and lead-zinc mineralizations at Cerro de Pasco are closely associated with igneous activity and clearly hydrothermal in origin. The general geology and major events related to the formation of certain of the ore bodies have been covered in a paper by McLaughlin, Graton and others.[1] Since the appearance of that brief report, numerous bodies of disseminated bornite-chalcocite-tetrahedrite ore have been encountered in a north-south zone within the enormous crescent-shaped pyrite replacement body. This zone may represent the original position of the sediment-agglomerate contact, that is, the wall of the pre-mineralization vent.

A recently discovered ore body of this disseminated type proved to be small in vertical extent. With stoping operations now nearing completion, it is clear that the ore cuts off sharply beneath a flat-lying dike and extends only a few floors below the dike. Apparently the mineralizing solutions, rising along some structural zone of weakness, mushroomed beneath the dike, causing the formation of the small high grade ore body.

It was on the outer fringes of this ore body (1400 level) that gratonite, $Pb_9As_4S_{15}$, was discovered. The more coarsely crystalline specimens were all taken from fractures and solution cavities in a thoroughly leached and altered, siliceous, apparently igneous rock lying on the east side of the stope area. Although it was here that the gratonite was most abundantly deposited, it was found in small amounts in a narrow peripheral zone completely encircling the high grade silver ore. None was found within the central, commercial portion of this ore body, indicating a definite zonal distribution of this mineral and its formation under more mild conditions than the silver mineralization within the stope.

Gratonite has been found in two other localities in the mine. A small amount has been observed replacing galena in a stope 150 feet north of the occurrence described above. Here again it is close to high silver values. In a third occurrence, on the *A* level, 300 feet below the surface, gratonite is associated with high grade copper-lead-zinc ore. The copper values are partly and perhaps entirely secondary, although the presence of chalcopyrite, not heretofore observed in the secondary copper ores of

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[1] McLaughlin, D. H., Graton, L. C., and others, Copper in the Cerro de Pasco and Morococha Districts, Department of Junin, Peru: *Copper Resources of the World, XVI International Geological Congress, Washington* 1933, **2,** 513–544 (1935).

the district, indicates some primary copper mineralization at this spot. An unusual ratio between lead and zinc with this latter occurrence of gratonite suggests that either additional lead was introduced as gratonite after the earlier sphalerite-galena-pyrite mineralization , or that some of the zinc has migrated away as it readily does in the zone of oxidation. The latter interpretation seems correct in view of the presence of secondary chalcocite, since sphalerite is a strong precipitant (by replacement) of copper from descending copper sulphate solutions.

FIG. 1. Nodular clusters of gratonite crystals radiating in all directions from no conspicuous point of attachment. Formed in loose, unconsolidated siliceous material. $\frac{1}{3}$ Natural size.

FIG. 2. Hemispherical clusters of gratonite crystals radiating from point of attachment on solid surface formed by solution of host rock. × .4.

FIG. 3. Small radiating clusters of gratonite crystals formed in solution pockets in siliceous host rock. ×.24.

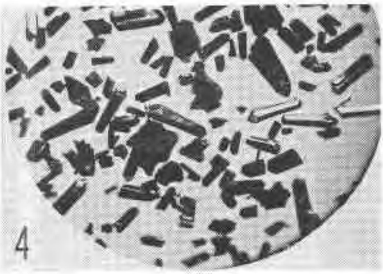


FIG. 4. Small crystals of gratonite brushed from a vug in pyrite. ×8.5.

OCCURRENCE OF GRATONITE

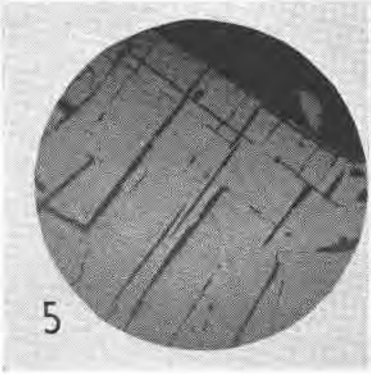
The ground from which the first specimens of gratonite were taken is unusually open in character, and to this condition is due the perfection of crystal growth, size of individual clusters, and general excellent quality of the material. Preceding the deposition of the lead as the sulpharsenide, the rock is believed to have been subjected to the influence of hydrothermal solutions which vigorously attacked it, removing all but the siliceous material from it. So extreme was this dissolution that a few feet to the north of the loose material in which the gratonite was deposited the ground has collapsed, leaving a large cave. This opening is about forty feet across and averages about fifteen 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 siliceous host rock has broken down into a loose sandy mass of quartz grains. Much gratonite occurs in this loose sandy material as isolated clusters of crystals that crudely radiate in all directions as shown in Fig. 1. Where crystallization started on a solid surface, such as in fractures and along solution cavities in the porous host rock, roughly hemispherical radiating masses were formed (see Figs. 2 and 3).

Paragenesis

The mineral most closely associated with gratonite is galena. Several types of relationships exist between these two minerals. Not uncommonly gratonite replaces galena along cleavage planes and fractures. Elsewhere galena is deeply corroded and etched along cleavage planes while vugs in the same specimen contain druses of well formed gratonite crystals (Fig. 4). The formation of the silver-copper ore, the dissolution of all but quartz from the rock in which the gratonite was found, and the corrosion of the pre-existing galena, are believed to have been caused by solutions during a single complex epoch of mineralization. Lead derived from the break-down of galena seems to have recrystallized, with little migration, as the then more stable sulpharsenide, gratonite.

Another expression of incipient corrosion of galena along cleavage planes is a very characteristic box-work habit which a fractured surface of galena shows only when it is closely associated with gratonite. Doubtless for every such surface another existed on the opposite side of the fracture, the two matching in a mold-cast relationship, except where tiny cleavage fragments may have fallen out. On a polished surface the edges of the typical triangular pits which galena normally exhibits are frequently seen to be corroded and rough; thus see Fig. 5 in which cleavage planes on a single crystal have been cut approximately at right angles. The box-work areas of galena contain gratonite replacing it in varying degrees from thin blades along cleavage planes to complete substitution. Even where completely replaced by gratonite the material still resembles galena on casual inspection. A few fragments, gouged from one such box-work surface, are shown in Fig. 6. This material, almost wholly gratonite but showing typical cubic outlines, was crushed and the powder is shown in

Fig. 7. Note the rough irregular outlines of the grains showing the absence of cleavage and compare these to the perfect rectangular outlines exhibited by the crushed galena of Fig. 8.



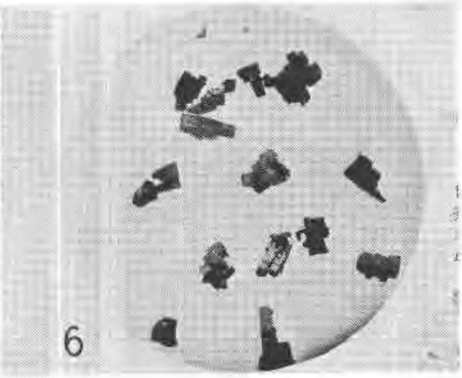
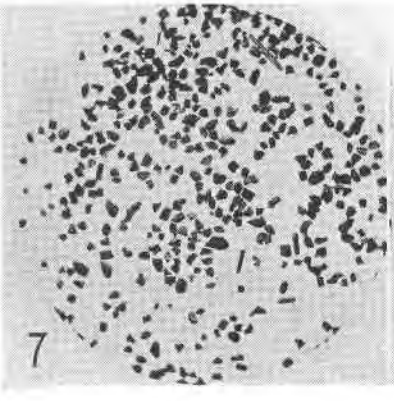


Fig. 5. Dissolution of galena along cleavage planes. This is typical of galena where closely associated with gratonite. ×17.

Fig. 6. Fragments of gratonite, pseudomorphic after galena. Gouged from typical box-work surface. ×8.5.



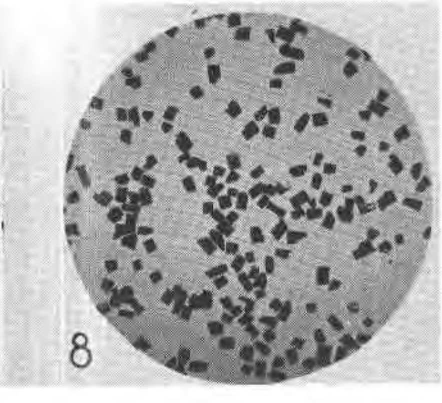


Fig. 7. Grains of gratonite derived from crushing of fragments shown in Fig. 6. Note irregular outlines indicating lack of cleavage. ×9.

Fig. 8. Grains derived from crushing of normal galena. Compare with grains from gratonite pseudomorphic after galena—Figs. 6 and 7. ×9.5.

In Fig. 9 galena is seen to be veined by gratonite. Figure 10 shows the same area with the galena tarnished by a 20% solution of ferric chloride, leaving the gratonite unaffected.

COPPER-SILVER ORE MINERAL SUITE

As mentioned above, gratonite is seen to have veined lead-zinc ore, and to have extensively replaced galena. However, the sphalerite-galena ore belongs to an earlier and distinct stage of the mineralization. A suite of minerals believed to belong to the same ore-depositional stage in which gratonite was deposited includes pyrite, freibergite, chalcocite, bornite and subordinate amounts of bismuthinite, chalcopyrite, covellite, and possibly arsenopyrite. Realgar appears locally but cannot be related definitely to this stage of mineralization. Gratonite was not found in such association with any of these minerals as to permit anything to be said as to the age relations between this mineral and those forming the main ore body. However, the definite zonal distribution of gratonite about the area of heavy silver-copper mineralization indicates its genetic relationship to the solutions responsible for that ore. As mentioned in an earlier paragraph, the lead is believed to have been derived from the dissolution or replacement of galena of an earlier stage and not introduced with the mineralizing solutions that formed the silver-copper ore.

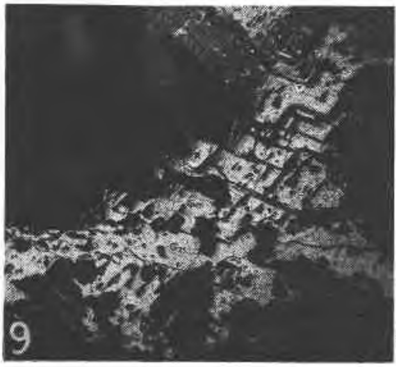


FIG. 9. Galena (gn) veined by gratonite (gr). ×19.

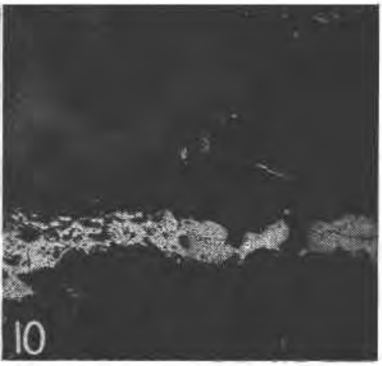


FIG. 10. Same area as shown in Fig. 9. Galena tarnished with a 20% solution of ferric chloride. Gratonite (gr). ×19.