A PYRRHOTITE-CUBANITE-CHALCOPYRITE INTERGROWTH FROM THE FROOD MINE, SUDBURY, ONTARIO

W. H. Newhouse, *Mass. Institute of Technology.*

Intergrowths of cubanite and chalcopyrite have been described from a number of localities by Schwartz[1] and Ramdohr.[2]

The origin of certain of these intergrowths is clearly due to the breaking down of a solid solution to form the two minerals. A solid solution forms at a temperature which experimental data[3] suggests is above 400°C. This solid solution becomes unstable at lower temperatures and with slow cooling breaks down into the two components.

The present note will serve to call attention to a more complex intergrowth of this general type which is found in ores from the Frood mine, Sudbury, Ontario.[4]

A double break down or unmixing in the series chalcopyrite-cubanite-pyrrhotite is indicated by the relations in polished sections of these ores.

The specimens examined contain the opaque minerals, magnetite, pyrrhotite, pentlandite, cubanite, and chalcopyrite. The proportion of each of the different minerals varies considerably in different specimens, but magnetite is present only in small amount in all.

Irregularly shaped masses of cubanite are found, but also chalcopyrite and cubanite form intergrowths of laths or bands of each mineral. The boundaries of the two minerals are usually sharp and straight. They may cut off sharply without narrowing and always end abruptly against the large irregular masses of pyrrhotite.

These relations are typical of those found in ores from other localities, which have been seen by the writer and have been described in the literature.

[1] Schwartz, G.M., Chalmersite at Fierro, New Mexico, with a note on its occurrence at Parry Sound, Ontario: *Econ. Geol.*, **18,** 270–277, 1923.

Intergrowths of chalcopyrite and cubanite; Experimental proof of the origin of intergrowths and their bearing on the geologic thermometer: *Econ. Geol.*, **22,** 44–61, 1927.

[2] Ramdohr, Paul, Neue Mikroskopische Beobachtungen am cubanite (chalmersite) und Überlegungen über seine lagerstättenkundliche Stellung: *Zeit. prakt. Geol.*, 169–178, **1928.**

[3] Schwartz, G. M., *op. cit.*

[4] Thanks are due to C. E. Locke, Professor of Mining Engineering, Mass. Inst. of Technology for the material on which this note is written.

In addition to the pyrrhotite found as irregular masses apparently deposited earlier than the other sulphides, it also is found intergrown with cubanite. Some of the cubanite does not contain intergrown pyrrhotite, but where the two minerals form this relation, the pyrrhotite may be present to the extent of several per cent of the mass or rarely in small areas 25 or 50 per cent. The distribution and orientation of the pyrrhotite in the intergrowths is clearly controlled by the structure of the cubanite crystals. The blade-like masses of pyrrhotite are always narrow, with fairly sharp borders, and instead of always being straight like those of cubanite in chal-

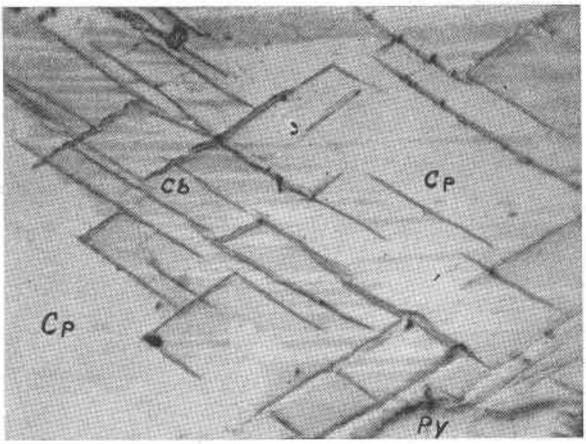

FIG. 1. (×210) Chalcopyrite-cubanite-pyrrhotite intergrowth. The chalcopyrite (Cp)-cubanite (Cb) laths are horizontal while the pyrrhotite (Py) forms two intersecting diagonal sets of crinkled blades. The blades of pyrrhotite join on a larger mass of pyrrhotite in the lower right corner of the figure.

copyrite, they are at times slightly crinkeled or contorted in appearance (Fig. 1). Two or more sets of blades of pyrrhotite are often present in the same crystal of cubanite (Figs. 2, 3). The parallel blades (considered in three dimensions probably plates) of pyrrhotite within a crystal of cubanite all show the same orientation in polarized light, similar to the albite in perthite. Also as observed in polarized light the pyrrhotite blades are aligned in different directions in adjacent grains of cubanite. The blades of pyrrhotite commonly end at the margins of the cubanite crystals where the adjoining mineral is chalcopyrite. Some similar appearing blades of pyrrhotite are, however, also found in the chalcopyrite. An area of mixed blades or laths of cubanite and chalcopyrite have the pyrrhotite in one, two or more rarely three sets of parallel blades, similar to the occurrence in cubanite alone (Fig. 1).

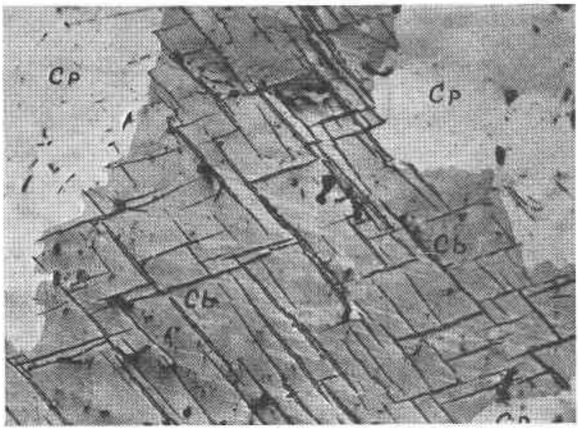

FIG. 2. (×68) An intergrowth partly surrounded by chalcopyrite (Cp). The intergrowth of cubanite (Cb)-chalcopyrite is mainly cubanite with small lighter colored laths of chalcopyrite in it. The pyrrhotite forms two sets of diagonal intersecting blades.

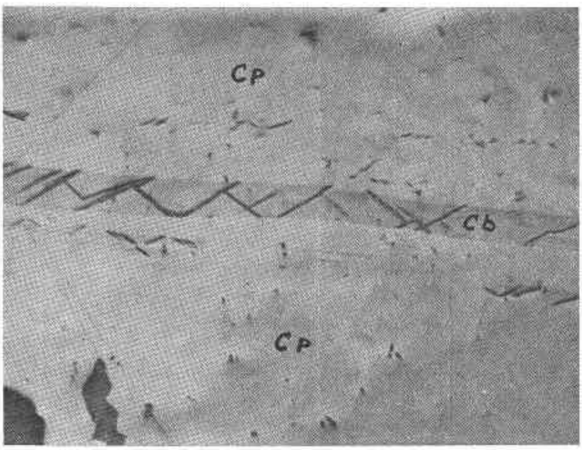

FIG. 3. (×68) A lathlike mass of cubanite (Cb) in chalcopyrite (Cp). Pyrrhotite forms two sets of blades in the cubanite. Two smaller parallel laths of partly resorbed cubanite with contained pyrrhotite blades appear above the main cubanite lath and one below it.

The pyrrhotite is usually more abundant in the intergrowths adjacent to the borders with magnetite, pyrrhotite and pentlandite.

At the junction with a large mass of pyrrhotite the blades of pyrrhotite frequently join or connect with the large mass of pyrrhotite (Fig. 1). They have a different crystal orientation than the large mass of pyrrhotite.

Pentlandite is often very thoroughly dissected by small veins of chalcopyrite.

Summary and Conclusions

The minerals appear to have been crystallized in the following order. Magnetite first in small subhedral to euhedral crystals well scattered in the sulphides, pyrrhotite next in irregular masses, then pentlandite, and finally a solid solution which apparently ranged from essentially pure chalcopyrite to one very rich in iron. The solid solution which was very rich in iron as compared with pure chalcopyrite, on cooling unmixed with the segregation of chalcopyrite and cubanite. The cubanite rich portions, such as the areas showing intergrowths of cubanite and chalcopyrite, and also individual laths of cubanite, unmixed to form cubanite and pyrrhotite. Occasional blades of pyrrhotite in chalcopyrite may be due to unmixing of iron rich chalcopyrite, but the evidence is not clear on this feature.

The pyrrhotite may not have all separated from solid solution at the same time. Some of it in the intergrowths of cubanite and chalcopyrite may have separated before the other two components.

There appears to be some later resorption, reforming of the solid solution or replacement of cubanite by chalcopyrite, as is shown by a variety of evidence chief of which is that laths of cubanite containing unmixed blades of pyrrhotite appear in all stages. One in which the cubanite lath with unmixed blades of pyrrhotite forms sharp straight borders with chalcopyrite, through others in which irregular portions interpreted as residuals, outline the former lath of cubanite, the pyrrhotite blades also outlining the former blade of cubanite (Fig. 3).

Final stages may be seen with blades of pyrrhotite forming exactly similar structures and little or no cubanite present (Fig. 3).