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MINERALOGICAL EXAMINATION OF A COMPLEX ORE FROM THE RED LAKE DISTRICT OF ONTARIO, SUBMITTED BY COCHENOUR WILLANS GOLD MINES LIMITED

by

L. J. CABRI

MINERAL SCIENCES DIVISION

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SUMMARY OF RESULTS

A mineralogical study of diamond-drill core and a head sample from this deposit shows that the ore is highly complex. The base metals of interest are Zn, Cu, and Pb, in decreasing order of abundance, and the presence of silver and tin minerals, if recoverable, should add value to the ore. By-products of antimony and cobalt may also be of interest. The complex mineralogy and the presence of certain gangue minerals may present difficulties in beneficiation.

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INTRODUCTION

Five pieces of split diamond-drill core and a packet of head sample (-10 mesh) were received from Mr. A. Stemerowicz (Mineral Processing Division) with a request for mineralogical examination in January 1969. The core and head sample were stated to have come from a Cu-Zn-Pb-Ag ore from a group of claims owned by Cochenour Willans Gold Mines Ltd., located twenty miles west of the town of Red Lake, Ontario, in the Township of Mulcahy, District of Kenora (Patricia Portion), Red Lake Mining Division. The sample submitted to the Mineral Processing Division consisted of 267 lb of split diamond-drill core said to be representative of the deposit. Correspondence from Mr. D. A. Hutton, Chief Geologist, Cochenour Willans Gold Mines Ltd. to Mr. R. W. Bruce, Head of the Non-ferrous Minerals Section of the Mineral Processing Division, indicated probable grade of blocked-out ore to December 1968 as being 7.53% Zn, 1.42% Cu, 0.22% Pb, and 1.62 oz. Ag/ton. Additional pieces of diamond drill core were subsequently obtained from Mr. Stemerowicz and Mr. Hutton.

METHOD OF INVESTIGATION

Twenty-six polished sections for microscopic study were prepared from the diamond-drill core, and eleven from fractions of the head sample. The -48 +100-mesh fraction of the head sample was first separated magnetically on a Franz magnetic separator, and then into sub-fractions using heavy liquids with specific gravities of 2.96 and 3.3 The non-opaque minerals were studied by means of microscopic examination of grain-immersion mounts and thin sections. Minerals were identified by microscopy, X-ray diffraction, and electron-probe microanalysis. X-ray fluorescence and emission-spectrographic analyses were also performed on the head sample.

RESULTS OF THE INVESTIGATION

Most of the pieces of diamond-drill core received consisted principally of sulphides with minor gangue; one piece, however, contained mainly gangue minerals. The ore minerals* consist chiefly of coarse grains and inclusions of pyrrhotite and sphalerite. Chalcopyrite is the next most common ore mineral and in a few sections is predominant. There are lesser amounts of galena, marcasite, arsenopyrite, cobaltite, CoSbS (a new mineral), pyrargyrite, gudmundite, stannite, argentian tetrahedrite (or freibergite), native silver (antimonial), "ϵ-phase" (Ag with ~ 16 wt % Sb) ilmenite, breithauptite, cassiterite, and $NiSb_2$ (a new mineral) listed approximately in decreasing order of abundance.

The mineralized host rock appears to be an altered mafic rock commonly called "greenstone" which consists mostly of anthophyllite, actinolite, chlorite, quartz, and talc. Other minerals present are sphene, calcite, muscovite mica, feldspar (probably albite); one grain of a zinc-bearing Mg spinel was also found. There appears to be a marked schistosity of the gangue minerals, which suggests a term such as chlorite-anthophyllite schist for a specific rock name.

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

DETAILED MINERALOGY

Common Ore Minerals

Pyrrhotite and sphalerite both occur in major amounts, and from the core it is hard to estimate which one predominates. The pyrrhotite is mainly the monoclinic or iron-deficient magnetic variety, although X-ray diffraction and etch analyses indicate there may also be a few percent (less than 10%) of the non-magnetic hexagonal variety. Electron-probe analysis revealed a cobalt content of about 0.1%; Ni and Cu were not detected. The pyrrhotite grains vary considerably in size, from several millimetres to less than 5 microns. It occurs as inclusions in chalcopyrite, sphalerite, and galena, and often contains inclusions of these three minerals (see Figures 1, 2, and 3). It also forms very fine intergrowths with some of the silver- and antimony-bearing minerals.

Sphalerite is generally coarse-grained, but is finer-grained in the chalcopyrite-rich portions of the ore. It often contains inclusions of chalcopyrite and pyrrhotite down to 10 microns, or less in size (see Figures 1 and 4). The sphalerite was analysed in situ with the electron probe micro-analyser for elements other than zinc, and was found to contain about 5% Fe, 0.1% Cd and 0.05% Mn; no Cu was detected.

Chalcopyrite varies in size from large aggregates more than one millimetre in diameter down to very small inclusions less than 5 microns in size (Figure 4). It also forms a fine intergrowth with some of the fibrous gangue minerals (Figure 2). It is ubiquitous and appears to be associated with all other ore minerals. A typical chalcopyrite-rich section is shown in Figure 5.

The galena occurs as coarse grains (1 to 2 mm) in only one section, the remainder generally occurring as grains 50 to 300 microns in diameter

(Figures 1 and 4). Electron-probe analyses of the galena did not reveal the presence of silver.

Marcasite was found in a few sections; it is typically coarse-grained (1 to 2 mm) and shows concentric growth rings or bands (Figure 3). Arsenopyrite occurs in some sections as large grains more than 200 microns in diameter, but also as smaller grains associated with cobaltite in a train set in a matrix of chalcopyrite (Figures 3 and 6). Cobaltite is often euhedral in morphology and occurs in grains up to about 150 x 90 microns, but is more often around 25 to 50 microns in size. Electron-probe analyses showed both arsenopyrite and cobaltite to have few impurities and to approach their stoichiometric formulas. Ilmenite grains were encountered as minor constituents in some sections.

Silver-bearing Minerals

Four silver-bearing minerals were found: native silver "ϵ-phase", pyrargyrite, and argentian tetrahedrite. Electron-probe analyses showed that the native silver is an antimony-bearing variety which is known as antimonial silver (about 3% Sb). The "ϵ-phase" is also an Ag-Sb alloy, but contains about 16% Sb. The pyrargyrite ($Ag_2Sb_2S_4$) appears to be normal, containing about 60% Ag and 22% Sb. The tetrahedrite was found to be very rich in Ag (about 30% Ag) which is very high for this mineral.

The antimonial silver ranges in size from 12 to 30 microns, but also as much smaller inclusions (Figures 7, 8, and 9). It occurs as rims around gangue and, more often, as inclusions in nearly all other minerals in the ore, except for marcasite and ilmenite. The "ϵ-phase" was identified by electron-probe analysis and occurs together with antimonial silver. It polishes somewhat better than the silver, which is badly pitted in all the photomicrographs. The pyrargyrite (Figures 4, 8, and 9) often occurs with chalcopyrite, pyrrhotite, and tetrahedrite in variously sized irregular grains up to about 120 microns in diameter. Tetrahedrite, typically 60 to 180 microns in size, but up to 650 x 120 microns in one grain, has a very irregular shape and is invariably full of inclusions such as chalcopyrite, galena, silver, pyrargyrite, and gudmundite (Figure 7). Most of the silver-bearing minerals were found in one galena-rich section, and are rarer in the other sections examined.

Antimony-bearing Minerals

Besides the four silver-bearing minerals discussed above, all of which also contain antimony to a greater or lesser degree, four other antimony-bearing minerals were observed. Two of these appear to be new minerals with compositions approximating CoSbS and $NiSb_2$ as determined with the electron probe. The other two are gudmundite (FeSbS) and breithauptite (NiSb). The CoSbS mineral was found in several sections and can be mistaken for cobaltite. It occurs as variously sized grains up to about 130 microns in size. (Figures 5 and 8). $NiSb_2$ is very rare, was found only in two sections, and invariably occurs with breithauptite. Gudmundite (Figure 9) was noted in a few sections. These antimony-rich minerals had their maximum development in the same galena- and silver-rich section described above.

Tin-bearing Minerals

Two tin-bearing minerals were found -- stannite and cassiterite. The stannite is the most common of the two minerals, and was found as small inclusions in several sections. One section was found to contain 19 grains (12 to 50 microns), and another, 30 grains (5 to 25 microns). Stannite occurs as inclusions in sphalerite and chalcopyrite (Figures 10 and 11) and typically appears either adhering to sphalerite grains (Figure 11) or as wedge-shaped inclusions along the borders of sphalerite grains (Figure 10). Cassiterite was found in only one section associated with sphalerite, gangue, and chalcopyrite, but may be more prevalent than its observance in only one section would indicate.

Mineralogy of the Head Sample

The -48 +100-mesh fraction of the head sample was separated into magnetic fractions, and polished sections were made of each fraction to determine the degree of liberation. A rough estimate is that 60 to 70% of the ore minerals are separated from the silicate gangue in that size range. Examination of the ore mineral inclusions in the gangue particles suggests that there are more chalcopyrite inclusions than sphalerite. Another section was made of the -100-mesh fraction, and examination indicates approximately 60 to 80% liberation from the silicate gangue.

CONCLUSIONS

The samples examined indicate a complex base-metal ore, with sphalerite and chalcopyrite as the principal sources of base metals. Three other important metals that would add to the value of the ore are lead, silver and tin. By-products in the form of antimony and cobalt may also be of interest.

Some of the factors that can be expected to adversely affect the beneficiation of the ore are:

1. The complex mineralogy and great diversity of the ore minerals.
2. The presence of fibrous amphibole (anthophyllite), chlorite and talc as gangue minerals.

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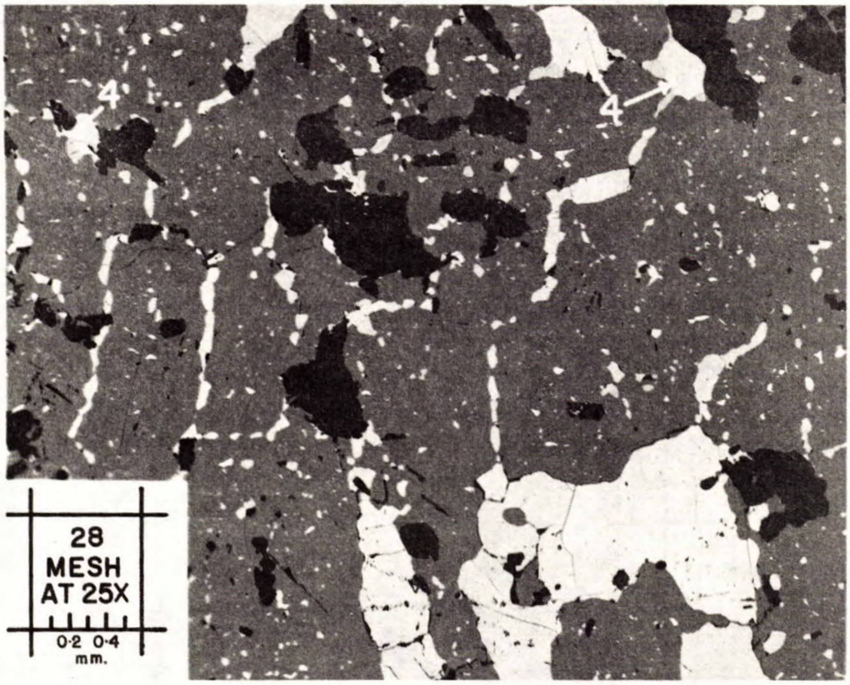

Figure 1. Sphalerite (grey) with inclusions of pyrrhotite (white) and galena (white,4). Some of the very fine small inclusions are chalcopyrite but they are indistinguishable from pyrrhotite in the photograph. Black areas are gangue and pits.

Figure 2. Sphalerite (dark-grey), chalcopyrite (white) and pyrrhotite (8, light grey) showing typical relationships with fibrous amphiboles (black).

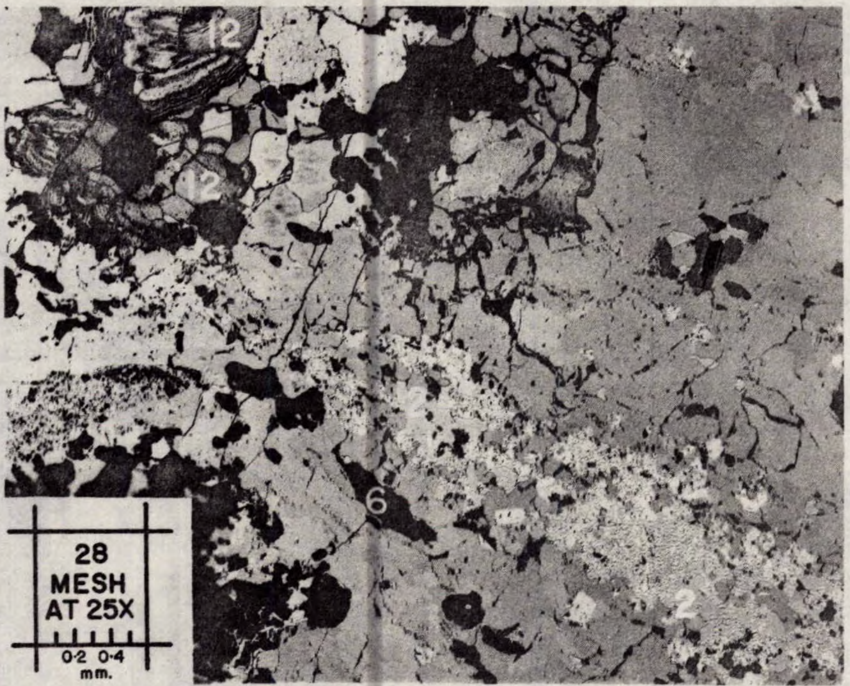

Figure 3. Pyrrhotite-rich section (shades of grey) with train of cobalt and iron arsenosulphides (white) associated with chalcopyrite (2). Typical marcasite (12) and some sphalerite (6) are also shown.

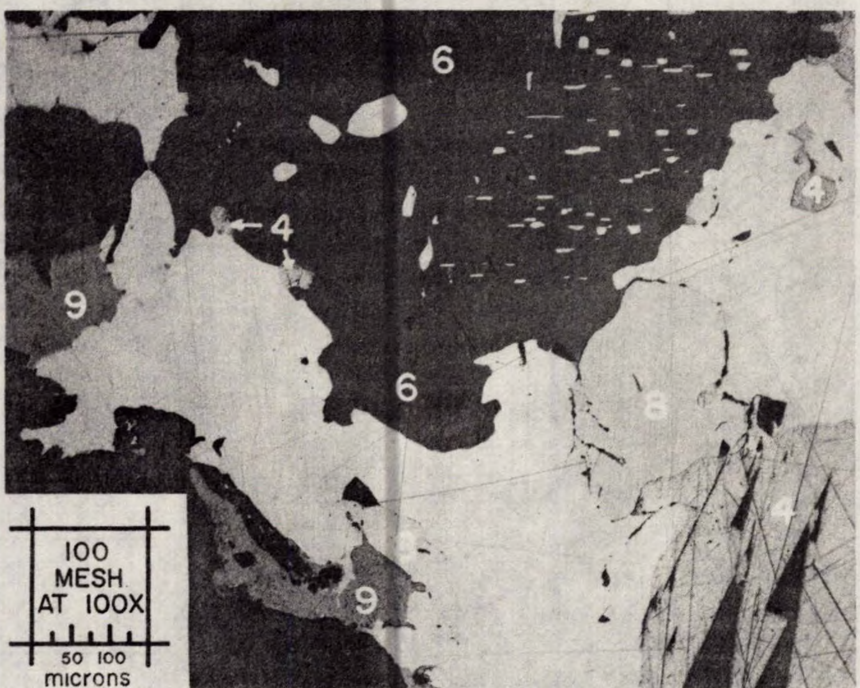

Figure 4. Sphalerite (6), chalcopyrite (white,unmarked), pyrrhotite (white, 8), galena (4), and pyrargyrite (9). The sphalerite contains small inclusions of chalcopyrite and galena. (in oil immersion).

Figure 5. Chalcopyrite-rich section (greyish white) with fine scattered inclusions of pyrrhotite (grey) and sphalerite (6). Also shown is one grain of CoSbS (11). The black areas are pits.

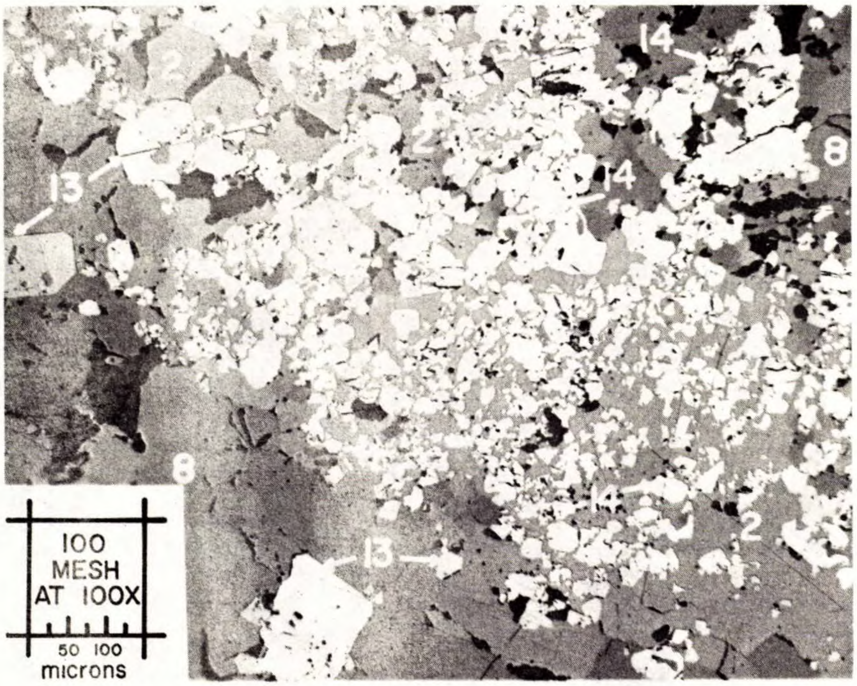

Figure 6. Higher magnification of a part of Figure 3 showing euhedral grains of cobaltite (13) inter-mixed with arsenopyrite (14) set in a matrix of chalcopyrite (2), and associated with pyrrhotite (8) (in oil immersion).

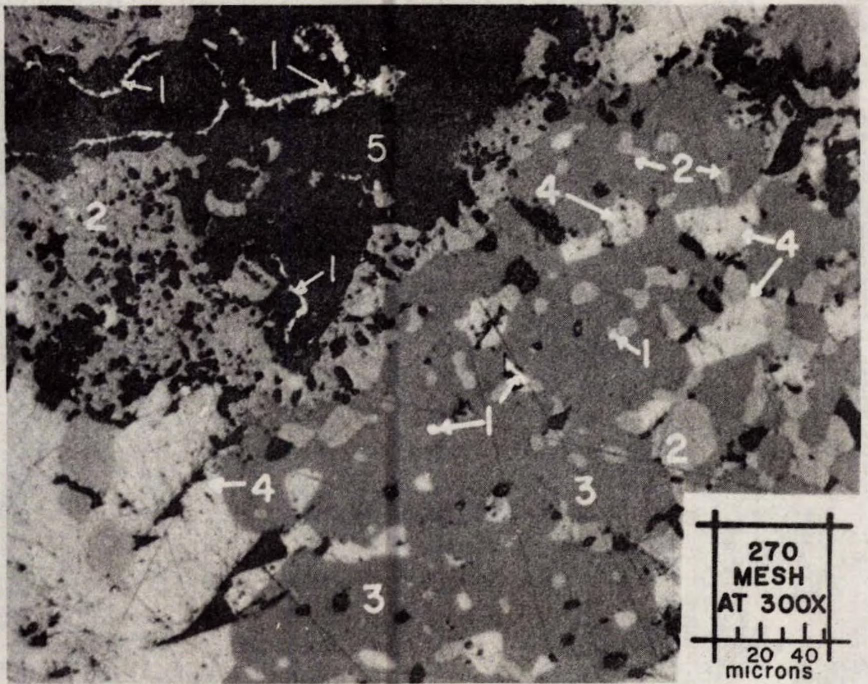

Figure 7. Tetrahedrite (3) with inclusions of silver (1), galena (4) and chalcopyrite (2). Silver (1) also occurs as rims around grains of gangue in the upper part of the photomicrograph. (in oil immersion).

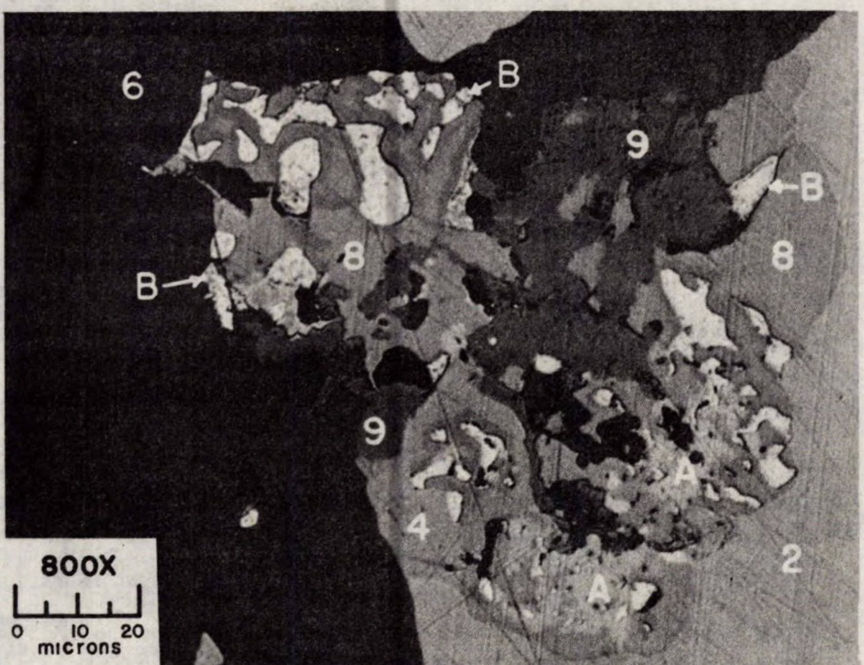

Figure 8. Photomicrograph, in oil immersion, showing relationship between silver (B), pyrrhotite (8), pyrargyrite (9), chalcopyrite (2), galena (4), sphalerite (6) and CoSbS (A). The darker rims around many of the silver inclusions were not identified.

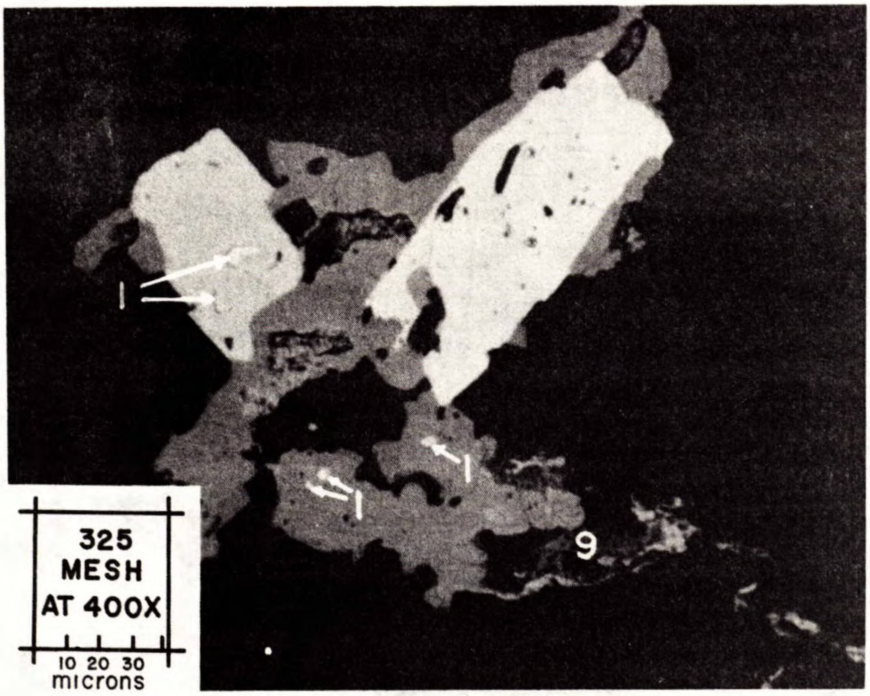

Figure 9. Two gudmundite grains (white) associated with chalcopyrite (grey) and with inclusions of silver (1) in both minerals. A small grain of pyrargyrite (9) adheres to chalcopyrite. The black areas are gangue. (in oil immersion).

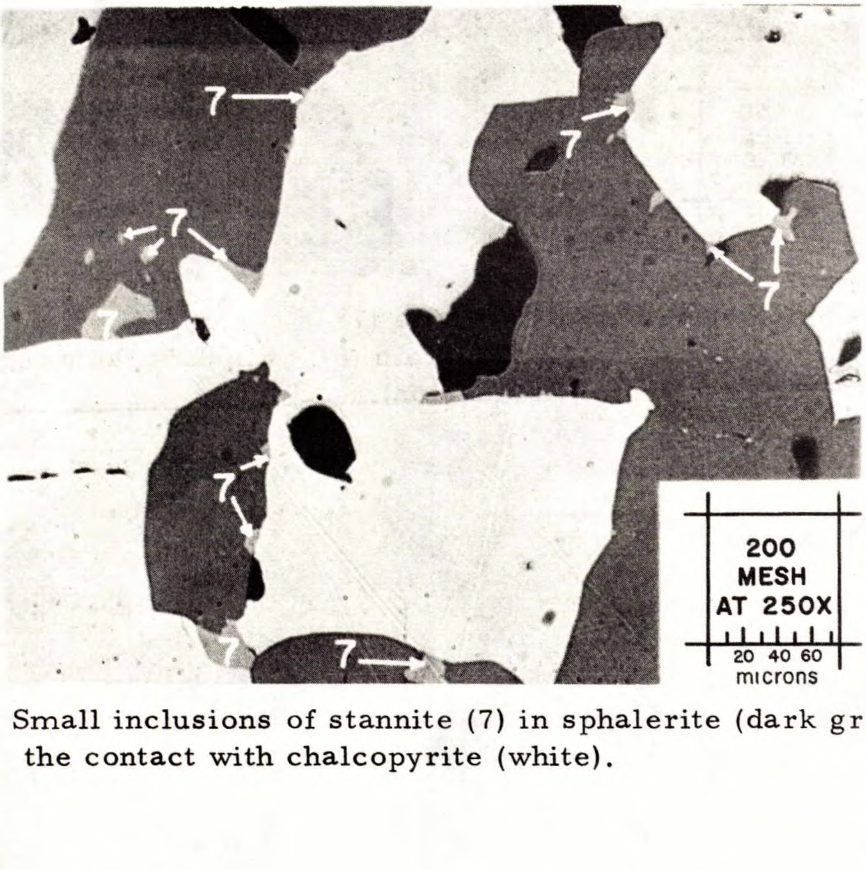

Figure 10. Small inclusions of stannite (7) in sphalerite (dark grey) along the contact with chalcopyrite (white).

Figure 11. Small inclusions of stannite (7) in chalcopyrite (white) and adhering to sphalerite grain (6). Black areas are pits or gangue. (in oil immersion).