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MINERALOGICAL EXAMINATION OF A LEAD-ZINC-SILVER ORE FROM THE SUNRISE SILVER MINES LIMITED, HAZELTON, B.C.

BY

D. OWENS

Mineral Sciences Division

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SUMMARY OF RESULTS

A sample of a lead-zinc-silver ore from the deposit of Sunrise Silver Mines Limited, located near Hazelton, British Columbia, has been investigated mineralogically. The investigation revealed that the ore sample consists primarily of massive sulphides in the form of sphalerite, boulangerite and galena. In addition to their massive form, they also occur as inclusions and veinlets in each other, and as veinlets and inclusions in gangue and the other metallic minerals in the ore. The silver in the ore occurs primarily in the form of freibergite (argentiferous tetrahedrite), and to a much smaller degree as a silver sulphosalt and bournonite. Other minerals identified in the sample include pyrite, arsenopyrite, goethite, quartz, siderite, chlorite, mica and feldspar.

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INTRODUCTION

A sample of a lead-zinc-silver ore from a deposit near Hazelton, British Columbia, was received from Mr. A. Stemerowicz of the Mineral Processing Division on January 22, 1968. Mr. Stemerowicz stated that the ore had originally been submitted to the Mines Branch by Mr. K.J. Christie, Consulting Mining Engineer for Sunrise Silver Mines Limited, Room 425, 718 Granville Street, Vancouver, B.C. Mr. Stemerowicz requested that the sample be examined mineralogically to identify its constituent minerals, and to determine their grain size and textural relationships.

SAMPLE

The sample, as received, consisted of 14 small hand specimens, each about one inch in size, and about 200 grams of composite head sample, crushed to minus ten mesh. The small hand specimens were composed largely of massive sulphides in the form of sphalerite, galena and boulangerite. The hand specimens contained only minor amounts of gangue, which consisted chiefly of quartz and carbonate minerals.

METHOD OF INVESTIGATION

Eleven polished sections were prepared from the small hand specimens, and examined under the ore microscope. In addition, the 100 to 200- mesh fraction was screened from the head sample and separated by heavy liquids. The lighter fractions of the gravity separations were run on the X-ray diffractometer to identify the principal gangue constituents. The heavier fraction of the gravity separations was used to prepared polished sections, which were examined to determine the liberation of the ore minerals. The minerals in the ore were identified by microscopical and X-ray diffraction methods.

RESULTS OF INVESTIGATION

General Mineralogy of the Ore

The minerals identified in the ore are boulangerite, galena, sphalerite, freibergite, silver sulphosalt, bournonite, pyrite, arsenopyrite, goethite, quartz, siderite, mica, chlorite and feldspar. The most abundant ore minerals are boulangerite, galena and sphalerite, with smaller amounts of pyrite and arsenopyrite, and only traces of goethite. Freibergite is by far the most dominant silver-bearing mineral found in the ore. The bournonite and silver sulphosalt mineral found in the ore were only noted in a few occurrences. The ore minerals occur in a wide variety of associations, as shown in the following section of the report.

Detailed Mineralogy

Boulangerite ($PbSb_4S_{11}$)

The boulangerite occurs chiefly in the form of highly irregular masses, which frequently tail off into veinlets ranging downward in width to about 0.02 millimetres. They occur predominantly in sphalerite (Figures 2, 3, 4 and 7) and in gangue (Figure 5). Figure 1 shows interbanded boulangerite and galena. The boulangerite also occurs as small scattered inclusions, particularly in sphalerite (Figures 2 and 6) and in gangue (Figure 4), and to a minor degree in pyrite, arsenopyrite and freibergite. The inclusions, in general, vary in size from about 2 microns to 2 millimetres. (The word "size" as used in this report, refers to the greatest dimension of the mineral grains being described). A minor amount of boulangerite also occurs as narrow veinlets along the boundaries in gangue (Figure 8).

The boulangerite frequently contains inclusions of other minerals, principally pyrite (Figures 3, 5, 9, etc) and, to a lesser degree, of gangue, arsenopyrite, galena, sphalerite and freibergite (Figures 2, 3, 4, 7 and 14). These inclusions range in size downward to about 2 microns. In some cases the inclusions are so numerous as to practically constitute mutual intergrowths (Figure 9). No silver was detected in the boulangerite by electron-probe micro-analysis of several grains.

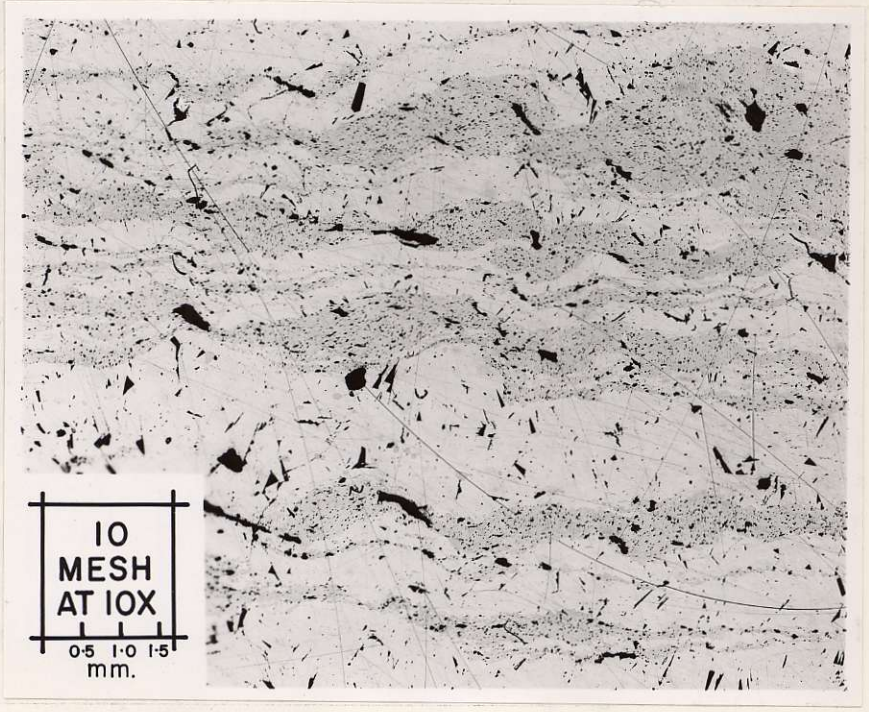

Figure 1. Photomicrograph of a polished section showing interbanded galena (white) and boulangerite (medium grey). The galena also contains a few small inclusions of boulangerite. The black areas are polishing pits.

Figure 2. Photomicrograph of a polished section showing irregular masses, veins and inclusions of boulangerite (light grey) in sphalerite (dark grey). Pyrite (white) and gangue (black) are present as inclusions in both boulangerite and sphalerite.

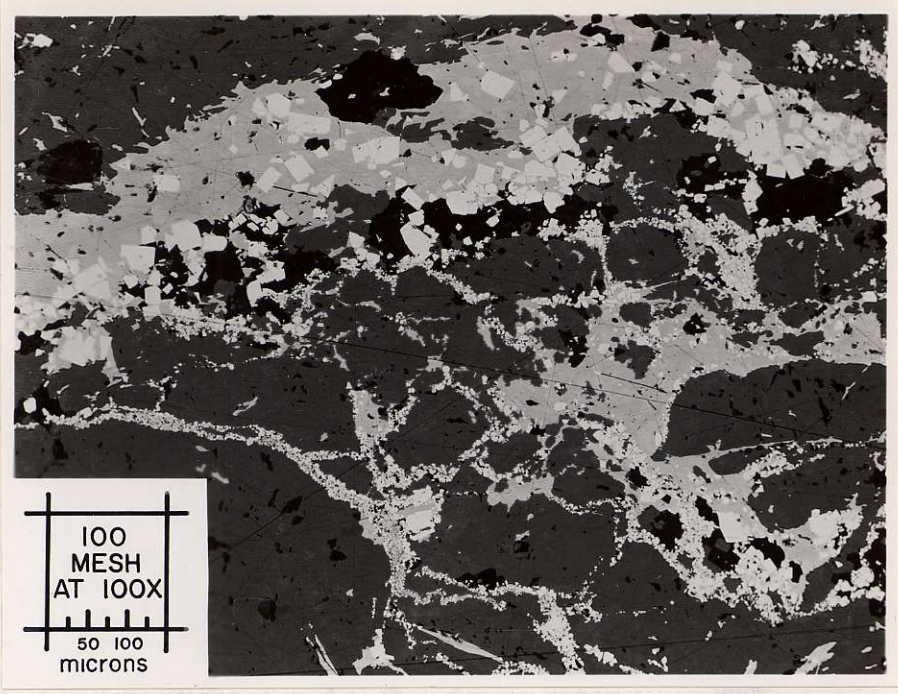

Figure 3. Photomicrograph (in oil immersion) of a polished section showing an area of sphalerite (dark grey) containing irregular intergrowths of boulangerite (light grey), a boulangerite vein, and inclusions of gangue (black). Fine-grained stringers of pyrite grains (white) cut both the sphalerite and boulangerite. Larger grains of pyrite are also present in the boulangerite.

Figure 4. Photomicrograph of a polished section showing small masses of boulangerite (greyish white) and sphalerite (medium grey) in gangue (dark grey).

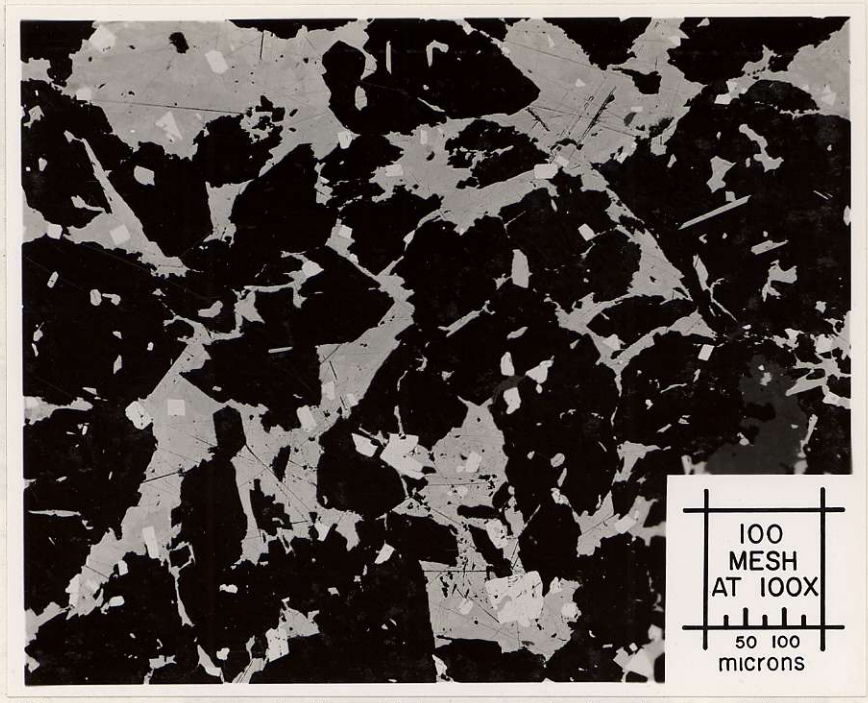

Figure 5. Photomicrograph (in oil immersion) of a polished section showing medium- to fine-grained boulangerite (light grey) in gangue (black). The boulangerite contains a few inclusions of pyrite (white).

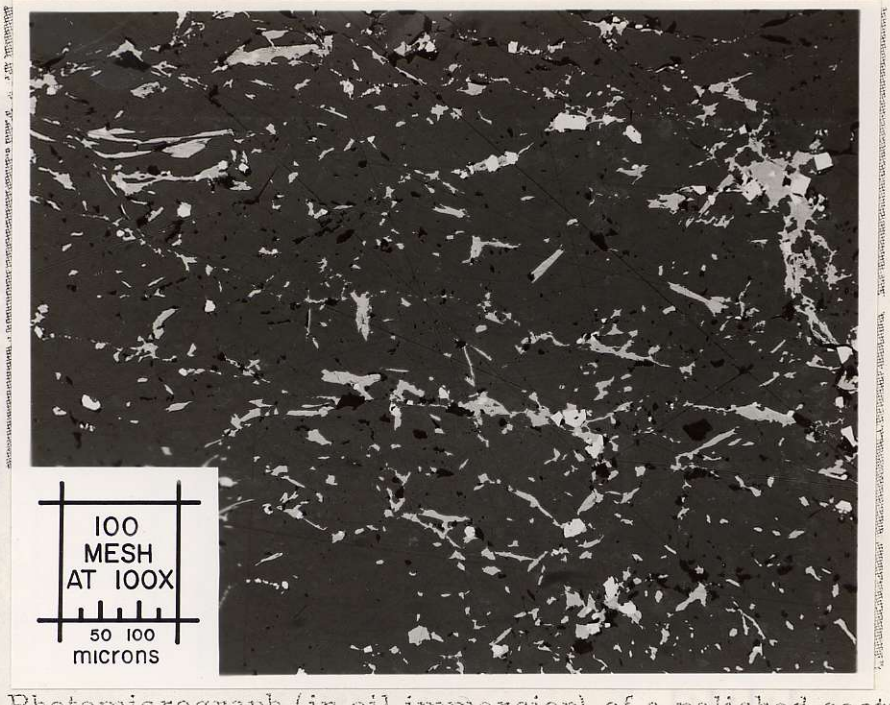

Figure 6. Photomicrograph (in oil immersion) of a polished section showing numerous irregular grains of boulangerite (light grey) and a few grains of pyrite (white) in sphalerite (dark grey).

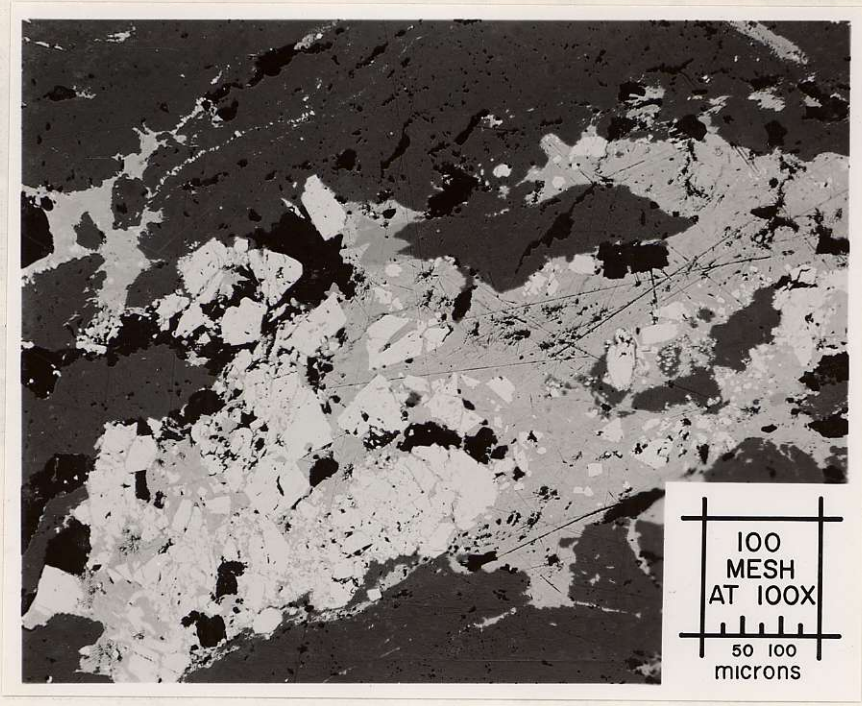

Figure 7. Photomicrograph (in oil immersion) of a polished section showing boulangerite (light grey) in sphalerite (dark grey). The boulangerite contains inclusions of arsenopyrite (white) and sphalerite. The black areas represent both gangue grains and polished pits.

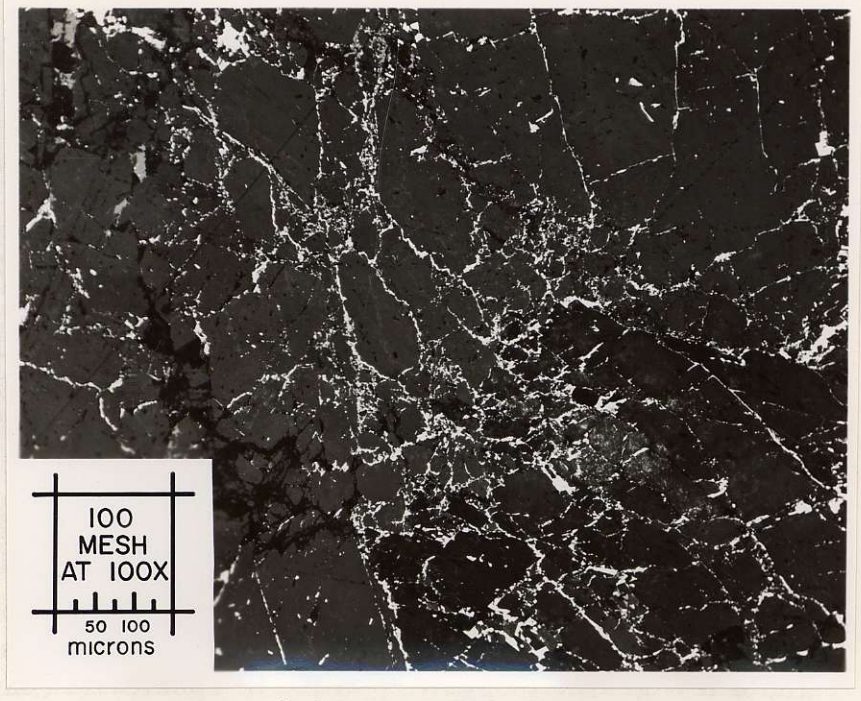

Figure 8. Photomicrograph (in oil immersion) of a polished section showing veinlets of boulangerite (greyish white) along the grain boundaries of gangue (dark grey).

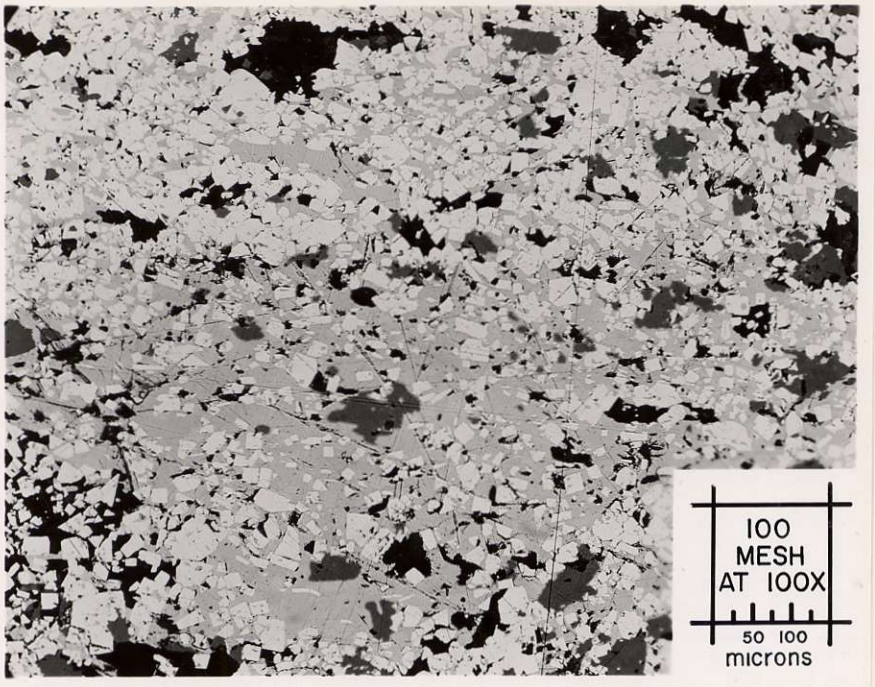

Figure 9. Photomicrograph (in oil immersion) of a polished section showing an intimate intergrowth of boulangerite (light grey), pyrite (white) and sphalerite (dark grey). A few grains of gangue (black) are also present.

Galena

Slightly less galena than boulangerite was found in the examination of the ore. The galena is present largely in a massive form and, to a lesser extent, as small masses and medium- to fine-grained inclusions in sphalerite (Figures 10, 11 and 12). The galena varies from small inclusions of a few microns up to small masses 4 millimetres in size. Most of the galena, however, is larger than 50 microns. As mentioned earlier in the report, the galena is interbanded with boulangerite (Figure 1), and contains inclusions of gangue, sphalerite, boulangerite, bournonite and pyrite (Figures 1, 10 and 12). The inclusions in the galena range in size from about 5 microns to 3 millimetres. The majority, however, are smaller than 300 microns in size.

Figure 10. Photomicrograph of a polished section showing small masses and grains of galena (white) in sphalerite (medium grey). The sphalerite occurs as inclusions in the galena, and itself contains inclusions and veinlets of gangue (dark grey). The black areas are polishing pits.

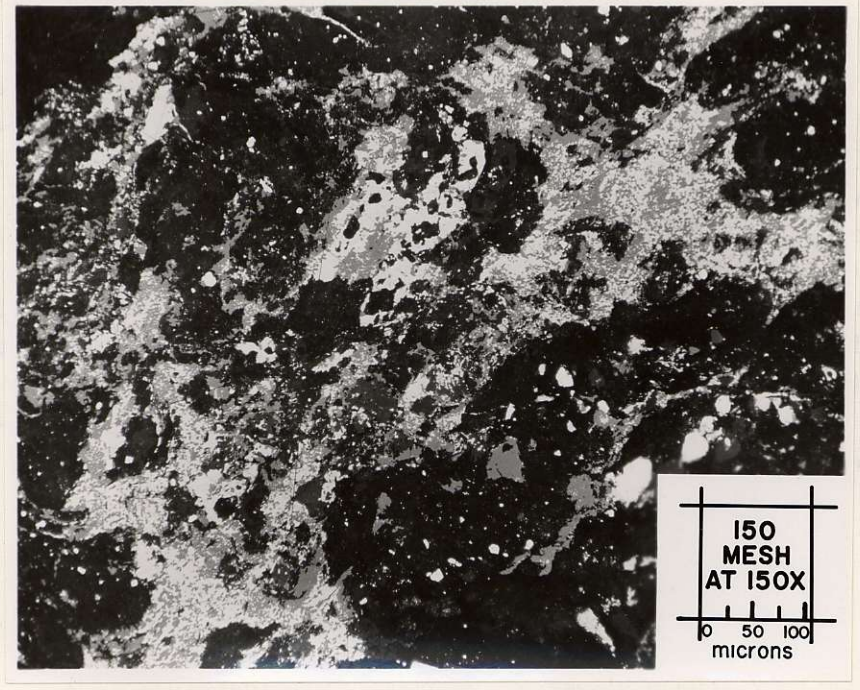

Figure 11. Photomicrograph (in oil immersion) of a polished section showing fine-grained inclusions of galena (white) in sphalerite (medium grey) and gangue (black).

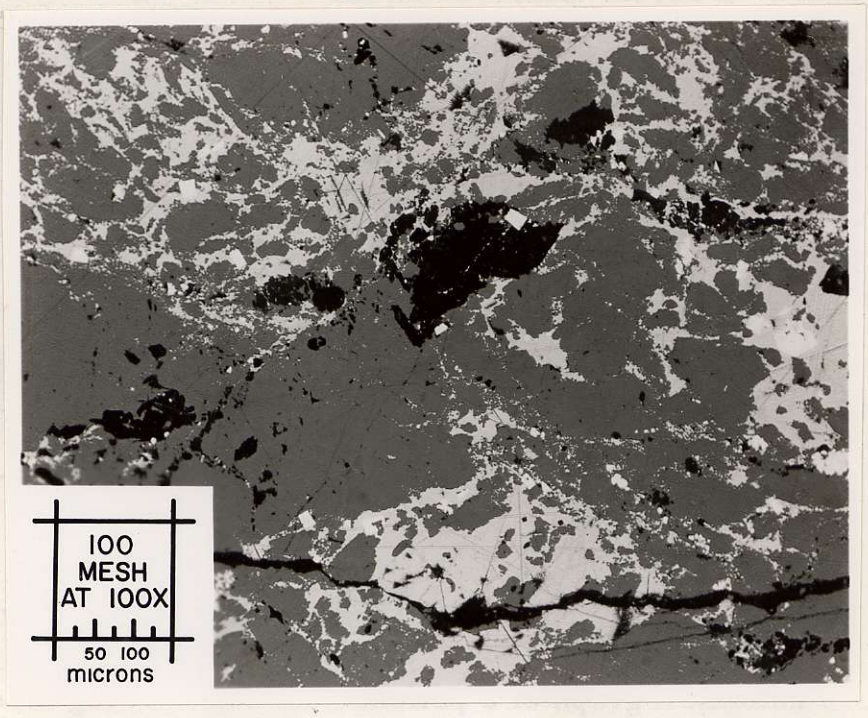

Figure 12. Photomicrograph (in oil immersion) of a polished section showing medium- to fine-grained inclusions of galena (white) in sphalerite (medium grey). The black areas represent both gangue inclusions and polishing pits.

Sphalerite

The sphalerite in the ore occurs mainly in a massive form (Figure 13). Some areas of the sphalerite are relatively free from inclusions, while other areas are saturated with inclusions of the other minerals in the ore. These inclusions consist largely of boulangerite, pyrite, galena and gangue, and, to a lesser degree, of freibergite, arsenopyrite, goethite and a silver sulphosalt (Figures 2, 3, 4, 6, 7, 10, 11, etc). These inclusions are present in a wide size range, and vary from 2 microns to about 3 millimetres. In addition, the sphalerite is cut by veinlets of freibergite, gangue, boulangerite and goethite, and stringers of very small pyrite grains (Figures 2, 3, 13, 16, 17 and 18). These veinlets vary in width from a few microns to about 1.5 millimetres; most of them, however, do not exceed 200 microns in width. Small amounts of sphalerite also occur as inclusions in gangue, boulangerite, galena and freibergite (Figures 2, 3, 4, 7, 10, 14 and 17). The sphalerite inclusions vary from about 5 to 700 microns in size. In a few few instances the sphalerite occurs in an intimate intergrowth with boulangerite, pyrite, arsenopyrite and gangue (Figures 9 and 19).

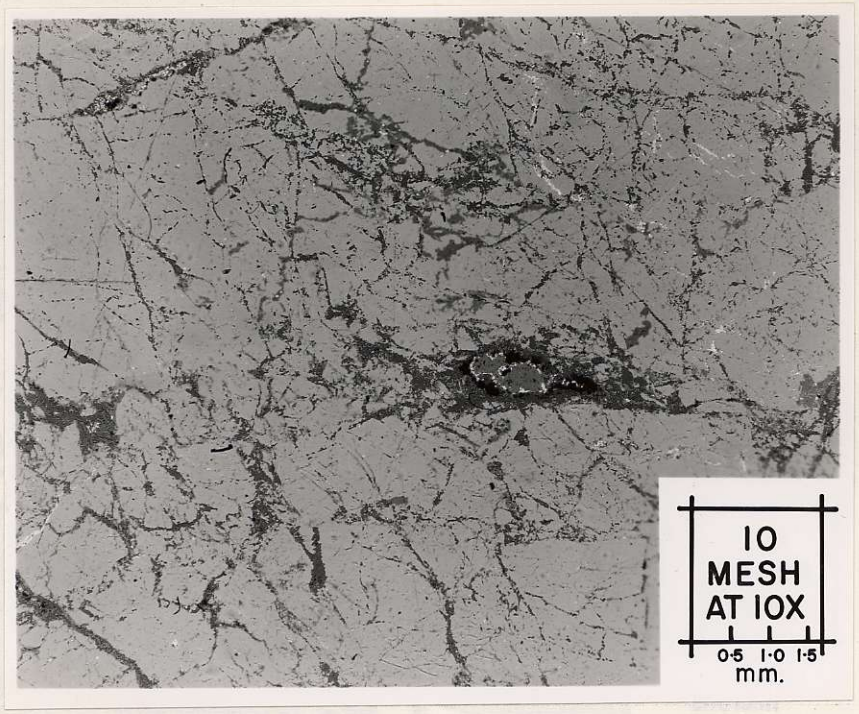

Figure 13. Photomicrograph of a polished section showing massive sphalerite (light grey) containing numerous veinlets and inclusions of gangue (dark grey) and a few grains of boulangerite (white).

Freibergite $[(Cu, Ag)_{12}(Sb, As)_4S_{13}]$

Freibergite is the principal silver-bearing mineral in the ore. It occurs primarily in association with boulangerite and sphalerite, to a much smaller degree with gangue, and, in one instance, with arsenopyrite. The freibergite is present as inclusions in boulangerite and gangue (Figures 14 and 15), as inclusions and veinlets in sphalerite (Figures 16, 17 and 18), and as an inclusion in arsenopyrite. The veinlets of freibergite range from about 4 to 150 microns in width, while the inclusions of freibergite in the aforementioned minerals generally vary from about 10 to 300 microns in size, although, two masses of freibergite 3 and 5 millimetres in size were found in massive boulangerite. The freibergite, itself, contains few inclusions. These are composed chiefly of boulangerite, and range in size from about 2 to 150 microns. Measurements of X-ray diffraction patterns of the freibergite show that it has a cell edge of about 10.52 Å, which corresponds to a silver content of about 15 per cent.

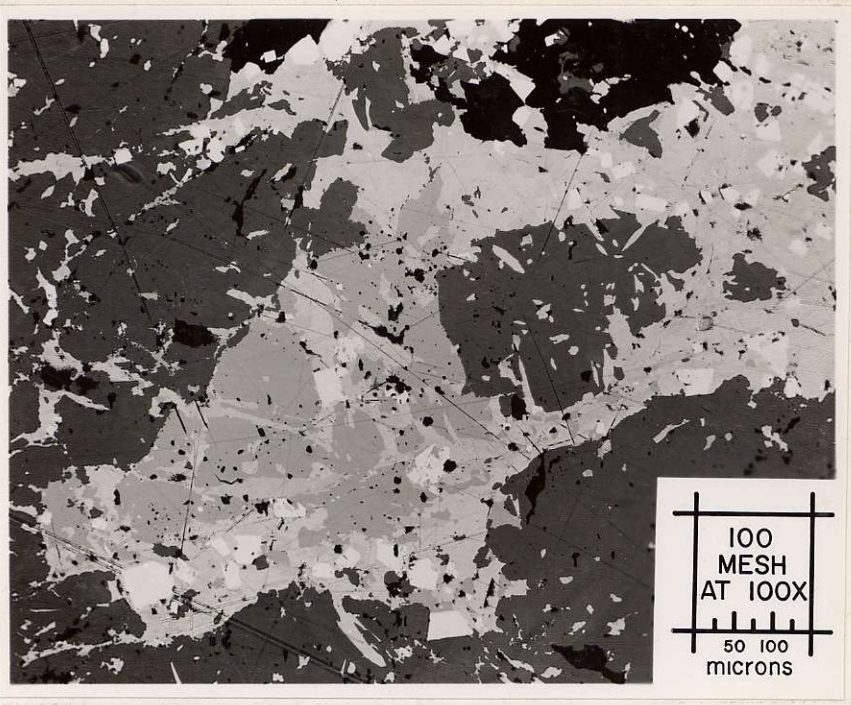

Figure 14. Photomicrograph (in oil immersion) of a polished section showing boulangerite (light grey) and freibergite (medium grey) in sphalerite (dark grey). The boulangerite contains a number of inclusions of freibergite, pyrite (white) and sphalerite. The black areas are gangue inclusions.

Figure 15. Photomicrograph (in oil immersion) of a polished section showing very fine-grained freibergite (white) in sphalerite grains (dark grey) and in gangue (black).

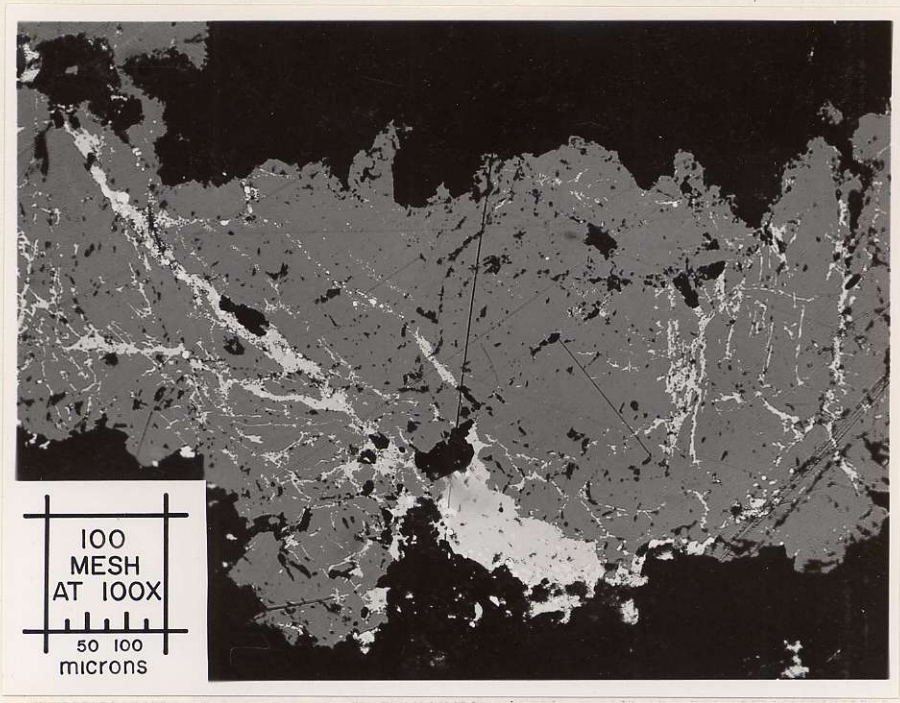

Figure 16. Photomicrograph (in oil immersion) of a polished section showing an area of sphalerite (dark grey) in gangue (black). The sphalerite contains numerous thin veinlets and inclusions of freibergite (greyish white).

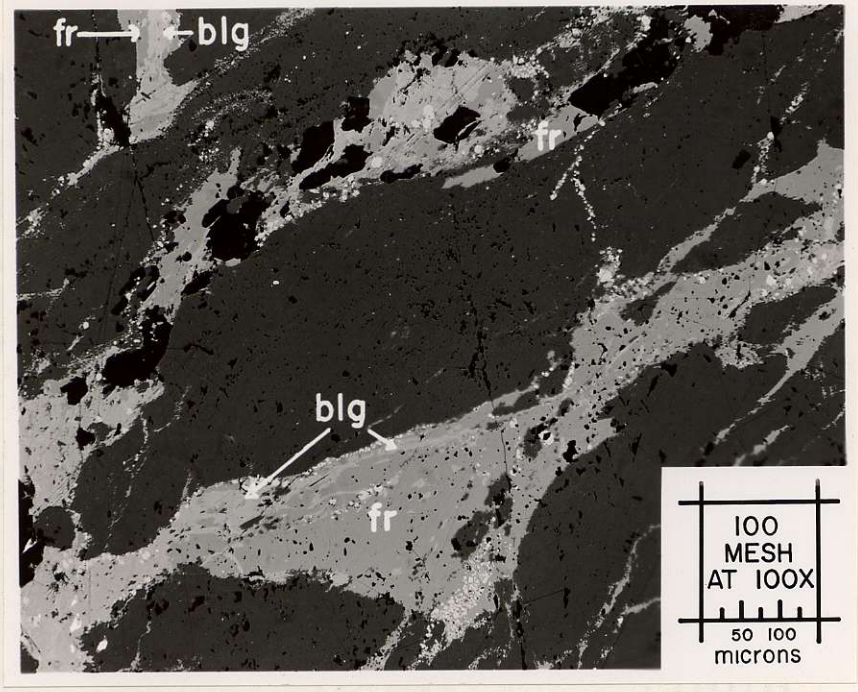

Figure 17. Photomicrograph (in oil immersion) of a polished section showing an area of sphalerite (dark grey) cut by veinlets of freibergite (fr) and boulangerite (blg). A few stringers of fine-grained pyrite (white) cut across the sphalerite and freibergite. Gangue minerals are black.

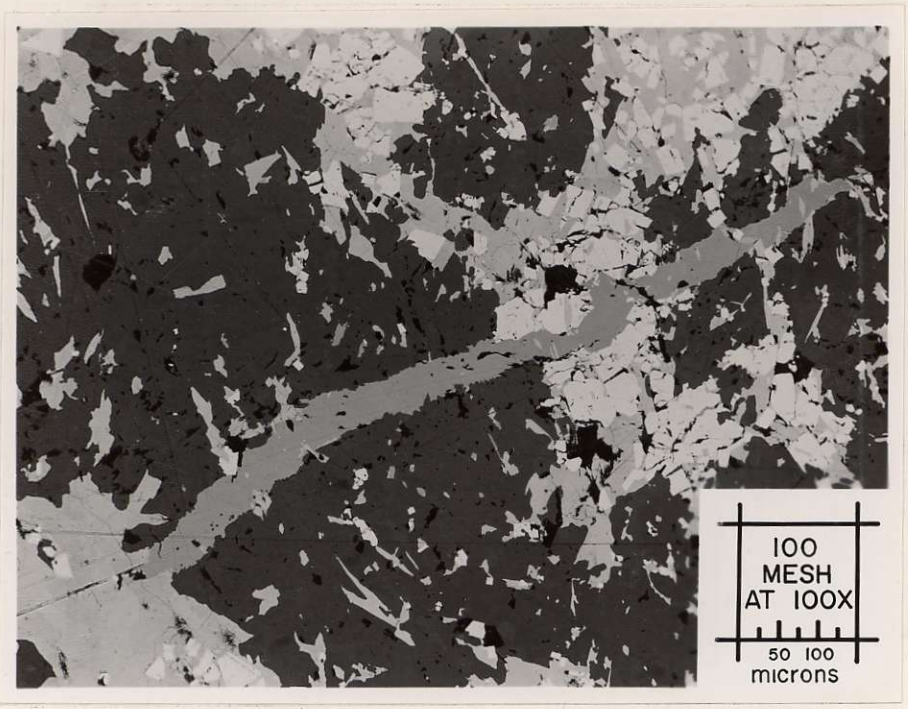

Figure 18. Photomicrograph (in oil immersion) of a polished section showing part of a veinlet of freibergite (medium grey) cutting across sphalerite (dark grey), boulangerite (light grey) and pyrite (white). The boulangerite also forms small inclusions in sphalerite and itself contains inclusions of pyrite (white).

Silver Sulphosalt

Two occurrences of what was tentatively identified as a silver sulphosalt mineral were noted during the examination of the polished sections of the ore. In one instance the silver sulphosalt formed a few very fine-grained inclusions in sphalerite, and in the other instance it formed part of a thin freibergite veinlet in sphalerite, similar to those illustrated in Figure 17. The inclusions range from about 5 to 20 microns, while the veinlet has a width of about 8 microns. Due to the very small size of the silver sulphosalt mineral, its exact identity could not be established.

Bournonite ($PbCuSbS_3$)

Only a few grains of bournonite were positively identified during the examination of the ore. The few grains found occur as inclusions in galena, and range from about 20 to 65 microns in size. Due to the optical similarity of bournonite to boulangerite it could only be positively identified by X-ray-diffraction analysis. Qualitative electron-probe micro-analysis of a few of these grains showed that they contain a very low silver content of about one per cent, or less.

Pyrite

A large amount of pyrite is present in the ore. It occurs as individual grains and clusters of grains disseminated throughout the other minerals in the ore, largely in boulangerite and sphalerite (Figures 2, 3, 5, 6, 7 and 14) and to a lesser degree as inclusions in galena and gangue. These inclusions vary in size from 2 to about 175 microns, but the majority are from 20 to 70 microns. It also forms intergrowths with sphalerite, arsenopyrite, boulangerite and gangue (Figures 9 and 19). In a few instances some of the larger grains of pyrite contain small inclusions of boulangerite from about 10 to 25 microns in size. Stringers of very small euhedral grains of pyrite occasionally cut across the sphalerite and boulangerite (Figures 3 and 17). These grains are of the order of 2 to 10 microns in size.

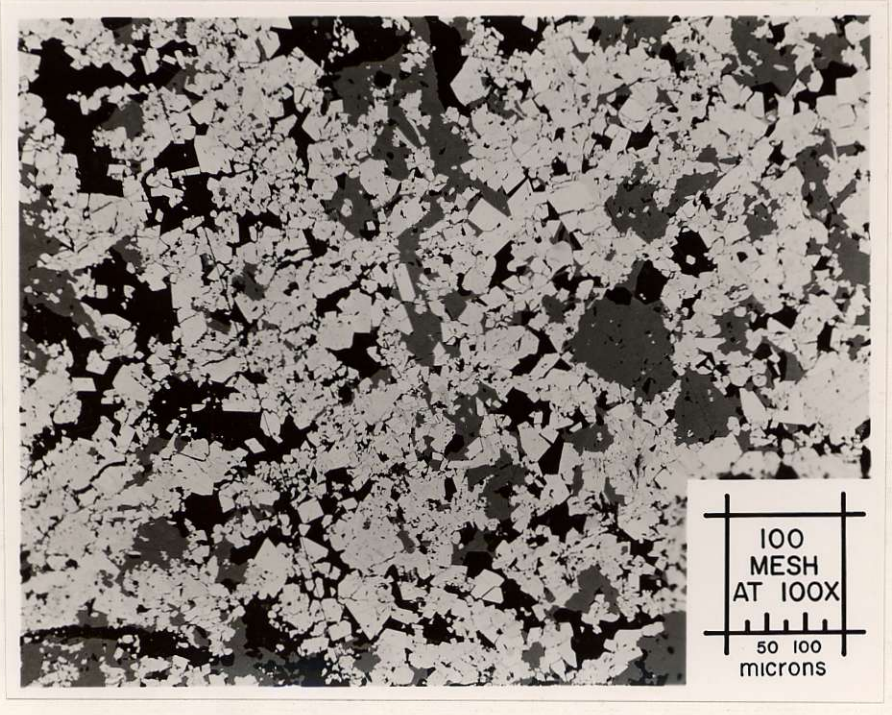

Figure 19. Photomicrograph (in oil immersion) of a polished section showing an intergrowth of arsenopyrite and pyrite (white) with sphalerite (dark grey) and gangue (black).

Arsenopyrite

Significant amounts of arsenopyrite are present in the ore; however, the quantity is much less than that of pyrite. It occurs as individual crystals and clusters of grains in a manner similar to that of pyrite. The arsenopyrite differs from pyrite in that it occurs mainly as inclusions in boulangerite (Figure 7) and gangue, with only minor amounts present in sphalerite and galena. The arsenopyrite grains are slightly larger than the pyrite grains and vary from about 5 to 300 microns in size, with an average grain size of about 70 microns. In a few instances the arsenopyrite is intergrown with pyrite, gangue and sphalerite (Figure 19). A few of the larger grains of arsenopyrite contain small inclusions of boulangerite, and, in one instance, a larger grain of arsenopyrite contained a very small grain of freibergite.

Goethite

Only a very small amount of goethite was found in the ore. It consists of a few small inclusions, and a number of veinlets in sphalerite. The inclusions of goethite range from 5 to 10 microns in size, while the veinlets are from 8 to 20 microns wide.

Gangue Minerals

As mentioned in the summary of this report, the ore consists essentially of massive sulphides, and contains only a small amount of gangue. The gangue minerals consist essentially of quartz, with lesser siderite, and traces of mica, chlorite and feldspar.

CONCLUSIONS

From the mineralogical examination of the ore a number of conclusions can be drawn. Firstly, the principal lead-bearing minerals are boulangerite and galena, with boulangerite predominating. Only traces of the lead-bearing mineral, bournonite, were found. Although small amounts of boulangerite and galena are present as fine-grained inclusions in the ore, they are generally relatively coarse and should be largely liberated during grinding; some galena and boulangerite will, however, remain with the sphalerite. Secondly, most of the sphalerite found in the ore is also medium- to coarse-grained, and should be largely liberated. It is probable, however, that many of the fine-grained

inclusions of galena and boulangerite, along with the very thin veinlets of freibergite in the sphalerite, will be difficult or impossible to liberate. Thirdly, freibergite is the dominant silver-bearing mineral found in the ore sample; the amount of bournonite and silver sulphosalt present is very small. The freibergite in boulangerite is present mainly as inclusions, which may be largely liberated by fine grinding. The freibergite in the sphalerite is of a finer size and occurs as quite thin veinlets. Difficulty will probably be encountered in achieving complete liberation, and it is likely that some of the freibergite will remain with the sphalerite.

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