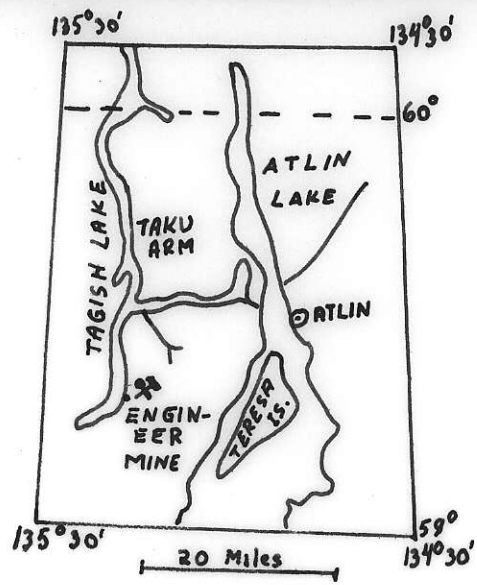


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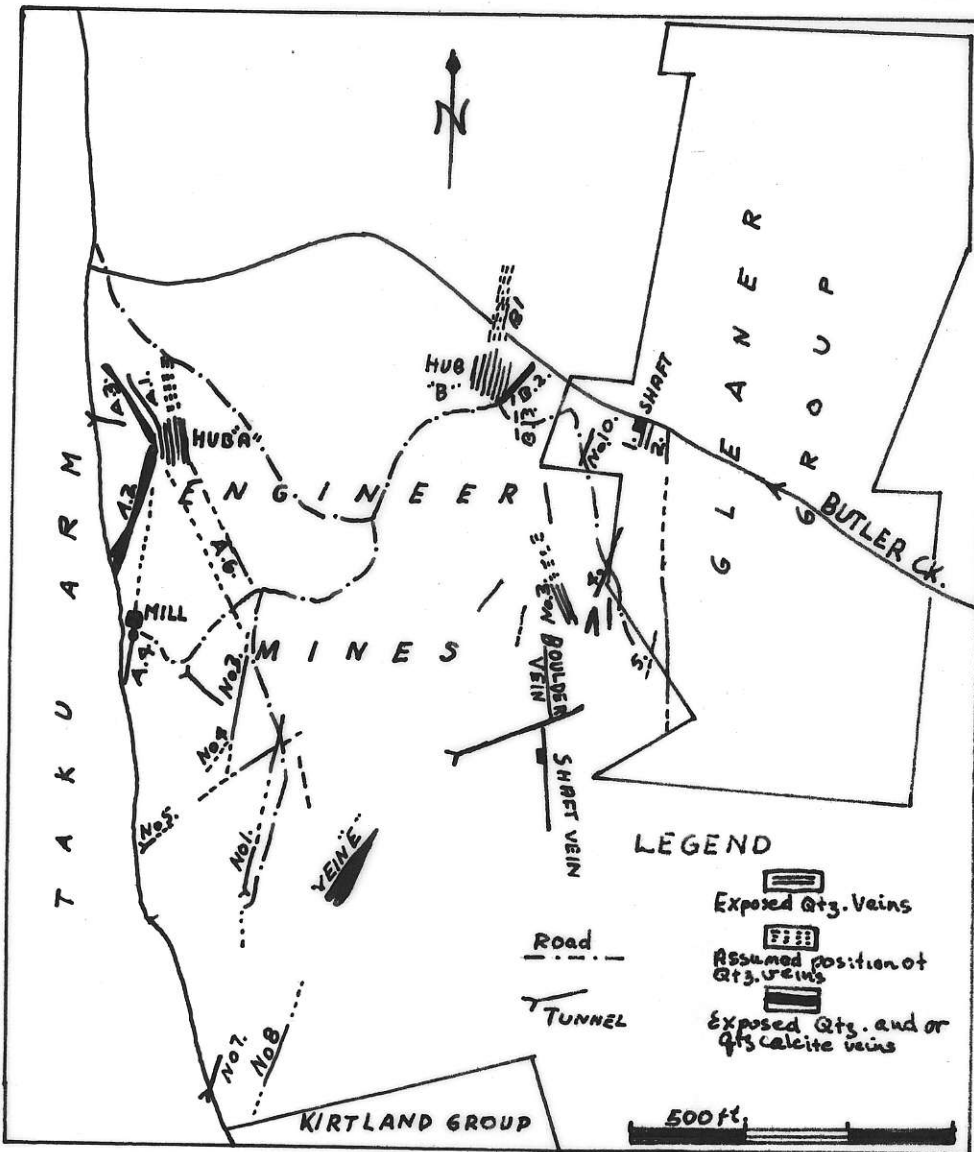
*A Mineralographic Study  
of the  
Engineer's Mine Mineral Suite*

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\* MAP SHOWING VEINS ON ENGINEER AND GLEANER GROUPS, ATLIN B.C.



\* B.C. MINISTER OF MINES REPORT 1918.

### General Geology.

The Geological formation at the Engineer Mine consists of fine grain greywacke, shales, slates and argillites of the Jurassic - Cretaceous Haberge series. These beds have been intruded by dykes of andesite and granite porphyry. In places, the rock has been faulted and folded. The beds strike and dip N 63° W and 35° East. All of the ore bodies at Engineer occur in the Haberge Series.

The "Resident Engineer" in 1933<sup>2</sup> made a study of the genetic relationship of the veins at Engineer to the granitic intrusion easterly and south easterly, of the Engineer vein system. This granite porphyry body intruded the Haberge Series at a flat angle to the south of the Engineer vein system and then plunges northwesterly beneath the shales and argillites of the Haberge series. Shear zones are believed to have acted as introductory channels for ascending mineralizing solutions.

### References.

- ① B.C. Minister of Mines Report - 1918
- ② B.C. Minister of Mines Report - 1933

## History of Development.

The Engineer Mine is located on Taku Arm of Tagish Lake in the Atlin Mining District. Gold was discovered on the East Shore of Tagish Lake in 1899 by a group of engineers working for the White Pass and Yukon Railways. The locators formed the Engineer Mining Co. of Skagway and began stripping and shaft sinking on the discovery vein. By 1910, they had installed a 2-stamp Joshua Hendy mill.

In 1914 the locators ran out of money and apparently enthusiasm too, because the company went broke and the engineers didn't attempt to raise more money.

The property was quickly restaked and sold to Captain James Alexander who, during the next two years, discovered much new gold ore. By 1914, nineteen high grade quartz veins occurring as 2 well defined series, had been mapped by Alexander. The veins of the first series radiate out from a central body. The veins of the 2<sup>nd</sup> series occur as well defined isolated fissures, usually in close proximity to igneous dykes which sometimes form one wall of the veins.

The so called E-vein was discovered in 1914. It belongs to the 2<sup>nd</sup> series. Mining was centered around this vein for the next four years. The E-vein is a clean cut well-defined fissure, about 6 feet thick at the surface, in slate country rock. Aluminite occurs as large colloform masses with gold occurring as free grains in the quartz. A 250 ft. drift was driven on the E-vein. Gold values in the E-vein are very erratic and discontinuous. Values range from 3.5 oz to 70 oz/ton. In 1915 it was reported that 6000 tons of ore had been blocked out and estimated "conservatively" at \$150/ton. In addition, streaks running several thousand dollars per ton were reported. Additional high grade ore was reported in 1917 but the owners were tight-lipped about

Values and tonnage. The 1918 Minister of Mines Report states "the Engineer Mine has all the earmarks of becoming the richest gold mine in B.C."

In 1918, the rich Boulder and Shaft veins were discovered. Three grades of gold were being mined from these veins: free-milling gold was sacked for treatment in the ball-mill; low showing no free gold but known from assay values to be high grade - ~ \$150 - \$180 per ton - was shipped. The third grade was dumped for future treatment.

Following the death of Capt. Alexander in 1916, the ownership of the mine was in dispute and the operations came to a halt in 1918, and operations didn't resume before 1925 when the legal tangle had been resolved.

With the announcement that production would resume at Engineer, Engineer Stock jumped to \$100 per share on the New York market.

Perhaps the Hay-day of Engineer Mine was during the next 2 years when 14000 oz. of gold were produced. The operations came to a standstill together with everything else in 1930.

Mining was resumed in 1933 with the aim of opening up large tonnage low-grade operations, using pockets of high-grade material to sweeten the ore.

No mining was done during the war years but mining was briefly resumed by two or three prospectors in 1946. Their pick-and-shovel operation ended in 1947.

During the last twenty years, the Engineer Mine has been evaluated by many companies but it appears unlikely that gold will be produced there again before gold prices rise.

Sources of Information: B.C. Minister of Mines Report: 1901 - 1930, 1933 - 1940, 1945 - 1947.

## Hand Specimens description

One hand specimen and two large polished sections were provided as hand specimens.

Specimen 1: Arsenopyrite, closely associated with electrum, occurs in the quartz portion of a quartz-calcite stockwork. The quartz portion of the vein also includes fragments of argillite country rock. The argillite has been chloritized around the borders of the veins. Coarse grain, white calcite - barren - forms the core of a  $\frac{1}{2}$  to  $1\frac{1}{2}$  inch wide crustified vein. No vugs or cavities occur in the stockwork, giving it a "tight" appearance. Many narrow fractures - less than 2 mm. in width - cut the stockwork and off-set some of the quartz veins of the stockwork.

These fractures are heeled with quartz and calcite.

These fractures appear to be barren.

Minerals: Quartz 80%  
Calcite 18%

Arsenopyrite  $1\frac{1}{2}$ %

Electrum  $\frac{1}{2}$ %

Chlorite

Specimen 2: Very coarse grain electrum occurs in curving syneresis cracks in chalcedonic quartz. The dendritic silver masses are up to two mm. wide and one centimeter or more in length. Arsenopyrite is not observed in this hand specimen. The electrum-bearing chalcedonic quartz is cut by a second vein of white vuggy chalcedonic quartz. Quartz crystals grow on the walls and in cavities in the latter chalcedonic quartz. This chalcedonic quartz exhibits well developed colloform banding. The electrum-bearing chalcedonic quartz appears to have been deposited in fractures in argillite. The argillite has been strongly chloritized - the

chlorite probably being core-stage alteration.

Minerals: Chalcedonic quartz 85%  
 Sclerum 5%  
 Chlorite 10%

Specimen 3

Massive colloform arsenic and antimony, with minor sulphur occur in a vein whose walls are banded chalcidonic silica. The walls of the veins are lined with minute crystals of quartz. The chalcidonic silica is similar in appearance to the youngest chalcidonic quartz occurring in Specimen #2. Sulphur is closely related to vugs in chalcidonic quartz wall-rock of arsenic-antimony veins. The arsenic-antimony vein is from  $\frac{1}{2}$  to  $1\frac{1}{2}$  inches wide.

Rhythmic bands of arsenic and antimony vary in thickness from  $\frac{1}{2}$  cm. to about 2 mm. The bands tend to decrease in thickness away from the centre of the colloform arsenic - allemontite - antimony masses. The arsenic and allemontite bands have been tarnished, whereas the antimony bands are fresh. Silver mineralization is not observed in the hand-specimen.

Minerals: Arsenic 80%  
 Antimony > 19%  
 Sulphur < 19%



	Colour	Hard- ness	Form/ Habit	Pleochro.	Anisotrop.	Association	Etch test	Microchem.	Other
ARSENOPYRITE	Galena white	F	prismatic, diamond shapes	weak	Strong in blues				
ARSENIC	white, → Sb dark to grey	C	colloform habit	weak	weak (appears I) in steel greys	with Sb, Ag (Sb, As)	FeCl <sub>3</sub> at 80°C* stains iridescent fast	As ± Sb	tarnishes faster than allemontite in air
ANTIMONY	white → As bright -er and lighter	C	colloform	non pleochro.-	fairly strong with grey, blue and tan colours	with As, Ag	FeCl <sub>3</sub> * at 80°C tarnishes but rubs off easily	Sb	doesn't tarnish in air after 4 weeks
ALLEMONTITE	white → As lighter → A ≈ same	C	colloform	nonpleochro.-	weak	with As, Sb Ag	FeCl <sub>3</sub> * at 80°C etches fairly strongly but not as much as As	As, Sb	
PYRRARGYRITE	blue-grey	≤ gn	-	weak	strong in faint colours	Silver, Sb As, (As, Sb)			Bright red internal reflection
SILVER	→ As yellow- ish white	Very sect- ile	-	-	strong - due to Sb in solid sol.	pyrrargyrite As, Sb	HgCl <sub>2</sub> : fast - iridesc. brown KOH: (-) KCN: tarnishes grey fast HCl: ± (slight tarnish?) FeCl <sub>3</sub> : stains iridesc HNO <sub>3</sub> : etch. + tarnishes iridescent	Ag(+) Au(-)	Dyscrasite <u>does not</u> effervesce with HNO <sub>3</sub>
ELECTRUM	yellow	m	dendritic	-	Seems to be anisotropic	Arsenopyrite	KCN: some grains etch weakly AgNO <sub>3</sub> : (-)	Au(+) Ag)	Tarnishes in air after a few days: Probably due to Ag

\* 1d. FeCl<sub>3</sub> + 1d. alcohol + 1d. H<sub>2</sub>O - all at ~80°C.

### Grain sizes and relative abundances

Two mineral associations are recognized :

- (1) Arsenopyrite - electrum association
- (2) Arsenic - allemontite - antimony - native silver - pyrrargyrite - sulphur - association

Minerals of Association 1 are not observed in contact with those of Association 2.

Mineral	Percentage	Grain size
Arsenopyrite	1%	max. 300 $\mu$
Electrum	1/2%	masses 1 cm long and ~ 2 mm wide
Quartz + Chlorite + Chalcedonic Qtz.	98 1/2%	
	<hr/> 100%	
Arsenic	45%	massive banded
Allerontite	20%	"
Antimony	5%	"
Native silver	1/2%	max. 200 $\mu$ , min 20
Pyrrargyrite	<<< .1%	max. 200 $\mu$
Sulphur	1/4%	massive
Chalcedonic Qtz.	29% <sup>+</sup>	
	<hr/> 100%	

### Explanations of Plates

Plate 1 Rhythmic banding here consists of alternate bands of antimony and allemontite. Rhythmic banding may be caused by fractional and rhythmic fractional crystallizations. Rhythmic banding (Edwards p. 19) form in the following manner. Allemontite in the S.E. quadrant is the older of the two allemontite bands. During crystallization of the gel, allemontite reached a degree of supersaturation before antimony with the result that allemontite crystallized first. During crystallization of allemontite, the degree of supersaturation of allemontite decreased below a point at which allemontite stopped crystallizing and antimony again began to crystallize — its concentration having reached supersaturation while allemontite crystallized. As the concentration of antimony <sup>again</sup> was reduced, allemontite again began to crystallize on the surface of the antimony.

Syneresis cracks are shrinkage cracks that form when a gel dries. (Boydell 1925)

The syneresis cracks tend to conform to banding. Radiating shrinkage cracks are quite common and they tend to control the prismatic-like shapes of silver in some bands.

Plate 2 Etching with  $FeCl_3$  brings out oolite-like growths rings in allemontite. The different degrees to which bands etch is probably due to different arsenic contents in the bands — those etched most strongly are probably richest in arsenic. The range of stability of allemontite at  $0^\circ C$  is from  $As_{47} Sb_{53}$  to  $As_{53} Sb_{47}$  — a miscibility gap of about 7%. Tiny grains of silver were probably deposited with the gel because these grains appear to have acted as centers of crystallization.

Plate 3 The order of deposition is ① arsenic, ② native silver and ③ pyrrargyrite. Silver mineralization appears to be associated with fractures. Pyrrargyrite clearly cuts and replaces silver. Tiny tear-drop shaped blebs of silver occur throughout the section. The blebs are elongated perpendicular to

fractures, It is highly unlikely that this silver formed by exsolution from antimony.

Plate 4 Electrum replaces arsenopyrite.

Plate 5 Etching with a solution of: 1 drop  $FeCl_3$  + 1 drop  $H_2O$  + 1 drop alcohol - heated to  $80^\circ C$  brings out apparent graphic eutectoid texture of antimony and stibarsenic. Edwards (1965) indicates this intergrowth homogenizes at  $470^\circ C$ . Lindgren (1933), according to Edwards (1965), believes graphic textures develop in compact host-rocks that were subjected to considerable pressure at the time of replacement. Edwards (1965) concludes therefore, that the texture indicates hypogene replacement. Edwards (1965) points out, however, that in the case of bournonite and chalcopyrite, such intergrowths are supergene.

Under high magnification, sheaf-like crystals of arsenic have formed perpendicular to banding. These crystals are probably the result of crystallization of amorphous material rather than recrystallization.

Numbers indicate position in the paragenetic sequence.

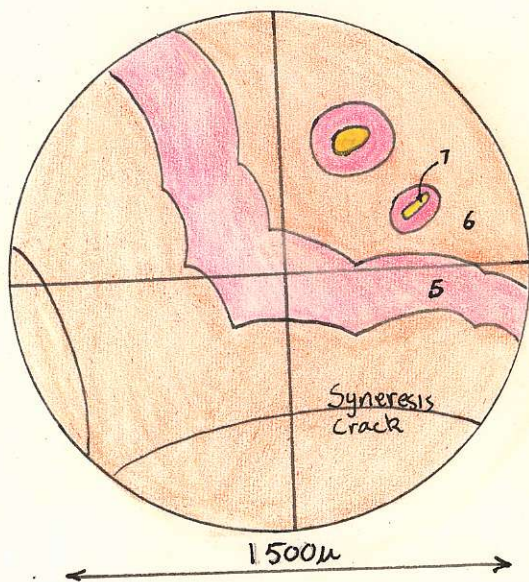


PLATE 1

- 5. Antimony
- 6. Allemontite
- 7. SILVER

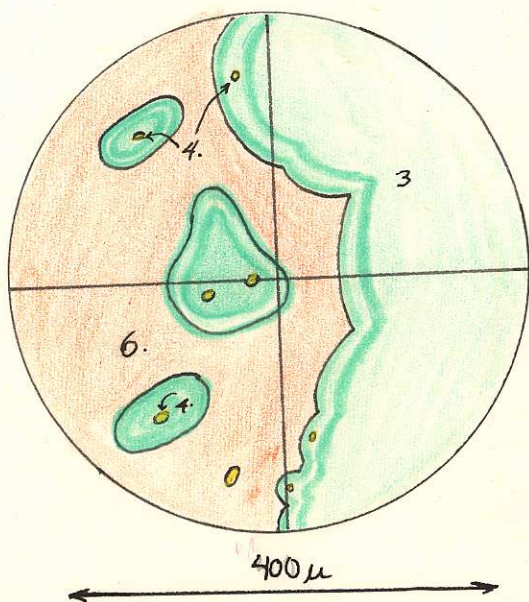


PLATE 2

- 3. Arsenic
- 4. Silver
- 6. Allemontite

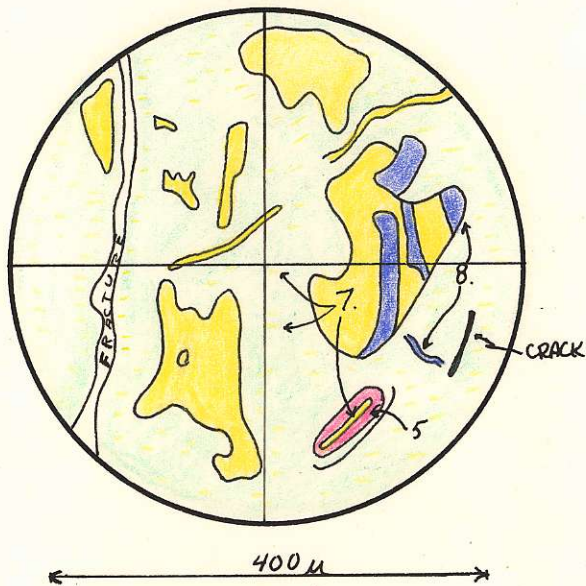


PLATE 3

- 3. Arsenic
- 5. Antimony
- 7. Silver
- 8. Pyrargyrite

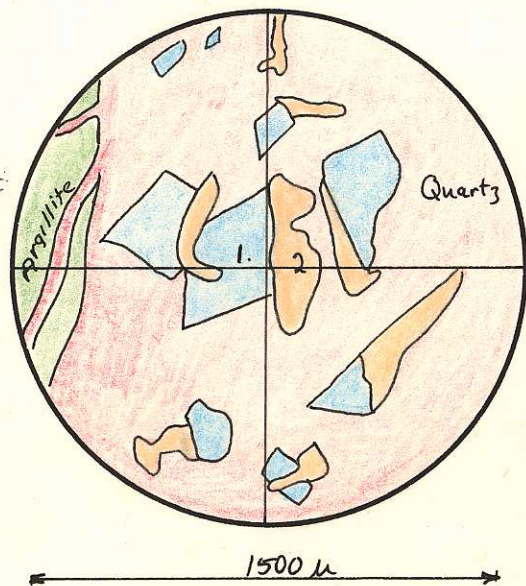
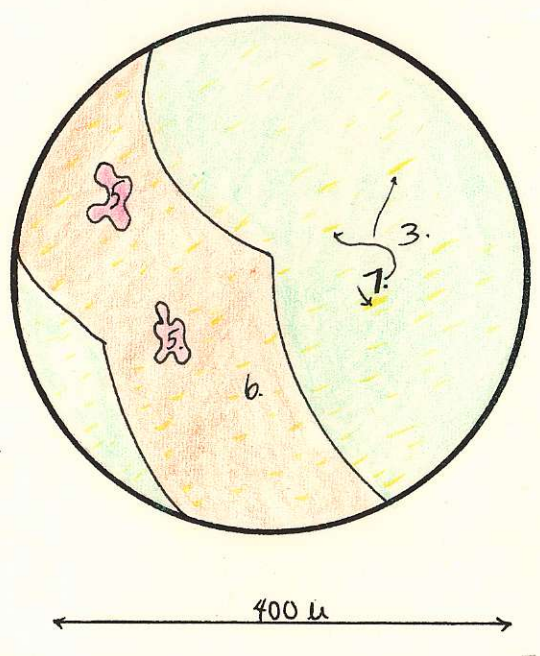


PLATE 4.

- 1) Arsenopyrite
- 2) Electrum



PLATES.

- 3. Arsenic
- 5. Antimony
- 6. Altemontite
- 7. Silver

A Discussion of Genesis

Textural and mineralogical evidence suggests the Engineer ore deposit formed at low temperature and at shallow depth. Colloidal arsenic and silica are generally thought of as representing low temperature deposition but the presence of arsenopyrite rhombes in shrinkage cracks in chalcidonic quartz is not as easily explained.

According to Lindgren (1933) Colloidal silica deposition is fairly common in hot spring associations. The gel, after deposition, crystallized to chalcidonic silica leaving fine banding to show the original amorphous form. Such siliceous sinters form today at Yellowstone National Park and according to Lindgren (1933) the waters which contain the siliceous sinter contain traces of arsenic, antimony and silver also. The mechanism responsible for precipitation of chalcidonic quartz is not clearly understood. Clark and Mendenhall have suggested and shown experimentally that  $H_2S$ , alumina and lime can cause flocculation of colloidal sulphide and sulphate particles. At Engineer, all three of these flocculants are present but there is little evidence to suggest that  $H_2S$  and calcite were present at the time colloidal silica was formed. However, the chalcidonic quartz is in contact with argillite which could have provided alumina for flocculation of silica. The occurrence of sulphur and calcite at Engineer indicates that both of them are post-chalcidonic - sulphur probably having formed by oxidation of  $H_2S$ .

It is interesting to note that Clark's experiment showed that 200-mesh arsenopyrite particles were capable of going into colloidal suspension to the extent of 15.8% after 67 days when placed in a slightly alkaline solution and  $H_2S$  gas passed through the solution intermittently for that length of time. Alumina and lime had the same effect on arsenopyrite, but to a much lesser extent. The most interesting observation in the experiment was that as soon as  $H_2$  gas was passed through



the suspension to drive out the  $H_2S$  left after the experiment, coagulation of the colloidal arsenopyrite began. This is analogous to  $H_2S$  escaping from a suspension on or close to the earth's surface.

This is one mechanism which could account for the apparent low temperature occurrence of arsenopyrite at Engineer.

Textures suggesting colloidal deposition of arsenopyrite are not observed in this suite, however, pellet textures, diffusion banding or preferably colloform texture would strongly suggest colloidal deposition.

Very high temperature gases can occur at fumaroles. Lindgren has suggested gas-phase deposition of tourmaline and carstite in these environments. Because the temperatures attained by such gases are about  $600^\circ C$ , arsenopyrite could conceivably form by gas phase deposition. Fumarole gases often contain considerable quantities of As, Fe, and S. Fumarole activity in the Engineer area is not known, however. Hot spring temperatures of the order of  $200^\circ C$  are mentioned by Lindgren (p. 454) but whether or not arsenopyrite could deposit at this temperature, is open to question.

Lindgren (1933) p. 75, states that springs at Smaloni, France, are genetically related to quartz veins containing pyrite and arsenopyrite. He doesn't elaborate. (French reference)

The spheroidal masses of arsenic occurring in some of the veins at Engineer are formed by surface tension acting on a flocculating colloidal precipitate with high viscosity. (Boydell). Shrinkage cracks have developed parallel to the rhythmic bands of antimony and allemontite. All of the bands in the arsenic at Engineer are probably not true 'Hiesegang' bands because the mineral composition of most of the bands are too similar, i.e. allemontite and arsenic. However, alternate bands of arsenic and antimony are quite distinctive and may be termed 'Hiesegang' bands. Lindgren (1933) p. 190, states Hiesegang bands

form by interaction of electrolytic solutions in a gel, that is, in this case, rhythmic precipitation of arsenic and antimony.

Stevenson (1943) has described a similar arsenic-antimony occurrence at Criss Creek, B.C. He contends the arsenic-antimony, there is hypogene in origin, because of the exsolution textures (Lasky) shown by arsenic and antimony. These exsolution textures consist of antimony exsolved from arsenic. He believes that calcium carbonate, from the wall-rock, was assimilated and served to flocculate the colloidal arsenic and antimony - the colloform arsenic at Criss Creek being in contact with the carbonate wall-rock.

Exsolution textures, similar to those described by Stevenson are not observed in the Engineer suite but the natural intergrowth of "allemontite I" occurs in one of the sections. "Allemontite I" consists of an intergrowth of the  $Sr_2$  phase and the (As<sub>2</sub>Sb) phase. The intergrowth observed has a graphic form. Graphic texture can form by exsolution, simultaneous deposition or replacement. (R.M. Thompson; notes)

Deposition of silver with the colloidal arsenic-antimony was limited to trace amounts. Etching with  $FeCl_3$ , reveals tiny grains of silver in the centre of colite-like forms. The silver grains appear to have acted as centres of crystallization. However, most of the silver was deposited after the development of syneresis cracks. One polished section shows how silver is related to these shrinkage cracks. Tiny droplets of native silver appear to have diffused out from these cracks and now occur fairly uniformly distributed throughout the section. Some places, close to the shrinkage cracks, silver has accumulated to form blebs up to 200  $\mu$  in diameter or more. In other places, they form prisms-like grains. The elongated blebs tend to be orientated approximately at right angles to the syneresis cracks and it is suggested that radiating

Shrinkage cracks control the prism-like forms. In other places, the larger silver grains have curving outlines, suggesting syneresis cracks controlled the shape of these silver grains. Limited solid solution of silver in antimony (R.M. Thompson: notes) is possible, but it is unlikely that all this silver could have formed by exsolution. Several veinlets of silver can be seen to cut the arsenic and antimony showing that the silver is post arsenic and antimony. Pyrrangyrite is clearly post silver.

## Paragenesis

1) Brecciation of argillite country rock and introduction quartz containing arsenopyrite. There was insufficient quartz to fill the veins with the result that crustified veins developed upon later introduction of calcite.

Arsenopyrite was also deposited in shrinkage cracks in chalcedonic quartz.

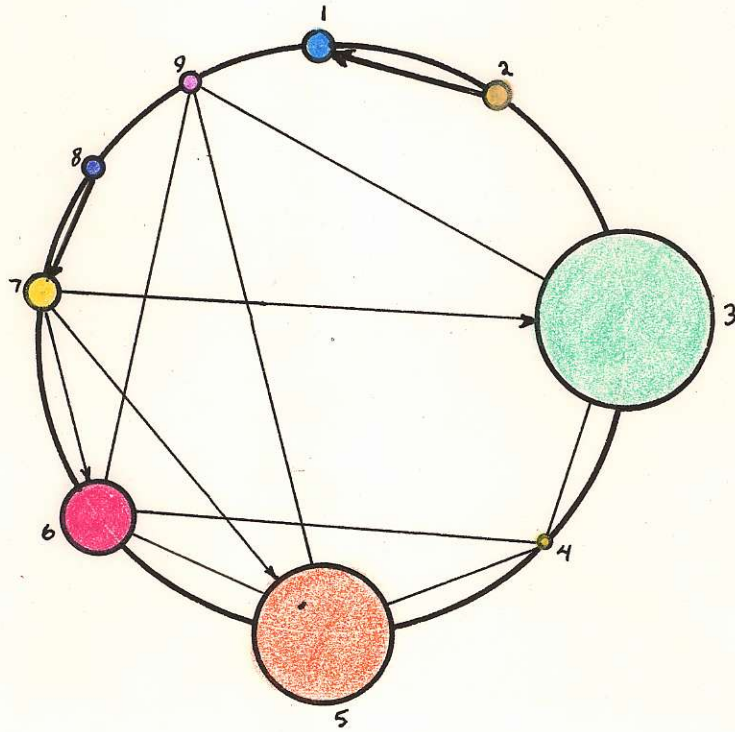
2) Electrum was deposited next in quartz and chalcedonic quartz. In chalcedonic quartz, syneresis cracks control electrum mineralization. Fractures in quartz control electrum mineralization. Chloritization of the argillite is associated with electrum deposition.

3) More chalcedonic quartz was deposited. This later stage of chalcedonic quartz is barren. This chalcedonic quartz form the walls of veins and cavities in which colloform arsenic and antimony were deposited next.

4) After drying of the arsenic-antimony gel and subsequent crystallization of these, native silver was deposited in syneresis cracks.

5) Trace amounts of pyrrhotite was deposited next.

VAN DER VEER DIAGRAM FOR THE  
ENGINEER MINE  
MINERAL SUITE



- ① ARSENOPYRITE
- ② ELECTRUM
- ③ ARSENIC
- ④ SILVER
- ⑤ ALLEMONTITE
- ⑥ ANTIMONY
- ⑦ PYRRARGYRITE
- ⑧
- ⑨ SULPHUR

→ ALWAYS IN CONTACT  
AND REPLACING

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