A careful study but fails to appreciate x-ray + spectrographic analyses. OK admitted error. Not too difficult a job.

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A REPORT ON THE MINERALOGY OF ESTELLA MINE, FORT STEELE MINING DIVISION, BRITISH COLUMBIA.

by

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A REPORT SUBMITTED TO

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ABSTRACT.

During the last few years, activities in British Columbia mining fields have greatly accelerated. One prime factor for this vigour is the current high values for base metals, notably lead, zinc, and copper. Consequently we find that mines which were formerly marginal producers, may now be exploited at a profit. Similarily, prospects are being investigated, and where ore indications are favorable, these properties are rapidly brought into production.

Estella mine may be chosen as a property whose development is a direct result of the high lead and zinc prices. Although this property has been known since the beginning of this century, it has only been several years since its acquisition and subsequent development.

Since this is the first mineralographic study of ore specimens from this camp, the writer hopes that this report may be of some value.

ACKNOWLEDGEMENTS

I would like to take this opportunity to express my appreciation for the valuable advice and constructive criticism offered to me by Doctors R. M. Thompson and H. V. Warren. Their suggestions and aid, based on wide experience in their respective fields, often enabled me to arrive at a conclusion much sooner than my own experience would have permitted. Confirmatory information obtained by Dr. R. M. Thompson, with X-ray powder pattern photographs, proved invaluable.

The writer is also indebted to Mr. J. A. Donnan, technician in the Geology department, for his excellent work in preparing bakelite mounts of zinc concentrate tips.

The co-operation of the Metallurgical department in the taking of microphotographs was also appreciated.

I am grateful to the members of my class, whose pertinent questions often brought to light details easily overlooked.

Lastly, I would like to thank the staff and directors of Estella mines for their specimens and data, and to wish them a long and prosperous career in their mining venture.

INTRODUCTION

The Estella group of mineral claims were first staked in 1895 by Frank Tracy and Harry Bradford. First significant development after the original staking came in 1897, when Alex Polson of Hoquiam, Washington, acquired the property.

By 1902, three thousand feet of underground drifting, surface trenching and other work had been completed. At this time however, lead-zinc ores were not amenable to separation, so the property lay idle until 1927. At this time the property was optioned to the Consolidated Mining and Smelting Company, who did diamond drilling and other exploratory work, during the summers of 1927, and 1928, but their option was allowed to lapse in 1929.

In April 1950, a private company known as Estella Mines Ltd., acquired the property. The portal of the Rover Tunnel was opened revealing a highly mineralized zone about 700 feet long. No caving of the workings had taken place from portal to the face.

Events aimed at an early working of the mine succeeded each other rapidly. By the end of 1950, diamond drilling had been started, and preparation was made for a permanent haulage way in the Estella Tunnel. Other development transpired quickly, and by November 1951, Estella mill began operations, at a capacity of 150 tons per day.[1]

1. "The Story of Estella." - W. M. Rand and Company.

GENERAL GEOLOGY.

The Estella group of claims are located at an elevation of 6100 ft., astride a portion of Pre-Cambrian Purcell formation, which outcrops on the west flank of the Rocky Mountains, about 30 miles north-east of Kimberley. The Purcell formation consists of gray-white banded quartzites, black argillites and at least one diorite sill. These formations are folded, forming a large, northerly striking anticlinal structure.

The Estella ore zone is a replacement type deposit, localized within a south-easterly trending shear zone, dipping about 50-55 degrees to the south-west. The ore occurs in shoots slong the mineralized zone that extends for about 700 feet in the upper level. These lenses or shoots vary both in number and width within this zone of shearing, which in turn varies from a few feet to 20 or 30 feet in width. Values are chiefly in zinc, although substantial lead occurs in the lower level immediately adjoining a fault displacing the mineralized zone.

Since the rock types of this area are identical to those of the Kimberley and Coeur d'Alene districts, the writer feels that the Estella mine is favourably located with regard to future possibilities.[2]

2. Personal observation.

LOCATION OF SECTIONS

A. Rover Level - Elevation 6250 ft.

Section No.	Location
R-1	Near foot wall No. 4 x-c.
R-2	Near hanging wall No. 4 x-c.
R-3	Near foot wall No.6 x-c.
R-4	No. 12 x-c.

B. Estella Level - Elevation 6100 ft.

Section No.	Location
E-1	15 ft. N. W. of No. 1 fault.
E-2	5 ft. N. W. of No. 1 fault.
E-3	100 ft. S. E. of No. 1 fault.
E-4	opposite E-4 raise stub.
E-5	E-4 raise,40 ft. above rail.
E-6	E-4 raise,55 ft. above rail.

MINERALOGY

A. Macroscopic

1. Specimens from the Rover Level.

The hand specimens from this level are very high grade, appearing at first glance to be composed entirely of reddish brown sphalerite. However, quartz grains averaging 3 m.m. in diameter, euhedral pyrite crystals up to 2 m.m. in diameter, together with a small amount of disseminated galena are also visible. The above mentioned minerals and a small amount of calcite, probably added subsequently to the main mineralization , composes virtually all of the visible mineralization.

2. Specimens from the Estella Level.

Specimens E-1 and E-2 are not as highly mineralized as those from the Rover Level. They are composed of resinous sphalerite, with bands of quartz and unreplaced lenticular particles of whitish-gray quartzite. Galena is more visibly present, occurring as tiny stringers and disseminated particles. Pyrite, as in the Rover specimens, tends to occur as euhedral grains.

Specimens E-3 to E-6 inclusive, selected from a section past a fault displacing the mineralized zone, show a marked change. These specimens are also high grade, but galena is the major metallic mineral. Specimen E-3 appears to consist almost entirely of galena. Closer examination however, shows that the galena has replaced the sphalerite, leaving well rounded or corroded particles of sphalerite up to approximately 3 c.m. in diameter, together with particles of wall rock, pyrrhotite, and grains of quartz.

The remainder of the specimens are taken from the same area, but are higher in elevation. They show a very fine grained mixture of galena and sphalerite present in about equal amounts.

In general the specimens exhibit strong replacement textures, namely sphalerite replacing country rock and lastly, galena replacing the sphalerite.

B. Microscopic

1. Sulphides

Sphalerite is by far the most common sulphide. Polished sections of specimens from the Rover Level, show very massive sphalerite, easily recognizable by its isotropic character under polarized light, internal reflection and mouse-gray color. Twinning in the sphalerite is very common, resulting in a banding effect and showing in some cases an apparent difference of relief between bands. However, these areas under reflected light, appear homogeneous. Sections E-4 to E-6, show a very fine grained mixture of sphalerite and galena. The sphalerite has been strongly replaced by the galena, the two showing distinctive replacement textures. Residual well rounded fragments of sphalerite in the more massive galena, range in size from several centimeters in diameter down to particles a few microns in width.

Inclusions of several other minerals in the sphalerite will be discussed under their appropriate headings.

Galena is the next dominant sulphide. Its distinctive pits and color under polarized light renders its identification simple. However, two methods of occurrence were noted by the writer. In all specimens from the mine, a large part of the galena occurs as very well-rounded inclusions in the sphalerite, and as diffusion bodies at quartz-sphalerite grain boundaries. These inclusions range in size from 60 microns down to the limit of microscopic resolution. Sections E-3 to E-6 show a different method of occurrence of the galena. In addition to rounded inclusions that are still present in the sphalerite, large massive veins and bands of galena transecting the sphalerite, are especially noticeable. Galena has completely replaced the sphalerite in sections, leaving only rounded "islands" of sphalerite and unreplaced pyrrhotite.

Grain boundaries of the host(sphalerite) and the metasome (galena) are generally smooth and curving. Not only is "caries" texture observed, but its reverse is more often than not the case. However, this is common in lead-zinc ores[3] and "caries" texture though suggestive of replacement, is not always a reliable indication.

3. Edwards - "Textures of Ore Minerals". p. 107

- This replacement texture was also observed to a much lesser degree in sections from other parts of the mine. It is also possible that some of these lesser replacement textures represent sphalerite fracture networks filled by galena during the sphalerite mineralization period. In any event, it appears that the major lead occurrence is confined to that section of the mine beyond No. 1 fault.

Careful observation of galena shows it to be apparently homogeneous, therefore the small amount of silver reported[4] is probably accomodated in the galena molecule.

Cleavage planes within the galena are often twisted or curved, as if the galena had been strained by small movements contemporaneous with its depostion.

<u>Pyrite</u> occurs in large, fairly euhedral grains throughout the sphalerite, in some sections more plentiful than others. The crystals are variable in size; their lower limit is about 500 microns. The pyrite content in the sections studied, would not appear to constitute much more than 5% of the mineralization.

<u>Pyrrhotite</u> is fairly common, occuring in part as randomly distrubuted particles in the sphalerite. Much of the pyrrhotite is also located at the quartz-sphalerite grain boundaries. The particles range in size from 65 microns to microscopic blebs.[5] According to Edwards, iron substituting for zinc in sphalerite, unmixes on cooling

4. 2 oz. Silver per ton- Company Reports.

into a mixture of sphalerite and pyrrhotite. The appearance of the pyrrhotite strongly suggests exsolution texture.

Pyrrhotite is usually readily identifiable because of its "pyrrhotite" color, anisotropism colors, relief, hardness and magnetic properties. Its magnetic properties were made use of in separating a small amount for X-ray purposes. ?

Chalcopyrite. A small amount of chalcopyrite is visible in some sections. Most areas are entirely devoid of chalcopyrite, but an occasional small area of sphalerite contains a myriad of small blebs and blades. A few of the blades are oriented parallel to the sphalerite twinning, but often crystallographic distribution is not apparent.

The writer is fairly confident that the chalcopyrite is of exsolution nature, since sphalerite and chalcopyrite are capable of some degree of solid solution at elevated temperatures.[6]

5. The identification of all the microscopic blebs as pyrrhotite may be incorrect.

6. Edwards - "Textures of the Ore Minerals". p. 79.

<u>Cobalt</u>. A careful search failed to reveal any cobalt mineral, although 0.05% is reported to be present in the zinc concentrate.[7] A small amount of concentrate was superpanned and a portion of the tip was X-rayed, while the remainder was mounted for microscopic inspection. spectrographed.

X-ray results showed cobalt to be present in the tip, although microscopic examination of the mount betrayed only sphalerite, galena, pyrite, pyrrhotite and very minor chalcopyrite.

A small amount of pyrrhotite was isolated and X-rayed. Only a faint trace of cobalt was reported by Dr. Thompson, who then requested a small amount of pure sphalerite. The material for analysis was selected under a binocular microscope, after polished section study had indicated that the sphalerite could thus be freed from other materials. X-ray photographs showed the presence of both cobalt and cadmium. a spectrographic analysis

It would appear therefore, that the cobalt is contained within the sphalerite molecule and as such cannot be removed from the zinc concentrate. Is this common in sphalerites?

7. ----------Company Reports.

Paragenesis

A partial understanding of the sequence of deposition of ore minerals may be determined from visual study of hand specimens, but a full understanding can be obtained only from textures revealed in polished sections. However, the paragenesis of this ore appears simple, and an almost complete understanding may be obtained from the study of the hand specimens.

The first mineral to be deposited was sphalerite, replacing the host rock. A small amount of galena appears to be contemporaneous, as it occurs as rounded inclusions and filling fractures within the sphalerite. Simultaneous deposition may be inferred for the pyrrhotite and chalcopyrite, since they occur as exsolution bodies within the sphalerite. Quartz has also been deposited with the sphalerite.

Most of the galena is later than the sphalerite, as excellent replacement textures indicate. No interruption of mineralization need be implied since a simple overlapping deposition may exist. However, the strong galena replacement textures in specimens past No. 1 fault poses an interesting question. Since the replacement textures are practically absent in other sections of the mine, has a period of galena mineralization followed the period of faulting that offsets the main mineralized zone? A straight mineralographic decision would assume this to be the case.

A sequence of events may be tabulated from mineralographic inferences.

1. Development of main shearing zone.
2. Main sphalerite mineralization along shear zone during or after

shearing.

3. Cross or transverse faulting, displacing the mineralized zone.

4. Period of galena mineralization terminating for the most part, at the displacing fault.

Since other factors depending on visual inspection of the mine may prove to be more conclusive, the writer feels that the mineralographic conclusion should be accepted as a purely academic solution.

Temperature of Formation.

The temperature of formation may in part be inferred from the apparent presence of two sulphide solid solutions, namely sphalerite-pyrrhotite and sphalerite-chalcopyrite. The following temperature ranges of sulphide solid solutions have been adopted from Edwards - "Textures of Ore Minerals."

Sphalerite-chalcopyrite - 350-400 degrees centigrade

Sphalerite-pyrrhotite - exsolution temperature not given.

Since a sphalerite-chalcopyrite system probably exists, a tenative temperature range would be at least 350-400 degrees centigrade. According to Edwards, the lower the concentration of solute, the lower the temperature at which unmixing occurs. In any case the temperature of formation was at least 350 degrees centigrade and probably considerably above it.

The presence of exsolution pyrrhotite may indicate a certain temperature range, however, information regarding unmixing temperatures of pyrrhotite could not be found or has never been determined by any investigators.

The deposit shows little, if any wall rock alteration, therefore, it is probable that only moderate temperatures prevailed at the time of mineralization.

Conclusions.

Several conclusions with respect to the sequence of mineralization and temperature of formation have been stated previously in this report. Other conclusions not yet mentioned may also be formed.

1. Only one period of sphalerite mineralization is indicated. Variations in the color of the sphalerite is due to the iron present in the sphalerite lattice.[8] Based on color, the average iron content of the sphalerite would be at least 5%. The sphalerite near the margins of individual ore bodies is usually of lighter color tan that centrally localized. It may also be noted that the sphalerite replacing quartzite is commonly more resinous than that replacing pyritized diorite; the latter probably assimilating pyrite from the diorite.

2. The writer could not notice any cobalt minerals in the polished sections. Since X-ray results indicated cobalt to be present in the sphalerite molecule, any attempt to remove it from the zinc concentrate by milling or flotation methods would be useless.

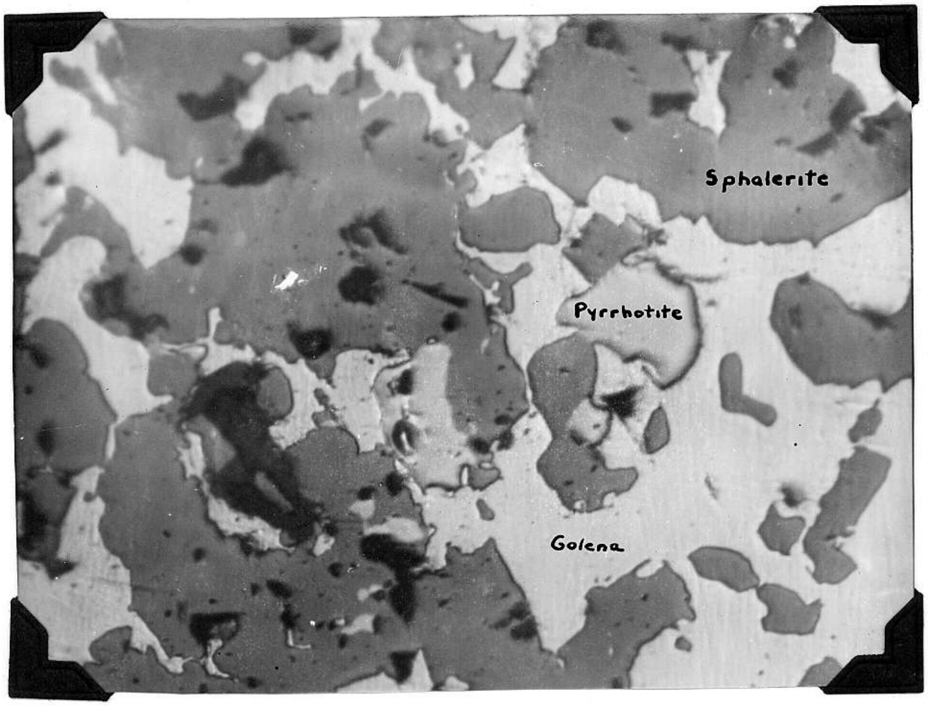
3. Some indication of zoning may be indicated in the south-eastern section of the mine past No. 1 fault on Estella Level. In this area massive galena gradually changes to a fine grained mixture of galena and sphalerite as we move higher in the ore zone. The amount of galena also appears to lessen not only upwards but also in a northerly direction along the drift past No. 1 fault.

4. Average grain sizes of the mineral constituents may be determined by **references** to photographs at the end of the report. Grinding to a size necessary to free all constituents would result in over grinding and

8. Edwards - "Textures of Ore Minerals."

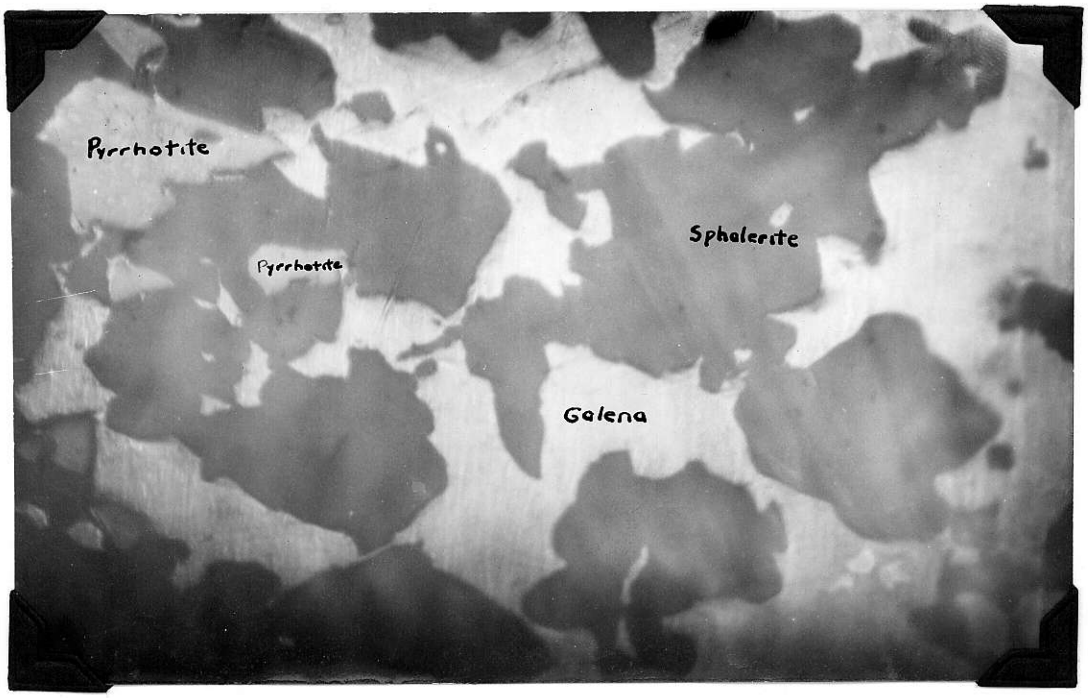
production of slime , especially of galena. It would therefore, probably be uneconomic to attempt to produce too pure concentrates of lead and sinc.

Plate 1 x300



Polished Sections E-6. Galena replacing sphalerite leaving remnants of sphalerite and unreplaced pyrrhotite.

Plate 2 x100



Polished Section E-5. Galena replacing sphalerite.

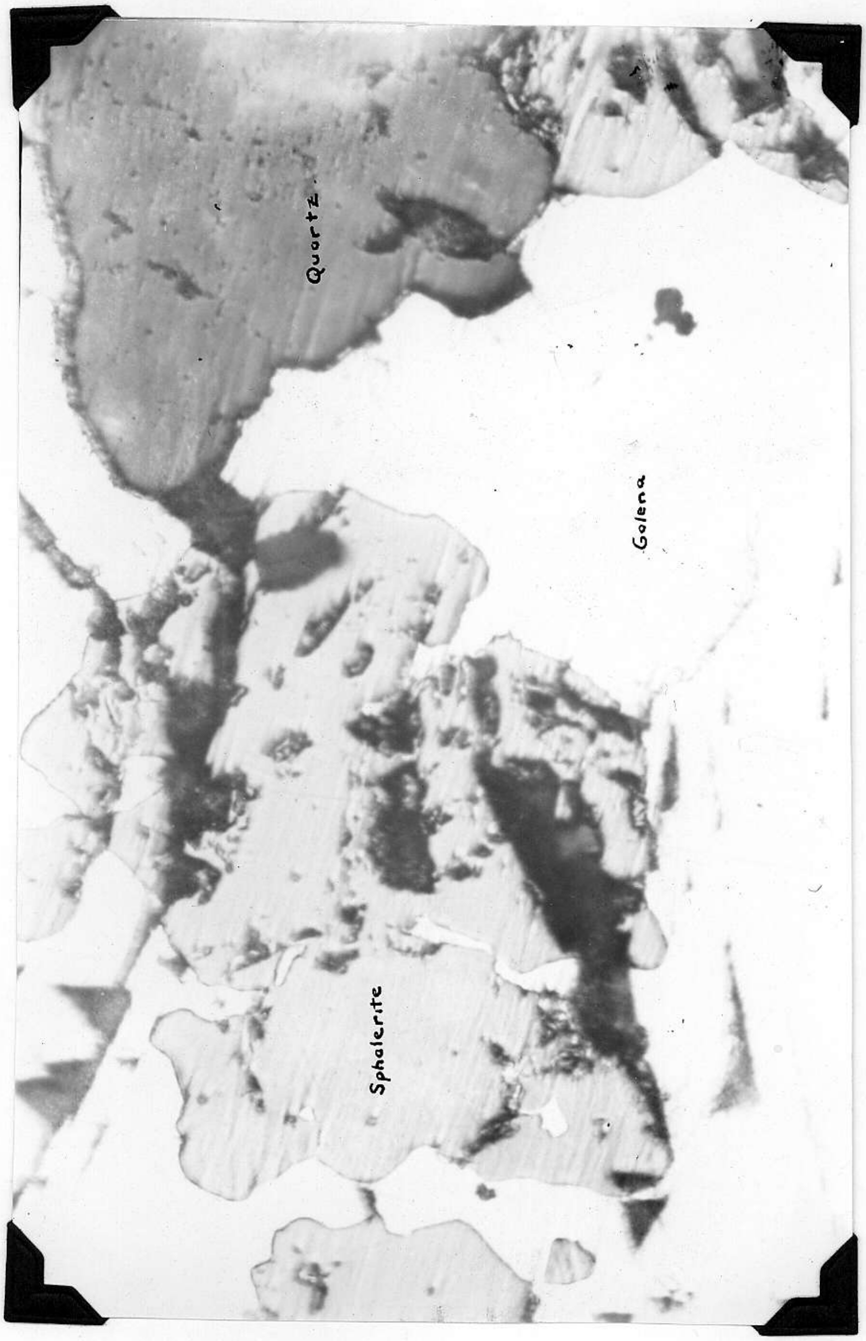
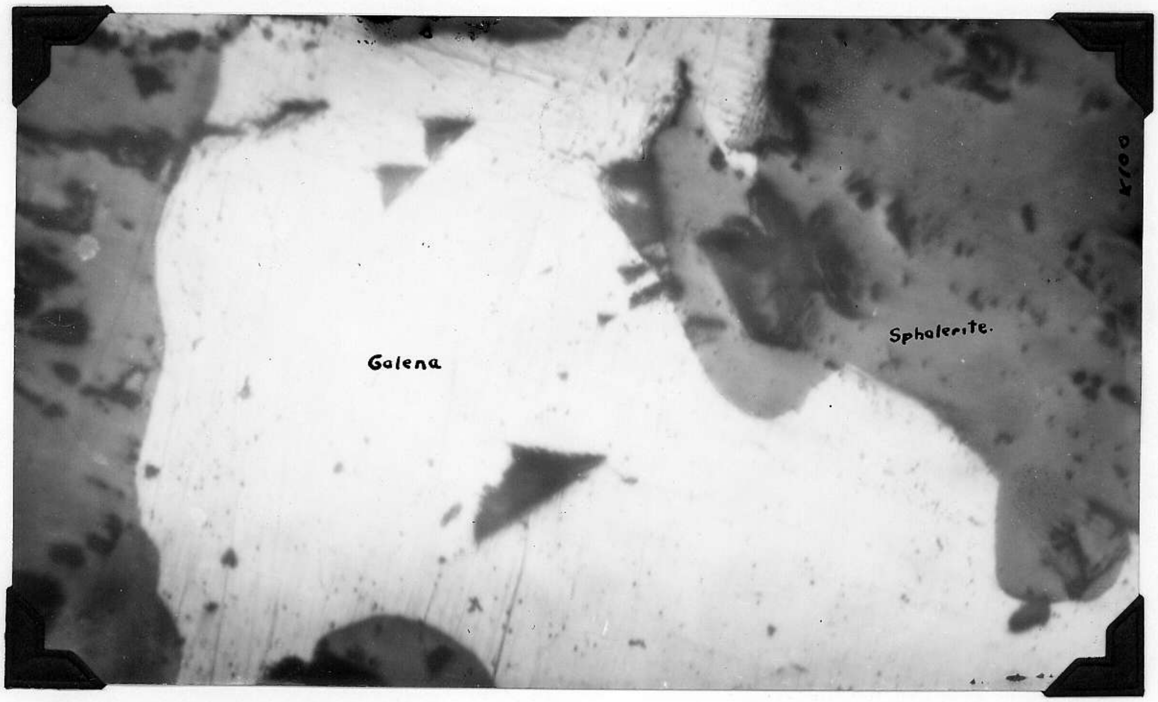


Plate 3

x300

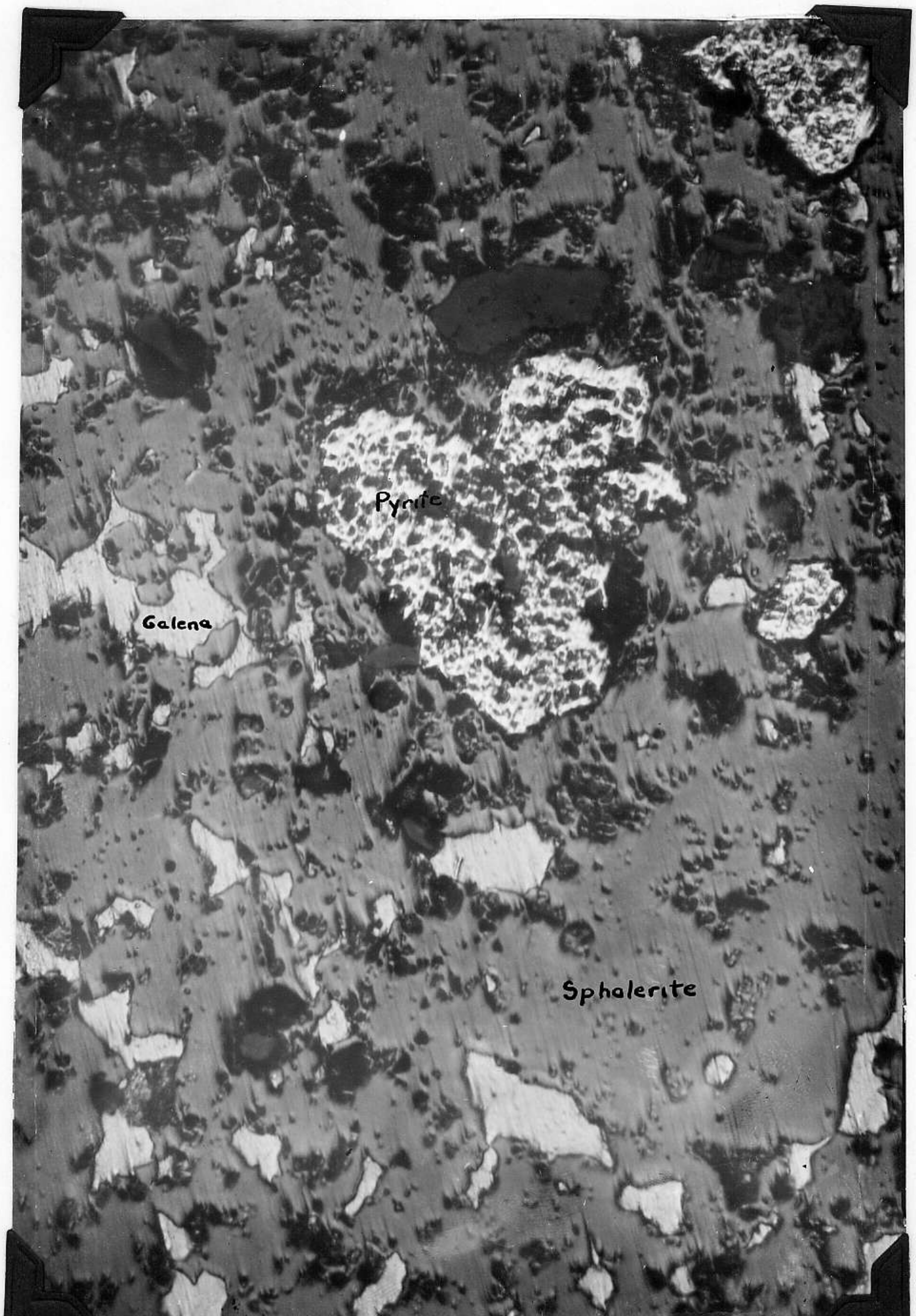
Polished Section E-3. Well **rounded** sphalerite remnants in massive galena.

Plate 4 x100.



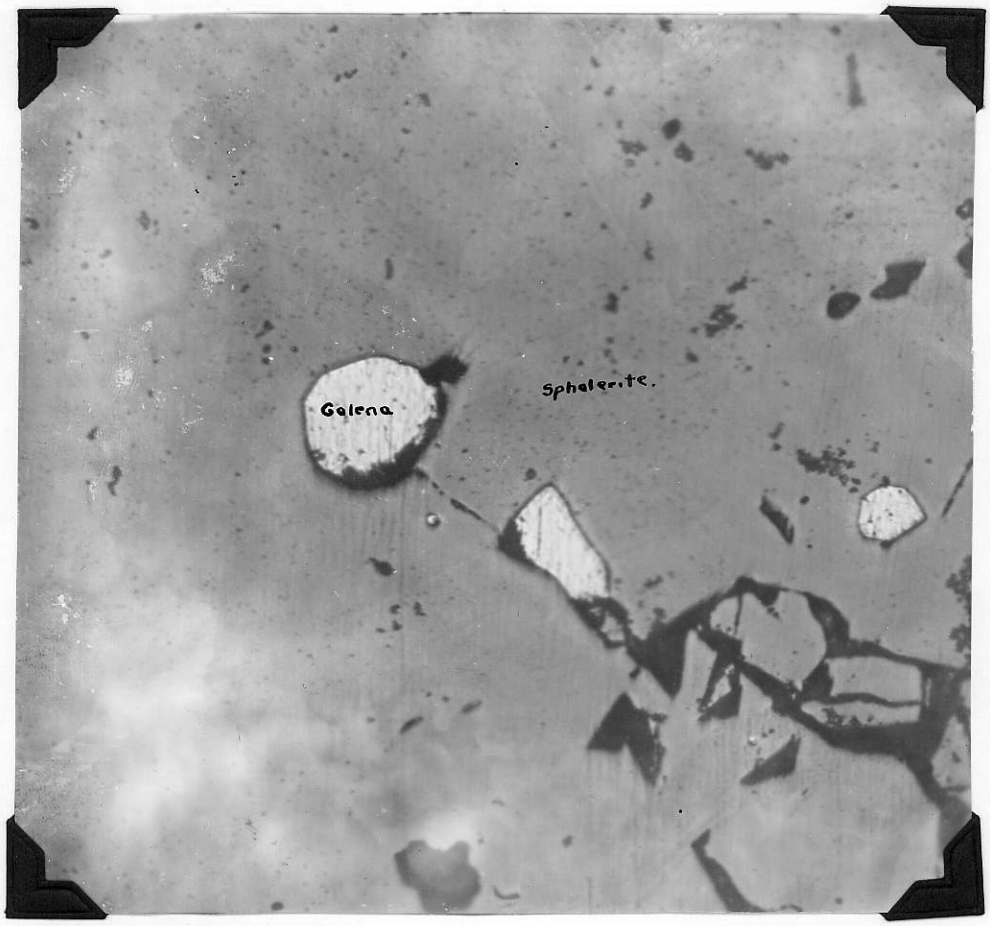
Polished section E-4. Galena stringer cutting sphalerite and replacing same.

Plate 5 x300



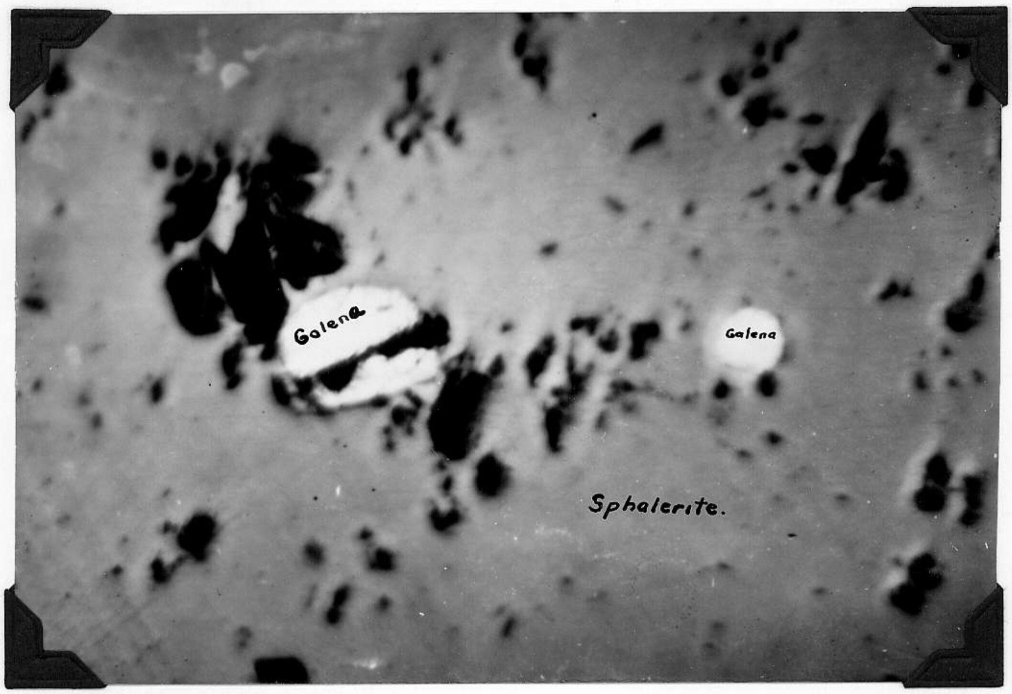
Polished Section R-4. Massive sphalerite containing galena inclusions and minor replacement galena.

Plate 6 x300



Rover Level. Rounded galena blebs in sphalerite.
Note twinning in sphalerite.

Plate 7 x100



Polished Section R-4. Similar to Plate 6. Rounded galena blebs in sphalerite.


ESTELLA MINES LTD
JUNE 1951
Scale 1" = 40'
Diorite
Sediments (Undifferentiated)
N
To Estella Portal
El. 6100
Rover Portal
El. 6250
R1 Raise
Rover Tunnel
Estella Tunnel North Drift
Estella Tunnel - South Drift.
No Fault
inches
centimetres