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CANADA

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MINERALOGICAL INVESTIGATION OF COPPER ORE FROM THE LORNEX MINE AND THE BETHLEHEM COPPER MINE, HIGHLAND VALLEY, BRITISH COLUMBIA ON BEHALF OF CANADIAN INDUSTRIES LIMITED

by

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MINERAL SCIENCES DIVISION

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SUMMARY

Mineralogical and electron microprobe studies were made on samples of copper ore from the Bethlehem Copper Mine and the Lornex Mine, both in the Highland Valley area of British Columbia, on behalf of Canadian Industries Limited. The results show that the samples consist essentially of siliceous gangue minerals. Copper mineralization in the Bethlehem Copper Mine is due primarily to malachite. Trace amounts of copper-sulphides; covellite, chalcocite, and bornite account for the remainder. Other minerals identified include magnetite, hematite, rutile, sphene, quartz, feldspar, mica, and chlorite.

The copper-bearing minerals in the Lornex Mine are mainly malachite, less chalcopyrite and bornite, and traces of covellite; an unidentified alteration product has replaced and often coats some of the copper sulphides. Other minerals identified include rutile, quartz, feldspar, and mica.

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INTRODUCTION

Two samples of copper ore from the Highland Valley area of British Columbia were received on February 19, 1973, from Dr. H.P. Schreiber, Canadian Industries Limited, Industrial Chemicals Limited, Chemicals Research Laboratory, McMasterville, Quebec. Dr. Schreiber requested that the samples be examined to identify the ore minerals present, and that the degree of copper dissemination in the gangue be determined by electron microprobe methods.

SAMPLES

The two samples, as received, consisted of plus 100-mesh ore. They were designated as being from the "Bethlehem Copper Mine, Heustis Pit Ore", and from the "Lornex Mine". Each sample weighed approximately 24 grams and was reported to contain 0.4% copper. The samples were composed essentially of siliceous gangue minerals, with some visible malachite and metallic mineralization.

METHOD OF INVESTIGATION

Mineralization in the samples was limited, therefore, the plus 35-mesh fractions were removed and hand-picked to recover as much of the visible ore minerals as possible. One polished section was prepared from each of these hand-picked fractions and from a representative portion of the minus 35-mesh fractions. The minerals present, their grain sizes, and textural relationships were determined by the combined methods of microscopy, electron microprobe studies, X-ray diffraction analyses, and X-ray diffractometry.

RESULTS OF INVESTIGATION

Bethlehem Copper Mine

The copper-bearing minerals consist chiefly of malachite, trace amounts of covellite and chalcocite with a few minute particles of bornite.

Malachite occurs as coarse free grains, as intergrowths with, inclusions in, and partial rims about the gangue minerals (Figure 1). The malachite grains are between 25 microns and three millimetres in size*.

Covellite occurs as small inclusions in the malachite as in phase (Figure 2) and as a partial replacement of a larger grain of chalcocite. All of the observed grains of covellite are smaller than 60 microns, and the single partially replaced grain of chalcocite is about 100 microns. This is the only observed occurrence of chalcocite in the sample. The few grains of bornite, all less than 10 microns, occur as inclusions in the gangue.

The remaining ore minerals** consist of magnetite, hematite, and rutile. Hematite replaces magnetite and they both occur as scattered inclusions in the gangue; whereas the rutile occurs as a number of clusters in sphene.

The principal gangue minerals are quartz and feldspar. Small amounts of mica and chlorite are also present.

Electron microprobe studies were made on the gangue minerals to determine if any copper silicates occur in the sample. None were detected.

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*The word "size" as used in this report, refers to the greatest dimension of the mineral grain being described.

**The term "ore minerals" as used in this report, does not necessarily have an economic connotation.

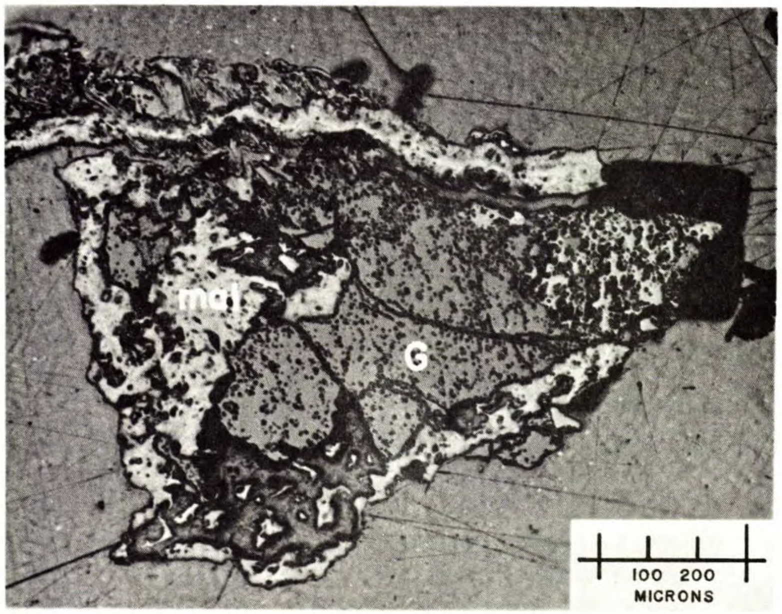

Figure 1. Photomicrograph of a polished section showing malachite (mal) rimming and penetrating a grain of gangue (G).

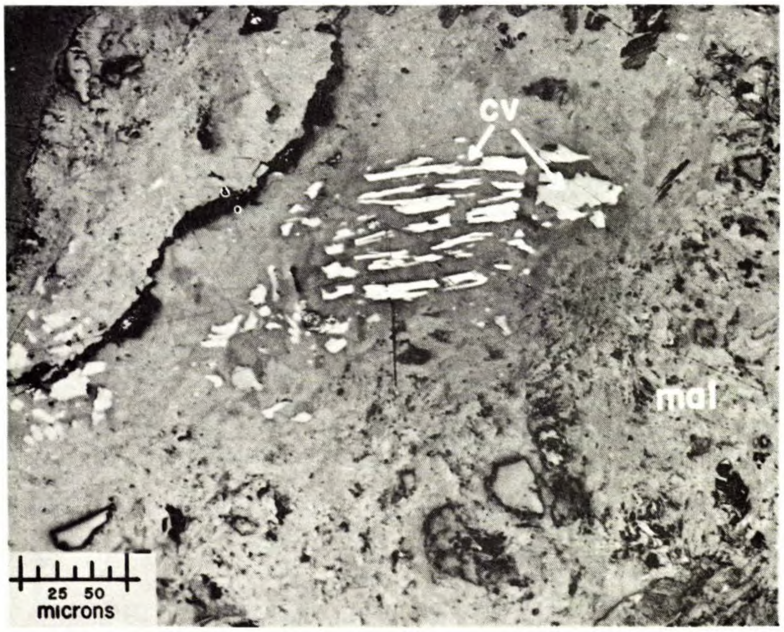

Figure 2. Photomicrograph of a polished section showing relict covellite grains (cv) in malachite (mal). The difference in the grey-white shading of the covellite grains is due to their strong pleochroism. A few inclusions of gangue, marked by a black line of relief, are also present in the malachite.

Lornex Mine

Copper in this sample is represented chiefly by malachite and to a lesser extent by chalcopyrite and bornite. In addition, the sample contains an unidentified alteration product of the copper sulphides and traces of covellite.

The occurrence of malachite in this sample is very similar to that of the Bethlehem Copper Mine in that the malachite is present as large free grains, intergrowths with, and inclusions in the silicate gangue minerals (Figure 3). Its grain size is also almost identical to the malachite in the Bethlehem Copper Mine sample.

The chalcopyrite and bornite are present as free grains (Figures 4 and 5), remnants in the alteration product (Figure 6) and as small inclusions in the gangue. All of the observed grains of bornite have exsolved lamellae of chalcopyrite. The mentioned sulphides are between 10 microns and one millimetre in size. The alteration product occurs as veinlets in the chalcopyrite and bornite, and as discontinuous rims (Figures 4 and 5). It also occurs as inclusions, in the gangue, that are either complete or partial replacements of either bornite or chalcopyrite. The rims and veins are between 20 and 130 microns wide, and the inclusions in gangue between 15 and 500 microns.

The alteration product appears to be multi-phase. This feature is illustrated in Figure 7, which is a photomicrograph of a portion of Figure 5, taken at a higher magnification. X-ray powder diffraction patterns of the alteration product, with one exception, showed the product to be amorphous. The exception indicated the presence of malachite as one of the phases. The remaining phases could not be identified. The alteration product was analysed by electron microprobe to determine its composition. A very thin (1 to 3-micron) discontinuous band of covellite exists as an interface (its only occurrence) between the copper sulphides and the alteration product. The second layer is believed to be malachite from qualitative microprobe analyses of this band. The extreme thinness of these bands prevented accurate analyses, but it can be stated however, that the bands, except for the malachite, are composed mainly of iron, copper, and silica, in proportions varying from phase to phase. From their occurrence and low weight per cent totals, it is probable that the phases are hydrous minerals. The detectable silica was mainly constant varying between 5.2 and 6.5 wt %; the iron between 19.4 and 44.2 wt %, and the copper between 8.9 and 34.7 wt %; traces of calcium (<0.5%) were also detected. No evidence of the dissemination of copper in the other silicates was detected. Electron backscatter images (E.B.S.) and X-ray images were made from areas of the alteration product in its replacement of the sulphides, to illustrate the distribution of the principal elements (Figures 8 to 17).

Other minerals identified were a few small grains of rutile and the gangue minerals -- quartz, mica, and feldspar.

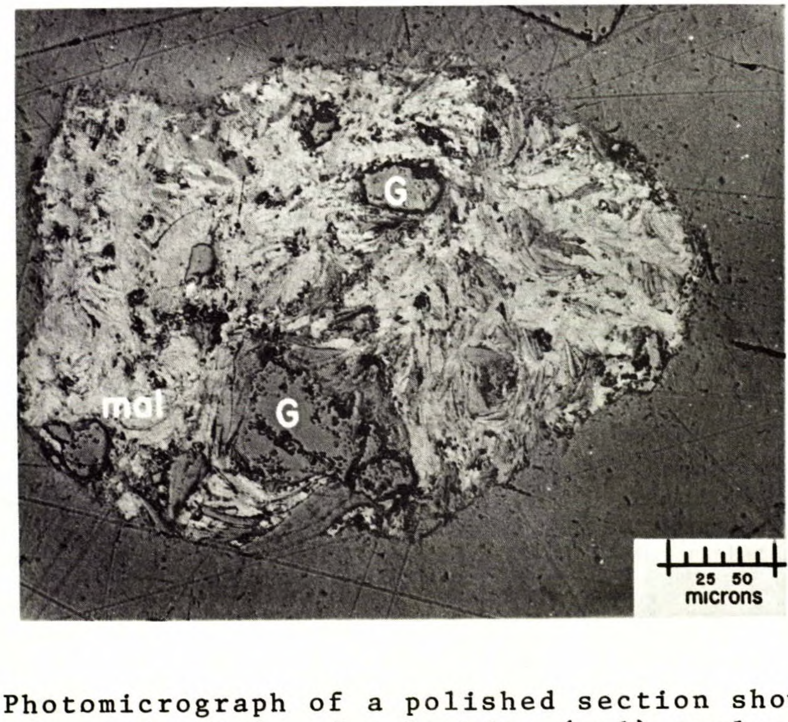

Figure 3. Photomicrograph of a polished section showing a grain composed mainly of malachite (mal) enclosing inclusions of grey gangue (G).

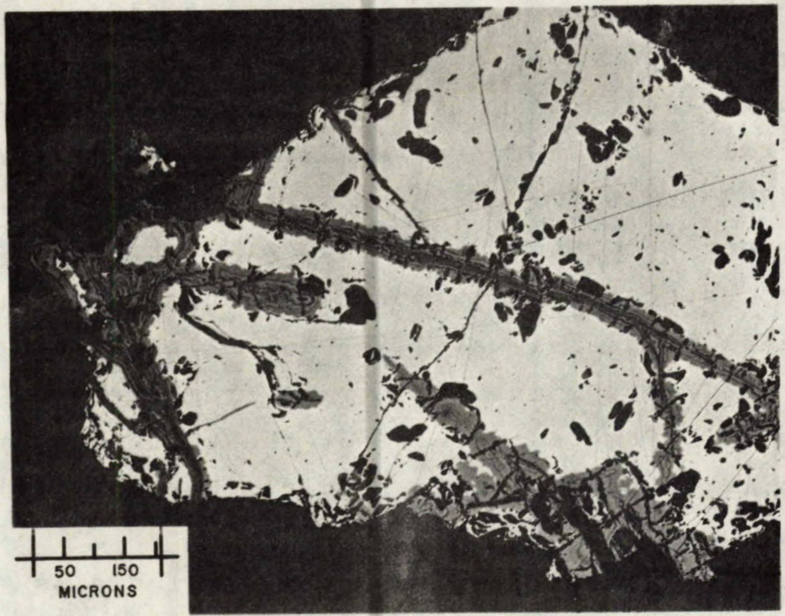

Figure 4. Photomicrograph of a polished section showing a large free grain of chalcopyrite (white) which is veined and partly rimmed by the alteration product.

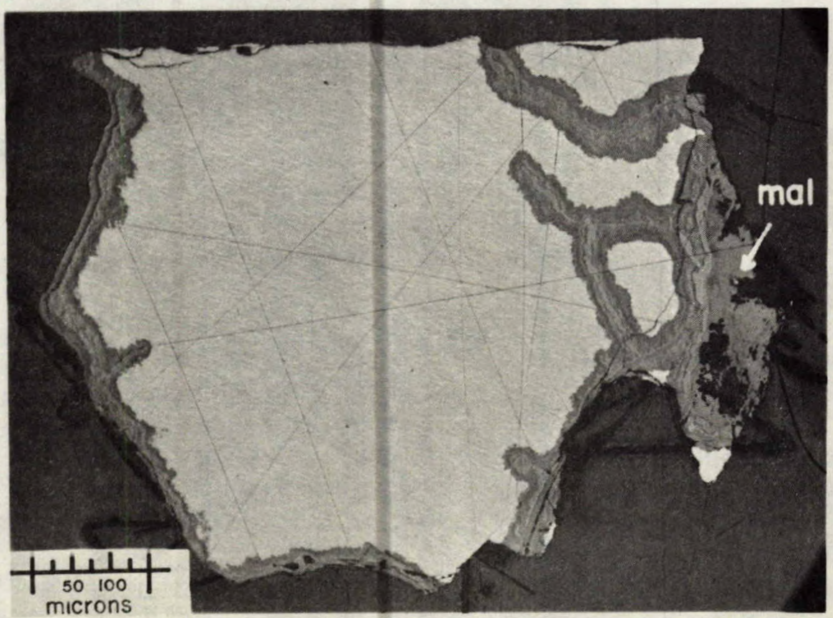

Figure 5. Photomicrograph of a polished section showing a grain of bornite (light grey) almost completely rimmed and partly veined by the alteration product (medium grey) An appendage of malachite (mal) is also shown. The bornite is saturated with minute exsolved lamellae of chalcopyrite.

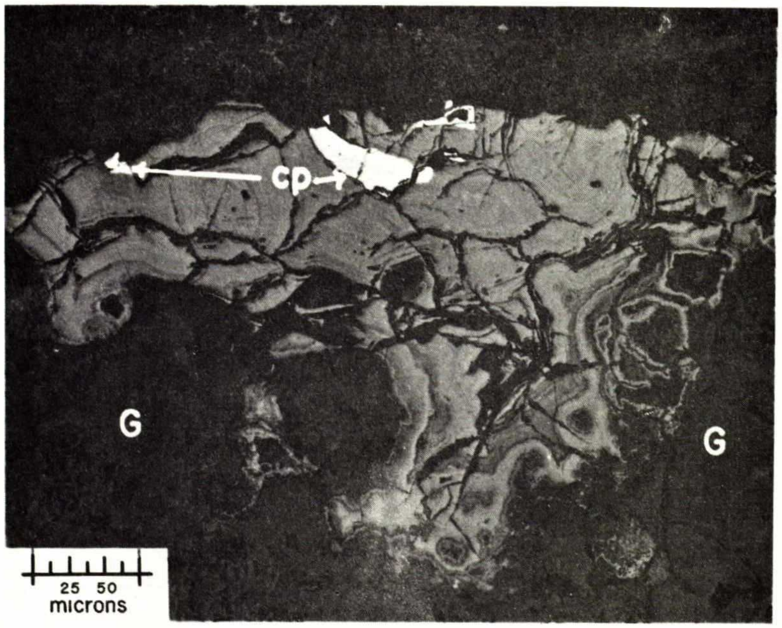

Figure 6. Photomicrograph of a polished section showing remnants of chalcopyrite (cp) in the alteration product (medium-grey) which is enclosed by gangue (G).

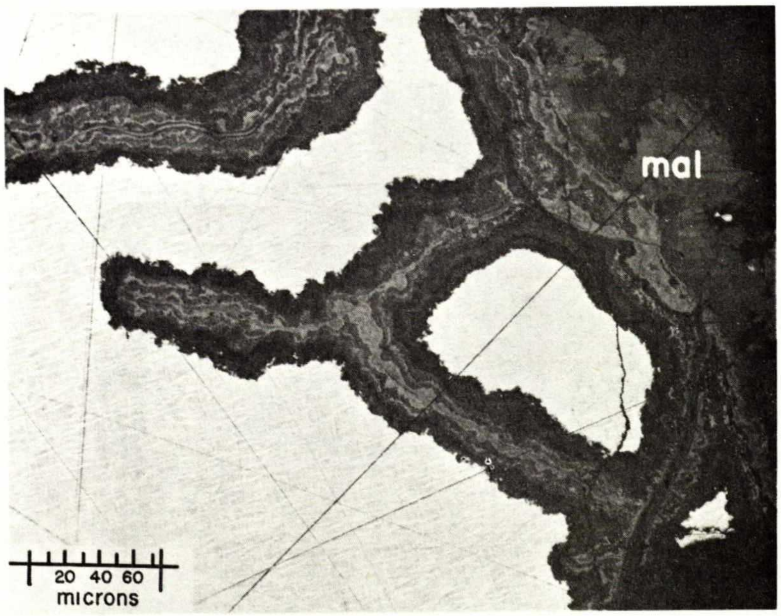

Figure 7. Photomicrograph (in oil immersion) at a higher magnification, of part of the field in Figure 5, showing the distinct zones in the alteration product (shades of grey) about bornite (white). A small area of malachite (mal) is also shown.

Figures 8 to 12 show the E.B.S. and X-ray images for the area of bornite and alteration product as shown in Figure 7. In the E.B.S. image, the white areas are bornite and the shades of grey are the alteration product.

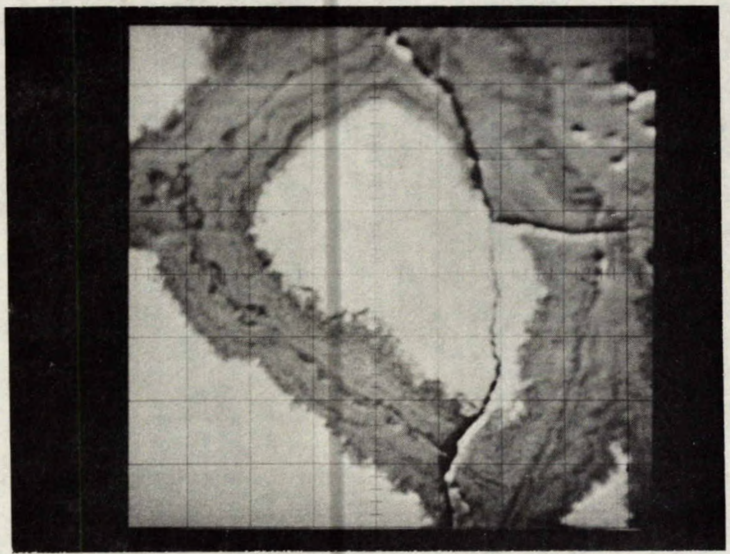

Figure 8. Electron backscatter image.

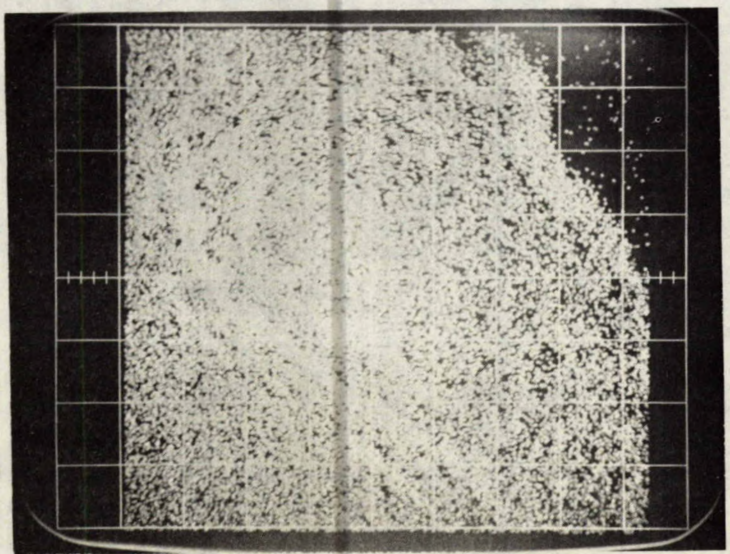

Figure 9. X-ray image for FeK_{α}.

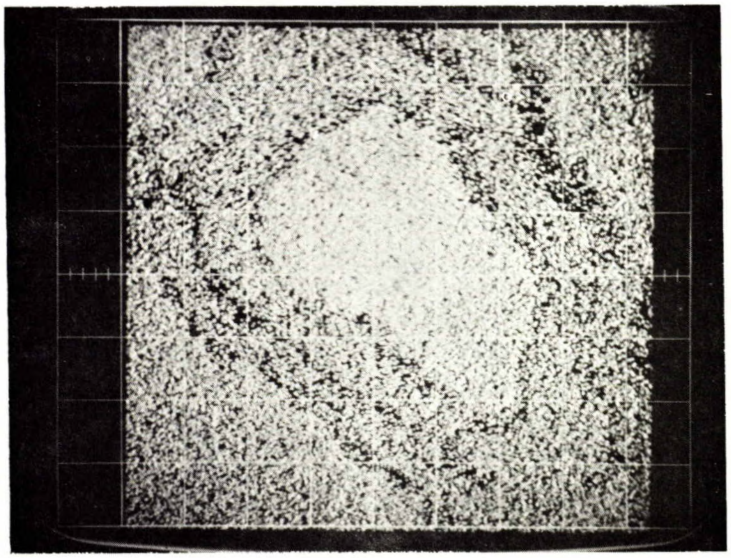

Figure 10. X-ray image for CuK_α.

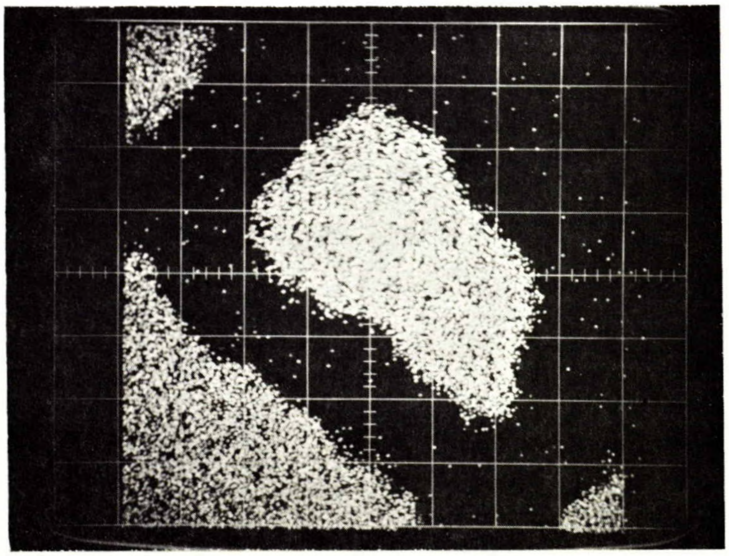

Figure 11. X-ray image for SK_α.

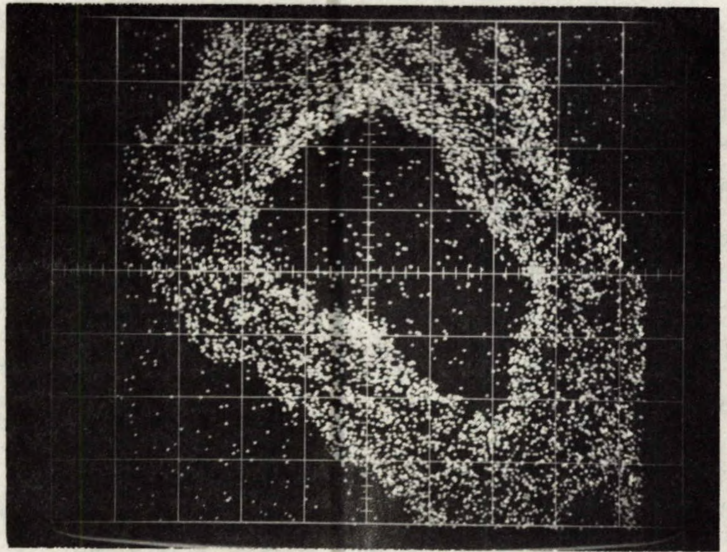

Figure 12. X-ray image for SiK_{α}.

Figures 13 to 17 show the E.B.S. and X-ray images for an area of the alteration product (grey) with chalcopyrite remnants (white).

Figure 13. Electron backscatter image.

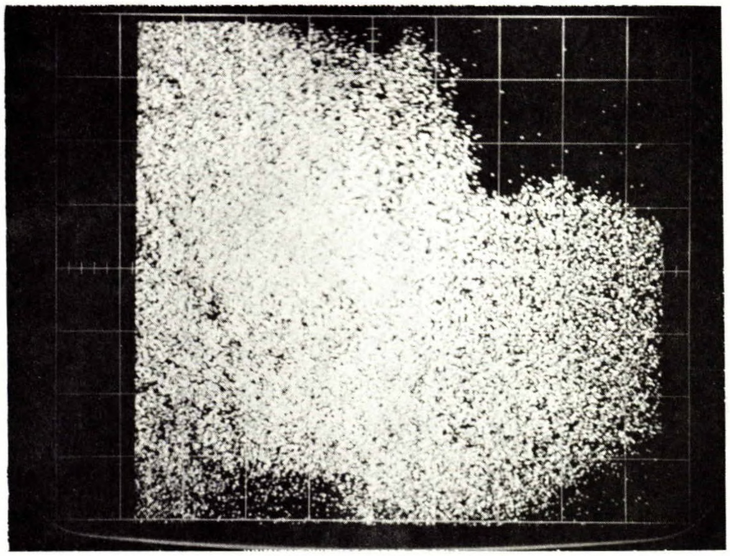

Figure 14. X-ray image for FeK_{α}.

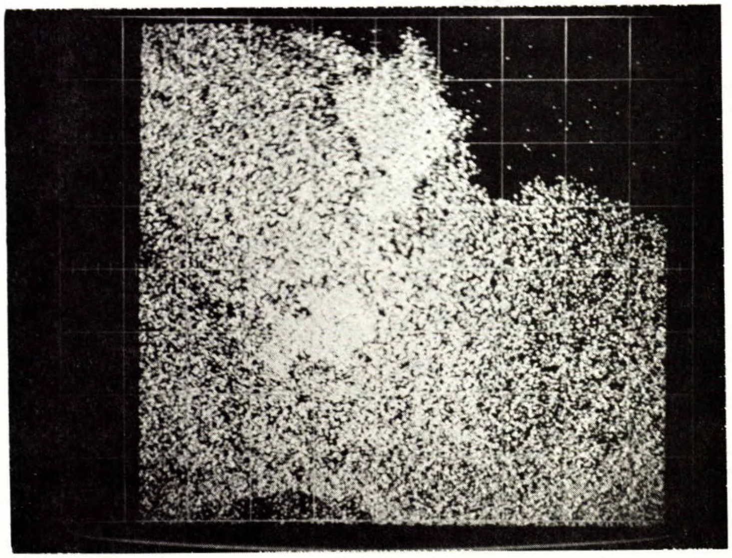

Figure 15. X-ray image for CuK_{α}.

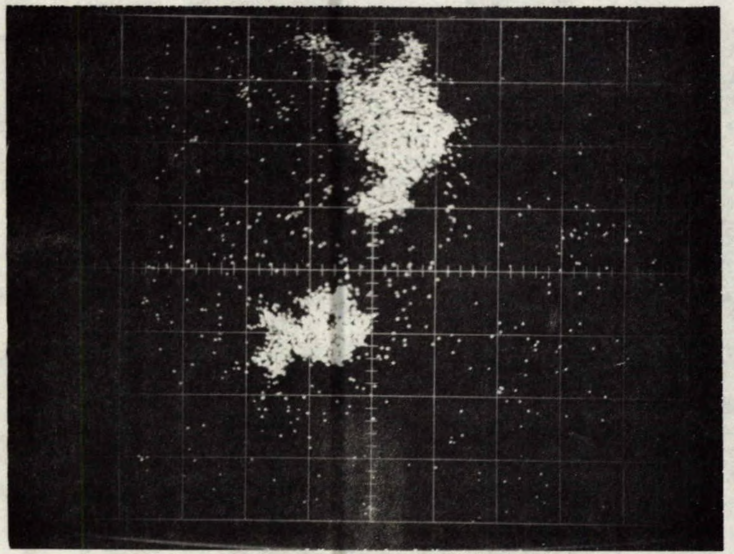

Figure 16. X-ray image for SK_{α}.

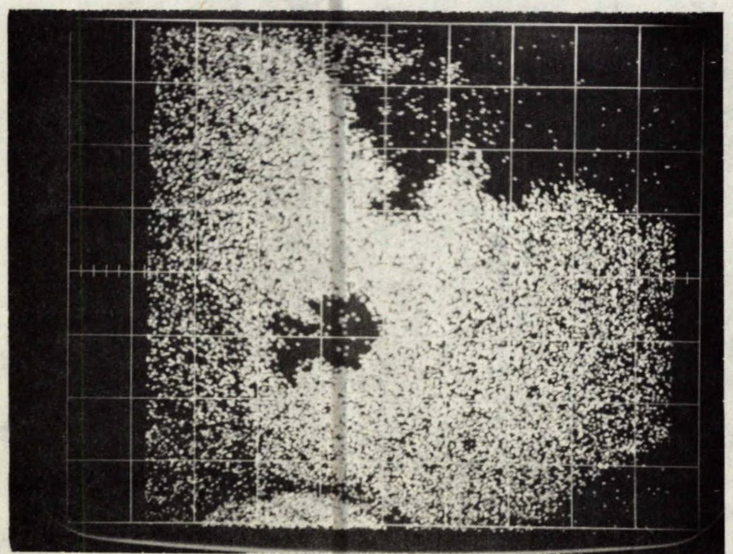

Figure 17. X-ray image for SiK_{α}.

CONCLUSIONS

The following conclusions can be made on the basis of this investigation:

Copper in the Bethlehem Copper Mine sample occurs principally in malachite, most of which appears to be relatively coarse-grained. The minute amounts of copper sulphides, except for the large grain of chalcocite, are much finer-grained, and liberation of these small particles will present some difficulty. There are no copper silicate minerals in this ore.

The Lornex Mine sample is somewhat more complex. The size range of the copper sulphides is more extensive and it is complicated by the alteration product coating the larger grains. What effect this product will have on the recovery of the copper sulphides, cannot be stated. The malachite, however, is relatively coarse-grained and should be quite readily liberated.

ACKNOWLEDGEMENTS

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