

GOLD AND SULPHIDE MINERALIZATION IN THE HUNKER CREEK AREA, YUKON TERRITORY, CANADA

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ABSTRACT

The Hunker Creek area is located 30 km southeast of Dawson City, Yukon. Gold and sulphide-bearing quartz veins (MINFILE 1150 067,068) crosscut metamorphic rocks of the Klondike Schist. The veins are enclosed by envelopes of sericitic (inner) and propylitic (outer) alteration. Locally, carbonatization occurs between propylitized and sericitized rocks. Three stages of vein mineralization can be distinguished: (I) quartz, carbonates, gold, arsenopyrite, pyrite, pyrrhotite, chalcopyrite, and galena; (II) quartz, carbonates, chalcopyrite, sphalerite, tetrahedrite, freibergite, polybasite, 'polyargyrite', argentite, pyrostitbnite and galena; (III) quartz and gold.

Fluid inclusion data indicate that stage I minerals precipitated from hydrothermal solutions containing CO₂. Homogenization temperatures range from 260° to 390°C. Stage II aqueous fluid inclusions homogenize between 190° and 260°C. Stage III inclusions homogenize between 120° and 210°C. Salinities of the three stages range from 0 to 7.2 wt-% NaCl equiv. and show no significant changes with time.

It is suggested that stage I mineralization was initiated by unmixing of an original single-phase H₂O and CO₂ bearing fluid, and that subsequent hydrothermal evolution was controlled mainly by decreasing temperature.

RÉSUMÉ

La région du ruisseau Hunker est située à 30 km au sud-est de Dawson City (Yukon). Des veines renfermant de l'or et du quartz recoupent le schiste métamorphique de Klondike. Les veines sont entourées d'enveloppes d'altération séricitique (intérieure) et propylitique (extérieure). Par endroits, il y a carbonatation entre les roches séricitisées et les roches propylitisées. Trois stades de minéralisation peuvent être distingués : I) quartz, carbonates, or, arsénopyrite, pyrite, pyrrhotine, chalcopyrite et galène, II) quartz, carbonates, chalcopyrite, sphalérite, tétrahédrite, freibergite, polybasite, «polyargyrite», argentite, pyrostitbnite et galène, III) quartz et or.

Les données sur les inclusions fluides indiquent que les minéraux du stade III ont précipité à partir de solutions hydrothermales renfermant du CO₂. Les températures d'homogénéisation varient de 260 à 390 °C. Les inclusions de fluide aqueux du stade II sont homogénéisées à des températures variant entre 120 et 210 °C. Pour les trois stades les salinités varient entre 0 et 7,2 % d'équivalent de NaCl en poids et ne présentent aucune variation importante en fonction du temps.

Il est suggéré que la minéralisation de stade I a été amorcée par séparation d'un fluide original à une seule phase renfermant H₂O et CO₂, et que l'évolution hydrothermale ultérieure a été principalement déterminée par une température à la baisse.

INTRODUCTION

The Hunker Creek area, located 30 km southeast of Dawson City, is part of the Klondike District (Fig. 1). Gold was discovered here in the late 19th century. The bulk of the gold production was derived from placer deposits. A relatively small amount of exploration was directed toward finding lode sources for the placer gold.

The purpose of this paper is to describe the mineralogy of three gold quartz veins (Mitchell Vein (MINFILE 1150 068a), Sheba Vein, (1150 068b) and Hunker Dome (1150 067) and to present a genetic model for the mineralizing events. The study is based on thin, polished and thick section microscopy, microprobe data, and fluid inclusion investigations.

GEOLOGY

The Hunker Creek area is underlain by metamorphic rocks of the Nasina Series, Klondike Schist, and the Moosehide Assemblage. The three units belong to the Yukon Cataclastic Complex (Tab. 1, Fig. 2). The Nasina Series consists of graphitic schist, graphitic quartzite, siliceous marble, and minor chlorite and muscovite schist. The Klondike Schist is represented by quartz-augen schist, quartz-chlorite-muscovite schist and muscovite schist. The metamorphic grade of the rocks ranges from upper greenschist to middle amphibolite facies (Mortensen, 1990). Mylonitic serpentinite, amphibolite, and chlorite and talc schist of the Moosehide Assemblage overlie the Klondike Schist. Tempelman-Kluit (1979, 1981) correlated this unit with the Anvil Allochthonous Assemblage, a sheared ophiolite sequence. Shear zones are developed between the Nasina Series, Klondike Schist and Moosehide Assemblage (Metcalf and Clarke, 1983; Mortensen, 1990).

Younger intermediate andesites and their equivalents occur in outcrops along Last Chance Creek. They do not show any indications of major tectonic deformation. According to Debicki (1984, 1985), these volcanic rocks can be correlated with the Carmacks Group volcanic suite. Felsic tuffs, monolithic and heterolithic felsic breccias (Skukum Group), and miarolitic quartz-feldspar porphyry (Nisling Range Alaskite) are of Eocene age (Debicki, 1984). The bedrock is covered by Pleistocene alluvial gravels.

MINERALIZATION

The steeply dipping, northwest striking Mitchell Vein (MINFILE 1150 068A) has an exposed length of about 100 m, an average thickness of 30 cm and an explored depth of about 25 m. The Sheba Vein, (MINFILE 1150 068b) is up to 1 m thick in surface exposures. It is located 850 m south of the Mitchell Vein and dips steeply to the northeast. At Hunker Dome (MINFILE 1150 067), quartz veins are highly variable in thickness to a maximum of 60 cm. The veins dip steeply to the east or west. Tectonic relationships indicate that the three veins formed during the same mineralizing event.

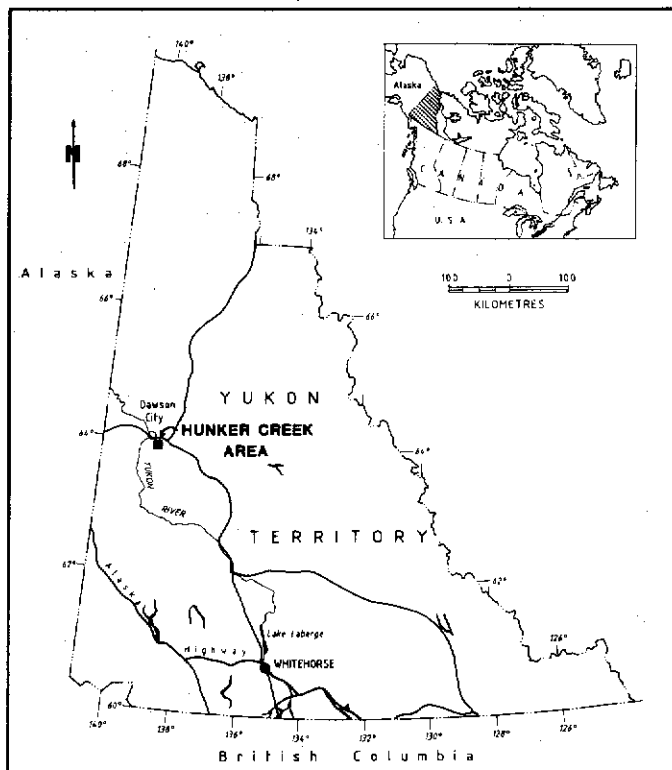


Figure 1. Location map of the Hunker Creek area.

Gold

Three different types of gold have been observed: (1) Inclusions of gold ($<0.01\text{mm}$) with a mean silver content of 17.58 wt-% occur in pyrite from Mitchell Vein (Fig. 3, Tab. 2). (2) Macroscopic visible gold containing small pyrite inclusions was found in quartz from Hunker Dome vein (Fig. 4). This type of gold has mean silver and tellurium contents of 12.74 wt-% and 0.08 wt-%, respectively. (3) Gold intergrown with galena from a Hunker Dome quartz vein (Fig. 5) contains high silver, averaging 22.07 wt-% (Tab. 2).

Silver

Silver-bearing minerals include tetrahedrite-tennantite group minerals, sulphosalts and galena.

Tetrahedrite-tennantite group minerals found in the Hunker Creek area are freibergite, arsenic-bearing freibergite, and arsenic-bearing tetrahedrite. Freibergite and tetrahedrite are characterized by highly variable iron, zinc and cadmium contents (Fig. 6). Freibergite and tetrahedrite intergrown with sphalerite have low zinc and cadmium (Fig. 7). Except for arsenic-bearing freibergite, there is a strong positive correlation between antimony and silver in freibergite and tetrahedrite (Fig. 8).

Freibergite inclusions are often myrmekitically intergrown with galena. This feature indicates dissolution processes along grain boundaries as described by Ramdohr (1980). Freibergite is also intergrown with pyrite, chalcopyrite, sphalerite,

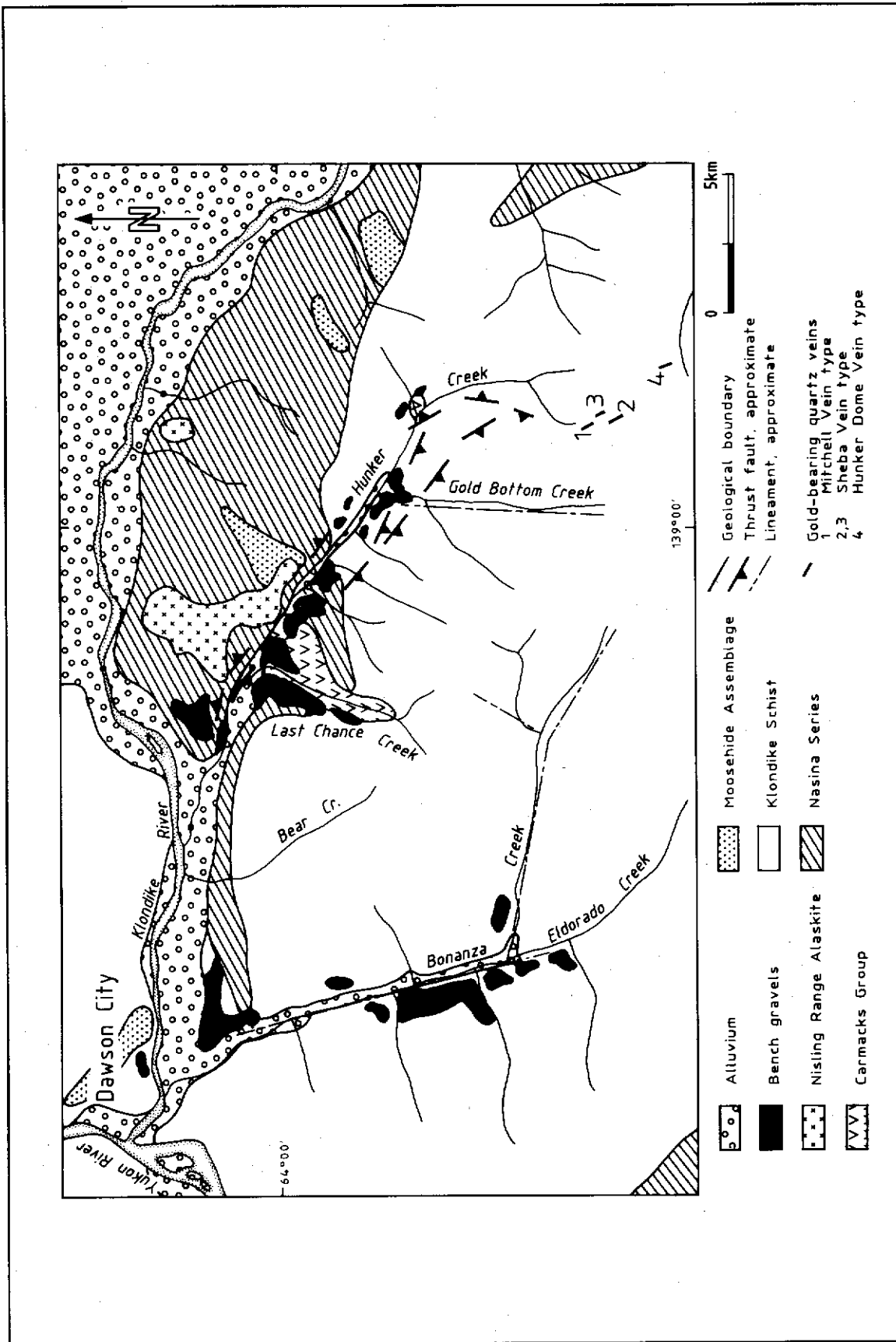


Figure 2. Bedrock geology of the Klondike area (modified after Bostock, 1942; Boyle, 1979, 1987; Debicki, 1984 and 1985, and Dufresne, 1987).

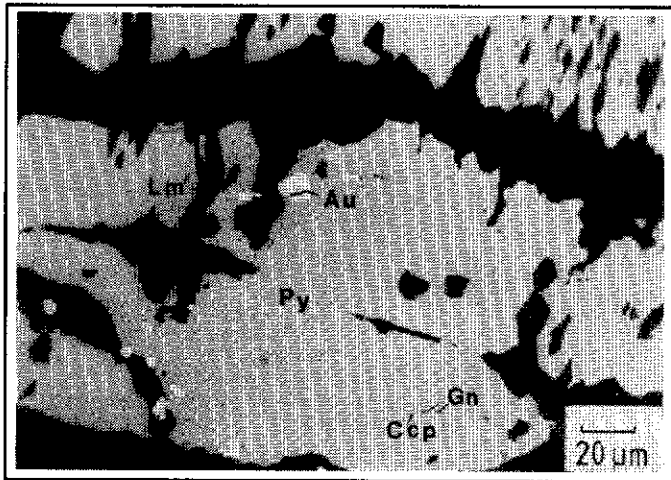


Figure 3. Minute anhedral chalcopyrite (Ccp), galena (Gn) and gold (Au) inclusions within pyrite (Py) which is partly replaced by limonite (Lm): Mitchell Vein.

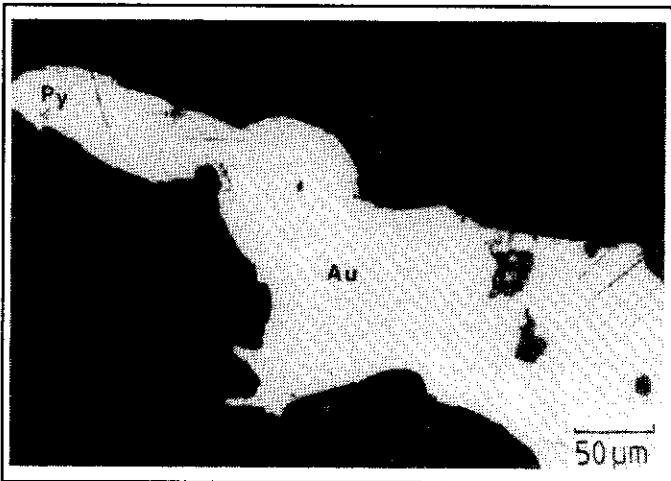


Figure 4. Irregular-shaped gold grain (Au) with anhedral pyrite (Py) inclusions in quartz matrix: Hunker Dome.

polybasite, argentite and 'polyargyrite' and contains rounded inclusions of galena and argentite (Fig. 9). Fractures within euhedral pyrite are partly healed by freibergite which is coated by galena. Freibergite contains high amounts of copper, silver, antimony and cadmium (Tab. 3).

Arsenic-bearing freibergite (<0.03mm) is often intergrown with chalcopyrite and sphalerite and also occurs in galena. Its chemical composition as shown in Table 3 differs from the above-mentioned freibergite: the average arsenic content is 3.68 wt%, the copper, sulphur, iron and zinc contents are higher, and silver and antimony are lower.

Arsenic-bearing tetrahedrite (<3mm) was found only as inclusions in galena from Vein 3 of the Sheba Vein system. It is intergrown with chalcopyrite, sphalerite and subhedral arsenopyrite (Fig. 10), and contains more copper and arsenic,

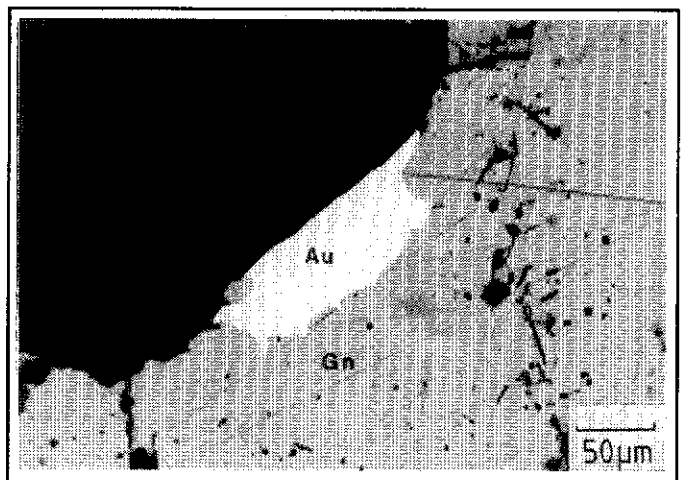


Figure 5. Anhedral gold (Au) intergrown with galena (Gn) in quartz (black): Hunker Dome.

and less silver than the freibergites (Tab. 3).

Sulphosalts like polybasite, 'polyargyrite', pyrostilbnite, and argentite are intimately intergrown with and occur as tiny inclusions in galena. Intergrowths with freibergite (Fig. 9), pyrite, coarse-grained chalcopyrite and sphalerite have also been observed. The term 'polyargyrite' is used in the sense of Dana and Dana (1946) and Strunz (1977) who describe 'polyargyrite' as a submicroscopic intergrowth between pyrrargyrite and polybasite or argentite and tetrahedrite.

Galena from the Mitchell Vein is intergrown with pyrrhotite and chalcopyrite. All three sulphides form inclusions in pyrite. The small galena inclusions contain an average of 0.5 weight per cent silver. Coarse-grained, euhedral to anhedral galena occurs at Sheba Vein, Vein 3, and at Hunker Dome. It contains euhedral pyrite and arsenopyrite, anhedral chalcopyrite, sphalerite, freibergite, tetrahedrite, polybasite, 'polyargyrite', argentite, and pyrostilbnite. The mean silver content is 0.2 wt-%.

Arsenopyrite occurs as subhedral inclusions (<0.03mm) in pyrite and as cataclastic single grains (<0.08mm) intergrown with coarse-grained chalcopyrite, arsenic-bearing tetrahedrite, and galena. Cataclastic arsenopyrite is partly replaced by chalcopyrite, sphalerite, and galena.

Euhedral **pyrite** from veins contains rounded inclusions of anhedral gold, pyrrhotite, chalcopyrite, galena, and arsenopyrite. Pyrite from wall rock has inclusions of pyrrhotite, chalcopyrite, galena, quartz, anhedral rutile, and carbonate. Microprobe analyses do not reveal any differences between pyrite from vein quartz or wall rock. Pyrite from Sheba Vein and Hunker Dome is fractured and healed by chalcopyrite, sphalerite, tetrahedrite, freibergite, galena, and quartz.

Chalcopyrite occurs intergrown with pyrrhotite and galena as inclusions in pyrite. Coarse-grained chalcopyrite contains grains of euhedral pyrite (<0.08mm), arsenopyrite and anhedral arsenic-bearing tetrahedrite, and is intergrown with galena, sphalerite and freibergite. Chalcopyrite also occurs in

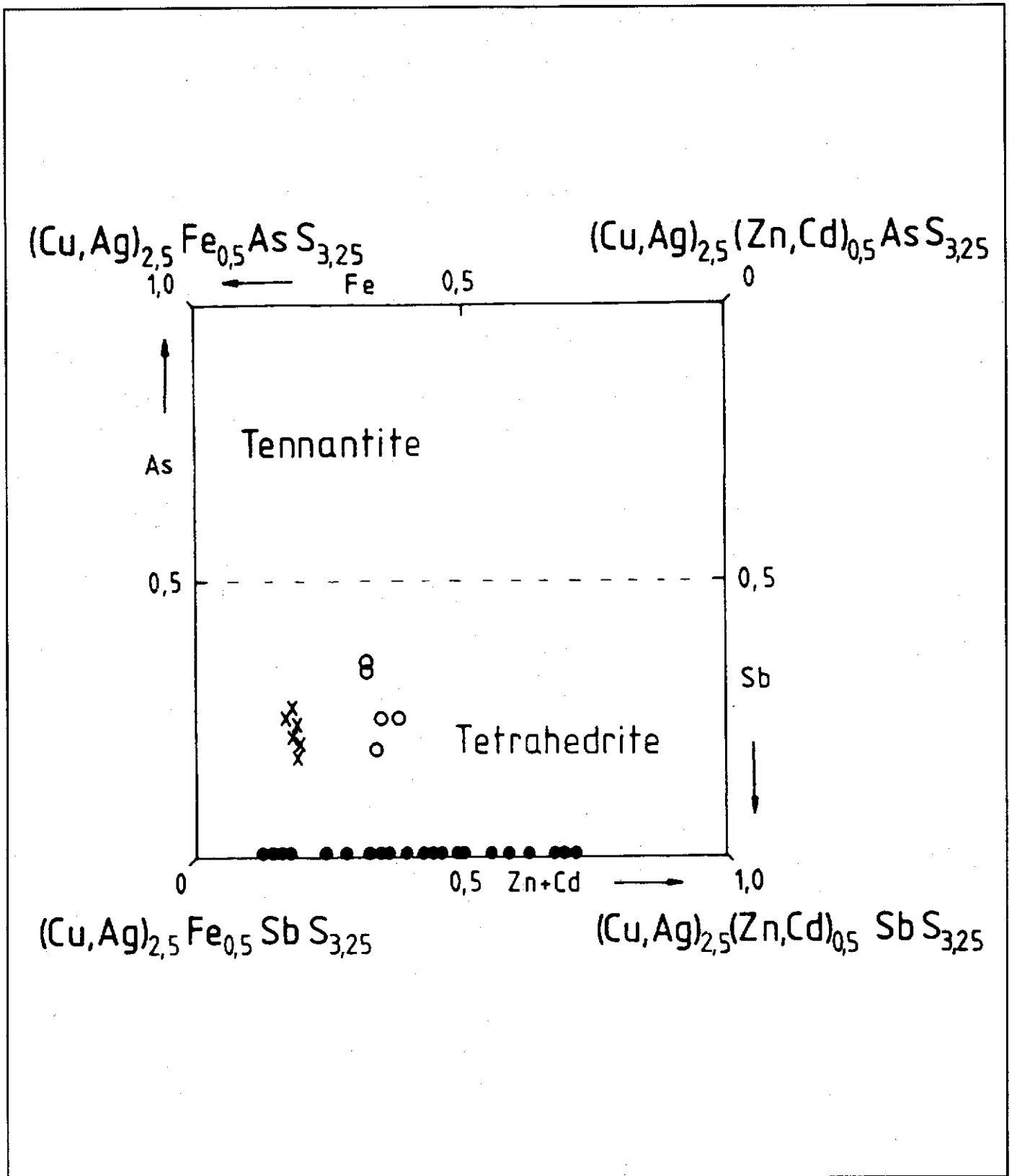


Figure 6. Composition of tetrahedrite-tennantite group minerals from Hunker Dome and Sheba Vein; freibergite = solid circles, arsenic-bearing freibergite = crosses, arsenic-bearing tetrahedrite = open circles (tennantite-tetrahedrite diagram, modified after Springer, 1969).

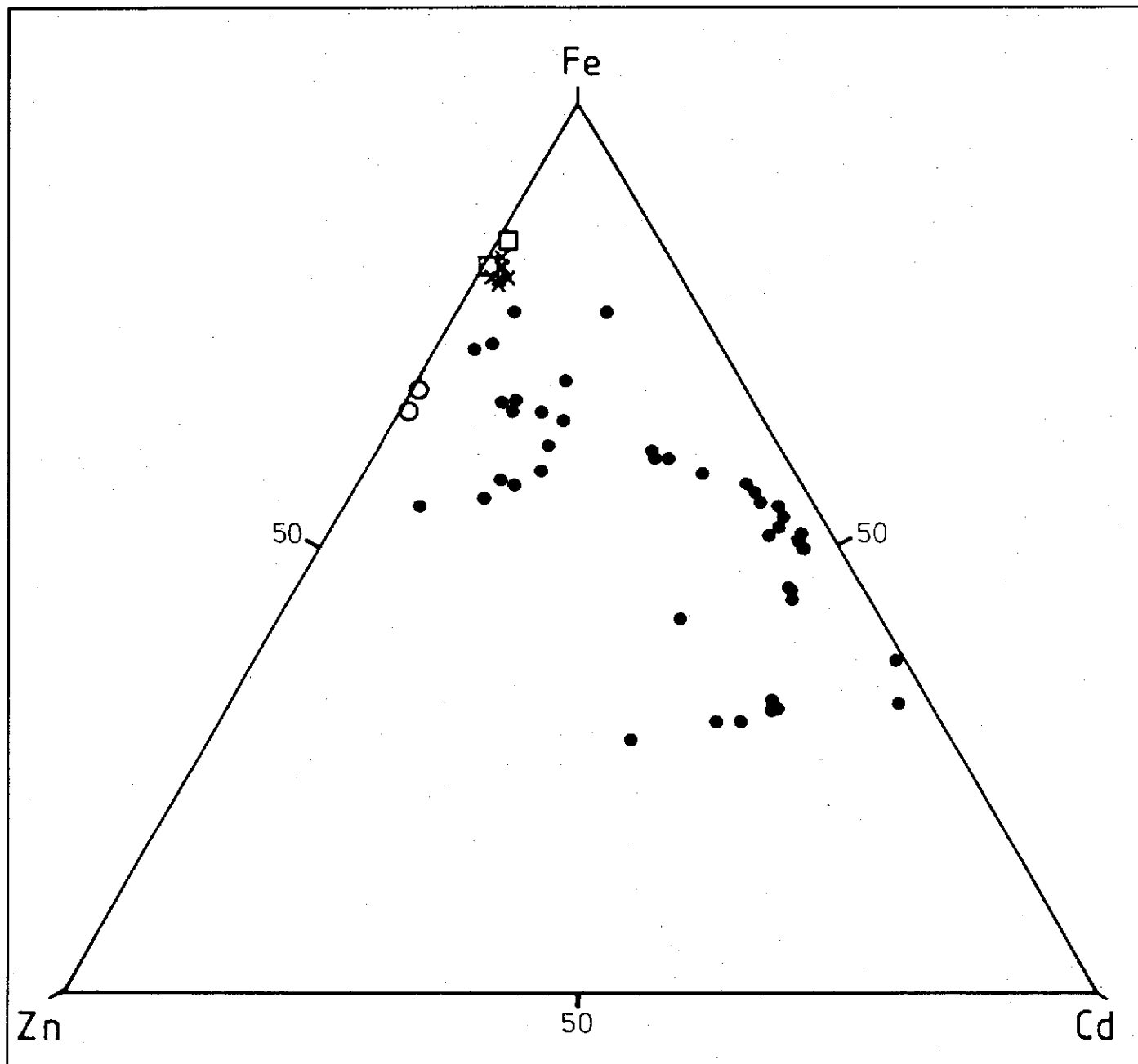


Figure 7. Relative portions of iron, zinc and cadmium (at-%) in tetrahedrite-tennantite group minerals from Hunker Dome and Sheba Vein; solid circles = freibergite not intergrown with sphalerite, open squares = freibergite intergrown with sphalerite, crosses = arsenic-bearing freibergite intergrown with sphalerite, and open circles = arsenic-bearing tetrahedrite intergrown with sphalerite.

galena as coatings on subhedral pyrite and euhedral arsenopyrite crystals. Microprobe analyses indicate no differences between the trace element content of coarse-grained chalcopyrite and the rounded chalcopyrite inclusions in pyrite.

Sphalerite (<3mm) is generally intergrown with arsenopyrite, freibergite, chalcopyrite, and tetrahedrite. Sometimes sphalerite contains drop-shaped chalcopyrite inclusions, and has grown onto subhedral pyrite crystals

enclosed by galena. Rounded chalcopyrite inclusions in sphalerite are interpreted as 'chalcopyrite disease' in the sense of Barton (1978).

Limonite, which formed from pyrite as a result of supergene processes, partly contains relict gold grains. Cerussite and finely disseminated covellite occur along fractures in galena. Covellite replacing chalcopyrite, freibergite and tetrahedrite contains up to 0.5 wt-% Ag.

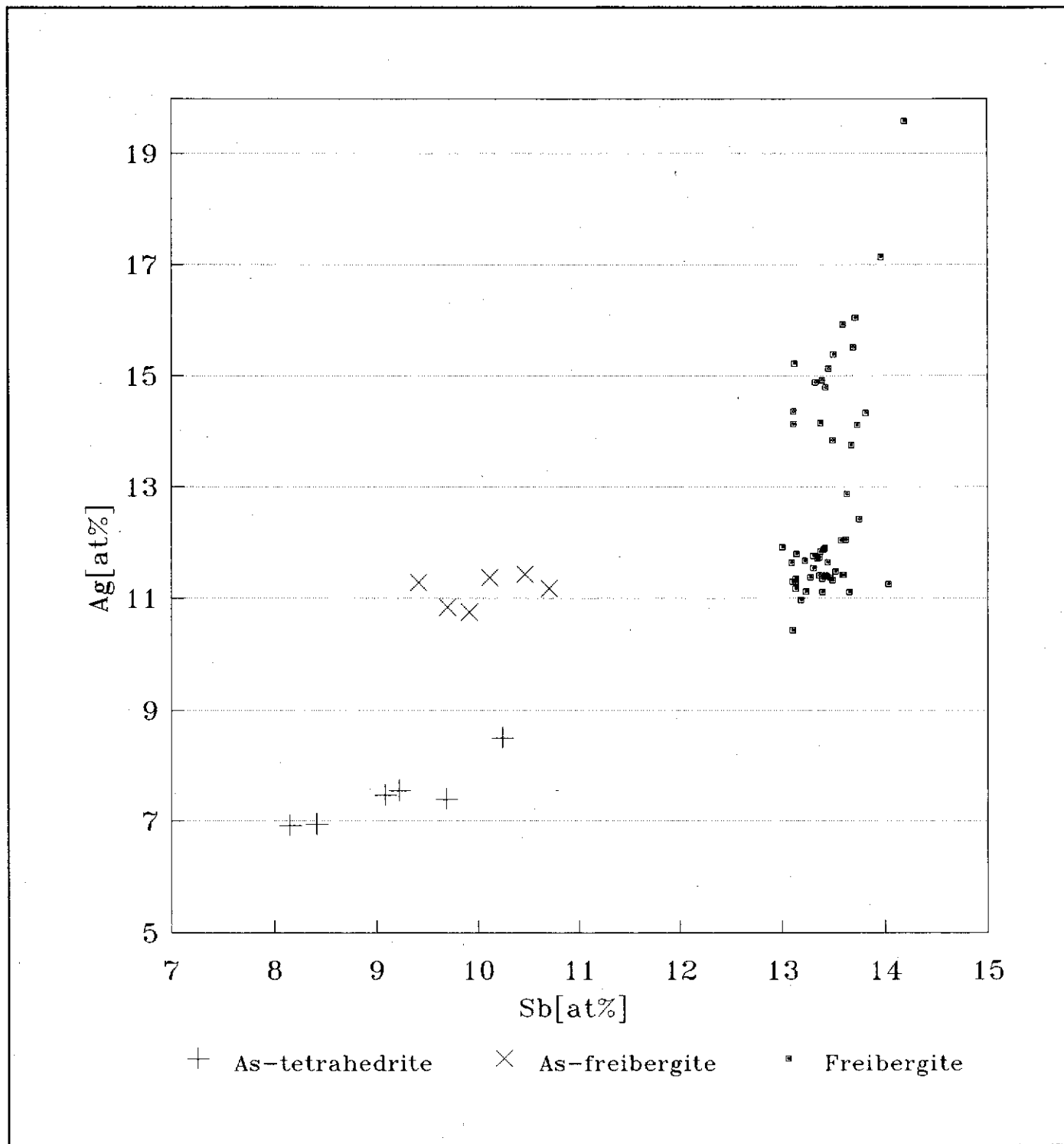


Figure 8. Relationship between silver and antimony (at-%) in tetrahedrite and freibergite from gold-bearing quartz veins; Hunker Dome and Sheba veins.

PARAGENETIC SEQUENCE

Three stages of mineralization are recognized (Fig. 11). Stage I was observed in the Mitchell, Sheba and Hunker Dome veins, and is characterized by the precipitation of

arsenopyrite, pyrite, pyrrhotite, chalcopyrite, galena, and gold. Rutile and carbonate form inclusions in pyrite of the wall rock.

Stage II mineralization is developed in the Sheba Vein and at Hunker Dome. The paragenesis consists of chalcopyrite,

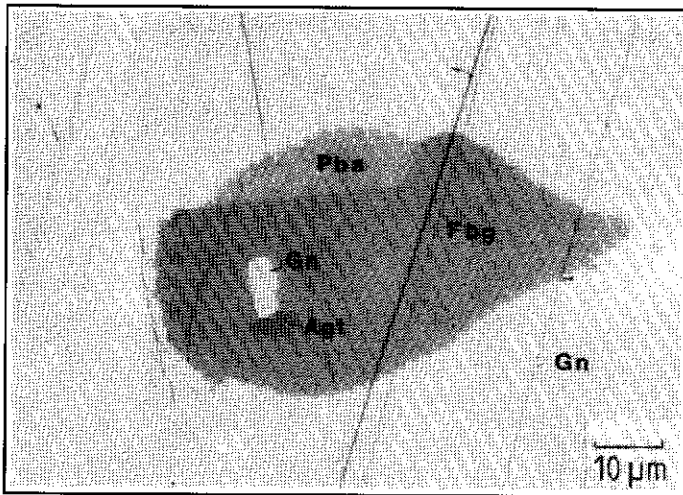


Figure 9. Sheba Vein: anhedral freibergite (Fbg) and polybasite (Pba) with inclusions of galena (Gn), and argentite (Agt) surrounded by galena.

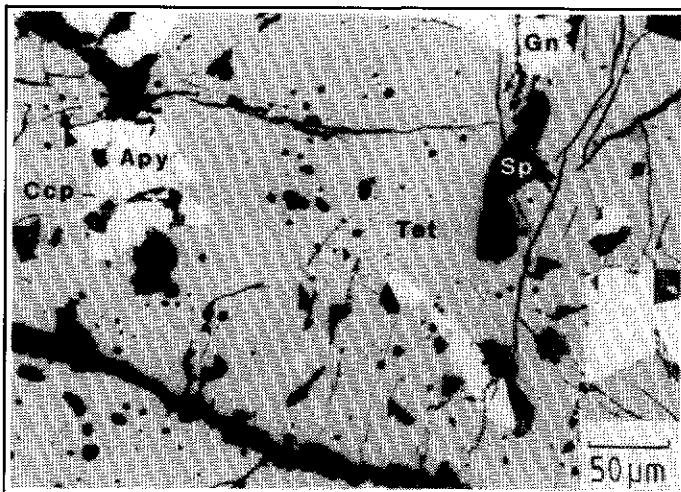


Figure 10. Coarse-grained, arsenic-bearing tetrahedrite (Tet) containing subhedral arsenopyrite (Apy), anhedral chalcopyrite (Ccp), and sphalerite (Sp). Galena (Gn) is the host of this mineral assemblage: Vein (3).

sphalerite, tetrahedrite, freibergite, polybasite, 'polyargyrite', argentite, pyrostitbnite, and galena. Coarse-grained sphalerite, tetrahedrite, chalcopyrite and freibergite of stage II replace pyrite and arsenopyrite of stage I. Coarse-grained chalcopyrite, sphalerite, and arsenic-bearing tetrahedrite are rimmed and partly enclosed by freibergite, polybasite, 'polyargyrite', and argentite. Remaining voids are filled by galena, the youngest mineral phase of stage II.

During Stage III, which was observed only in a quartz vein at Hunker Dome, silver-rich gold intergrown with galena was formed. Quartz is abundant in all three stages.

	Stage I	Stage II	Stage III
Quartz			
Carbonate			
Rutile			
Arsenopyrite			
Pyrite			
Pyrrhotite			
Chalcopyrite			
Galena			
Gold			
Sphalerite			
Tetrahedrite			
Freibergite			
Polyargyrite			
Polybasite			
Argentite			
Pyrostitbnite			

Figure 11. Paragenetic sequence of gold-sulphide mineralization: Mitchell Vein, Sheba Vein and Hunker Dome.

WALL ROCK ALTERATION

Gold-bearing quartz veins are surrounded by a distinct alteration envelope, consisting of an inner zone of sericitization which grades outward into a propylitic zone. A more intensive carbonatization is occasionally developed between the outer propylitic and inner sericitic zone. The alteration envelope ranges up to about 2 m in thickness. The inner zone is characterized by sericite/phengite, quartz and minor amounts of euhedral to subhedral pyrite which contains inclusions of mica, chlorite and quartz. Sericite/phengite micas replace plagioclase, muscovite and chlorite. The propylitic zone contains mainly chlorite, epidote and plagioclase. Muscovite, secondary quartz, and carbonates like calcite/dolomite, occur in smaller amounts. In the carbonate zone, secondary quartz and carbonates replace plagioclase, muscovite and chlorite.

MICROTHERMOMETRIC STUDY

Fluid inclusion studies were carried out in order to relate the paragenetic sequence to the evolution of the hydrothermal fluids. Investigations focused on vein quartz with several different habits: clear and euhedral, milky and brittle, cataclastic, and late stage quartz. Fluid inclusion data confirmed the three stages of mineralization established by microscopic observations.

Stage I: Two phase H₂O-bearing fluid inclusions, as well as three phase H₂O and CO₂-bearing inclusions, were identified to be of primary origin due to their spatial distribution in quartz grains. Homogenization temperatures range from 260° to 390° C with a maximum at about 300° ± 40° C (Fig. 12). Melting of frozen CO₂ occurs between -60.2° and -56.6° C.

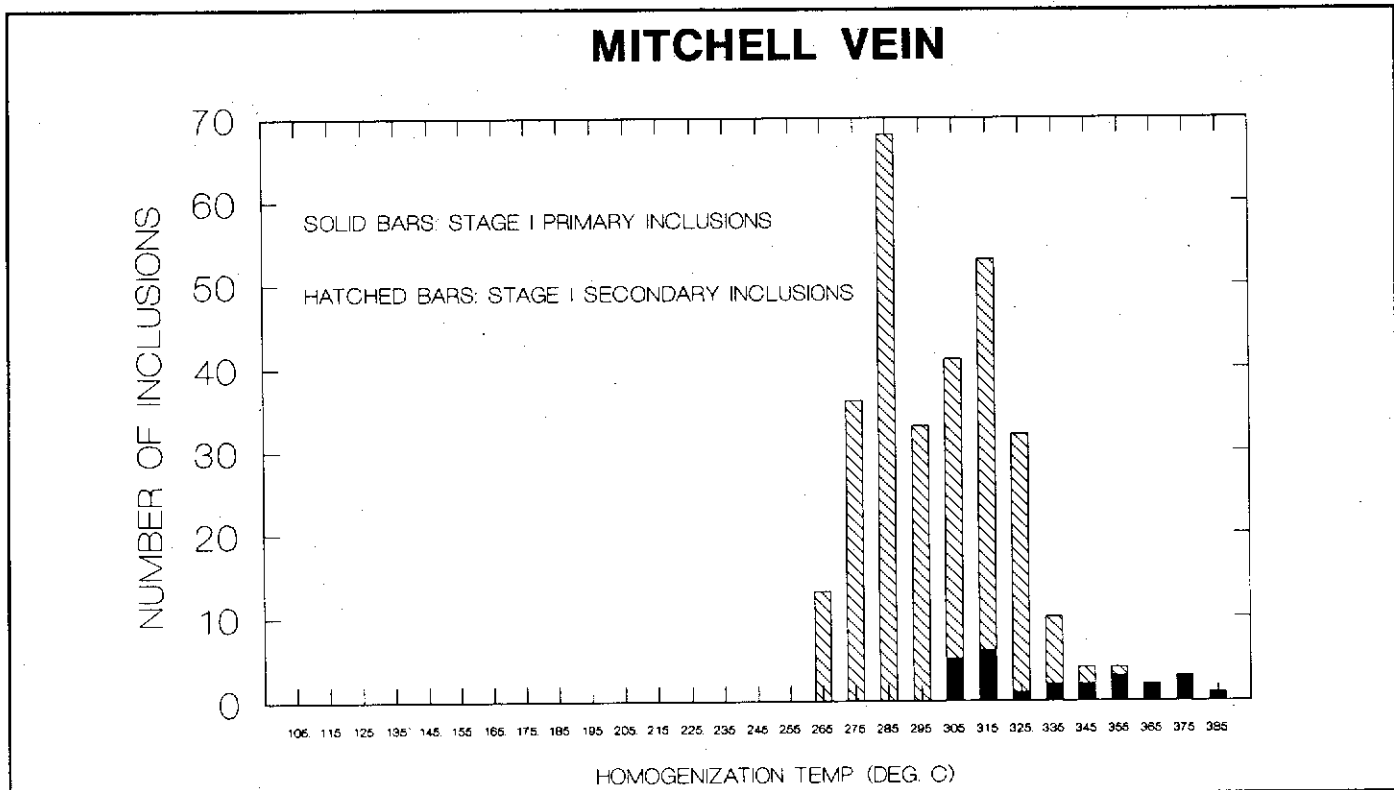


Figure 12. Histogram showing frequency distribution of homogenization temperatures for stage I inclusions in quartz: Mitchell Vein.

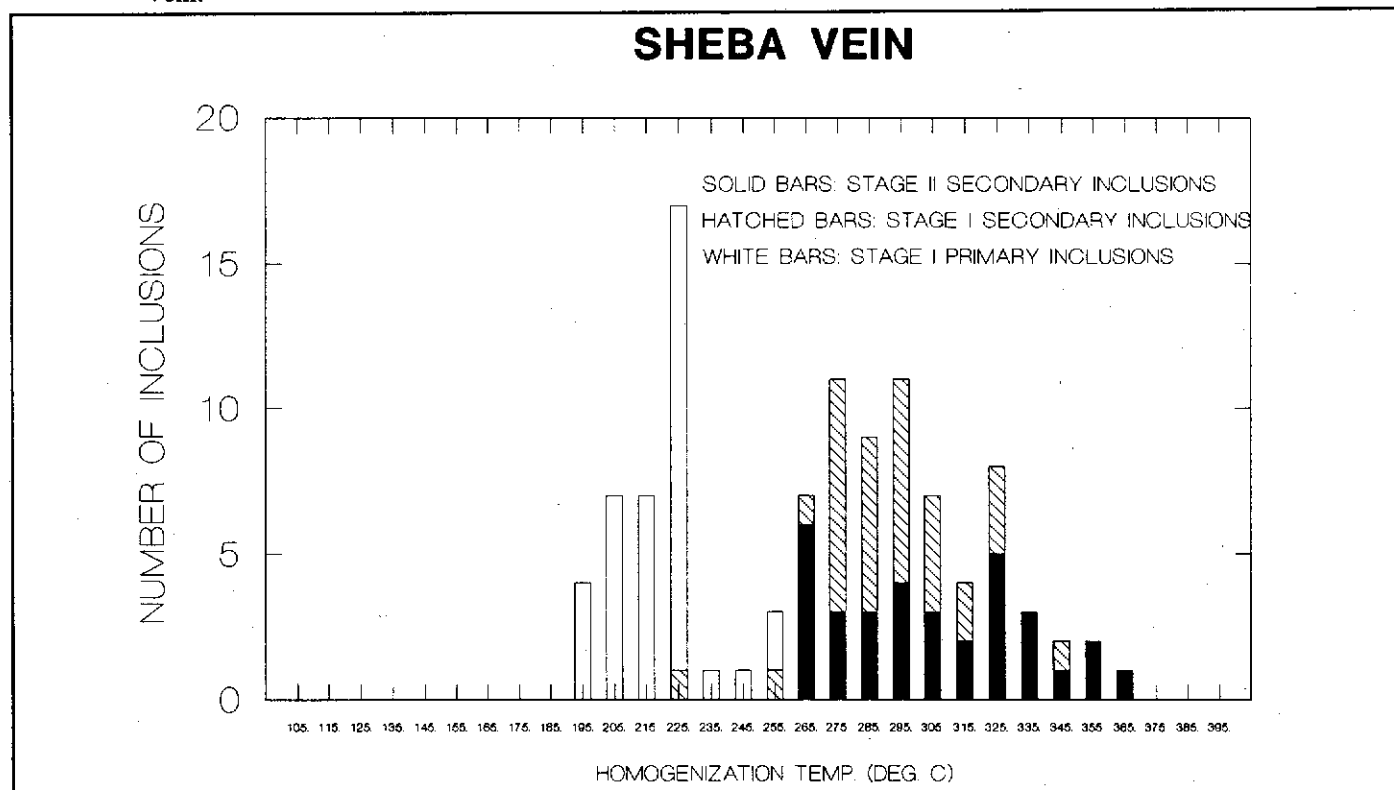


Figure 13. Histogram showing frequency distribution of homogenization temperatures for stage I and II inclusions in quartz: Sheba Vein.

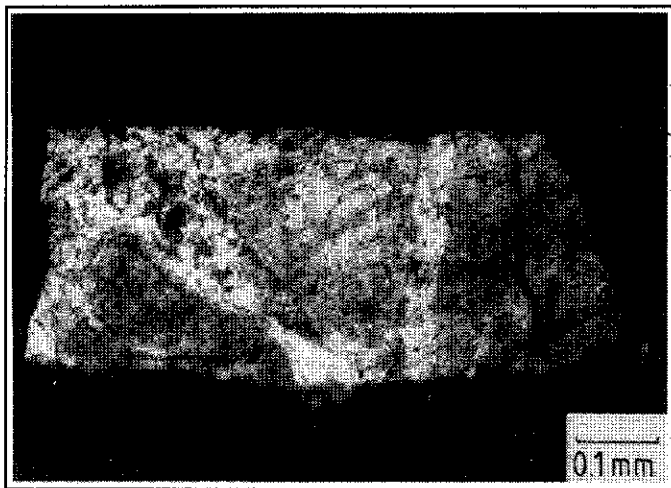


Figure 14. Earlier cataclastic quartz relics (medium to dark grey) healed by late, fine-grained quartz (white): Hunker Dome.

The deviation from the melting point of pure CO_2 (-56.6°C) is evidence of the presence of gases like CH_4 or H_2S (Hollister and Crawford, 1981). Melting point measurements of the aqueous phase show salinities ranging from 0 to 7.2 wt-% NaCl equivalent. Secondary fluid inclusions of stage I occurring along microfractures are similar to primary inclusions with respect to their phase relationships and fluid characteristics. Stage I primary and secondary inclusions are observed in all veins.

Stage II: Another type of secondary, H_2O -bearing fluid inclusion was identified in quartz from Sheba Vein (Fig. 13). Homogenization temperatures are significantly lower than for stage I fluid inclusions and vary from 190° to 260°C . Indicated salinity values are scattered between 1.5 and 5.7 wt-% NaCl equivalent.

Stage III: Aqueous fluid inclusions of stage III were observed only in late stage quartz at Hunker Dome. While fluid inclusions representing all stages of mineralization are present in quartz clasts, stage III inclusions occur only in quartz cement healing cataclastic vein quartz (Fig. 14). Homogenization temperatures of stage III inclusions range from 120° to 210°C with a maximum at about 170°C (Fig. 15). Last melting of ice occurs between -0.2° and -2.5°C corresponding to salinities between 0.4 and 4.2 wt-% NaCl equivalent.

Eutectic melting of ice was observed between -28° and -38°C in inclusions representing all three stages. This can be explained by the presence of a variety of dissolved salts, among which NaCl, KCl, MgCl_2 , Na_2CO_3 , and NaHCO_3 are the most important (Shepherd et al., 1985; Leeder et al., 1987).

SUMMARY AND CONCLUSIONS

The gold-bearing quartz vein system in the Hunker Creek area is an excellent example of the relationship between

mineralizing events and changes in the evolution of hydrothermal fluids. Three stages of mineralization recognized in the Mitchell (Stage I only), Sheba (stages I & II) and Hunker Dome (Stages I, II and III) veins are related to three generations of fluid inclusions (Fig. 16).

During stage I (gold, arsenopyrite, pyrite, pyrrhotite, chalcopyrite, rutile, quartz and minor carbonates), H_2O -rich and aqueous CO_2 -bearing fluids with homogenization temperatures of $300^\circ \pm 40^\circ\text{C}$ and salinities between 0 to 7.2 wt-% NaCl equiv. were involved.

Stage II mineralization consists of chalcopyrite, sphalerite, tetrahedrite, freibergite, 'polyargyrite', argentite, pyrostitbnite, galena, quartz, and accessory carbonate. Fluid homogenization temperatures are $230 \pm 40^\circ\text{C}$ and salinities range from 1.5 to 5.7 wt-% NaCl equivalent.

Fluid inclusions formed during late stage III mineralization homogenize at $170^\circ \pm 40^\circ\text{C}$. Salinities of hydrothermal fluids range from 0.4 to 4.2 wt-% NaCl equivalent.

The sericite/phengite alteration around the gold-sulphide-quartz veins indicates slightly acid conditions ($\text{pH} = 5 \pm 1$) during the mineralizing events (Hayba et al., 1985; Henley et al., 1984). The sulphide-sulphosalt mineral paragenesis suggests that reduced sulphur was abundant in the hydrothermal fluids. The abundance of sulphur, reducing conditions during gold deposition, and homogenization temperatures (minimum formation temperatures), at and far below 300°C imply that gold was been transported either as a bisulphide (Henley, 1973; Seward, 1973; Huston and Large, 1989) or as a sulpharsenide complex (Boyle, 1979).

The following model of the mineralization process is consistent with the petrographic and fluid inclusion data: gold deposition was initiated by unmixing of an original one phase H_2O and CO_2 -bearing fluid accompanying a drop in pressure and temperature. The loss of CO_2 caused an increase in pH and a decrease in the bisulphide concentration in the aqueous phase, favouring the formation of sulphides and the precipitation of gold. Subsequent mineralization processes were mainly influenced by decreasing temperature of the hydrothermal fluid.

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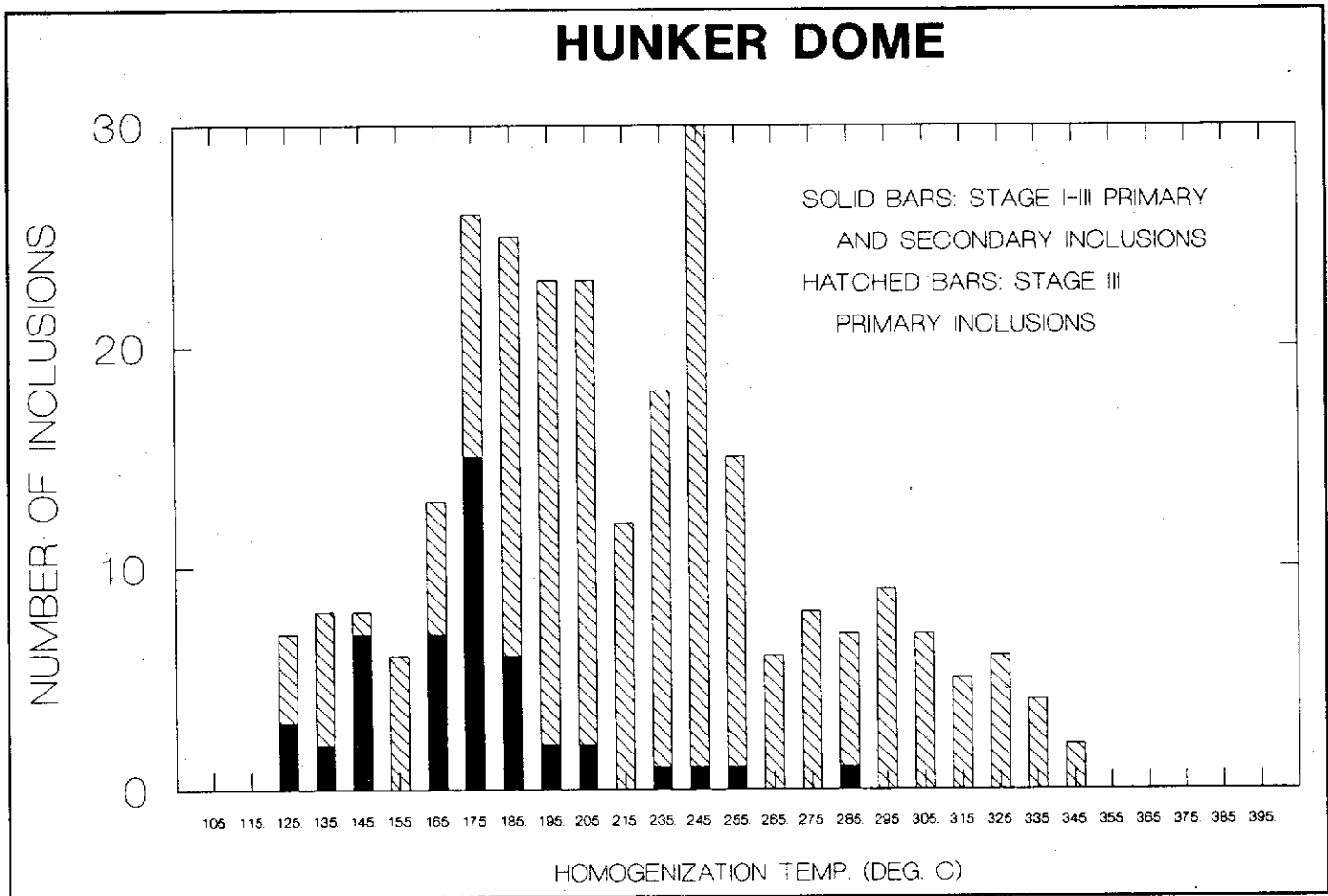


Figure 15. Histogram showing frequency distribution of homogenization temperatures for stage I, II and III inclusions in quartz: Hunker Dome.

	Stage I	Stage II	Stage III
Homog. Temp. (°C):	260-390	190-360	120-210
Salinity (wt% NaCl eq.):	0-7.2	1.5-5.7	0.4-4.2
Mitchell Vein	_____		
Sheba Vein	_____	_____	
Hunker Dome	_____	_____	_____

Increasing Temperature →

Figure 16. Mineralization stages and fluid inclusion data for gold-sulphide mineralization: Mitchell, Sheba and Hunker Dome veins.

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Table 1: Lithostratigraphy of the Klondike area (compiled from Green, 1972; Tempelman-Kluit, 1977; Htoon, 1979; Debicki, 1984 - 1985; and Dufresne, 1987. Formation names of magmatic rocks are used in the sense of Armstrong, 1988).

PERIOD	FORMATION	LITHOLOGY
LATE PLEISTOCENE	low level gravels	alluvial sediments
EARLY PLEISTOCENE, PLOCIENE	gravels at intermediate levels; high level bench gravel	alluvial sediments
EARLY TERTIARY	Skukum Group	felsic tuff, felsic breccia
	Nisling Range Alaskite	rhyolite porphyry
LATE CRETACEOUS	Carmacks Group	andesite, dacite and tuff
PERMIAN?	Moosehide Assemblage	serpentinite, amphibolite
PERMIAN	Klondike Schist	quartz-feldspar-muscovite schist, quartz-feldspar-biotite gneiss
DEVONIAN AND MISSISSIPPIAN	Nasina Series	graphite - muscovite schist, quartz-muscovite schist, limestone

TABLE 2. Chemical composition (in wt-%) of gold in quartz sulphide veins from the Hunker Creek area; ϕ = mean value, σ = standard deviation, DL = detection limit

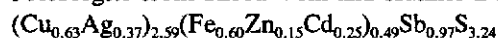
		Au	Ag	Te	Fe*	S*	Total
Hunker Dome gold in quartz n = 16	min.	85.96	12.48	0.04	-	-	99.00
	max.	87.26	13.15	0.11	-	0.02	100.40
	ϕ	86.57	12.74	0.08	-	0.01	99.40
	σ	0.39	0.20	0.02	-	0.01	0.45
	DL	0.15	0.12	0.06	0.03	0.02	
Mitchell Vein gold in pyrite n = 6	min.	77.13	16.77	-	0.91	0.06	95.90
	max.	79.38	18.06	0.15	1.89	0.12	99.25
	ϕ	78.61	17.58	0.05	1.37	0.08	97.69
	σ	0.81	0.50	0.06	0.45	0.02	1.30
	DL	0.18	0.29	0.16	0.06	0.03	
Hunker Dome gold intergrown with galena n = 11	min.	71.20	20.37	0.02	-	-	96.25
	max.	77.34	24.84	0.12	-	0.03	98.28
	ϕ	74.77	22.07	0.07	-	0.02	96.93
	σ	1.78	1.38	0.04	-	0.02	0.61
	DL	0.15	0.12	0.06	0.03	0.02	

* Fe- and S- contents are probably due to pyrite influencing the microprobe measurements.

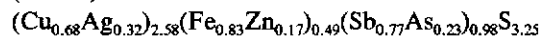
Table 3. Chemical composition (in wt-%) of freibergite and tetrahedrite in quartz sulphide veins from the Hunker Creek area; ϕ = mean value, σ = standard deviation, DL = detection limit

		Cu	Ag	Fe	Zn	Cd	Sb	As	S	Total
1.	min.	15.68	18.48	1.44	0.04	-	24.74	-	20.30	98.16
	max.	25.97	31.52	5.57	2.60	7.29	26.69	0.01	23.80	101.47
	ϕ	22.27	21.82	3.46	1.01	2.93	25.63	-	22.44	99.56
	σ	2.33	3.22	1.17	0.59	2.29	0.36	0.01	0.61	0.71
	DL	0.04	0.10	0.03	0.05	0.30	0.10	0.50	0.03	
2.	min.	24.42	19.34	4.72	1.15	0.19	18.81	2.92	23.38	98.07
	max.	26.17	20.06	5.14	1.23	0.37	21.43	4.30	24.21	99.81
	ϕ	25.26	19.75	4.88	1.19	0.25	20.12	3.68	23.79	98.91
	σ	0.69	0.32	0.14	0.04	0.07	0.90	0.52	0.29	0.76
	DL	0.04	0.10	0.03	0.05	0.30	0.10	0.50	0.03	
3.	min.	28.99	12.64	4.02	2.33	-	16.94	3.02	23.39	98.00
	max.	31.87	15.22	4.41	2.72	-	20.70	5.76	24.57	98.42
	ϕ	30.68	13.61	4.15	2.45	-	18.82	4.42	24.05	98.17
	σ	1.03	0.93	0.16	0.14	-	1.33	1.05	0.54	0.15
	DL	0.04	0.10	0.03	0.05	0.30	0.10	0.50	0.03	

1. Freibergite from Sheba Vein and Hunker Dome (n = 54):



2. Arsenic-bearing freibergite of Sheba Vein and Hunker Dome (n = 6):



3. Arsenic-bearing tetrahedrite of Vein 3 (n = 6):

