A Mineralogical Study of the Tommy Jack Property.

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Presentation
not so good

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Introduction

The Tommy Jack property is a gold prospect in northern British Columbia currently under development by Canex Aerial Explorations. Preliminary exploration work, including geochemical sampling and mapping, was supervised by Will Thompson of Canex in the summer of 1963. More extensive work is planned for the coming field season. Information on the location and regional geology is of a confidential nature and is not included in this report.

With the permission of Canex, the writer undertook a mineralographic study of Tommy Jack ore as a laboratory project in Geology 409 (Mineralography) at U.B.C. Polished sections, prepared from hand specimens provided by Will Thompson, were studied with emphasis placed upon ascertaining occurrence of free gold.

Description of Hand Specimens

Hand Specimen #1 The sample is essentially a 2-inch-thick quartz vein parallel to the bedding of black argillite. Angular fragments of the wallrock have been broken off and are randomly oriented along one wall of the vein. White quartz forms a crust along one side of the vein 1/4-to-1/2-inch thick and penetrates as veinlets into fractured argillite. The main quartz vein is coarsely crystalline, cloudy grey and has sulfides concentrated in a 1-inch band in the center. Small prisms of arsenopyrite and ~~p~~ cubes of pyrite occur in the vein and also disseminated in argillite near the vein. A few larger, irregular grains of sphalerite occur near the walls. Minor amounts of galena and ruby silver are disseminated in the vein. A small vug is occupied by euhedral quartz and sphalerite crystals.

<u>Hand Specimen #2</u> The sample is a ½- to ¾-inch-wide vein of coarse, granular white quartz in argillite, with the long axes of quartz crystals oriented normal to walls. Argillite is penetrated by a few quartz veinlets and contains disseminated cubes of pyrite. Arsenopyrite prisms up to ¼ inch in length are oriented normal to the vein walls in quartz. Lesser amounts of pyrite occur with the arsenopyrite. The most plentiful sulfide is galena. Large cubes of galena replace most other minerals, particularly massive dark brown sphalerite with which it is most closely associated. The ruby silver proustite is relatively plentiful in this hand specimen, compared to others

studied. It occurs as small, fine-grained masses in galena and sphalerite and apparently later than the sulfides.

Hand Specimen #3 The sample is an irregular ½-inch-wide quartz vein in black argillite. A few small fragments of argillite are inclusions in the vein. Numerous small prisms of arsenopyrite near the borders of the vein are oriented normal to the wall. Small crystals of arsenopyrite and pyrite are disseminated in argillite near the vein. One part of the vein has a mass of galena with a little proustite associated. Proustite also occurs in the quartz, filling interstices between the grains. A few small grains of chalcopyrite were noted in the quartz.

Hand Specimen #4 The sample is an irregular, 1½-inch-wide quartz vein cutting black argillite. The most plentiful sulfide is pyrite which is distributed as crystalline aggregates and masses in center portion of vein. A few small grains of sphalerite apparently have replaced pyrite. Arsenopyrite prisms are located near the vein walls associated with minor amounts of galena. Vein walls are slightly brecciated and penetrated by quartz veinlets. Tiny star-shaped crystals of arsenopyrite and tiny grains of pyrite are disseminated in argillite inclusions and wallrock.

Hand Specimen #5 The sample is an irregular quartz vein which has been injected parallel to the bedding of argillite. Beds of argillite

1/4 to 1/2-inch thick cut across the vein, and are replaced by pyrite. Zones of arsenopyrite prisms occur in the vein with galena and sphalerite associated. Sphalerite had small exsolved grains of chalcopyrite associated.

<u>Hand Specimen #6</u> The sample is a 1/10-inch-wide vein of arsenopyrite in argillite. Small prisms of arsenopyrite are closely packed together in a quartz matrix. Some of the prisms have broken and are surrounded by quartz. Some pyrite occurs with the arsenopyrite in the vein but most pyrite occurs as disseminated cubes in argillite a short distance from vein walls. Small prisms and star-shaped crystalline aggregates of arsenopyrite are disseminated in the argillite ~~about~~ in a zone 1/4-inch wide on each side of the vein; The development

of pyrite in argillite preceded the arsenopyrite vein, since the pyrite cubes are apparently oriented along bedding planes which are cut by the arsenopyrite vein. Quartz needles penetrating bedding planes diverge around pyrite cubes.

Hand Sample #7 The sample is a quartz vein in argillite similar to previous samples. The principal sulfides are galena and sphalerite in coarsely-crystalline masses. Arsenopyrite crystals occur near the vein walls, in quartz. Close examination of sphalerite showed irregular grains of tetrahedrite to be inclosed. Proustite was [illegible] intimately associated with tetrahedrite. Tetrahedrite apparently had replaced galena in sphalerite. Minor pyrite in the quartz vein had replaced some arsenopyrite. Fine-grained, disseminated pyrite occurred in argillite.

Hand Specimen #8 The sample is very similar to #7. Coarse-grained galena and sphalerite in the quartz vein are replaced to a small extent by tetrahedrite. Proustite is associated with tetrahedrite. Prisms of arsenopyrite are aligned normal to vein walls in zones near the quartz-argillite boundary. Argillite is mineralized with disseminated arsenopyrite and pyrite.

Hand Specimen #9 The sample is mainly massive pyrite in a quartz vein. Pyrite is replaced by coarse-grained galena and sphalerite. A little tetrahedrite occurs in the sphalerite. No proustite is present.

Metallic Minerals Identified in Polished Section

A total of eleven polished mounts were prepared from hand specimens. The difficulty in obtaining a fine polish on the harder minerals arsenopyrite and pyrite necessitated additional diamond-polished sections. Five diamond-polished sections were prepared from those polished mounts which showed a preponderance of arsenopyrite. These mounts were examined closely for gold.

Arsenopyrite: FeAsS Arsenopyrite was readily identified in hand specimen by hardness, colour, and crystal form. In section, the mineral showed excellent polish, white to creamy yellow colour, high hardness and strong anisotropism. (blue to brown). Euhedral prisms of arsenopyrite in quartz were up to 1/4-inch long and oriented normal to vein walls. The prisms showed characteristic rhomb-shaped cross section (Plates 2 and 3). Arsenopyrite also occurs as disseminated acicular prisms in argillite wallrock. Some prisms coalesce into star-shaped bodies (Plate 4). A narrow zone of disseminated arsenopyrite gives way to pyrite farther out from quartz vein.

② Pyrite FeS_2. Pyrite was readily identified in hand specimens by colour, hardness and crystal form. In section pyrite resembled arsenopyrite in hardness, colour, reflectivity and form. Pyrite is isotropic compared to strongly anisotropic arsenopyrite. Aqua regia etch was negative for pyrite and positive for arsenopyrite. Pyrite occurs as massive grains in quartz and also as finely disseminated grains and larger cubes in argillite. Pyrite shows orientation along bedding and is replaced by arsenopyrite in the disseminated arsenopyrite zone close to quartz vein.

③ Sphalerite : ZnS Massive dark brown grains of sphalerite occur in the quartz vein. It was identified by pitchy lustre, hardness and streak. Sphalerite is pale to medium grey in in polished section, isotropic, and shows yellow-brown internal reflection. No etch test or microchemical tests were needed. Rounded blebs of chalcopyrite were exsolved along 111 planes of sphalerite.

④ Galena : PbS Galena occurs as coarse cubic crystals and masses in quartz veins. It was identified by colour, hardness, cleavage and crystal form. In section the galena was identified by good cubic cleavage, oriented triangular pits, bright white colour, low hardness and isotropism. Etch tests confirmed. Galena showed strong tendency to replace sphalerite and pyrite, and lesser tendency to replace arsenopyrite.

Tetrahedrite

$5\,Cu_2S \cdot 2(Cu,Fe)S \cdot 2Sb_2S_3$

Tetrahedrite is commonly ~~mainly~~ associated with sphalerite as irregular, penetrating stringers and masses. Tetrahedrite tends to replace galena enclosed in sphalerite. Tetrahedrite is a minor mineral in the vein and was not identified in hand specimen. In section, the mineral showed olive grey colour - a lighter grey than sphalerite - isotropism and lack of internal reflection. Etch tests confirmed tetrahedrite. The mineral was first thought to be freibergite due to numerous proustite inclusions and positive microchemical test for silver. However etch tests and hardness did not indicate freibergite (Ag-tetrahedrite) and the high silver content was due to exsolved proustite.

⑥ Proustite
$3Ag_2S \cdot As_2S_3$

The ruby silver proustite occurs as small irregular grains which have replaced galena, sphalerite and tetrahedrite, and also as small oval or elongate exsolution bodies in tetrahedrite. The mineral is very similar to pyrargyrite in section with bluish-grey colour, low hardness, pleochroism, distinct anisotropism and internal reflection. The very bright red internal reflection differs from the deeper red of pyrargyrite. Aqua regia etch effervesced and HCl etch was negative, both of which indicated proustite. A positive microchemical test for arsenic confirmed proustite.

Polybasite
$8(Ag, Cu)_2S.(Sb, As)_2S_3$

Polybasite occurs as small oval exsolution bodies in tetrahedrite only visible under high power magnification. The mineral appears similar in texture and occurrence to exsolved proustite, with which it is closely associated. Polybasite is brownish grey, slightly darker than the enclosing tetrahedrite and shows distinct anisotropism in brown to grey. No internal reflection was seen in the small grains. No etch tests could definitely distinguish polybasite from pearceite, the arsenic-rich member of the isomorphic series. Lack of distinct pleochroism and strong anisotropism in purples and browns seemed to indicate polybasite rather than pearceite,

Chalcopyrite
$Cu_2S.Fe_2S_3$

Small brass-yellow exsolution blebs of chalcopyrite in sphalerite were isotropic and negative to all reagents except aqua regia.

Optical Data and Etch Tests

Mineral	Hard.	Colour	Etch Tests	Optical Prop's, Miscellaneous
Arsenopyrite $FeAsS$	F	white to creamy yellow.	Aqua regia (+) As microchem (+)	Excellent polish. Strong anisotrop. blue – brown Rhombic cross sections
Pyrite FeS_2	F	yellow – white	Aqua regia (–) All others (–)	Good polish. Isotropic Square crystals.
Sphalerite ZnS	C	grey	No etch tests.	Distinct 110 cleavage. yellow - brown internal reflet. Isotropic
Galena PbS	B	Bright white	HNO_3 (+) - no eff. HCl (+) $FeCl_3$ (+)	Good polish. Cubic cleav., triangular pits Isotropic.
Tetrahedrite $5Cu_2S.2(Cu,Fe)S.2Sb_2S_3$	D	olive - gray	HCl tarn. irrid $HgCl_2$ neg. Aq. regia (+)	Isotropic Reflectivity higher than sphal. No int. reflection seen.
Proustite $3Ag_2S.As_2S_3$	B	Bluish grey	Aqua regia eff. HCl (–) As microchem (+)	Pleochroic Strong anisotropism Bright red int. reflection
Polybasite $8(Ag,Cu)_2S.(Sb,As)_2S_3$	C	Brownish grey	Etch tests same as for proustite.	Anisotropism brown – grey weak pleochroism.
Chalcopyrite $Cu_2S.Fe_2S_3$	C	Brass yellow	Aqua regia (+) All others (–)	Isotropic – greenish colour on extinction

Abundance of Metallic Minerals

Most hand specimens showed arsenopyrite and galena to be the most abundant metallics. Two hand specimens were mainly pyrite. Sphalerite occurred in most specimens, and was most abundant in those with plentiful galena and pyrite. The sulfosalts were all of low abundance; tetrahedrite and proustite in small local concentrations. Diamond-polished sections were taken mainly from arsenopyrite-rich portions of specimens since gold was believed to be associated with arsenopyrite. The average abundance of minerals in nine hand specimens, eleven polished mounts and five diamond-polished sections is:

arsenopyrite	35 %
pyrite	22
galena	18
sphalerite	15
tetrahedrite	5
proustite	3
chalcopyrite	1
polybasite	<1

Textures and Paragenesis

Stage ① Small cubes of pyrite are disseminated in argillite with a general tendency to concentrate along bedding planes. Quartz veinlets injected along small fractures and bedding planes from larger quartz veins are diverted by these pyrite crystals. The pyrite is probably authigenic. It may have crystallized and grown in situ due to low-grade metamorphism of the ferruginous sediments, prior to silicification. The regional extent of pyritization is not known to the writer. The pyrite may represent an early stage of mineralization related to some intrusive body in the area and controlled by fractures in the argillite beds.

Stage ② Quartz and arsenopyrite were the first vein minerals to crystallize. The quartz forms dense, crystalline crusts along the vein walls with the c-axes of the crystals oriented normal to the walls. Small quartz stringers penetrate argillite and in places break away fragments of wallrock. Arsenopyrite was introduced slightly later than quartz and it forms crystalline bands closer to the center of the vein. The arsenopyrite is strongly idiomorphic. Small, closely-packed euhedral monoclinic prisms are oriented normal to vein walls. At the time of its deposition in the vein, arsenopyrite also migrated a short distance into the argillite wallrock where it deposited as small, disseminated prisms and star-shaped bodies (Plate 4). The zone of disseminated arsenopyrite cuts quartz veinlets and pyrite cubes of an earlier phase. The principal mode of deposition

Plate 1

Arsenopyrite (1) and pyrite (2) have been replaced by galena (3). Gray mineral is quartz. (Low power.)

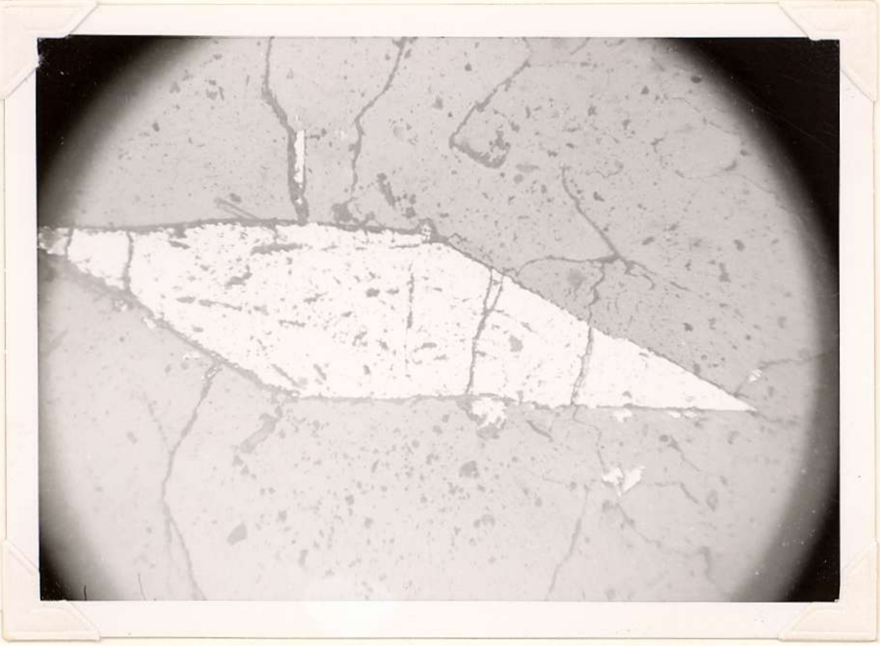


Plate 2

Rhomb-shaped cross section of a large monoclinic prism of arsenopyrite in quartz. (Medium power)

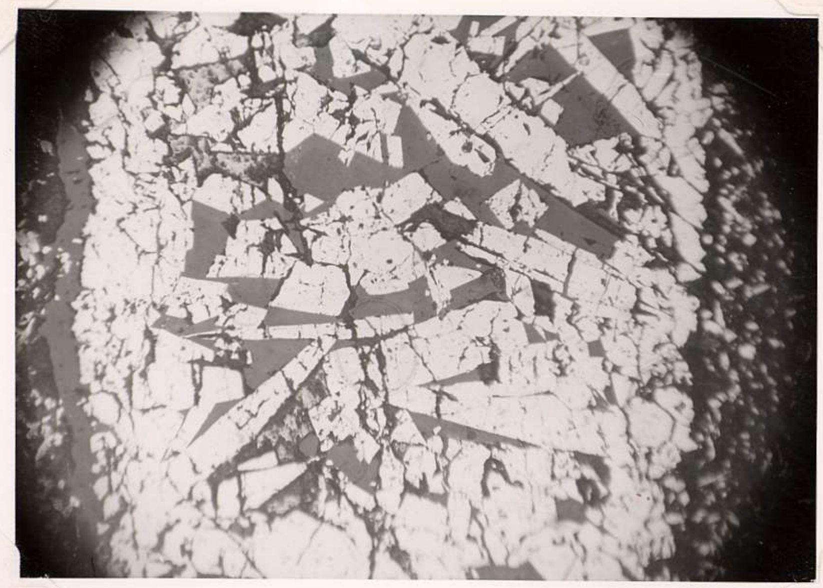


Plate 3

Arsenopyrite vein in argillite. Prisms are fractured, slightly displaced, and filled by quartz. (Medium power)

Plate 4

Contact of arsenopyrite vein with argillite Disseminated "stars" and prisms of arsenopyrite near vein (1) cutting earlier pyrite grains (2). (Medium power) of arsenopyrite was open-space filling and some metasomatic replacement of wallrock was contemporaneous.

Most arsenopyrite prisms are fractured and displaced slightly (Plate 3) The fractures are filled with quartz, indicating silicification of the veins persisted after arsenopyrite minerallization had ceased. The extensive fracturing of arsenopyrite and the brecciation of wallrock to a smaller degree, suggest deformation of the beds at time of minerallization.

<u>Phase ③</u> Pyrite was introduced slightly later than arsenopyrite. The majority of pyrite occurs as irregular masses in the central part of the vein. Some euhedral cubes of ~~[illegible]~~ pyrite occur in the vein, usually closely

associated with arsenopyrite. Pyrite often encloses arsenopyrite but exhibits only limited replacement of that mineral.

Phase ④. Sphalerite was introduced after pyrite and occurs as large irregular grains and masses confined to the central part of the vein. The sphalerite is dark brown and probably contains about 5% iron in solid solution. Relict grains of pyrite enclosed in sphalerite and tongues of sphalerite projecting into pyrite at boundaries indicate that sphalerite has replaced pyrite. No replacement of arsenopyrite by sphalerite was seen. Small round or oval exsolution grains of chalcopyrite occur in the sphalerite as oriented lines of grains along the 111 planes. Some sphalerite showed both oriented intergrowths and emulsion texture.

A few larger grains of chalcopyrite were noted outside the sphalerite boundary. These grains were probably caused by migration of chalcopyrite to the grain boundaries of the sphalerite host and aggregation of the exsolution bodies.

Phase ⑤ Galena was introduced into the veins later than sphalerite. It shows replacement textures with all earlier minerals, but preferentially replaces sphalerite. Arsenopyrite enclosed in galena usually retains its euhedral outlines, but a small amount of replacement of arsenopyrite was noted (Plate 1). Pyrite is more extensively replaced by galena. Galena generally occurs as coarse crystalline masses closely associated with sphalerite, and occasionally proustite.

Phase ⑥ Tetrahedrite occurs as irregular masses in sphalerite. Boundary relations between the two minerals are inconclusive, but the generally smooth boundaries indicate exsolution aggregation rather than replacement. The exsolved tetrahedrite tends to replace galena in the sphalerite host. Both sphalerite and tetrahedrite show exsolution of chalcopyrite, and tetrahedrite also has exsolved grains of ruby silvers inclosed. These minerals are believed to have precipitated from a complex solid solution series. Sphalerite was the first mineral to precipitate after higher temperature pyrite and arsenopyrite. The temperature at which sphalerite first started to crystallize was 550-600°C. Sphalerite retained a small amount of chalcopyrite in solid solution at this high temperature. Galena was deposited shortly after sphalerite but before tetrahedrite. The temperature at which galena crystallized was probably 500-550°C. With cooling of the environment, the sphalerite started to exsolve tetrahedrite below 500°C. Tetrahedrite was the first mineral to exsolve from sphalerite, the host mineral for a complex Zn, Cu, Fe, Ag, Sb, As, S solid solution series. The exsolved tetrahedrite rapidly formed aggregate bodies within the sphalerite, and along its grain boundaries. Some galena enclosed in sphalerite was replaced by tetrahedrite at this stage.

Phase ⑦ Chalcopyrite was contained as a solute in sphalerite and tetrahedrite ~~as~~ at higher temperatures, and exsolved from both those minerals with falling temperature. Edwards (1954, P.92) given solid solution unmixing temperatures for tetrahedrite-chalcopyrite and sphalerite-chalcopyrite at ~500°C and 350-400°C respectively. It is probable that tetrahedrite exsolved chalcopyrite first, and then sphalerite also exsolved chalcopyrite at at a lower temperature. The preservation of oriented unmixing intergrowths in sphalerite may indicate an environment of rapidly-falling temperature. A small amount of chalcopyrite migrated from the hosts and concentrated outside their grain boundaries.

Phase ⑧ The last minerals to form were the ruby silvers, proustite and polybasite. Proustite is many times more abundant than ~~proustite~~ polybasite. Both were exsolved from tetrahedrite as the final members of the sphalerite-sulphosalt solid solution series. Both ruby silvers were probably exsolved at the same time, at a temperature less than 250°c, the melting point of proustite. Proustite showed strong tendency to migrate to the boundaries of the tetrahedrite host. Some small grains of proustite were noted as interstitial grains in quartz, considerable distance from other sulfides. This occurrence may represent a late supergene ~~[illegible]~~ deposition of proustite by circulating ground water. The minor amounts of polybasite ~~pearceite~~ occurring with proustite are probably due to a little Cu and Sb remaining in excess after the formation of tetrahedrite and chalcopyrite. Plates 5 and 6 show the sphalerite-tetrahedrite-chalcopyrite-ruby silver textures.

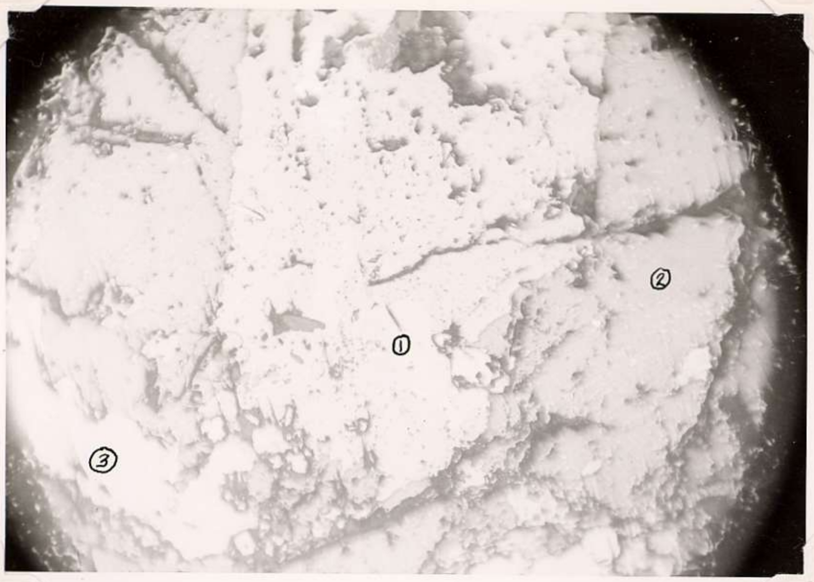


Plate 5

Sphalerite (light grey) encloses tetrahedrite (1), and shows oriented unmixing intergrowths (2) and exsolution aggregates (3) of chalcopyrite. Small, dark gray grains of proustite are barely visible in tetrahedrite. (Medium power)

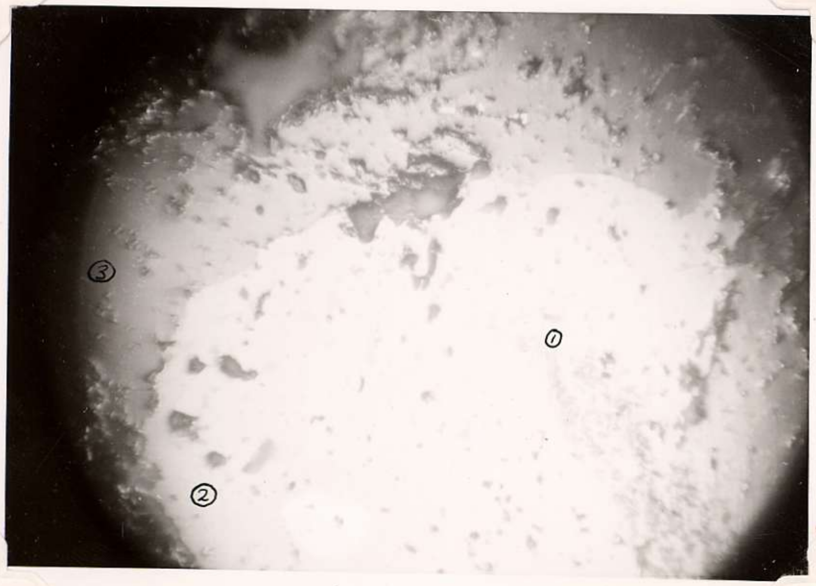
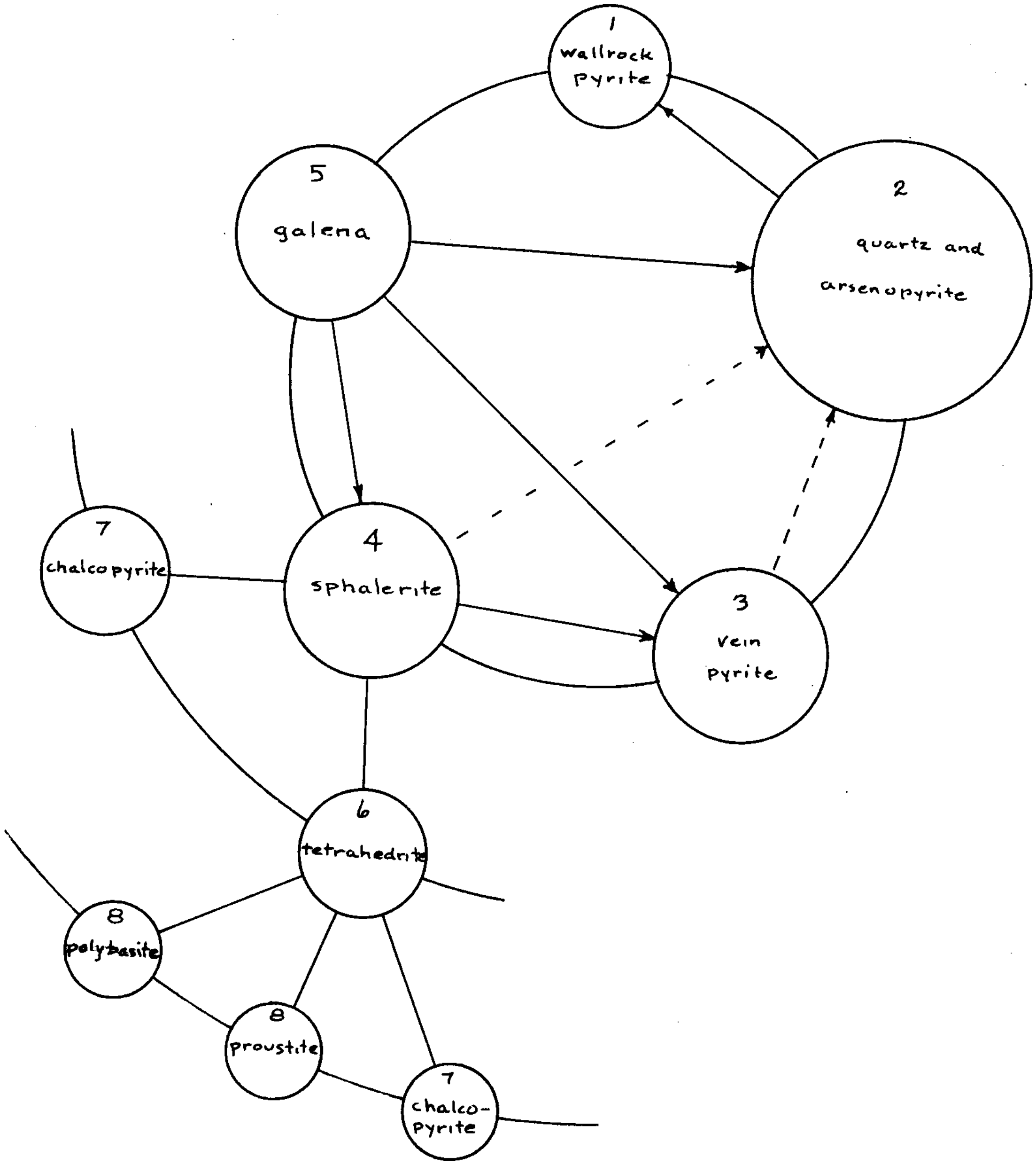


Plate 6

Proustite (1), chalcopyrite (2) and polybasite (not visible) exsolved from tetrahedrite (white) in sphalerite (gray). Sphalerite also has exsolved chalcopyrite (3). (High power)

Paragenesis



Legend

Ⓐ→Ⓑ A replaces B

Ⓐ- - →Ⓑ Weak replacement

Ⓑ—Ⓐ Exsolution - exsolved mineral on outer circle.

Conclusions

In the samples studied, no free gold was located either in quartz or associated with sulfides and sulfosalts present. No gold minerals were located. Geochemical assays show high As and high Au values to be congruent. Gold is probably present in concentrations of 0.5 oz. per ton or less as solid solution in arsenopyrite. Annealing the ore for several hours at 500°c might promote diffusion and aggregation of the gold to grains visible under the microscope

The paragenesis of the deposit has been discussed. The veins were introduced into argillite under high temperature hydrothermal conditions, accompanied by some movement.

The sulphides arsenopyrite, pyrite and sphalerite were introduced at temperatures probably in the range 500-600°C. Lead present deposited as galena before tetrahedrite exsolved from sphalerite, since lead sulfosalts of Sb and As would not crystallize at that high temperature. A complex solid solution series of Zn-Cu-Fe-Ag-Sb-As-S was initiated by sphalerite, and tetrahedrite, chalcopyrite and ruby silver followed in that order with falling temperature.

Brecciation of wallrock indicates a lack of plasticity in the wallrock during deformation at shallow depth. Vugs in the veins, crustification and banding are all indicative of shallow-depth mineralization by open-space filling.

The presence of high temperature minerals arsenopyrite and pyrite, and evidence of arsenopyrite metasomatism of wallrock indicate high temperature. Exsolution textures indicate rapid cooling from a temperature of formation 450 - 550°C. The deposit is a hydrothermal vein deposit which has been emplaced at shallow depth but shows high temperature, as well as low temperature mineralogy. It would possibly fit Graton's classification as a "Leptothermal" deposit. The deposit is probably genetically related to nearby high-level intrusions which probably fractured as well as mineralized the argillite.

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