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MINES BRANCH INVESTIGATION REPORT IR 63-67

MINERALOGY OF A SULPHIDE TIN-SILVER ORE FROM BOLIVIA FOR PROSPECTION LIMITED

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by

W. PETRUK

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MINERALOGY OF A SULPHIDE TIN-SILVER ORE FROM BOLIVIA FOR PROSPECTION LIMITED

by

W. Petruk*

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SUMMARY OF RESULTS

The sulphide tin-silver ore from Bolivia is very complex mineralogically, as an unusually large number of metallic and non-metallic minerals were found in the samples studied. The most abundant metallic minerals are pyrite, galena and boulangerite. Most of the tin occurs as cassiterite, but a small amount is also contained in the mineral stannite. Silver occurs in freibergite, stephanite and possibly also in galena. The freibergite occurs as relatively large grains, whereas the stephanite occurs as minute inclusions in galena.

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*Scientific Officer, Mineralogy Section, Mineral Sciences Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

INTRODUCTION

Samples of a sulphide tin-silver ore from Bolivia were received from G.O. Hayslip of the Mineral Processing Division in April, 1963. Mr. Hayslip stated that the ore was submitted to the Mines Branch by Prospection Limited, 80 Richmond Street West, Toronto, Ontario, who requested a mineralogical investigation. As received, the samples consisted of hand specimens, a head sample ground to about -10 mesh, and a galena concentrate ground to about -100 mesh.

METHOD OF INVESTIGATION

Polished and thin sections were prepared from the hand specimens and the minerals were identified by means of microscopical and X-ray diffraction studies.

The head sample and the galena concentrate were analysed spectrochemically. They were also sized and separated into fractions by means of heavy liquids and the micropanner. The resulting fractions were studied microscopically and analysed by X-ray diffraction. Some of the fractions were analysed chemically and spectrochemically.

RESULTS OF INVESTIGATION

Chemical Composition

The elements present in the head sample, as determined spectrochemically, are given in Table 1.

TABLE 1

Elements Present in Head Sample of Sulphide Tin-Silver Ore from Bolivia*

Element	Approximate amount present (see legend)	
Fe	A	
Si	A	
Al	B	
Pb	B	
Sn	C	
Mg	C	
Na	C	
Sb	C	
Cu	D	
Ti	D	
Ba	D	
Mn	D	
B	D	
Cr	D	Legend
Ag	D	A = +5%
Ca	D	B = 1 to 5%
V	D	C = 0.1 to 1%
Bi	D	D = 0.01 to 0.1%
Sr	D	E = 0.001 to 0.01%
Ni	D	tr = trace
Zr	E	
Ga	E	
Mo	E	
Zn	tr	
Co	tr	
As	tr	

*Semi-quantitative spectrochemical analysis by E.M. Kranck, Report SL-63-077, Analytical Chemistry Subdivision, Mineral Sciences Division, Mines Branch.

Mineralogy

General Mineralogy

The metallic minerals found in the ore are cassiterite (SnO_2), stannite (Cu_2FeSnS_4), galena (PbS), boulangerite ($Pb_5Sb_4S_{11}$), bournonite ($Pb_2Cu_2Sb_2S_6$), stephanite (Ag_5SbS_4), freibergite ($(Cu, Fe, Ag)_{12}Sb_4S_{13}$), sphalerite (ZnS), pyrite (FeS_2), marcasite (FeS_2), pyrrhotite (FeS), arsenopyrite (FeAsS), and goethite ($Fe_2O_3.H_2O$). These minerals occur as masses and disseminated grains in a porphyritic tuff or fragmental volcanic rock (see Figure 1).

The non-metallic minerals are quartz (SiO_2), feldspar ($(K, Na)AlSi_3O_8$), tourmaline ($B_3Al_3(AlSi_2O_9)_3(O, OH, F)_4$), topaz ($(AlF)_2SiO_4$), fluorite ($CaF_2$), mica ($KAl_2(AlSi_3O_{10})(OH)_2$), pyrophyllite ($H_2Al_2(SiO_3)_4$), chlorite ($(Mg, Fe)_6(Al, Si)_4O_{10}(OH)_8$), rutile ($TiO_2$), svanbergite ($Sr_2Al_6O_{11}P_2O_5(SO_3)_2.6H_2O$) and jarosite ($K_2Fe_6(OH)_2(SO_4)_4$).

Metallic Minerals

Cassiterite

Cassiterite is the principal tin bearing mineral. It is commonly buff to yellow, but occasionally may be colourless. Polished and thin sections show that it occurs as inclusions in gangue, galena, boulangerite and pyrite (see Figure 2), and is frequently intergrown with kaolin, svanbergite and tourmaline. Some of the cassiterite grains are single well-developed crystals, but usually the mineral does not show well-developed crystal forms and sometimes occurs as aggregates of irregular grains. The single crystals range from about 5 to 150 microns in size and the aggregates are up to 1 millimetre in size.

Stannite

Only a small amount of stannite was found in the sections examined, mostly as inclusions in galena (see Figure 3). These inclusions range from about 1 to 100 microns in size.

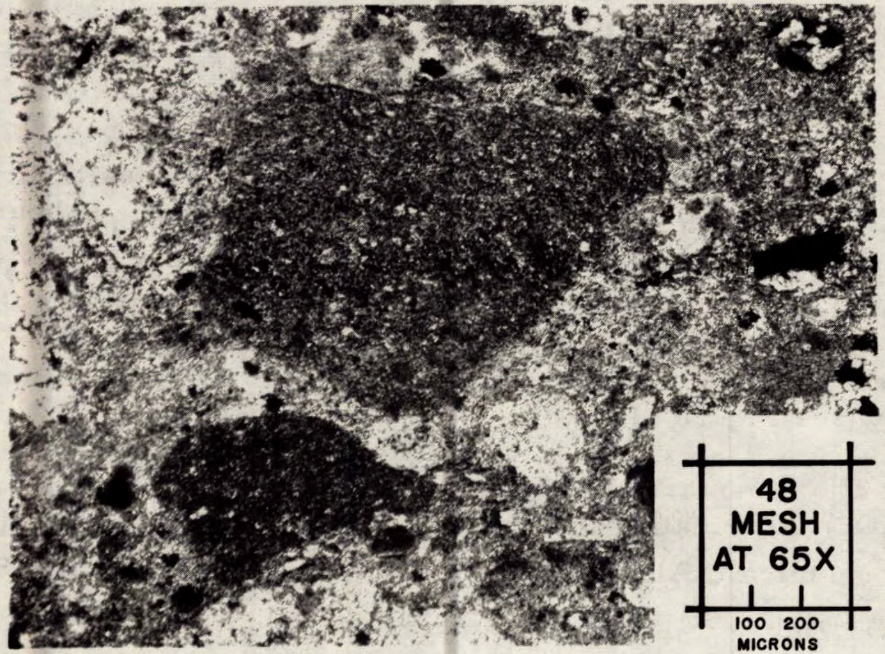

Figure 1. Photomicrograph of a thin section of the host rock. It shows (1) fragments or volcanic bombs in the fine grained matrix, (2) inclusions of non-metallic minerals, and (3) grains of metallic minerals (black).

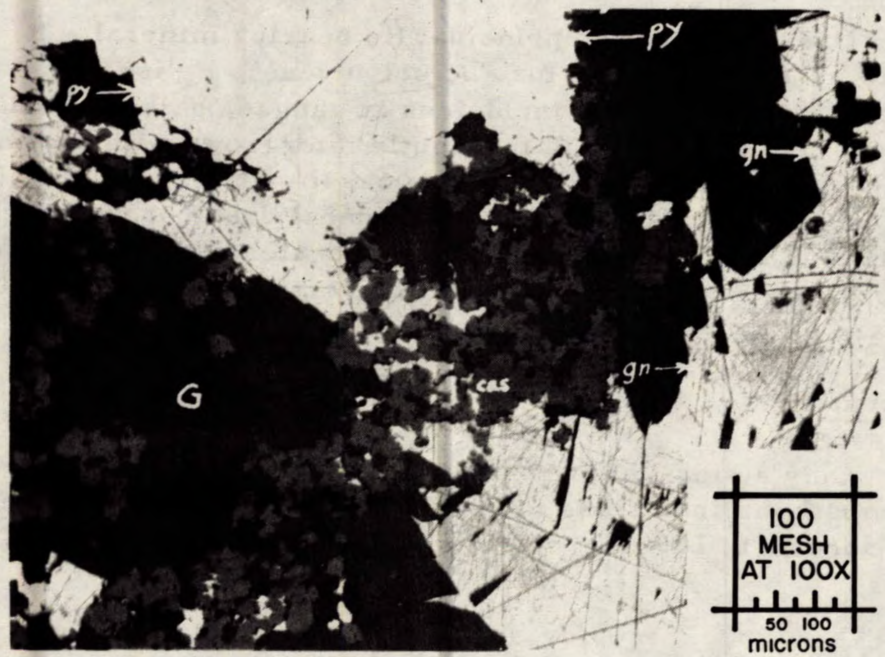

Figure 2. Photomicrograph of a polished section showing cassiterite (cas) in galena (gn), pyrite (py) and gangue (G).

Galena

Galena is the principal lead-bearing mineral. It occurs as masses and as disseminated grains in gangue and pyrite, and contains inclusions of boulangerite, stannite, stephanite, freibergite, bournonite, and sphalerite.

The cell-edge of the galena was determined as 5.935 A. This value agrees precisely with that of pure PbS and it would appear almost certain that the galena cannot contain significant amounts of silver or bismuth in solid solution. Spectrochemical analysis of the galena shows that it contains at least spectrographic traces of In, Bi, Ga, Ni, and Ag*.

A -100 mesh galena concentrate prepared by G.O. Hayslip, and known to contain approximately 250 ounces per ton of silver, was studied in detail. It was separated into a -200 mesh fraction, a +200 mesh micropanner head fraction, and a +200 mesh micropanner tail fraction. These fractions were studied by microscopical and X-ray diffraction methods and analysed chemically for silver. The results are given in Table 2.

TABLE 2

Mineralogy and Silver Content of Fractions Prepared from a Galena Concentrate

Fraction	Wt. % of Fraction	Ounces per Ton Ag**	Minerals Present in Fraction
Sample supplied	100.00	250.00	galena, boulangerite, pyrite, stannite, stephanite, freibergite, cassiterite and sphalerite.
-200 mesh	88.90	239.14	galena, boulangerite, pyrite, stannite, stephanite, freibergite, cassiterite and sphalerite.
+200 mesh (micropanner head)	5.82	116.34	galena, stephanite, and traces of pyrite and cassiterite.
+200 mesh (micropanner tail)	5.82	680.86	pyrite, galena, freibergite, boulangerite, and traces of stannite, sphalerite, and possibly stephanite.

* Analysis by E.M. Kranck, Report SL-63-094, Analytical Chemistry Sub-Division, Mineral Sciences Division, Mines Branch.

** Analysis by L. Lutes, Analytical Chemistry Subdivision, Mineral Sciences Division, Mines Branch.

Estimates of the relative quantities of the minerals listed in Table 2 support the view that freibergite, and to a lesser extent stephanite, are the chief silver-bearing minerals.

Boulangerite and Bournonite

A significant amount of boulangerite is also present in the ore. It occurs as masses and as inclusions in galena (see Figures 3 and 4). The masses frequently contain cassiterite, pyrite and gangue. The inclusions of boulangerite in galena are occasionally intergrown with bournonite (see Figure 4), and this is the only mode of occurrence of the latter mineral observed in this ore.

Stephanite and Freibergite

Stephanite and freibergite were found only in the galena concentrate. Stephanite occurs as inclusions in galena (see Figure 5), and freibergite as freed grains and as intergrowths with galena.

Sphalerite

A few isolated sphalerite grains that range from about 10 to 300 microns in diameter are present in the ore. Some of them contain lamellae of chalcopyrite.

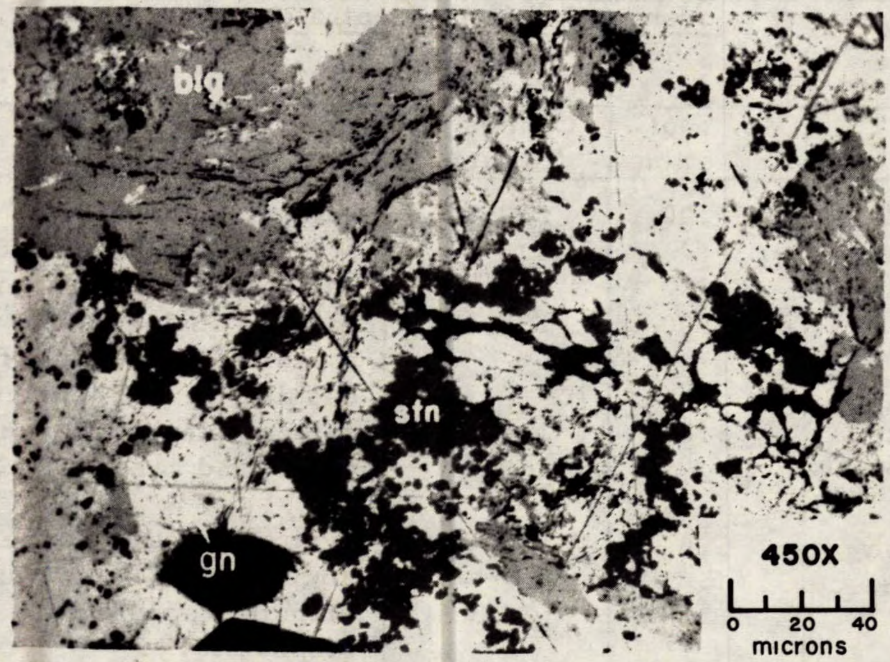

Figure 3. Photomicrograph of a polished section showing inclusions of finely-divided stannite (stn) and boulangerite (blg) in galena (gn). The black areas represent pits.

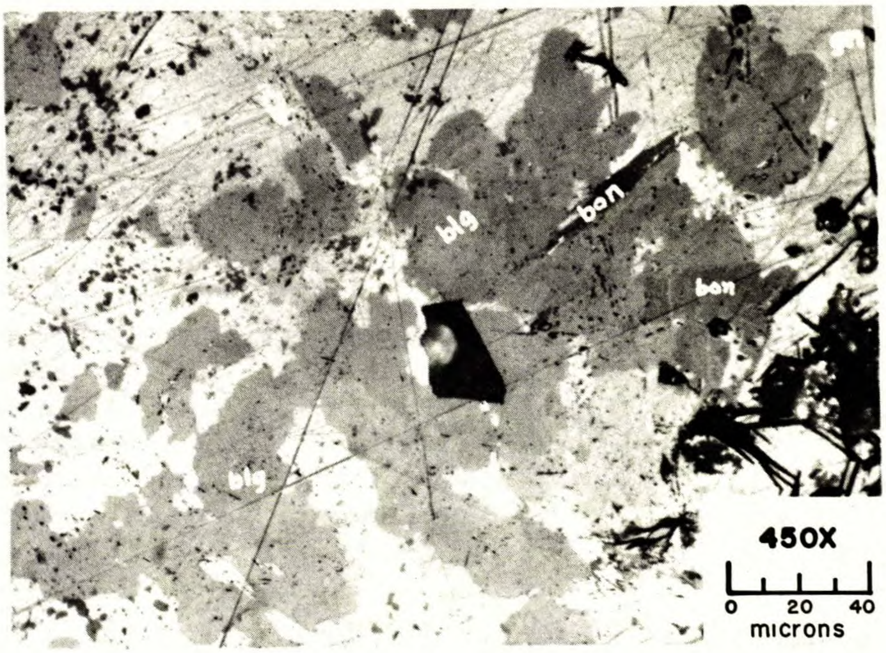

Figure 4. Photomicrograph of a polished section showing inclusions of boulangerite (blg) and bournonite (bon) in galena (gn). (Nicols partially crossed).

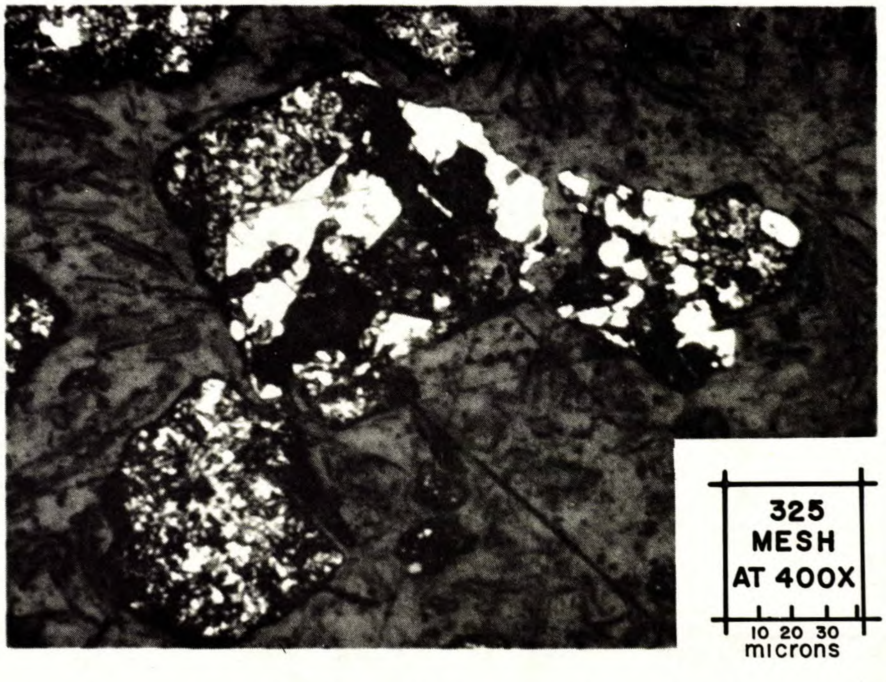

Figure 5. Photomicrograph of a polished section showing several grains of galena that have been etched with HNO_3. The white irregular areas represent inclusions of stephanite in galena.

Pyrite

Pyrite is the most abundant metallic mineral in the ore. It occurs chiefly as masses and contains inclusions of galena, boulangerite, sphalerite, cassiterite, pyrrhotite, marcasite, and arsenopyrite. In some of the polished sections the pyrite grains show pitting in linear or rectangular patterns (see Figure 6). This may be due to zoning during the early stages of crystallization of the pyrite.

A relatively clean pyrite concentrate was prepared from a -65+200 mesh fraction of the head sample. This concentrate was analysed chemically and spectrochemically. The results show that it contains 8.94* ounces per ton of Ag and traces of Sn and Ni**. The presence of Ag and Sn is probably due to small quantities of freibergite and cassiterite in the concentrate, but this could not be checked microscopically because all of the sample was used for analysis.

Pyrrhotite, Marcasite, Arsenopyrite, and Goethite

Only small amounts of pyrrhotite, marcasite and arsenopyrite were found in the ore and these generally occur as minute inclusions in pyrite. The goethite occurs as an oxidation product of pyrite.

Non-metallic Minerals

Quartz

Quartz is the principal constituent of the fine-grained matrix of the rock. It also occurs as inclusions in the matrix, some of which are single crystals and some of which are crystal aggregates. A few of the single crystals are bordered by narrow reaction rims (see Figure 7). The aggregates, on the other hand, do not have reaction rims, but occasionally contain inclusions of tourmaline, mica, and topaz.

Tourmaline

The tourmaline occurs primarily as aggregates of minute crystals (see Figure 8), some of which show intergrowths with pyrophyllite, quartz and topaz.

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* Analysis by L. Lutes, Analytical Chemistry Subdivision, Mineral Sciences Division, Mines Branch.

** Analysis by E.M. Kranck, Report SL-63-094, Analytical Chemistry Subdivision, Mineral Sciences Division, Mines Branch.

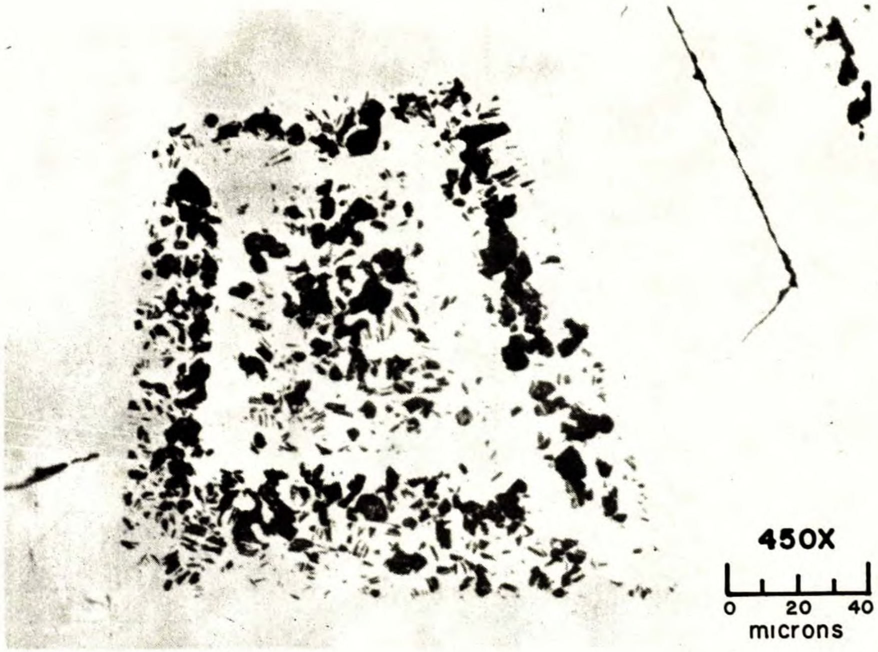

Figure 6. Photomicrograph of a polished section of pyrite showing the minute pits that are so aligned as to produce a distinct pattern.

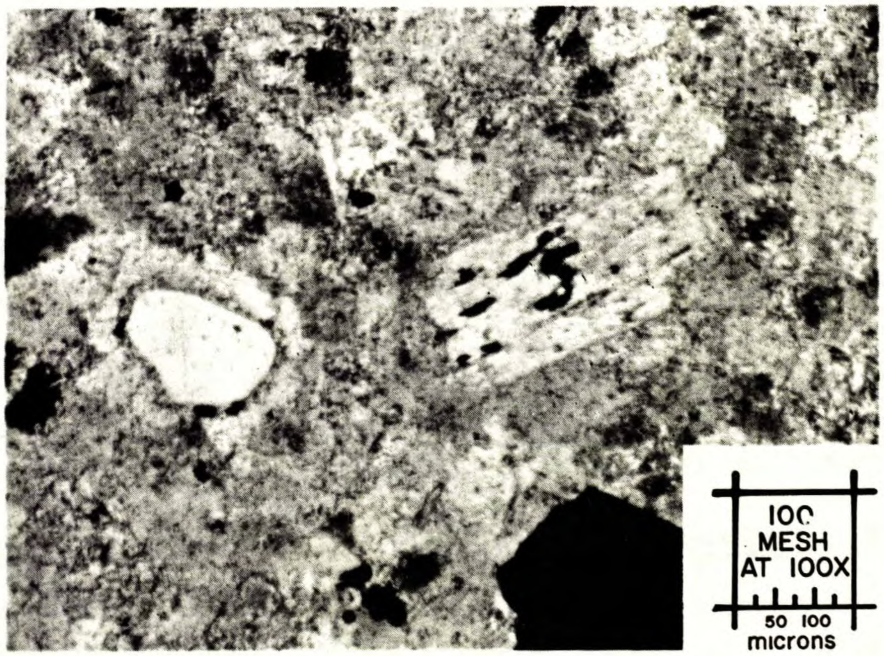

Figure 7. Photomicrograph of a thin section of the rock showing quartz and muscovite inclusions. The quartz inclusion (white) is rounded and is bordered by a reaction rim. The muscovite crystal (white) is elongated and contains a small amount of jarosite (black). Other black areas represent metallic minerals.

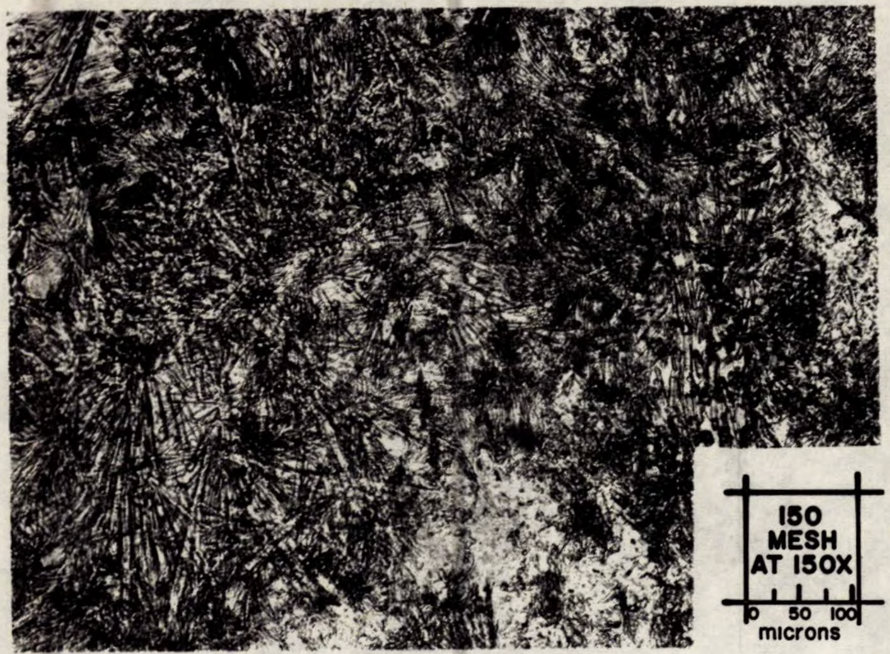

Figure 8. Photomicrograph of a thin section showing an aggregate of fine tourmaline crystals.

Mica

The mica is a colourless variety. It occurs as a constituent of the fine grained matrix of the rock, and as larger individual euhedral crystals (see Figure 7). The mica occurring in the matrix is probably sericite, whereas that occurring as euhedral crystals is probably muscovite. The latter contains a few inclusions of jarosite.

Topaz

The topaz occurs as small irregular grains that are frequently intergrown with sericite, tourmaline (see Figure 9) and fluorite.

Pyrophyllite

The pyrophyllite is yellow in thin sections. It occurs as masses of minute crystals and contains inclusions of fluorite and jarosite (see Figure 10). The crystals are so finely divided that under crossed nicols, pyrophyllite behaves as an isotropic mineral.

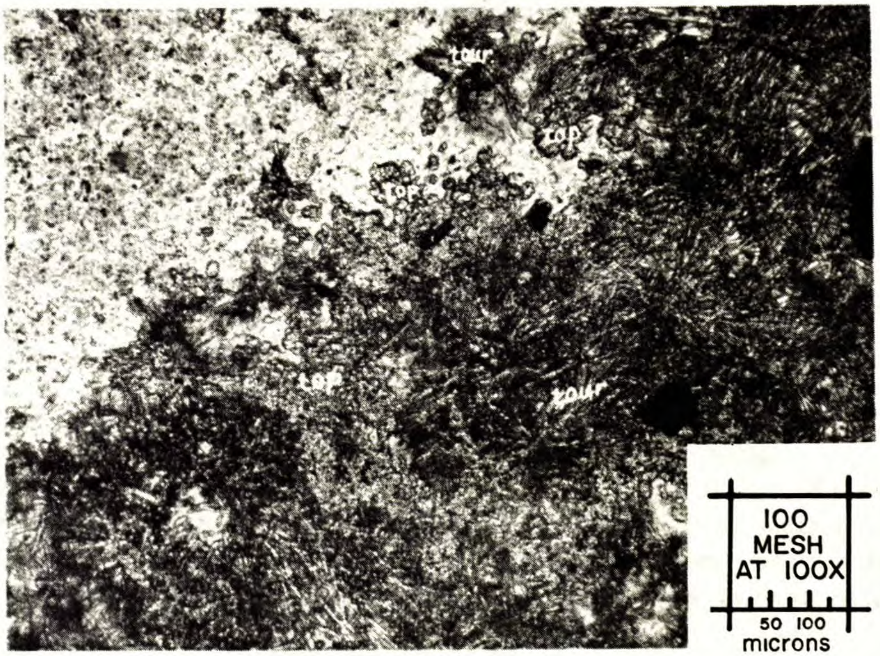

Figure 9. Photomicrograph of a thin section showing topaz (top), tourmaline (tour), and the fine grained matrix of the rock (G).

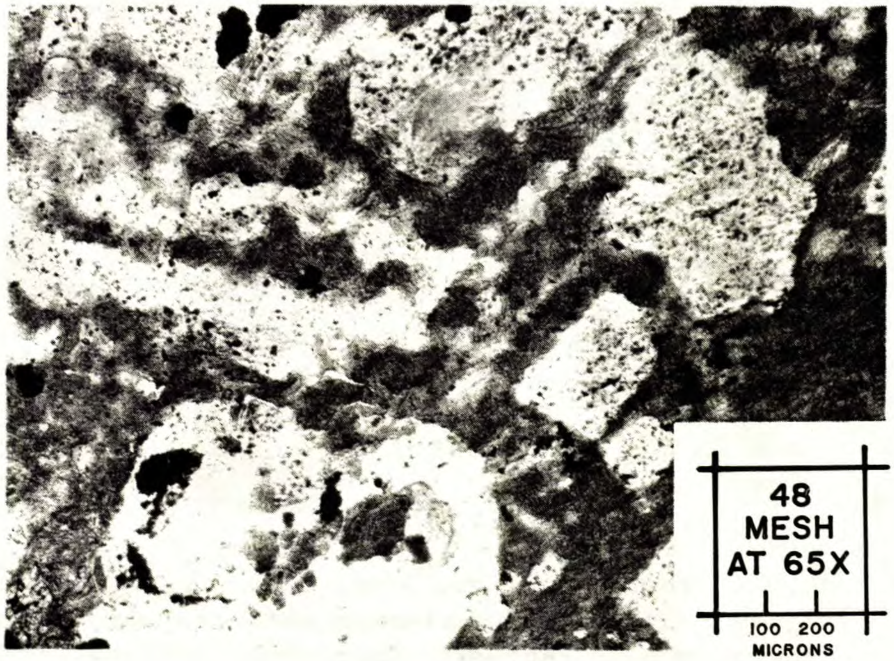

Figure 10. Photomicrograph of a thin section showing pyrophyllite (dark grey) with fluorite inclusions (white). The black areas in the fluorite and pyrophyllite are jarosite.

Fluorite

The fluorite occurs as irregular grains, and frequently contains minute inclusions of metallic minerals and of jarosite (see Figure 10).

Chlorite

A small amount of chlorite is present as irregular grains throughout the rock (see Figure 11).

Rutile

Rutile was observed only as minute crystals in quartz (see Figure 12). The crystals have high refractive indices, high birefringence, and are identified as rutile on the basis of these properties. X-ray diffraction patterns of composite samples of this ore, however, have a few of the typical rutile peaks, and support the above identification.

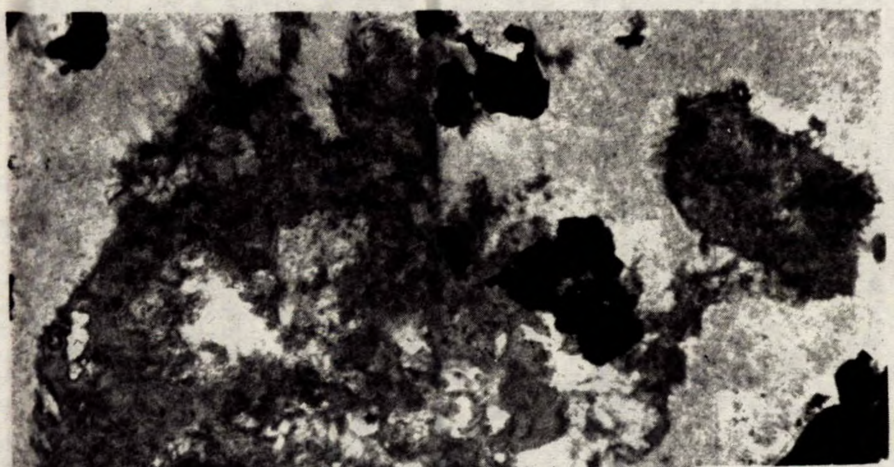

Figure 11. Photomicrograph of a thin section showing a chlorite grain (grey). The black areas represent metallic minerals and the white ones represent the matrix of the wall rock.

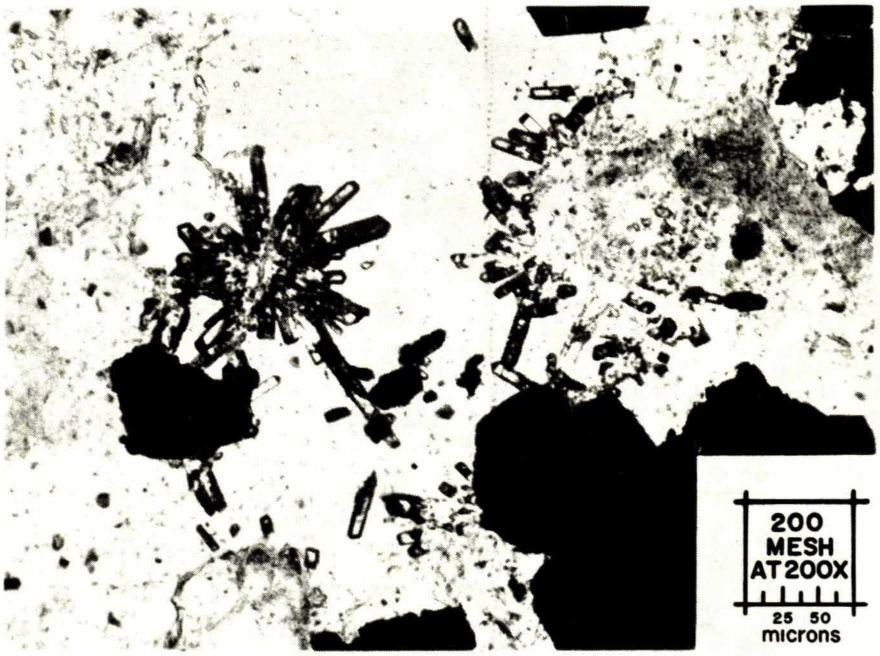

Figure 12. Photomicrograph of a thin section showing prismatic euhedral rutile crystals in quartz.

Svanbergite

Svanbergite was observed in thin sections and in the heavy fractions of the crushed ore. It is colourless and generally occurs as rhombohedral crystals (see Figure 13). It appears to be most abundant adjacent to masses of pyrite and galena. Some of the svanbergite crystals contain remnants of pyrite, which suggests that the svanbergite may have replaced pyrite.

Jarosite

A small amount of jarosite is present in the ore. It occurs as inclusions of yellow powder in muscovite, fluorite, pyrophyllite and chlorite (see Figures 7 and 10).

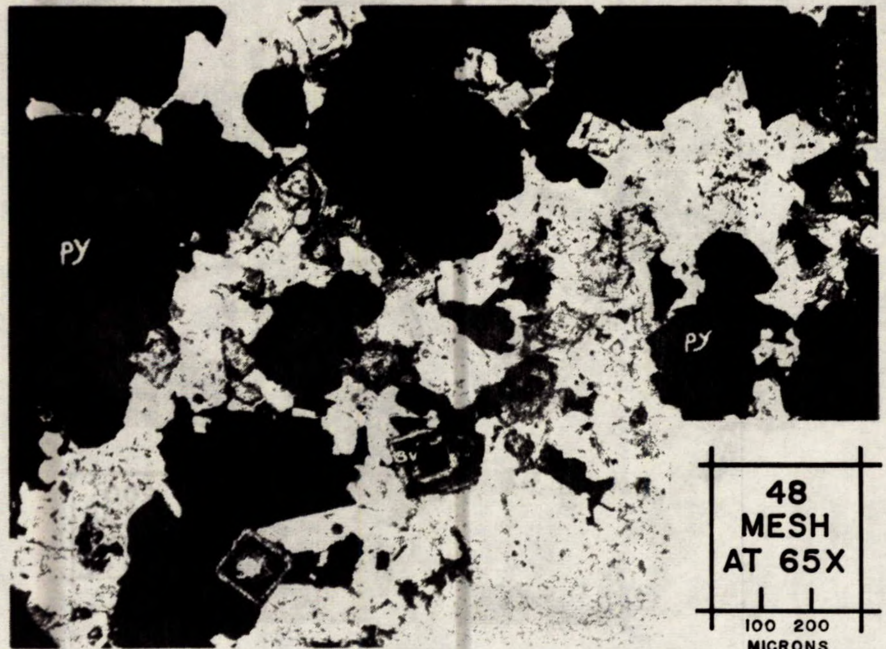

Figure 13. Photomicrograph of a thin section showing svanbergite (sv), pyrite (py) , and the fine grained matrix of the rock (white).

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