STUDIES OF THE MINERALOGY OF THE DEEPER OREBODIES AT THE SILBAK PREMIER MINE

A Report Submitted in Partial Fulfilment of
the Course in Geology 409 at the
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ILLUSTRATIONS AND TABLES

STUDIES OF THE MINERALOGY OF THE DEEPER OREBODIES AT THE SILBAK PREMIER MINE

The Silbak Premier Mine now owned and operated by the Silbak Premier Mines Limited is in the Portland Canal Mining Division of the coast of Northern British Columbia. The mine camp and workings are on the west slope of Bear River Ridge. They overlook the Salmon River Valley and are connected to the town of Stewart at the head of Portland Canal by a 15 - mile motor road.

Orebodies in the mineralized zones now covered by Silbak Premier holdings have been mined continuously since 1918. Lead has been produced intermittently since 1923 and copper since 1927. Silbak Premier has thus become one of the important silver - gold mines in British Columbia.

GENERAL GEOLOGY

The Silbak Premier orebodies lie near the eastern contact of the Coast Range Batholith and are thought to be genetically related to the batholith.

Two main types of country rock are important in the mine. These are (1) volcanics of the Bear River Series, locally subdivided into greenstones and purple tuffs; and (2) feldspar porphyry which intrudes the volcanics in sill-like tongues. The feldspar porphyry was intruded before the Coast Range Batholith and is thought to be Late Upper Jurassic in age.

The main orebodies are confined to two ore zones, one striking northwest and the other northeast. Both dip steeply to the north. The orebodies lie between elevations of 700 and 2100 ft. above sea level; the northwest zone is 3000 ft. long, while the northeast is 5200 ft. long. The northwest zone is cut off on the west by the steeply dipping surface of Bear River Ridge. At the junction of the two ore zones large orebodies have been mined. In the northeast zone narrower orebodies occur at irregular intervals, but in places they show a well developed enechelon arrangement.

The position and size of these orebodies is controled to some extent by the competency of the country rock. The porphyry holds a fracture well, and hence orebodies are confined to it, or to greenstone - porphyry contacts. The purple tuffs, ~~on the other hand~~ which, are very incompetent, ~~They~~ form a blanket overlying the ore zones and somewhat parallel to the slope of the hill. The base of the tuffs generally corresponds to the top of the orebodies except where porphyry has intruded the tuffs and later been fractured and mineralized.

No important orebodies have been found below No. 6 Level, at an elevation of 780 ft. above sea level, and only small orebodies have been mined between 5 and 6 Level in the main ore zone. Recently, however, important orebodies were discovered about 600 ft. northwest of the main northeast zone, extending from an elevation of 790 to 1200 ft. above sea level. These proved to be in the form of a small crescent similar to that at the junction of the main northeast and northwest zones. Recent mining has been confined mainly to these orebodies. They will be refered to in this report as the hanging-wall orebodies.

MINERALOGY AND STUDY OF POLISHED SECTIONS

Detailed studies of the mineralogy of the main ore zones at Silbak Premier have been made by W.D. Burton (1) and W.H. White (2). Hanson (3) and others have discussed the mineralogy in connection with the general geology of the mine. It is the purpose of this investigation to study the mineralogy of the hanging-wall orebodies and to compare it with that of the main zones as described by the above writers. To do this, eight polished sections were made from specimens obtained from the hanging-wall orebodies and two from 10 L stope. Each was studied under the microscope. Individual minerals were identified by means of physical properties such as color, hardness, and polarization colors, and by chemical etch tests. A possible sequence of deposition was worked out from the age relations and general associations of the minerals.

Table 1 gives the location and description of each specimen.

TABLE 1 LOCATION AND DESCRIPTION OF SPECIMENS

Specimen	Location	Coordinates N	Coordinates E	Elevation	Assay Au Oz/T	Assay Ag Oz/T	Notes
20 - 11	9E Stope	7300	5700	980			Typical Ore
20 - 18	9D Stope	6950	5450	980	1.2	15	
20 - 19	781 Stope	7150	5200	900	Tr	13.8	
20 - 21	781 Stope	7150	5200	900	Tr	5.2	
20 - 22	781 Stope	7150	5200	900	Tr	35.6	High Lead Ore
20 - 27	789 Dr	7600	5650	800	1.6	9	
20 - 30 A & B	9C Stope	7150	5100	980			High Grade Ore
20 - 7	10 L Stope	9100	6450	1140	5.0	18.4	
F - 2	10 L Stope	9100	6450	1140			

Megascopically the ore appears to be composed of solid, medium - grained sulfides. Pyrite, galena, and sphalerite are most abundant but chalcopyrite is generally present in minor amounts. Quartz and calcite are the main gangue minerals. The following minerals were identified in polished sections:

Pyrite	Tetrahedrite
Galena	Polybasite
Sphalerite	Gold
Chalcopyrite	

Descriptions and associations of the Minerals

Pyrite ($Fe\ S_2$)

Pyrite is abundant in most sections, occuring as well formed crystals,or angular grains up to four millimeters across. Some grains of pyrite are highly fractured, the fractures being filled by other sulfides but not replaced by them (Fig. 1). Other grains appear to be very little fractured but widely replaced by galena, sphalerite and chalcopyrite and occassionally by quartz and gold (Fig. 2 & 3). Several sections show a marked difference in the extent of the replacement. In general the two sections from 10 L Stope show much more replacement of the pyrite than those from the rest of the mine (Fig. 1 & 3).

Sphalerite ($Zn\ S$)

Sphalerite is abundant in many sections but in others it is present in only small amounts. It occurs as irregular or well rounded areas surrounding, replacing, or filling fractures in pyrite. In places sphalerite, with other sulfides fills fractures in quartz and calcite.

Galena - sphalerite contacts are generally well rounded but some are feathery showing that galena has replaced the sphalerite (Fig. 4.) Sphalerite almost always contains minute inclusions of chalcopyrite and is often definitely replaced by chalcopyrite.

Thus, although sphalerite is obviously younger than pyrite, its age in relation to galena and chalcopyrite is not particularly clear.

<u>Galena</u> (Pb S)

Galena appears as small irregular areas often adjacent to, or replacing sphalerite, or as rounded inclusions in pyrite. Galena is the commonest mineral filling fractures in pyrite. It also occurs with other late sulfides filling fractures in quartz.

As stated above, the age relations of galena and sphalerite are not particularly clear. Galena in many places appears to have been deposited later than sphalerite, and to have replaced it to some extent. On the other hand, smooth, rounded contacts (Fig. 5 & 6), and single inclusions containing both galena and sphalerite in pyrite, suggest simultaneous deposition. Hence, although much of the galena is later than sphalerite there is probably some overlap in the deposition of these sulfides.

Section Premier 20 - 22 was cut from a specimen of massive galena. The polished surface showed that it contained small rounded or irregular areas of chalcopyrite, tetrahedrite, and polybasite. There is no evidence to show that these sulfides have replaced galena and it seems probable that all four were deposited simultaneously.

Chalcopyrite ($Cu\ Fe\ S_2$)

Chalcopyrite may occur as rounded inclusions replacing pyrite or as irregular areas commonly in galena at sphalerite contacts. Like the other late sulfides, chalcopyrite also fills fractures in quartz.

Inclusions of chalcopyrite in sphalerite have been mentioned above. These may be rounded or of irregular shape but invariably they are small averaging about five microns across. In places they appear to be irregularly spaced along straight lines, possibly cleavage traces. (Fig. 7). In other places they show no orderly arrangement (Fig. 6), while in others they are very closely spaced and follow curved lines as if they were favorable lines for replacement (Fig. 4). These relations together with the fact that some chalcopyrite occurs as isolated grains in galena indicate that chalcopyrite was deposited later than sphalerite. It is possible, however, that the inclusions of chalcopyrite in sphalerite and the chalcopyrite closely associated with sphalerite may have formed by the unmixing of the chalcopyrite and sphalerite during deposition. This, therefore, would suggest simultaneous deposition.

Tetrahedrite ($3\ Cu_2\ S.S\ b_2\ S_3$ - probably silver bearing)

Tetrahedrite always occurs as irregular grains in galena. Most of these are in contact with sphalerite (Fig. 5 & 6), but some are isolated, and others are in contact with chalcopyrite. Galena - sphalerite contacts, however, form the most favorable place for the deposition of tetrahedrite. The largest grain of tetrahedrite seen in the sections studied was two millimeters across but most are less than one millimeter.

Tetrahedrite almost certainly carries silver, although no satisfactory microchemical tests were obtained to prove this. Some specimens which assayed high in silver, appeared under the microscope to contain no silver mineral. Samples cut adjacent to section Premier 20 - 19, for example, assayed 13.8 oz. per ton in silver, ~~but~~ and no silver minerals ~~and~~ but abundant tetrahedrite appeared on the polished surface. Galena carries silver in solid solution, but this, according to White, amounts to only 2.5 oz. per ton in some Premier ores. Hence, it is probable that much of the silver is carried in tetrahedrite.

Tetrahedrite was originally identified by its hardness, color, and chemical etch reactions. It may be readily recognized, however, by its grey color which is darker than galena but lighter than sphalerite.

<u>Polybasite</u> ($9\ Ag_2S \cdot Sb_2S_3$)

Polybasite was found in section Premier 20 - 22 as isolated grains in galena. Most grains are of irregular shape and not well rounded (Fig. 8). Only very few are in contact with chalcopyrite or tetrahedrite, most being entirely surrounded by galena. Many grains average 15 microns but a few are as much as 40 microns across. The intimate association of polybasite with galena makes it almost certain that these two sulfides were deposited simultaneously.

Under normal reflected light polybasite is slightly darker than galena and shows a brown tinge. Under crossed nicols it shows strong anisotropism and distinctive green and brown polarization colors. Etch reactions were not satisfactory in identifying polybasite as the grains are small, and the surrounding mineral is galena which reacts with many of the reagents. Hence, the identification of this mineral is based mainly on its polarization colors.

Gold

Although two samples assayed over one ounce per ton in gold, no gold was positively identified in sections made from ore of the hanging-wall ore zone. Several occurences of gold, however, were found in one section from 10 L Stope. These are in the form of (1) rounded replacements in pyrite, either isolated or in contact with galena and sphalerite (Fig. 3); or (2) minute grains in galena at sphalerite contacts (Fig. 6). Nowhere in this last association are grains of gold over five microns in diameter.

Too few occurences of gold were found to make possible any generalizations as to its commonest associations. It is evident, however, that gold was deposited with the late sulfides particularly galena.

Gold shows a rich yellow color, and etch reactions serve to distinguish it from electrum, the natural alloy of silver and gold. Electrum is reported to be the main gold-carrying mineral in Premier ores. This, together with the fact that one distinguishing etch reaction was not decisive, may cast some doubt on the exact identity of this mineral. The following etch reactions were noted

HNO_3 - negative

KCN - slowly stains brown

$HgCl_2$ - some negative some slowly stain brown

These reactions would indicate that the mineral is gold rather than electrum.

Quartz and Calcite

Quartz and calcite are common in most sections. Quartz invariably fills fractures in pyrite and is itself fractured and filled by galena, sphalerite and chalcopyrite. Quartz, however, also replaces sphalerite and this indicates an extended period of deposition. W.H. White suggests that the later quartz is formed by recrystallization of early quartz.

Calcite shows similar relations to the sulfides but generally appears to be later than quartz.

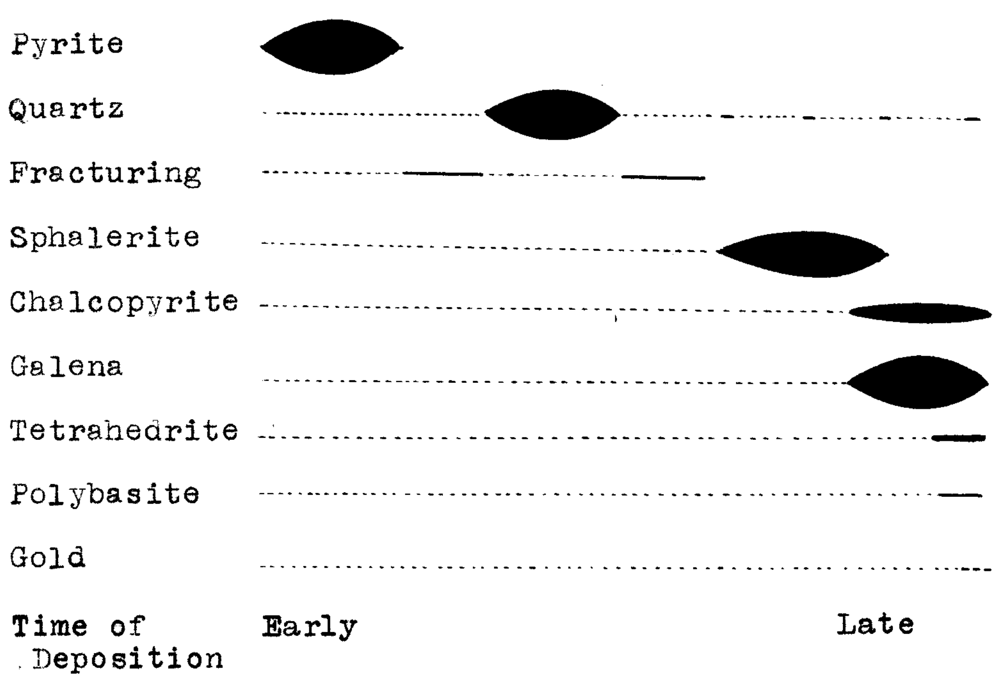
Paragenesis

The age relations of the minerals described above are based on the occurences, types of contacts, and general associations of the minerals as they appear in polished sections. In many places these criteria lead to fairly definite conclusions, but others are indecisive. The following paragenisis, therefore, merely suggests a general history of the deposition of the vein minerals.

The first sulfide-bearing solutions, following channels produced by original widespread fracturing apparently deposited little beside pyrite. The deposition of pyrite was followed by relatively minor fracturing and the deposition of quartz. Both pyrite and quartz were then fractured and sulfides deposited over a relatively long interval. First sphalerite, some galena, and possibly chalcopyrite filled fractures and replaced some of the pyrite. Finally chalcopyrite and galena, carrying with it tetrahedrite, polybasite and possibly gold came in to replace sphalerite and pyrite. Some quartz was deposited during this last long interval, possibly from the solution and redeposition of the original quartz.

Table 11 gives the paragenesis in a diagramatic form.

TABLE 11 Paragenesis



Comparison of the Mineralogy of the Hanging-Wall Ore Zone with that of the Main Ore Zone

As stated previously, W.H. White and W.D. Burton have made microscopic studies of ore from several levels in the main ore zones at Silbak Premier. White reports the presence of pyrite, galena, sphalerite, chalcopyrite, pyrargyrite, argentite, and electrum. Burton found tetrahedrite, native silver, and polybasite in addition to these. The associations given by White for many of the minerals are identical with those seen in the present study. Similarly, the associations reported by Burton are essentially the same as those described here.

Burton points out that the silver-bearing sulfides decrease with depth and die out entirely below a depth of 650 ft. (probably about 1500 ft. above sea level). The present study, however, shows that silver-bearing sulfides are present down to an elevation of 800 ft. above sea level.

Burton suggests that the deposit at Premier is of the epithermal type. This conclusion is based on the minerals present, and on his observation that in the case of the silver-bearing sulfides and electrum "a vertical zoning has occured", which he explains "by the assumption of a steep temperature gradient." White has shown that the temperature gradient has had little to do with the deposition of electrum. The present study shows that the silver-bearing sulfides extend to greater depths than had been anticipated and that there is little change in the mineral associations over a vertical range of at least 700 ft. and possibly over a range of 1000 ft. Hence, the orebodies may not be of the epithermal type.

Burton also shows that at least in the old Premier Mine many of the high-grade orebodies have been produced by supergene enrichment. In the deeper orebodies, however, there is no evidence of supergene enrichment. All the minerals, except possibly polybasite, are commonly of hypogene origin, and there is no sign of oxidation or alteration after the deposition of the latest sulfides.

CONCLUSIONS AND OBSERVATIONS

Although few definite conclusions have been arrived at in this study, the following may be stated.

(1) The minerals of the deeper orebodies at the Silbak Premier Mine are of hypogene origin, the valuable minerals having been deposited late in the period of mineralization.

(2) There appears to be very little difference between the mineralogy of the deeper arebodies and that of the main ore zone.

The following observations may be significant and deserve noting in further investigations.

(1) The change in the abundance of tetrahedrite and its importance as a silver-bearing mineral may show some definite trends.

(2) It is possible that at depth the sulfides provide the main source of silver and the gold is relatively free of silver.

(3) The difference in the extent of the replacement of pyrite may indicate different physical-chemical conditions in various places in the mine.

(4) There may be some doubt that the orebodies of the Silbak Premier Mine are of the epithermal type.

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(1) Burton, W. D., Ore Deposition at Premier Mine B.C., Ec. Geol. Vol. XXI No.6, 1926.

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(3) Hanson, G., Portland Canal Area, B. C., Geol. Surv. Can., Mem.175, 1935.

(4) Langille, E. G., Some Controls of Ore Deposits at the Premier Mine, Western Miner, June 1945.

(5) Schofield, S. J., and Hanson, G., Salmon River District B. C., Geol, Surv. Can., Mem. 132, 1922.

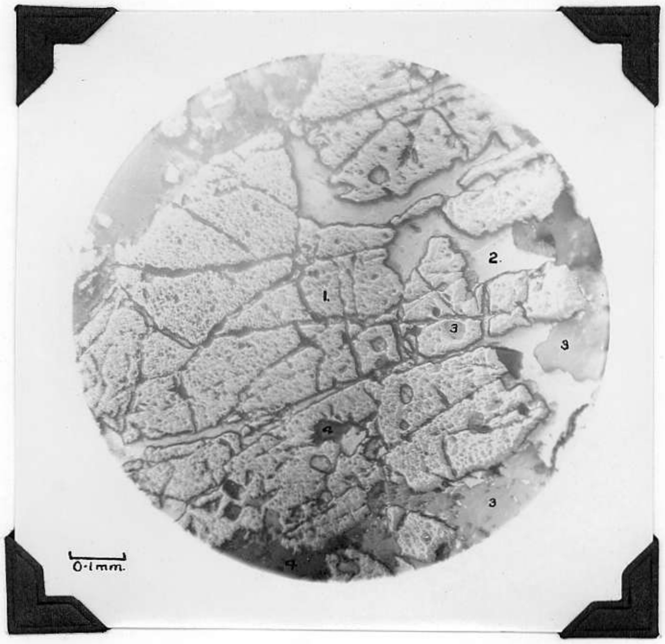


Fig 1. Pyrite grain fractured and filled by galena, and slightly replaced by galena, sphalerite, and quartz.

1. Pyrite	3. Sphalerite
2. Galena	4. Quartz

Section: Premier 20-21 Log: 249,482

Microscope: Leitz No. 305897

Objective: 3b

Ocular: 10x

Illumination: Leitz 6v,6a Daylight Filter

Plate: Wratten M

Exposure: 15 Sec.

Magnification: x70

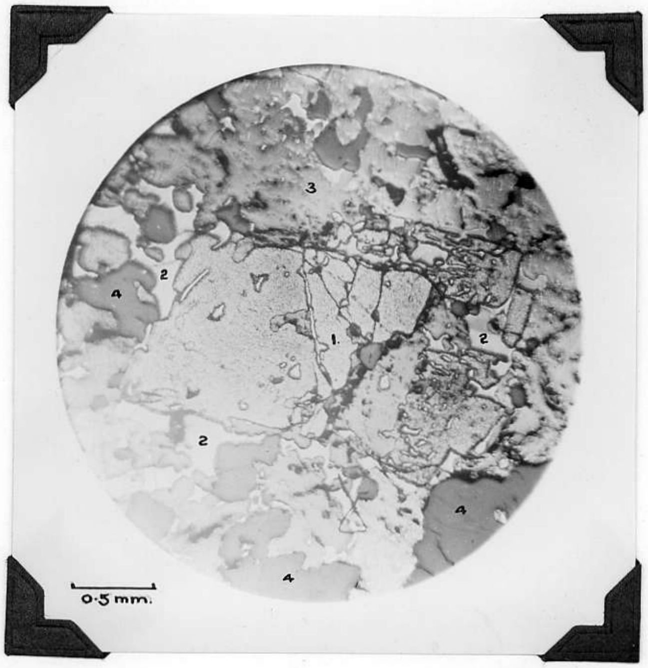


Fig.2. Pyrite grain highly corroded by galena, sphalerite,and some quartz.

1. Pyrite   3. Sphalerite

2. Galena   4. Quartz

Section: Premier 20-7   Log: 200,484

Microscope: LeitzNo. 305897

Objective: lb

Ocular: 10x

Illumination: Leitz6v,6a Daylight Filter

Plate: Wratten M

Exposure: 15 Sec.

Magnification: 23x

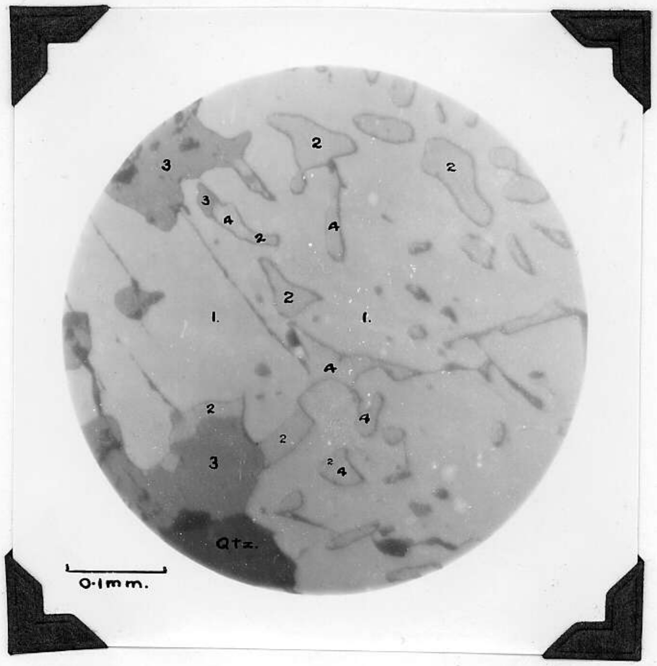


Fig 3. Replacement of Pyrite by galena, sphalerite, quartz, and gold.

1. Pyrite
2. Galena
3. Sphalerite
4. Gold

Section: Premier 20-7 Log: 175,546

Microscope: Leitz No. 305897

Objective: 3b

Ocular: 10x

Illumination: Leitz 6v,6a Daylight Filter

Plate: Wratten M

Exposure: 15 Sec.

Magnification: x135

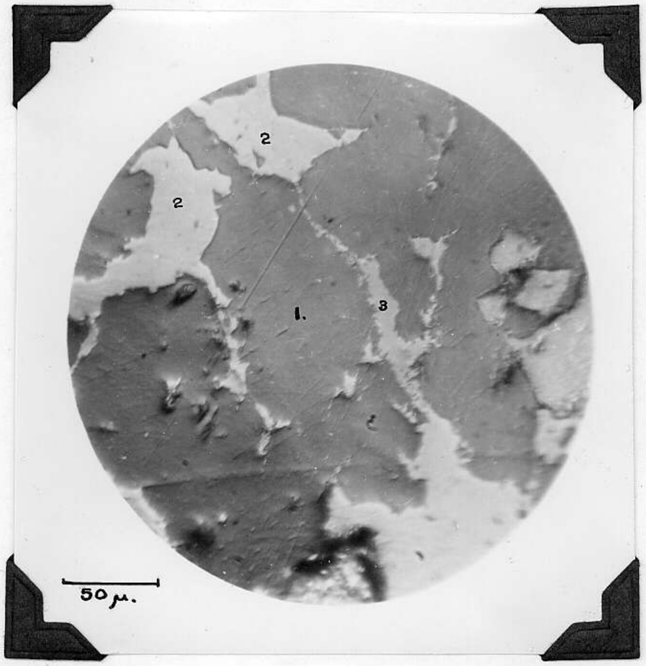


Fig 4. Replacement of sphalerite by galena and chalcopyrite.

1. Sphalerite 2. Galena 3. Chalcopyrite

Section: Premier 20-21 Log: 088,544

Microscope: LeitzNo. 305897

Objective: 6a

Ocular: 10x

Illumination: Leitz 6v,6a Daylight Filter

Plate: Wratten M

Exposure: 20 Sec.

Magnification: x250

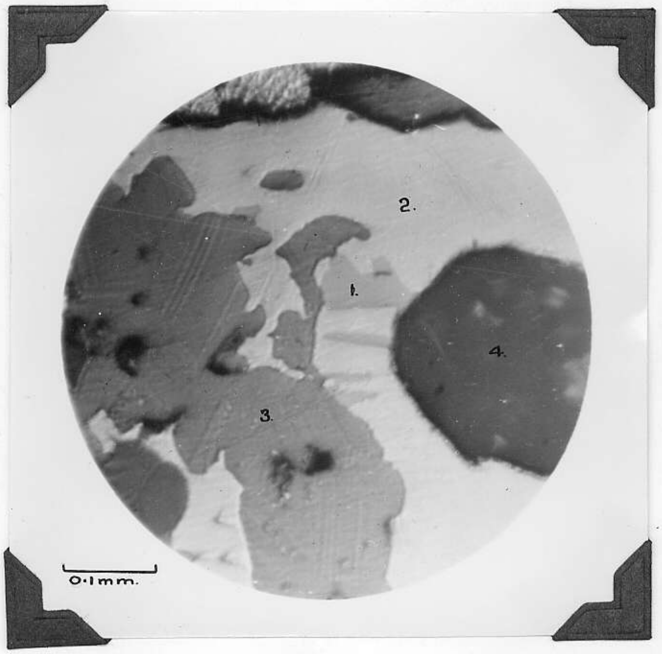


Fig 5. Typical occurence of tetrahedrite in galena

1. Tetrahedrite   3. Sphalerite

2. Galena   4. Quartz

Section: Premier 20-27   Log: 111,454

Microscope: Leitz No. 305897

Objective: 3b

Ocular: 10x

Illumination: Leitz 6v,6a, Daylight Filter

Exposure: 20 Sec.

Magnifaction: x175

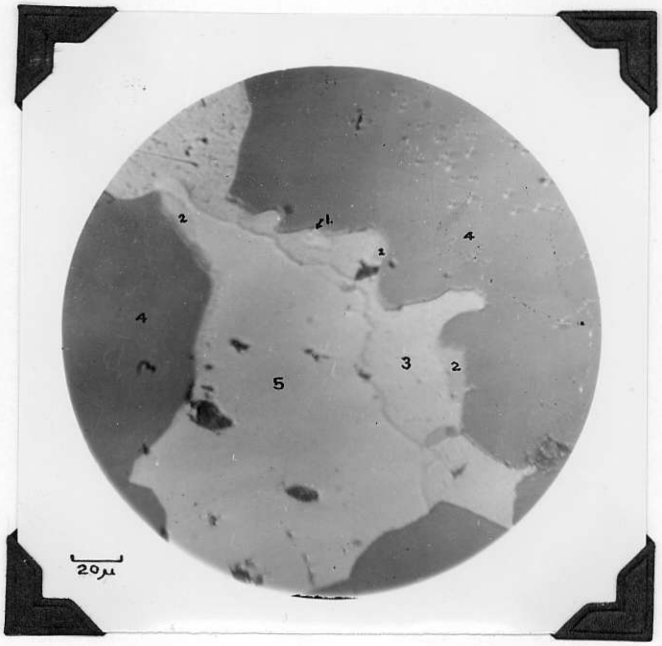


Fig 6. Tetrahedrite and gold in galena at sphalerite contacts. Light dots in sphalerite are inclusions of chalcopyrite

1. Gold　　3. Galena　　4. Sphalerite

2. Tetrahedrite　　5. Chalcopyrite

Section: Premier 20-7　　Log: 204553

Microscope: Leitz No. 305897

Objective: 6a

Ocular: 10x

Illumination: Leitz 6v,6a

Exposure: 20 Sec.

Magnification: x350

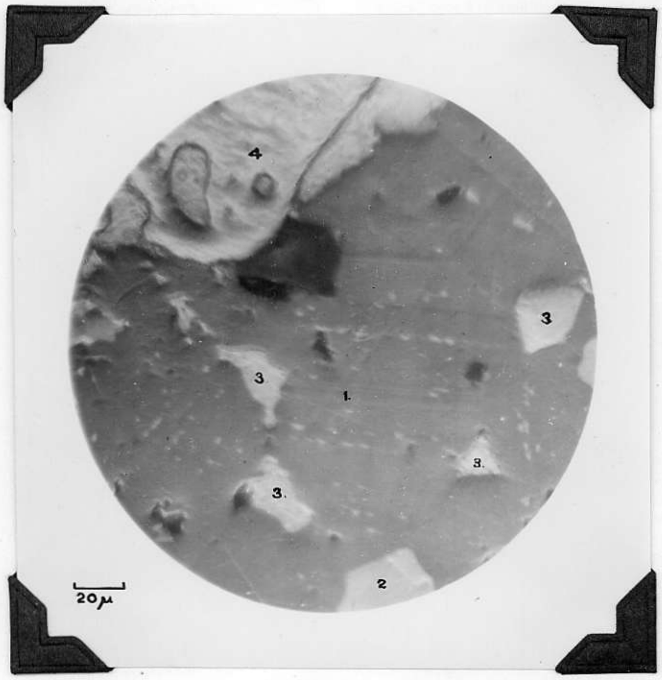


Fig 7. Chalcopyrite inclusions in sphalerite irregularly spaced along straight lines, possibly cleavage traces.

1. Sphalerite 3. Galena

2. Chalcopyrite 4. Pyrite

Section: Premier 20-22 Log: 098,521

Microscope: Leitz No. 305897

Objective: 6a

Ocular: 10x

Illumination: Leitz 6v, 6a

Plate: Wratten M

Exposure: ,30 Sec.

Magnification: x360

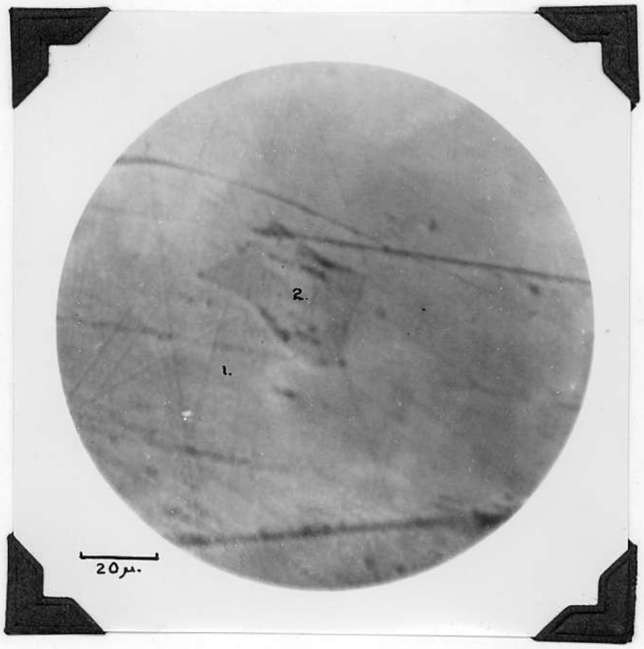


Fig 8. Isolated grain of polybasite in galena

1. Galena 2. Polybasite

Section: Premier 20-22 Log: 164,537

Microscope: Leitz No. 305897

Objective: 6a Oil Immersion

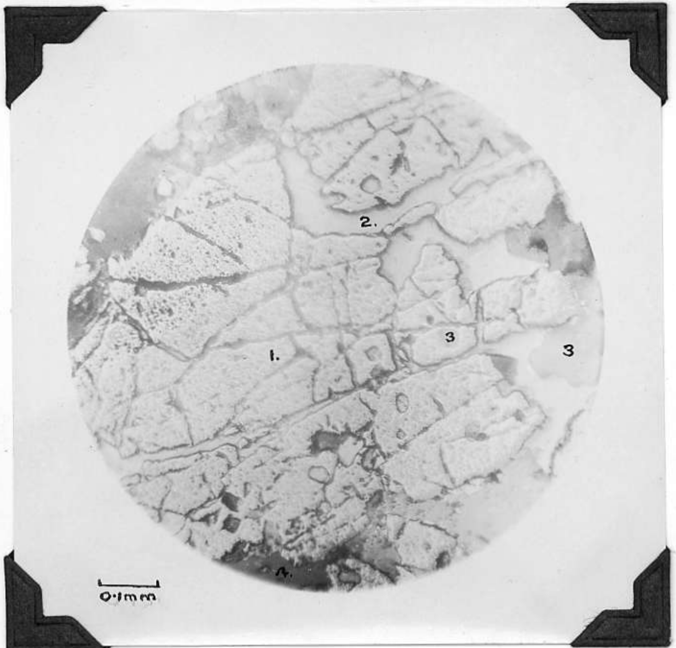
Ocular; 10x

Illumination: 6v,6a Leitz

Plate: Wratten M

Exposure: 20 Sec.

Magnification: x ~~750~~ 500



Silbak Premier

Section: Premier 20-21

Log: 249,482

Microscope: Leitz No. 305897

Objective: 3b

Ocular: 10x

Illumination: Leitz 6v,6a
Daylight Filter

Plate: Wratten M

Exposure: 15 Sec.

Magnification: x70

Fig 1. Pyrite grain fractured and filled by galena, and slightly replaced by galena, sphalerite and quartz

1. Pyrite 3. Sphalerite

2. Galena 4. Quartz

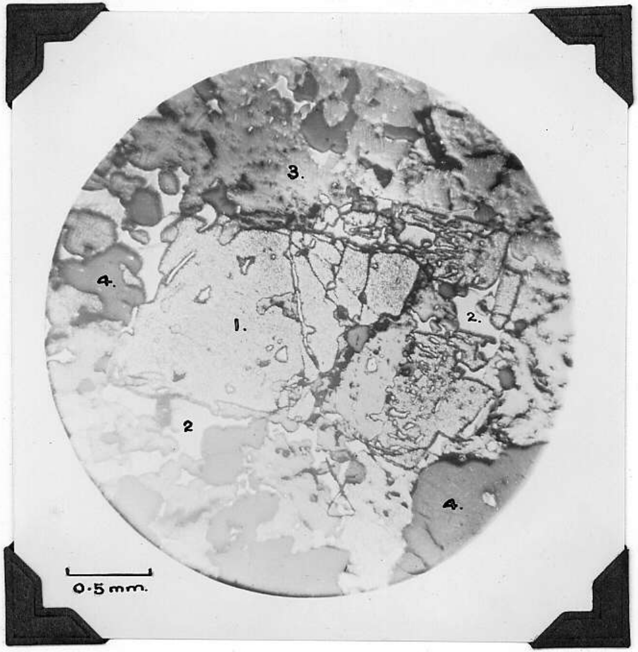


Fig 2. Pyrite grain highly corroded by galena, sphalerite, and some quartz.

Silbak Premier

Section: Premier 20-7

Log: 200,484

Microscope: Leitz No. 305897

Objective: 1b

Ocular: 10x

Illumination: Leitz 6v,6a
Daylight Filter

Plate: Wratten M

Exposure: 15 Sec.

Magnification: 23x

1. Pyrite 3. Sphalerite

2. Galena 4. Quartz

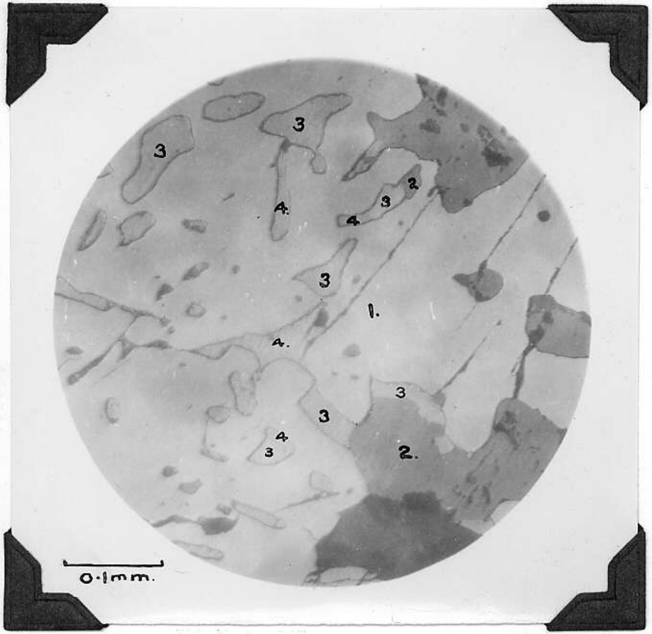


Fig 3. Replacement of pyrite by galena, sphalerite, quartz, and gold

Silbak Premier

Section: Premier 20-7

Log: 175,546

Microscope: Leitz No. 305897

Objective: 3b

Ocular: 10x

Illumination: Leitz 6v,6a
Daylight Filter

Plate:Wratten M

Exposure: 15 Sec.

Magnification: x135

1. Pyrite 2. Sphalerite

3. Galena 4. Gold

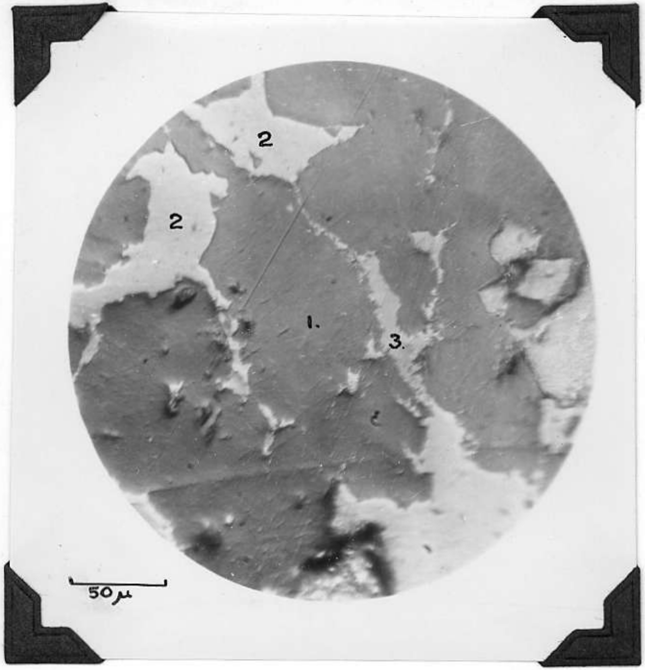


Fig 4. Replacement of sphalerite by galena and chalcopyrite.

Silbak Premier

Section: 20-21

Log: 088,544

Microscope: Leitz No. 305897

Objective: 6a

Ocular: 10x

Illumination: Leitz 6v,6a
Daylight Filter

Plate:Wratten M

Exposure: 20 Sec

Magnification: x250

1. Sphalerite 2. Galena

chalcopyrite ?
3. Sphalerite

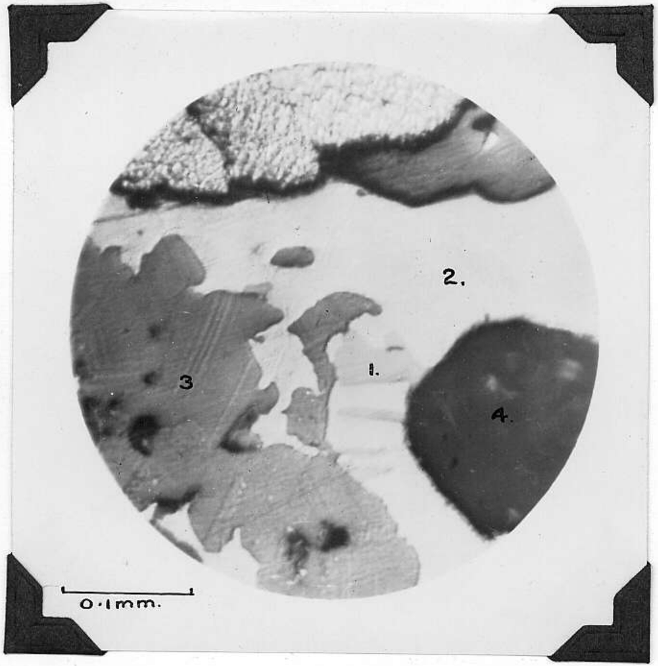


Fig 5. Typical occurence of tetrahedrite in galena

Silbak Premier

Section: Premier 20-27

Log: 111,454

Microscope: Leitz No. 305897

Objective: 3b

Ocular: 10x

Illumination: Leitz 6v,6a
Daylight Filter

Exposure: 20 Sec.

Magnification: x175

1. Tetrahedrite 3. Sphalerite

2. Galena 4. Quartz

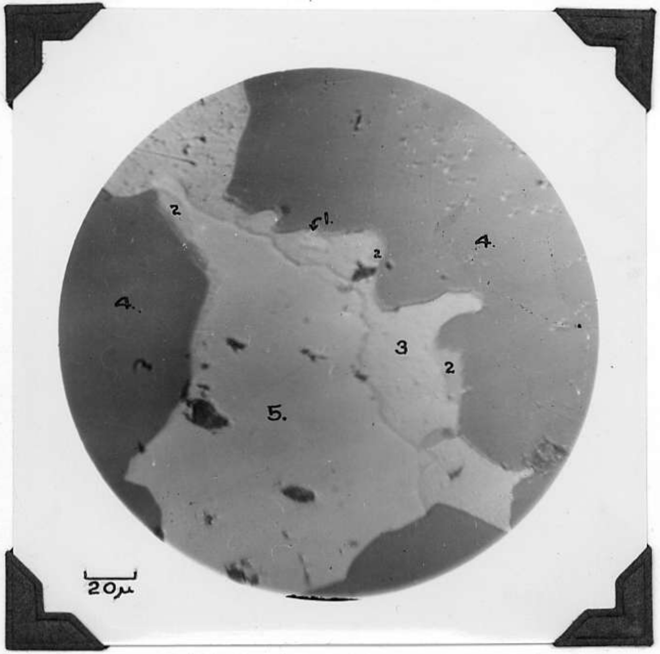


Fig 6. Tetrahedrite and gold in galena at sphalerite contacts.

Silbak Premier

Section: Premier 20-7

Log: 204, 553

Microscope: Leitz No. 305897

Objective: 6a

Ocular: 10x

Illumination: Leitz 6v,6a

Plate: Wratten M

Exposure: 20 Sec.

Magnification: x350

1. Gold 3. Galena

2. Tetrahedrite 4. Sphalerite

5. Chalcopyrite

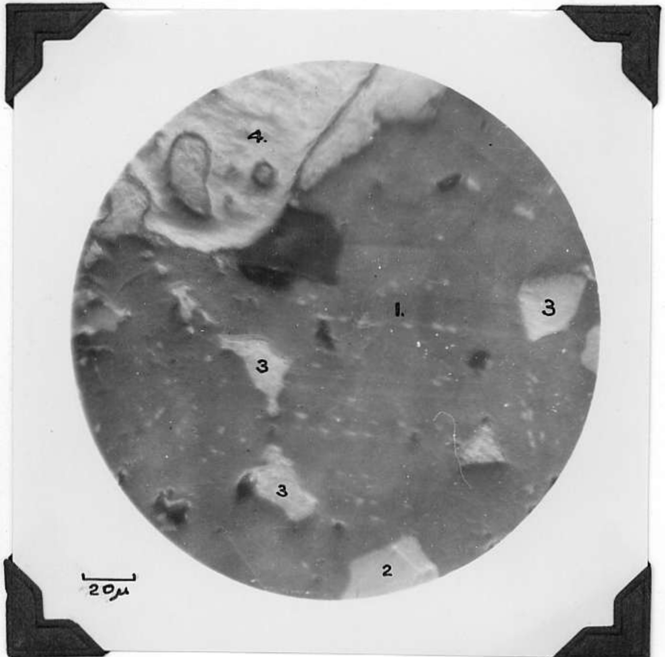


Fig7. Chalcopyrite inclusions in sphalerite along straight lines, possibly cleavages traces

Silbak Premier

Section: Premier 20-18

Log: 098,521

Microscope: Leitz No. 305897

Objective: 6a

Ocular: 10x

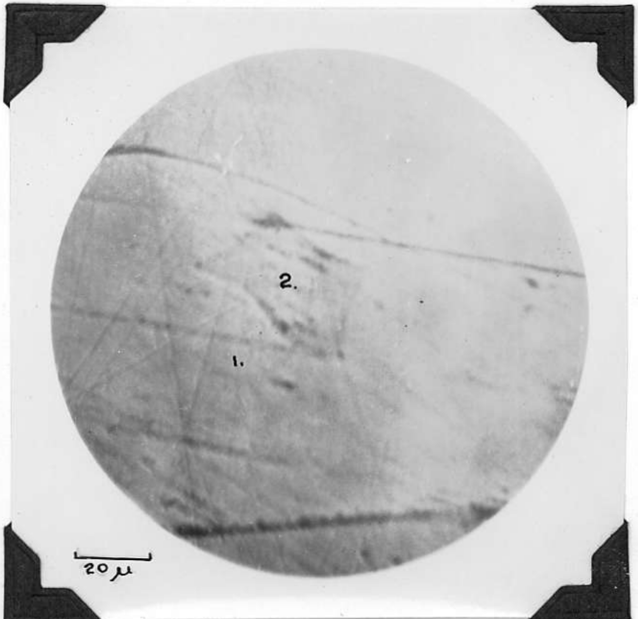
Illumination: Leitz 6v,6a

Plate: Wratten M

Exposure: 30 Sec

Magnification: x360

1. Sphalerite
2. Chalcopyrite
3. Galena
4. Pyrite



Silbak Premier

Section: Premier 20-22

Log: 164,537

Microscope: Leitz No. 305897

Objective: 6a Oil Immersion

Ocular: 10x

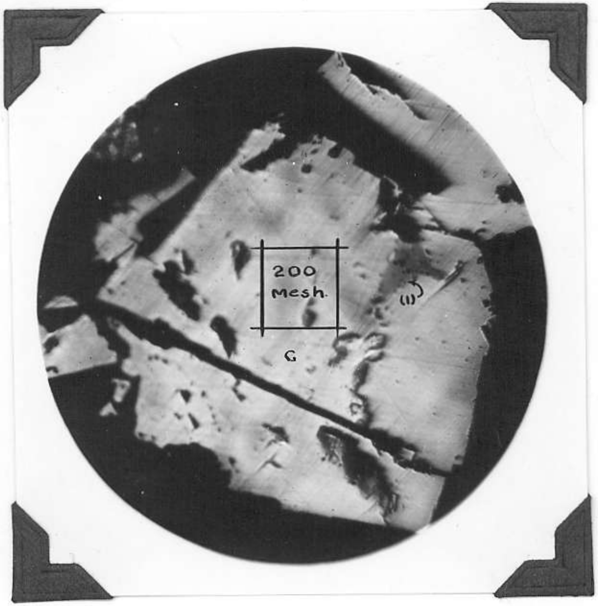
Illumination: 6v,6a Leitz

Plate: Wratten M

Exposure: 20 Sec.

Magnification: x ~~750~~ 500

Fig 8. Isolated grain of polybasite in galena. 1. Galena 2. Polybasite



Silbak Premier

Section: 20-7-T

Microscope: Panphot

Log: 033,436

Objective: 8mm oil immersion

Ocular: No.2

Exposure: 3 sec Double Daylight Filter

Plate: Kodak M

Magnification: x135

Fig 9. Polybasite and tetrahedrite(1) in a grain of galena from a superpanner concentrate.

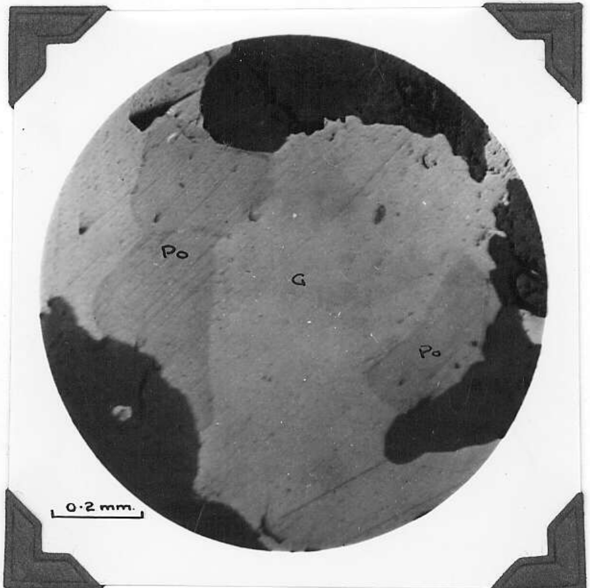


Fig 10. Polybasite in galena from section of ore from No.4 Level.

Silbak Premier

Section: 6-37

Log: 200,163

Microscope: Panphot

Objective: 3b

Ocular: No.2

Exposure: 7 sec

Plate: Kodak M

Magnification: x57

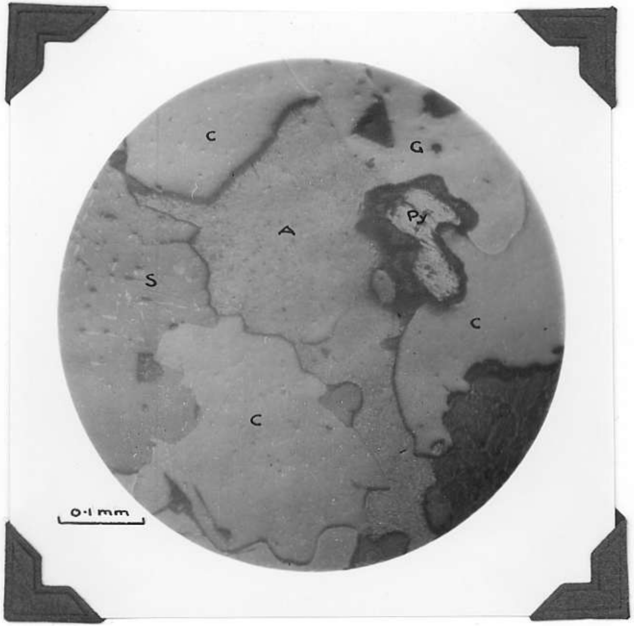


Fig 11. Argentite with galena and chalcopyrite from No.4 Level.

Silbak Premier

Section: 10-37

Log: 091,079

Microscope: Panphot

Objective: 3b

Ocular: No.2

Exposure: 7sec

Plate:Kodak M

Magnification: 110x

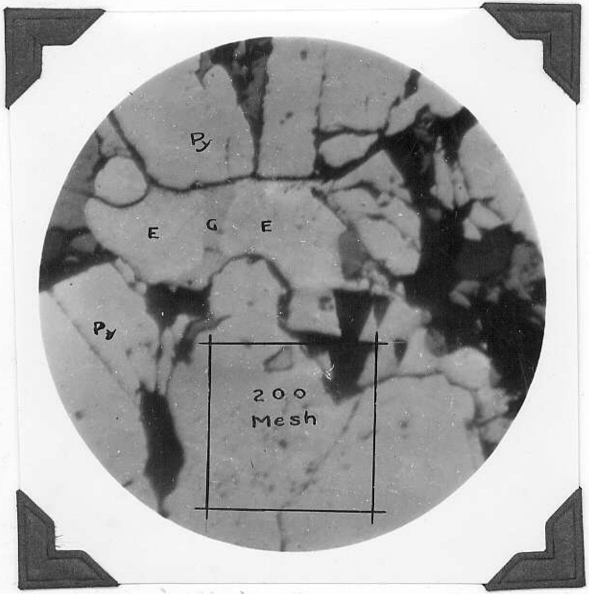


Fig 12. Electrum in galena with quartz and pyrite.

Silbak Premier

Section: A-37

Log: 144,040

Microscope: Panphot

Objective: 3b

Ocular: 12x

Exposure: 3 sec. Daylight Filter

Plate: Kodak M

Magnification: x300

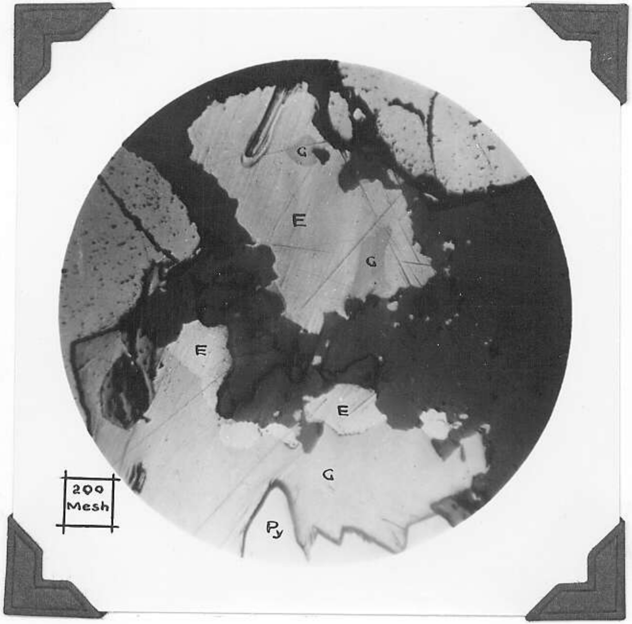


Fig 13: Electrum in galena with quartz and pyrite.

Silbak Premier

Section: 18-37

Log: 080,033

Microscope: Panphot

Objective: 3b

Ocular: No.2

Exposure: 3 sec. Daylight Filter

Plate: Kodak M

Magnification: x90

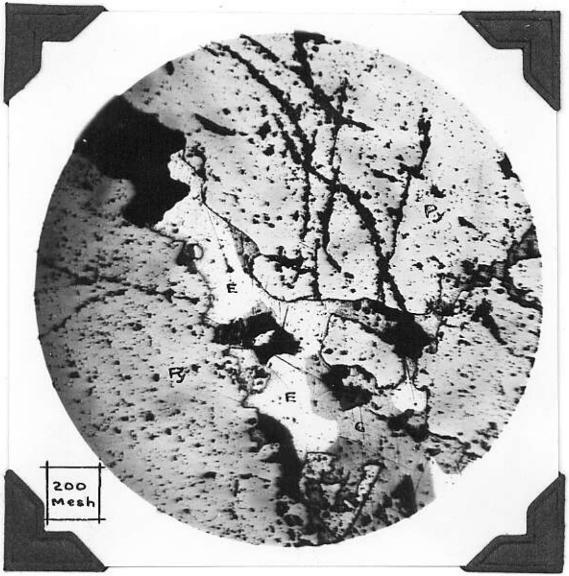


Fig 14. Electrum from the hanging-wall orebodies.

Silbak Premier

Section: 20-30-D

Log: 071,082

Microscope: Panphot

Objective: 3b

Ocular: No.2

Exposure: 3 sec Double Day-light Filter

Plate Kodak M

Magnification: x100

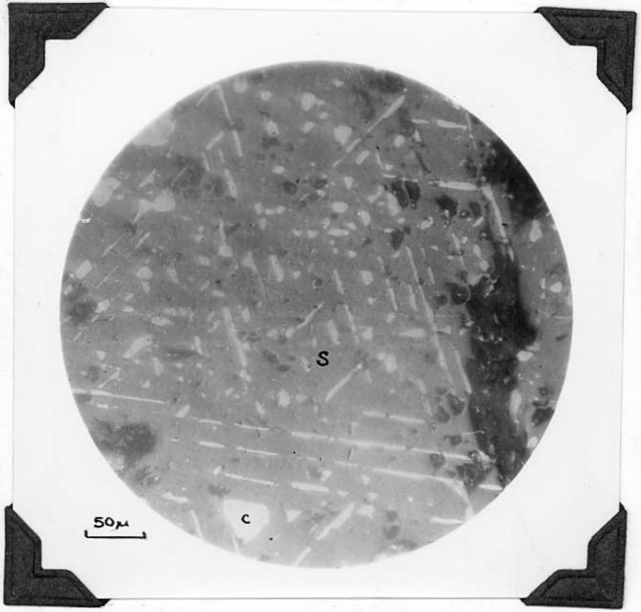


Fig 15. Coarse intergrowth of chalcopyrite and sphalerite.

Silbak Premier

Section: 10-37

Log: 142,198

Microscope: Panphot

Objective: 8mm oil immersion

Ocular: No.2

Exposure: 10 sec

Plate: Kodak M

Magnification: x175