SOME STUDIES OF GOLD AND ITS ASSOCIATED MINERALS

by

E.P. Davis.

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Thanks are also extended to Mr. W. H. White, who collaborated in the work of examining the Chelan tailings, and to Mr. J. Domnan for his excellent workmanship in mounting and polishing some very difficult telluride sp ecimens.

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Part 1.

STUDIES OF SECTIONS AND TAILINGS

CHELAN DIVISION

HOWE SOUND COMPANY, Holden,

Washington.

LOCATION:

The Holden gold-copper property is in the Chelan range on Railroad Creek and about fifty-two miles north west of the town of Chelan, Washington.

The topography near the mine consists of a series of more or less parallel high hills, some rising to more than eight thousand feet, with narrow creeks in between.

GENERAL GEOLOGY.

In this deposit the ore occurs in metamorphosed sediments, probably, pre Cambrian, and consists of an irregular lense. The ore itself appears to be of Mesozoic Age. It is intruded by Mesozoic acid and intermediate intrusions, and the end products that have formed, have appeared as small dykes. There was considerable silification with the deposition of the ore. With one exception no major faulting has taken place. Minor movements, however, are numerous.

The strike of the ore body is S. 35^{o} E., and it dips S. W. between 65^{o} and 75^{o}.

Mineralogy of the Ore:

The Chelan is a contact type of deposit.

The percentage composition of the ore is approximately:

35 % Quartz

5 % Pyrite

25 % Sphalerite

15 % Chalcopyrite

20 % Pyrrhotite.

The principal shlphides in order of relative abundance are;- Sphalerite, Pyrrhotite, Chalcopyrite, and pyrite.

Six representative sections were examined. A general idea of the mineralogical relations was ascertained.

PYRITE:

It occurs as irregular fragments varying in size from several mms. to one or two microns. Generally, it is fairly well crystallized but is also fractured and corroded with quartz.

SP HALERITE:

This is the most abundant of the sulphides. It is in intimate contact with the chalcopyrite and pyrhotite. Some irregularities in the outline of the sphalerite indicate that it tended to crystallize first.

CHALCOPYRITE:

This comprises about twenty per cent of the sulphides present. It has smoothly rounded boundaries.

how reconcile with the figures?

PYRRHOTITE:

This represents about fifteen per cent of the sulphides. The regular contacts of the sphalerite, chalcopyrite, and pyrrhotite, denote them to be of contemporaneous deposition.

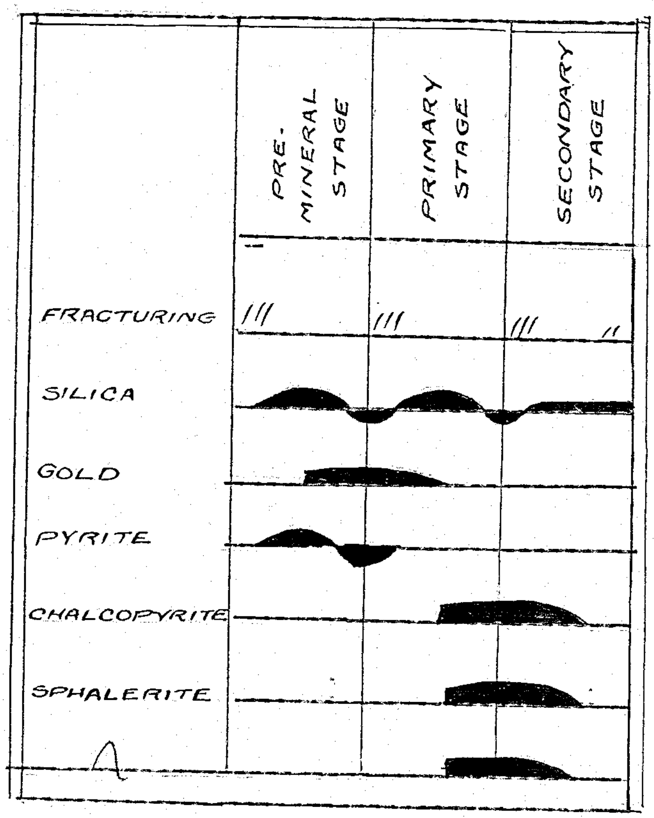
The gangue is composed of quartz and sericite. The quartz is of two ages. The original material being clear, while the second generation, or recrystallized quartz, is dark and veins the earlier mineral.

Gold was found to be disseminated through the original quartz. Assays run on rejects from the polished sections showed that the sulphides also carried a minor amount. The gold was very fine, the sizes being less than a micron. None was seen in association with the sulphide minerals.

ASSAYS.

245	cross cut	.04 oz./Ton.
550	stope	Trace
700	" , 243 chute	Trace
243	"	Trace
700	" , 248 chute	.01 Oz/Ton.

PARAGENESIS.



A study of the above sections showed two probable periods of mineralizations. Emanations from the granite high in silica and sulphur dioxide first made their way along the fractured contact zone.

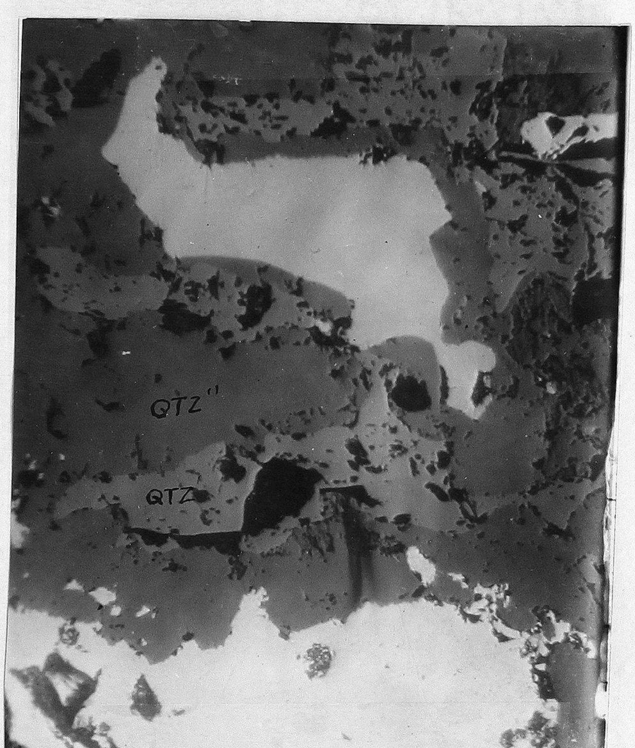
Pyrite was probably the first mineral to crystallize--as shown by the good crystal outline of some and also by the fracturing and corrosion of other crystals. Gold precipitated with the quartz and became finely dessiminated through it, a typical high temperature occurrence.

Later there was fracturing of the original zone material and what appeared to be in the section another later generation of quartz, is in reality , a recrystallization of the original quartz; and this process of solution and recrystallization parallelled the deposition of the sulphides. Thus, as the mineralization solution was injected, the sulphides came in contact with gold already present, which may account for its being associated with the chalcopyrite, sphalerite and pyrrhotite.

Mag. x 154

ILLUSTRATION 1.

This shows the pyrite veined with pyrrhotite, sphalerite and quartz. The sulphides, veining the pyrite, are obviously later.



Mag. x 154

ILLUSTRATION 2.

This photo micrograph clearly shows the original and recrystallized quartz. Note the chalcopyrite crystal surrounded by the recrystallized quartz.

ILLUSTRATION 3.

This illustrates clearly, by their smoothly rounded boundaries, the contemporaneous deposition of the chalcopyrite, pyrrhotite and sphalerite. Sericite is also present.

Mag. x 154

ILLUSTRATION 4.
x 2430

This photo micrograph shows the gold in islands thru the original quartz. The average size of the gold particles is about .4 microns.

DISTRIBUTION OF GOLD IN ROUGHER TAILINGS FROM CHELAN DIVISION
HOWE SOUND COMPANY, HOLDEN, WASH.

After flotation of a copper concentrate the rougher tailings from the Chelan mill still carry appreciable amount of gold. A sample of these tailings was received by the Dept. of Geology, University of B.C., for investigation of the mineralogical association and distribution of the gold.

Briefly, the method was to screen-size a large sample down to +200 mesh, size the -200 material into seven products with the Haultain 'Infra-sizer', and to 'pan' all the products. Four mineral products were taken from the Panner. In the tables these are designated: Tip, Pyrite, Middling and Tail; and the mineralogical compositions are as follows:

Tip - - free gold, galena, plus some pyrite.

Pyrite- at least 99% pure pyrite.

Mid. -Sphalerite, any chalcopyrite present, or pyrrhotite, plus up to 30% pyrite, and a small amount of siliceous material.

Tail - Siliceous material containing under 1% sulphur.

Finally, all the products were weighed and assayed using one, two, three, or four assay ton charges, depending on the amount of material available and the importance of the assay. From these weights and assays the following tables have been constructed:

TABLE #1 - SIZE DISTRIBUTION OF GOLD.

PRODUCT	SIZE	Oz.AU./ton	Content Mg. Au.	DISTRIBUTION % Wt.%	Au %
Head Sample	-	0.024	4;20	100.0	100.0
+35		0.032	.020	0.4	0.4
+65		0.047	1.338	4.1	6.9
+100		0.050	1.048	12.0	21.5
- +150		0.060	1.770	16.8	36.4
+200		0.020	.725	20.9	15.0
I-S #1		0.025	.143	3.3	2.9
#2		0.015	.334	12.7	6.8
#3		0.010	.150	8.6	3.1
#4		0.010	.101	5.8	3.1
#5		0.007	.049	4.0	1.0
#6		0.005	.035	2.9	0.8
#7		0.010	.151	8.5	3.1
			4.864	100.0	100.0

size range?

Note: Weight loss in screening - 1.5 %) Weight-Corrected
Infrasizing - 1.9 %) in Table # 1.

Assayed head - 0.024 Oz. Au. per ton.
Calculated head - 0.028 Oz. Au. per ton.
Calculations are based on the latter as this is regarded as more nearly correct (see E. & M. Jour. Vol. 138 pp.353)

TABLE #2 - MINERALOGICAL DISTRIBUTION OF GOLD

CT	Au. Oz/ton	Content Mg. Au.	DISTRIBUTION IN PRODUCTS WT. %	DISTRIBUTION IN PRODUCTS Au.%	TOTAL DISTRIBUTION % WT. %	TOTAL DISTRIBUTION % Au.%
35	0.032	0.020	-	-	0.4	0.4
65 FEED	.047	.338			4.1	6.9
Tip	194.5	.200	0.014	59.2	.0006	4.1
Mid.	.29	.010	.4	3.0	.016	.2
Tail	.017	.123	99.6	36.4	4.1	2.6
		.333	100.0	98.6		
0 FEED	.050	1.048			12.0	21.5
Tip	214.0	.330	.007	31.5	.0008	6.8
Pyrite	2.335	.160	.3	15.3	.036	3.2
Mid.	.350	.120	1.6	11.4	.20	2.5
Tail	.019	.390	98.1	37.3	11.8	8.0
		1.000	100.0	95.5		
50 FEED	.060	1.770	-	-	16.8	36.4
Tip	14.60	.500	.120	28.2	.02	10.3
Pyrite	.233	.160	2.5	9.0	.4	3.2
Mid.	.197	.257	4.5	14.5	.7	5.3
Tail	.030	.820	93.0	46.2	15.7	17.0
		1.737	100.0	98.9		
00 FEED	.020	.725	-	-	20.9	15.0
Tip	2.92	.015	.014	2.0	.003	.3
Pyrite	.020	.072	10.0	10.0	2.1	1.5
Mid.	.035	.123	9.6	16.9	2.0	2.6
Tail	.021	.617	80.4	85.0	16.8	12.7
		.827	100.0	113.9		
#1 FEED	.025	.143	-	-	3.3	2.9
Tip	5.82	.010	.03	6.9	.001	.2
Pyrite	.020	.049	42.8	34.3	1.4	1.0
Mid.	.035	.069	33.9	48.2	1.2	1.4
Tail	.010	.013	23.3	9.1	.7	.3
		.141	100.0	98.5		
#2 FEED	.015	.334	-	-	12.7	6.8
Tip	.25	.005	.09	1.5	.012	.1
Pyrite	.010	.027	12.1	18.1	1.5	.6
Mid.	.020	.040	8.9	12.0	1.1	.8
Tail	.013	.228	79.0	68.4	10.1	4.7
		.300	100.0	90.0		
#3 FEED	.010	.150	-	-	8.6	3.1
Tip	2.10	.005	.016	3.3	.0013	.1
Pyrite	.023	.025	7.3	16.7	.6	.5
Mid.	.035	.025	4.8	16.7	.4	.5
Tail	.007	.095	87.9	63.3	7.6	1.9
		.150	100.0	100.0		
#4 FEED	.010	.101	-	-	5.8	2.1
Tip	1.46	.005	.017	4.9	.001	.1
Pyrite	.017	.011	6.4	10.9	.4	.2
Mid.	.026	.046	17.3	45.5	1.0	.9
Tail	.006	.047	76.3	46.5	4.4	1.0
		.109	100.0	107.8		
5 FEED	.007	.049	-	-	4.0	1.0
Tip	.87	.005	.015	10.2	.0006	.1
Pyrite	.06	.010	2.5	20.4	.2	.2
Mid.	.013	.015	16.3	30.6	.6	.3
Tail	.005	.027	81.2	55.2	3.2	.6
		.057	100.0	116.4		
#6 FEED	.005	.035	-	-	2.9	0.8
Tip	2.10	.005	.05	14.3	.0015	.1
Pyrite	.007	.005	1.4	14.3	.04	.1
Mid.	.027	.015	11.1	42.8	.3	.3
Tail	.004	.017	87.5	47.6	2.5	.4
		.042	100.00	119.0		
#6	.010	.151	-	-	8.5	3.1
TOTALS		4.848			100.0	99.5

SUMMARY AND CONCLUSIONS.

1. SIZE DISTRIBUTION OF GOLD: Inspection of Table #1 indicates that about 80% of the gold is in the /200 mesh material which constitutes about 52% by weight.

2. MINERALOGICAL DISTRIBUTION OF GOLD: The middling products average about 25% pyrite and 5% siliceous impurities, and the tabulation below is slightly corrected for these figures:

Mineralogical association.	% total Wt.	% total Au.	% Au/%Wt.
Free gold.................	-	22.2	100.00
Pyrite.................	8.5	13.3	1.56
Sphalerite,pyrrhotite,chal.	5.3	11.7	2.21
Siliceous gangue.......	77.7	49.4	0.63
/35 mesh & #7Infrasizer		96.6	
products were not panned	8.5	3.4	
	100.0	100.0	

6666

Mineralogically the gold tends to favor the sphalerite and/or pyrrhotite, probably the latter. The inference is that sections of the mine rich in pyrrhotite would be richer in gold.

About 50% of the gold is associated with the gangue. In view of the fact that the finest pure gangue carries at least .005 Oz. Au / ton, we can say that at least 20% of the gold occurs as finely-disseminated particles throughout the ore-body.

Such an occurrence of disseminated gold, which does not notably favor any particular mineral, is typical of the high-temperature, contact-metamorphic ore-body.

3. It was not possible to demonstrate that the loss of free gold in the flotation circuit is due to refractory coatings. True, the gold particles do appear rather dark colored but are similar in appearance to gold particles from other deposits. A chemical test of gold concentrate indicated about one part in ten million of manganese, but this might have come from other sources, such as tramp iron.

4. The fact that 'tips' gave no test for copper indicates that native copper is not present in the rougher tailings.

TELLURIDES.

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The Occurrence of Telluride Minerals
at Kalgoorlie....................F.L Stillwell.

Erzmikraskopische Bestimmungstafeln
......H. Schneiderholm und P. Ramdohr.

Microscopic Determination of the Ore Minerals
..........................M.N. Short.

TELLURIDES.

Introduction:

This work was undertaken in an endeavour to find a possible way of more accurately identifying the gold-bearing tellurides. As these minerals rarely occur as single specimens, but usually as intergrowths of several tellurides, it was necessary to study as many members of the family as possible.

A large number of specimens were collected which were supposedly identified. On checking these specimens, by etch tests, with those of the present authorities, Schneiderholm und Ramdohr, Short, and Stillwell, it was found that these workers disagreed among themselves and also that specimens acquired by us were incorrectly labelled.

Accordingly all available information on the characteristics of this family was procured, a summary of which is included in this paper.

Summary of Available Information Concerning Tellurides.

HESSITE: Ag_2Te Isometric.

Crystals sometimes highly modified and distorted; also massive compa ct or fine-grained; rarely coarse granular.

Cleavage: Indistinct.

Fracture: Even -- somewhat sectile.

Hardness: 2.5 - 3.

Spec. Gr: 8.45 - 8.89

Color : between lead and steel gray.

Color in section	HNO_3	HCl	KCN20%	$FeCl_3$ 20%	$HgCl_2$(Sat)	KOH(Sat)
Galena white	P	P	P	P	P	N

When isolated in areas of quartz or carbonate, its color is distinctly creamy white, but in contrast with creamy white sylvanite, krennerite, or calaverite, there is a bluish tint while in contact altaite its color becomes purplish gray.

OCCURRENCE:

Hessite occurs both as a primary and secondary telluride. It is associated with Petzite and other tellurides, gold and sulphides. It may be in rounded areas without crystalline form or as ragged inclusions.

PETZITE: $(AgAu)_2Te$. Isometric.

Massive fine to comp act.

Fracture: Subconchoidal.

Slightly sectile to brittle.

Hardness: 2.5 - 3.

Spec. Gr: 8.7 - 9.02.

Color : Steel or iron gray to iron black...often tarnishing.

Color in section	HNO_3	HCl	KCN 20%	$FeCl_3$ 20%	$HgCl_2$ (Sat)	KOH (Sat)
Grayish white	P	N	N	P	P	N

Petzite may be identified by its characteristic gold etch pattern, ? its Triangular cleavage pits and its isotropism. Hessite shows none of these properties.

Is not hessite isotropic?

In contrast to Hessite it shows a faint bluish tinge on well-polished surfaces. It is more brittle than Hessite.

OCCURRENCE:

Similar to and associated with Hessite.

ALTAITE: PbTe Isometric.

Cleavage: Cubic.

Fracture: Subconchoidal.

Sectile.

Hardness: 3.

Spec. Gr: 8.16.

Color : Tin white with a yellowish tinge, tarnishing to bronze yellow.

Color in section	HNO_3	HCl	KCN20%	$FeCl_3$20%	$HgCl_2$(Sat)	KOH(Sat)
White	P.E.	P	N	P	N	N

Altaite readily distinguished from other tellurides in polished section by its white color, cubical cleavage and its etching with Hydrochloric acid. It is closely similar to Naumannite$(Ag_2Pb)Se$, the distin ction being dependent on a micro-chemical test for Selenium.

OCCURRENCE:

It is primary and is associated with other tellurides, free gold and the usual sulphide minerals.

TETRADYMITE: $Bi_2(TeS)_3$ Rhombohedral.

Cleavage: Basal perfect.

Laminae flexible - not very sectile.

Hardness: 1.5 - 2 - soils paper.

Spec. Gr: 7.2 - 7.6.

Lustre : Metallic splendent.

Color : Pale steel gray.

Color in section	HNO	HCl	KCN20% etching	$FeCl_3$ 20%	$HgCl_2$ (Sat)	KOH(Sat)
Galena white	P.E.	N	N	P	N	N

Available information concerned only atomic structure.

RICKARDITE:) Cu_4Te_3

WEISSITE.) Cu_5Te_3

Both massive.

Hardness: 3.5 - and - 3.0

Spec. Gr: 7.5 and 6.0

Colors : Deep purple and dark bluish black -- black.

Color in section	HNO_3	HCl	KCN20%	$FeCl_3$20%	$HgCl_2$(Sat)	KOH(Sat)
Purple	P.E.	P	P	P	P	P

These show no difference. The color may be bluish gray or even blue as well as purple. The details of etching are similar to Chalcocite.

OCCURRENCE:

It is secondary and its association is similar to other tellurides.

CALAVERITE: (AuAg) Te_2

Massive indistinctly crystalline - Brittle.

Hardness: 2.5

Spec. Gr: 9.045

Color : Pale bronze yellow.

Calaverite has a much higher per cent of gold than sylvanite.

Color in section	HNO_3	HCl	KCN 20%	$FeCl_3$ 20%	$HgCl_2$ (Sat)	KOH(Sat)
Creamy white	P.E.	N	N	P	N	P

It is anisotropic and shows fine etch lines. It does not show any cleavage as opposed to Krennerite. Calaverite is generally allotriomorphic.

OCCURRENCE:

A primary telluride and is most commonly associated with Coloradoite. It dissociates at a shallow level into secondary Sylvanite, Petzite, and free Gold. Other associates are the tellurium minerals and sulphides.

NAGYAGITE: Au_2Pb_{14} Sb_3 Te_7 S_{17} (?) Orthorhombic.

Cleavage: (B) Perfect.

Thin laminae flexible.

Hardness: 1 - 1.5.

Spec. Gr: 6.8 - 7.2.

Lustre : Metallic Splendent.

Streak and Color: Blackish--lead gray.

Color in section	HNO_3	HCl	KCN20%	$FeCl_3$ 20%	$HgCl_2$ (Sat)	KOH(Sat)
White	P	N	N	N	N	N

Its identification is assisted by the peculiar uneven surface and polish. It is anisotropic.

OCCURRENCE:

Same as other tellurides.

KRENNERITE: $(AuAg)Te_2$ (?) Orthorhombic.

Cleavage: One direction (C) perfect.

Fracture: Subconchoidal to uneven.

Brittle.

Spec. Gr: 8.3.

Color : Silver white to brass yellow.

Color in section	HNO_3	HCl	KCN 20%	$FeCl_3$ 20%	$HgCl_2$ (Sat)	KOH(Sat)
Creamy white	P.E.	N	N	P	N	P

Krennerite has perfect cleavage, develops etch lines and may be silver white.

OCCURRENCE:

It has not been recognized in any association suggestive of secondary origin and its associations are similar to Sylvanite.

SYLVANITE: $(AuAg)Te_4$ Monoclinic

Cleavage: one direction perfect (b).

Fracture: uneven

Hardness: 1.5 - 2 Brittle.

Spec. Gr: 7.9 - 8.3.

Color : Pure steel gray to silver white inclining to yellowish.

Color in section	HNO_3	HCl	KCN 20%	$FeCl_3$ 20%	$HgCl_2$ (sat)	KOH(Sat)
Creamy White	P.E.	N	N	P	N	N

Sylvanite sometimes shows lamellar twinning and bireflection. It is difficult to tell from Krennerite but where it is able to show good cleavage, the mineral is described as Krennerite where it is not clearly Sylvanite. Sylvanite does not develop fine etch li nes.

OCCURRENCE:

In primary associations with Calaverite, Petzite, Hessite, Altaite, Nagyagite, Seligmannite, Gold, and Sulphide minerals.

COLORADOITE: HgTe

Cleavage: One direction - ///

Hardness: 2.5

Spec. Gr: 8.07

Color : Iron black.

Color in section	HNO_3	HCl	etching KCN 20%	$FeCl_3$ 20%	$HgCl_2$(Sat)	KOH(Sat)
Grayish white	P	N	N	P	N	N

This is one of the hardest and more brittle tellurides. Its color in polished section varies from grayish white to brownish white or white. Etched surfaces treated with $FeCl_3$ and cleaned with HCl show strong anisotropism.

OCCURRENCE:

It occurs in veins with Calaverite, and also with Krennerite, Sylvanite, Petzite and Altaite. In comparison with other tellurides, it is conspicuously an associate of primary free gold.

MELONITE: $NiTe_2$

Cleavage: One perfect.

In indistinct granular and foliated particles.

Color : Reddish white.

Lustre : Metallic.

Hardness: 1 - 1.5.

Spec. Gr: 7.3.

etching

Color in Section	HNO_3	HCl	KCN20%	$FeCl_2$20%	$HgCl_2$(Sat)	KOH(Sat)
Creamy pink	P.E.	N	N	P	N	N

This is the hardest telluride, and the most brittle. These with its creamy pink color, make it easily recognized.

OCCURRENCE:

Whether primary or secondary is not known. Associations similar to other tellurides.

ANTAMOKITE: AuAg Telluride.

No available information.

ETCH TESTS.

Color in section	HNO_3	HCl	etching KCN20%	$FeCl_3$20%	$HgCl_2$(Sat)	KOH(Sat)
Grayish white	P	N	N	P	P	N

STUTZITE: Ag_4Te (?)

A rare silver telluride.

Negative to standard etching tests.

Hardness low.

Associated with other tellurides.

Follows edges of Hessite vein and transgresses it in part.

Kalgoorlie, Australia.

Color in section	HNO_3	HCl	etching KCN 20%	$FeCl_3$20%	$HgCl_2$(Sat)	KOH(Sat)
Grayish white	N	N	N	N	N	N

TELLURIUM: Te Rhombohedral.

In prismatic crystals.

Commonly columnar to fine granular massive.

Perfect prismatic cleavage.

Hardness: 2 - 2.5.

Spec. Gr: 6.2

Lustre : Metallic.

Color and streak: Tin white.

Color in section	HNO_3	HCl	etching KCN 20%	$FeCl_3$ 20%	$HgCl_2$(Sat)	KOH(Sat)
White	P.E.	N	N	N	N	N

GRÜNLINGITE: Bi_4TeS_3

Massive.

Cleavage: one direction perfect.

Color : Gray.

Spec. Gr: 7.32.

No available information.

ORUETITE: Bi_8TeS_4

Similar to Grünlingite.

No available information.

 15.

		HNO_3 1:1			HCl 1:1			KCN 20%			$FeCl_3$ 20%			$HgCl_2$			KOH.			
	Color in Section	F.L.S.	N.M.S.	Ger.	F.L.S.	N.M.S.	Ger.	F.L.S.	N.M.S.	Ger.	F.L.S.	N.M.S.	Ger.	F.L.S.	N.M.S.	Ger.	N.M.S.	F.L.S.	Ger.	REMARKS.
Altaite	White	PE	PI		P	PI N		N	N		P	PI		N	N		N	N		Isotropic
Antamokite	Grayish white	P			M			N			P			P			N			
Calaverite	Creamy	PE	PES	P	N	N	N	N	N	N	P	P	P	N	N	N	P	N	P	Anisotropic
Coloradoite	Grayish "	P	PS	P	N	PS	N	N	N	N	P	N PI	P	N	N	N	N	N	N	
Hessite	Galena "	P	PI	P	P	PS	N	P	PS	P	P	PI	P	P	PS		N	N	N	Isotropic and Anisotropic
Krennerite	Creamy	PE	PES		N	N		N	N		P	PI		N	N		P	N		Anisotropic
Melonite	Cream	PE	PES		N	PS N		N	N		P	PS		N	N		N	N		
Nagyagite	White	P	PI N	P	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Anisotropic
Petzite	Grayish "	P	PI		N	PI N		N	N		P	PI		P	PS		N	N		Isotropic
Rickardite	Purple	PE	PE	P	P	PS	N	P	P	N	P	P	N	P	PS	N	P	P	N	
Sylvanite	Creamy	PE	PI	P	N	N	N	N	N	N	P	P	N	N	N	N	N	N	N	Anisotropic
Stutzite	Grayish "	N			N			N			N	N		N			N	N		Anisotropic
Tellurium	White	PE	PE	P	N	P N	N	N	N	N	N	PS	P	N	N	N	N	N	N	Anisotropic
Tetradymite	Galena	PE	PE	P	N	PI	N	N	N	N	P	N PI	P	N	N		N	N	N	Anisotropic

Legend:

FLS.......FL Stillwell.

NMS.......NM Short.

Germ......H. Schneiderholm und Rhamdohr.

P.........Positive N......Negative.

PE........Positive with effervescence.

PI......Positive with iridescence.

PES.....Positive with effervescence and stains.

PS......Positive with stains.

Examination of Labelled Specimens.

Section #1.

This specimen was acquired from a reputable scientific house and was marked Altaite. Upon examination, the polished section was found to contain three intergrown tellurides, the properties and etch reactions of which were as follows:

(a) Position of mineral in the section

log - 53.1 and 22.1

color : creamy white

Hardness: B -

Anisotropic : Light to dark

No visible cleavage.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	N	N	P. stains	N	N

This mineral is believed to be Sylvanite but no twinning lamellae were seen.

(b) log - 51.0 and 24.0

color : creamy white

hardness : B

Anisotropic : Light to dark.

This mineral was in intimate smooth contact with (a).

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	N	N	N	N	N

This mineral is probably Nagyagite.

(c) log - 49.5 and 13.5

color : Grayish white.

hardness: A.

Isotropic.

In contact with (a).

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	N	N	P. stains	P	N

This was considered to be Petzite but lacks the characteristic triangular cleavage pits described by other workers. It should be intergrown with Hessite.

Section #2.

This specimen was acquired from the same source as #1. It was labelled Sylvanite. The results of tests were:

log: 40.4

color: Creamy white.

Hardness: C ≠

Anisotropic slightly.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	N	N	N	N	P stains.

This mineral does not check with the etch test reactions of any known telluride nor does it show lamellar twinning. Identification by this means is impossible.

Section #3.

This telluride was received from the same source as #1 and #2. It was marked Calaverite.

log 53 and 15.

color : creamy white.

hardness: C.

Anisotropism strong.

Habit: Long acicular crystals.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P with eff.	N	N	N	P dark stain	N

As these etch reactions do not correspond to any given in the proceeding table identification was impossible.

Section #4.

This was also received with the previous specimens. It was labelled Petzite. It was found to contain an intergrowth of two tellurides.

log 53.1 and 15.

(a) Color : Creamy white.

Hardness B

Anisotropic.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	N	N	P stains	N	N

From the etch tests this would appear to be Sylvanite, but it shows no twinninhg.

(b) Color : Greyish white.

Hardness: A

Isotropic.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P eff,	N	N	P darkens	P	N

This may be Petzite but does not show the cleavage pits described by Short and Stillwell. Also, according to them, it should be intergrown with Hessite.

These etch tests were all checked independently by Mess s. W.H. White and E. Schmidt. From this work it was realized that some other means of identification must be found. In order to do this, it was necessary to get as many specimens of each mineral as possible.

CRIPPLE CREEK TELLURIDES.

Some samples from Cripple Creek, Colorado, were collected by Dr. H.V. Warren,. These were mounted in bakelite and polished. The set included some high grade concentrates which were treated similarly.

The following is the result of microscopic examination and etching:

Section #1.

Log 15 and 52

Two tellurides were present.

(a) Color : Grayish white.

Hardness: A

Anisotropism doubtful.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	N	N	P	P	N

Due to the fact that Petzite may be either positive or negative with HCl, this probably is it. Apparently the reaction varies with the direction in which the section is cut.

Spec. #2.

Log 43 and 14.75.

Color : Creamy white.

Hardness: C.

Anisotropic.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P stains	N	N	P	N	P

From its etch tests, this is Calaverite. M.N.Short states that it is Negative to KOH but both Stillwell and Schneiderholm and Ramdohr state that it is possible.

Other sections from this suite were examined but due to the wide difference in etch reactions, the results were considered of no value,

The positions of the minerals were logged with the large scale toward the lamp and the small scale on the left hand side of the microscope stage. The number on the section faces the operator.

Through the efforts of Dr. H.V.Warren arrangements were made with the Washington Geophysical Laboratory, that they should send us some specimens. These were three in number, and consisted of X-rayed specimens. The X-ray examination of minerals is supposed to be the last word in accuracy, and the identification by this method considered definite.

However, after mounting and polishing, and making a microscopic examination of the three spedimens, it was found that one of them contained two intergrown tellurides and also free gold.

Results of Etch Tests on X-rayed Specimens.

Section #1.

Specimens marked Calaverite.

Color : creamy white

Hardness : C

Anisotropic.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	N	N	Pdarkens	N	N

This agreed with Short. Both Stillwell and Schneiderholm und Ramdohr make Calaverite positive with KOH.

Section #2.

Specimen marked Sylvanite.

Color : creamy white

Hardness : C-

Anisotropic.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	N	N	P	N	P

This specimen showed the distinct lamellar twinning described in the literature as being distinctive of Sylvanite. However, none of the reference works give a positive reaction with KOH.

Illustration 1.

Section #3.

Specimen marked Krennerite.

Color : Creamy white

Hardness : C

Anisotropic.

(a)

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	N	N	N	N	N

From the color in section, hardness and anisotropism, this is assumed to be Krennerite. However, it gives the etch reactions for Nagyagite.

(b) Color : Grayish white

Hardness : A

Isotropic.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	N	P	P	N	N

The identification of this is doubtful as it does not check with any given reactions. It is thought to be Petzite. This section also contained free gold.

Illustration 2.

All these tests were checked independently by Dr. Warren. From the results , it may be seen that the etch reactions are of doubtful value in determining the members of the telluride family, assuming X-ray analysis to be correct.

Mag. x 154

ILLUSTRATION I.

Lamellar twinning as exhibited by some specimens of Sylvanite.

Mag. x 154

ILLUSTRATION 2.

Three tellurides and free gold in X-Rayed specimen marked Krennerite.

Examination of Wilke Sections.

A number of specimens were obtained from Wilke in California. These were all identified. After mounting and polishing, the check etch tests were as follows:

Section #1. Sp ecimen marked Sylvanite.

Color : Creamy white

Hardness : C

Anisotropic.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	N	N	P	N	N

This agreed with the work of others but did not show the twinning of the Washington specimen. Also, it was not positive to KOH.

Section #2. Specimen marked Tetradymite.

Color : Galena white

Hardness : B

Anisotropic.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	P	N	P	N	N

This agreed with the reactions given by M.N. Short. It shows perfect basal cleavage. It is undoubtedly Tetradymite.

Section # 3. Specimen marked Altaite.

This contains two tellurides intergrown. The Altaite was white while the other a much darker-almost brownish mineral-was unidentifiable.

Color : White

Hardness : B

Doubtfully Isotropic.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	P	N	P	N	N

This is believed to be Altaite. According to Stillwell, the stain with $FeCl_3$ persists after buffing which was a noticeable feature of this mineral.

Section #4. Specimen marked Nagyagite.

Color : White

Hardness : B

Anisotropism doubtful.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	KOH
P	N	N	N	N	N

This agreed with the tests of other workers.

Section #5. Specimen marked Calaverite.

Color : Creamy white

Hardness : C

Anisotropic.

HNO_3	HCl	KCN	$FeCl_3$	$HgCl_2$	~~KOH~~
P	N	N	P	N	P

This agreed with Stillwell and Schneiderholm und Ramdohr, but Short states it negative to KOH. It is probably correctly identified.

From the reaults of this series of etch tests, it can be seen that, with regard to the telluride family, very little confidence may be placed in these reactions. In the writer's opinion, much of the discrepancy is due to crystal orientation. Unfortunately, in the specimens used, cleavage has not been sufficiently discernible to prove this assertion. It may be proved at a later date.

Identification of Tellurides by Selective Iridescent Filming.

Attention was drawn to this method of identification by the success of A.M. Gaudin, and his assistants, at the Montana School of Mines, in the filming of the Silver Sulphide minerals.

Gaudin, A.M., . . .Economic Geology, Volume 33, No. 2, Page 145.

The method of selective iridescent filming consists in creating on the surface of minerals transparent films of such thickness that light interference takes place between beams reflected from the top and from the bottom of the film; the selective character of this filming arises from the fact that films of different thickness and different optical prop erties are formed on different minerals, thus giving different colors.

Aside from the composition of the filming medium, two other important factors affect the color obtained; namely the length of filming time, which should be controlled with a stop watch, and the temperature of reaction.

The color obtained on the same mineral is not always exactly the same; this happens if the mineral is chemically anisotropic, because the film thickness is not the same on the crystals cut in different orientations. In addition, minor differences in color may occur because of local differences in stirring of the bath, or because of other details such as macrostructure of the specimens. Differentiation by selective iridescent filming does not have to depend on minor color differences; it depends on sharply contrasting colors, each perhap s of several shades, obtained by filming for a precisely controlled length of time at a definite temperature.

In its application, the method of iridescent filming has consisted so far in oxidizing the surfaces of the minerals by immersion in a liquid bath.

FILMING MEDIA.

The first filming solution used on the tellurides was the standard chromium Tri-oxide--Hydrochloric acid bath. This was made up of one part of Chromium tri-oxide dissolved in five parts of water, two parts of this solution being mixed with three parts of concentrated Hydrochloric acid and then diluted 2:1 with water.

This solution was found unsatisfactory. A faint film of fourth order colors was formed on one or two minerals while others were not oxidized at all.

It was then attempted to film the minerals by adjusting the amounts of the various reagents in the above solution, but the results were negligible.

Other solutions were investigated. A two per cent solution of iodine in Methanol, plus an equal volume of Hydrochloric acid was tried. This gave no results. Other liquids composed of salts of iron in nitrate and nitrite solutions were tried. They gave fair results, but difficulty was found in controlling them. The writer has noticed that nearly all the tellurides react with Nitric acid, and most of them film with Ferric chloride; so that some solution may eventually be evolved which contains these reagents. Further work is to be done next year.

Finally, the standard silver filming solution, used by Gaudin, was tried. This solution is composed of one part two per cent iodine-methyl alcohol solution and one part concentrated Sulphuric acid by volume. Also a solution containing Potassium Permanganate, instead of Iodine, was tried but was found unsatisfactory. The first solution gave fairly good results over a limited range of minerals.

Results of filming with Standard Filming Solution.

Solution used: Standard Silver Filming Solution.

Time : 10 seconds.

Temperature : 22° C.

Only the minerals of which the writer was reasonably certain were used for filming.

PETZITE: First order, orange to purple.

CALAVERITE: Tan to pale purple.

SYLVANITE: Light tan to pale pink and purple--lighter tan than Calaverite.

KRENNERITE: Second order blue to pink. Dominantly pink.

Various times and temperatures were tried, but the filming with this solution seemed most effective at the ten second immersion period. Also, the solution itself and the acetone used for washing tended to attack the bakelite mounts of the minerals, making longer immersion dangerous to the sp ecimens themselves.

CONCLUSION.

Several of the tellurides may be distinguished directly, in polished section, by their physical characteristics, Tetradymite and Rickardite in particular, the former by its hardness and basal clea vage, the latter by its purple color. However, the majority varying as they do between cream, gray, and white, and with many similarities in behaviour to etching, need at present a very complicated method of attack.

In the writer's opinion, the solution of the problem lies in filming, as the foregoing results seem to indicate. It is his intention to continue this work next year in an endeavour to formulate a solution which will differentiate completely and easily between any of the telluride family.

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APPENDIX.

Development of Etch Cleavages.

Of the reagents commonly used in routine mineragraphic tests, only nitric acid yields definite etch patterns on Calaverite, Krennerite, and Sylvanite. Three strengths of acid were used: 1:1 , 3:2 , and concentrated HNO_3 . The time of etching is an important factor, one minute being used for the 1:1 acid and forty seconds for both the other concentrations.

For a comparative study of these three tellurides, specimens of known crystal orientations must be used. The results obtained on each specimen by each concentration of acid are totally different.

The sections used by the writer were cut in a random direction but upon comparison with the illustrations shown in "Etch Tests on Calaverite, Krennerite, and Sylvanite", by M.N. Short, the reactions showed striking similarity when treated with 1:1 HNO_3.

Calaverite. When etched with 1:1 acid, upon washing and drying the specimen, the surface breaks up into irregular areas, each consisting of a flake a few microns thick. The curled edges give a somewhat shingled effect.

With 3:2 acid, a distinct parallel etch structure is developed.

With concentrated acid a more uniform etch cleavage is developed, consisting of fine parallel line, across the surface of the specimen.

Krennerite.

Did not check with Short, probably due to the crystal orientation.

Sylvanite.

With 1:1 acid etchings, takes the form of short discontinuous cracks which give the surface a vernicular appearence.

With 3:2 acid, two etch directions are clearly brought out and seem to be of equal importance.

With concentrated acid tests, two cleavages at right angles are shown. Parts of the section do not react.

SUMMARY.

Etch Tests On Calaverite Krennerite and Sylvanite......M.N. Short.

American Mineralogist Vol. 22. #5.

The results of etching the three tellurides are not as simple and conclusive as had been hoped for. The variations in results when different strengths of acid and different times of etching are employed call for control of both factors. On the other hand, the etch patterns are not capricious; each figure illustrates several experiments performed under the same conditions, and the conclusion is justified that, under the same conditions, a given specimen will yield the same etch patterns.

C alaverite and krennerite give similar patterns, but krennerite will give two etch-cleavages at right angles in certain sections whereas calaverite apparently will give an etch-cleagage in only one direction. Both krennerite and calaverite flake, and many specimens of both minerals develop circular areas that may represent spherical inclusions when etched with 1:1 HNO_3. Etch-cleavage in one direction indicates, but does not prove calaverite.

Sylvanite gives an etch-cleavage similar to that of krennerite but the cleavages develop while the drop is on the specimen and the surface does not flake when washed and dried.

In conclusion, etching with both 1:1 and concentrated nitric acid will usually lead to a decision whether an anisotropic gold and silver telluride is sylvanite or one of the other two minerals, calaverite and krennerite. It is difficult to distinguish calaverite from krennerite by etching with nitric acid in some cases, but if two etch-cleavages at right angles are developed the mineral is probably krennerite.

Results meagre and inconclusive but that
not the authors fault. There has been a great
necessary but unproductive work done and the
author has to my knowledge worked well
and conscientiously. Recommend that a
nominal 75% be awarded both for essay and for
.....
 9.24.

J.H. Warren