VEIN-LIKE MASSES OF PYRRHOTITE IN CHALCOPYRITE FROM THE WAITE-ACKERMAN-MONTGOMERY MINE, QUEBEC[1]

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Recently in the study of polished sections, certain masses have been described as residual veinlets,[2] but it is found that when some of these are critically studied, and attention directed to crystallographic units and grain boundaries, they possess characteristics indicating that they are not residual veinlets.

According to a publication on the geology of the Waite-Ackerman-Montgomery Mine; "Residual veinlets of pyrrhotite are common in chalcopyrite."[3] No proof is given for this statement. On a priori grounds, the possibilities are that these pyrrhotite masses are either pre-wall, that is residuals, or contemporaneous ex-solved material from chalcopyrite, or post-wall true veinlets. The results of a detailed examination indicate, however, that they consist of pyrrhotite which has been formed by ex-solution from the chalcopyrite.

While with the Geological Survey of Canada in 1931, the author collected some ore specimens from the above named mine. The most common minerals present are chalcopyrite, sphalerite and pyrrhotite. The characteristics of and the relationships between the chalcopyrite and certain masses of pyrrhotite will be discussed in this paper.

The pyrrhotite occurs as curving hairlike areas, which may be described as resembling either wisps or vermicules (Fig. 1). These pinch and swell from being extremely fine to widths of 0.007 mm., and vary in length from 0.08 mm. to 0.5 mm. They have smooth boundaries against the surrounding mineral which is always chalcopyrite. The wisps may occur singly or as three distinct units radiating from a common centre.

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[1] Published with the permission of the Director, Geological Survey of Canada, Department of Mines, Ottawa. Presented before *The Mineralogical Society of America*, Cambridge, Mass., December 29, 1932.

[2] Peale, Rodgers, The Geology of the Waite-Ackerman-Montgomery Ore Deposit: *Trans. Can. Inst. Min. and Met.*, **34,** p. 208, 1931.

[3] *Loc. cit.*

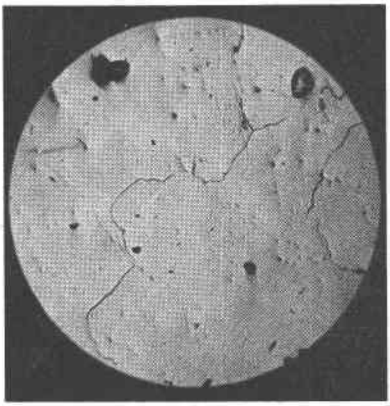

FIG. 1. Polished section of chalcopyrite containing vermicules or wisps of pyrrhotite; individual grains or crystals are not visible on this unetched surface. ×24.

Without exception these pyrrhotite vermicules occur as thin sinuous areas of single crystals. That these are single pyrrhotite crystals is clearly shown by their behavior under polarized light. Any one wisp extinguishes uniformly and instantly along its entire length; that is, there is no variation in anisotropic colors or in extinction angle, all of which show that each pyrrhotite vermicule is a single crystal. This unity of crystallization is a property which frequently characterizes the minor constituent in accepted unmixing textures. It is to be observed here that, had the process been one of replacement of pyrrhotite by chalcopyrite to form residual veins, at least some of these vermicules should have consisted of more than a single crystal because the grain size of the coarsest pyrrhotite is only about one half the average length of the vermicules. On the other hand, had the grain size been sufficiently large it would appear most fortuitous indeed that no crystal boundaries are found in any one elongated area. For comparison specimens have been examined from other localities showing typical veins of pyrrhotite and of other minerals, and it was found that in every case the vein consisted of several crystals diversely oriented. In no case was a vein found to be composed of only one crystal, although it is possible that some may exist. It is obvious, then, that these vermicules differ also from later introduced material.

Not only are these vermicules developed as single crystals, but they are found only between crystals of chalcopyrite (Fig. 2).

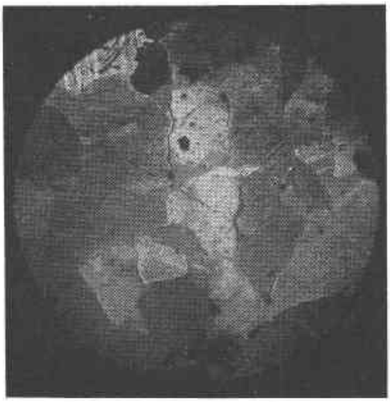

FIG. 2. Etched surface of chalcopyrite showing boundaries of the chalcopyrite crystals and the intra-crystalline nature of the pyrrhotite vermicules. ×24.

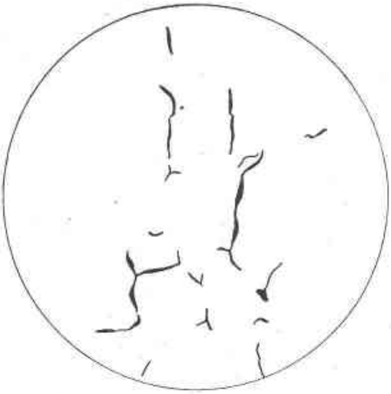

FIG. 3. Outline sketch of Fig. 2 showing location of the pyrrhotite vermicules The thickness of the vermicules has been exaggerated slightly in the sketching. ×24.

Under polarized light the crystal structure of the chalcopyrite is shown by the various anisotropic colors possessed by the different crystals, and by the interruption of the twinning lamellae at crystal boundaries. This structure is still more clearly shown when the chalcopyrite is etched with an acidic potassium dichromate solution.[4] The most interesting fact revealed by the crystal structure

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[4] Schneiderhöhn, Hans, Anleitung zur mikroscop. Bestimmung von Erzen. **1922,** pp. 116–117.

of the chalcopyrite is that the pyrrhotite wisps are always between the crystals of the former. The vermicules never cross-cut crystals of chalcopyrite as is a common habit of true veinlets. In some cases, a single vermicule may surround a chalcopyrite crystal on as many as three sides. Furthermore, even when three of these meet at a point, each one is seen to maintain very faithfully this inter-crystalline relationship to the chalcopyrite.

It is also significant that where vermicules join large rounded masses of early pyrrhotite there is always a crystallographic discontinuity at the edge of the rounded mass. Under polarized light, such a combination of vermicule and rounded mass always shows within itself different anisotropic colors and different extinction positions as between the single crystal of the wisp and the one or more crystals of the rounded mass. This feature has been observed and described before as an unmixing phenomenon. In some Frood ores described by W. H. Newhouse[5] such a crystallographic break obtains at the junction of large early pyrrhotite masses and later blades. The pyrrhotite blades in the Frood ore were held to be the result of unmixing. It is evident that the present described material shows analogous relations.

In addition to these features, the pyrrhotite masses fulfill three of the criteria[6] which are considered as suggesting ex-solution. First, the boundaries of the vermicules are smooth even when observed under very high magnifications; second, there is a total absence of these wisps outside of the chalcopyrite; and last, and most important, there is always a distinct narrowing of the vermicules where two or more join each other.

The chalcopyrite which is associated with this pyrrhotite is somewhat anomalous in that it is slightly more anisotropic than is usually the case. In addition, it shows very well developed twinning lamellae; the anisotropism is, however, not nearly as strong as that displayed by cubanite. The strong anisotropism may perhaps be explained by supposing that more iron is present in the space lattice than is usual in chalcopyrite. It may be suggested that all the excess pyrrhotite components have not been forced out of the chalcopyrite space lattice.

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[5] Newhouse, W. H., A Pyrrhotite-Cubanite-Chalcopyrite Intergrowth from the Frood Mine, Sudbury, Ontario: *Am. Mineral.*, **16**, p. 337, 1931.

[6] Schwartz, G. M., Textures due to Unmixing of Solid Solutions: *Econ. Geol.*, **26**, pp. 761–762, 1931.

In summary, this would appear to be an unusual occurrence of pyrrhotite unmixing from chalcopyrite with no cubanite present. It might be noted in passing that a very careful study of crystal boundaries and of the crystallographic relationships between the different minerals present may be necessary before the origin of the veinlike masses may be determined.

The writer wishes to express his thanks to Professor W. H. Newhouse of the Department of Geology, Massachusetts Institute of Technology, for proposing the investigation and for valuable suggestions offered during its progress, and to the Geological Survey of Canada for permission to use the material collected while with them.

STABILITY RELATIONS OF A COLORADO PISANITE (CUPRIAN MELANTERITE)

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Several specimens of pisanite, the isomorphous mixture of cupric and ferrous sulphates with 7 H_2O, were collected in the Rico mining district in southwestern Colorado during the 1931 field season. Following Schaller's suggestion[2] the mineral should be called cuprian melanterite, as it contains more iron than copper. The rapid dehydration of the specimens after collection suggested a laboratory study of the relation between water content and humidity in this mineral. The results, which are recorded in this paper, have proved of considerable importance in the preservation of specimens and in the analytical determination of water of crystallization. The writer wishes to acknowledge his indebtedness to his colleague Mr. T. S. Lovering, for many valuable suggestions regarding the laboratory investigation, and to Mr. P. G. Nutting, also of the Geological Survey, for notes on the dehydration method adopted.

The cuprian melanterite was found only in one stope of the Wellington mine at Rico. It occurs as crusts on timbers or on the walls of a large body of pyrite which has almost completely re-

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[1] Published by permission of the Director, U. S. Geological Survey, The Colorado State Geological Survey Board, and the Colorado Metal Mining Fund.

[2] Schaller, W. T., Adjectival ending of chemical elements used as modifiers to mineral names: *Am. Mineral.*, **15**, pp. 566–574, 1930.