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MATTAGAMITE AND TELLURANTIMONY, TWO NEW TELLURIDE MINERALS FROM MATTAGAMI LAKE MINE, MATAGAMI AREA, QUEBEC *

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Abstract

Mattagamite is a new mineral with the composition $Co_{.54}Fe_{.37}Te_{2.00}$. The name is for the locality and is to be applied to the end member $CoTe_2$. The analyzed material is a ferroan mattagamite. The mineral is orthorhombic; the unit-cell for $CoTe_2$ is *a* 5.31, *b* 6.31, c 3.89Å whereas for $FeTe_2$ (frohbergite) it is *a* 5.29, *b* 6.27, c 3.86Å. The strongest lines on the *x-ray* power pattern are 3.31(3), 2.805(10), 2.703(8), 2.066(6), 1.843(4), 1.583(3), 1.514(2), 1.354(2)Å. The mineral occurs as equidimensional grains (110 microns or less) isolated in altaite and as irregular rims (<30 microns) on pyrrhotite and chalcopyrite in contact with altaite. Under reflected light the mineral is violet, particularly in contrast to the pink of cobaltite. Anisotropism is weak, varying from a pinkish violet to greyish violet. Reflectance measurements at 470, 546, 589 and 650 nm gave 53.1, 51.4, 51.7, and 52.7%. Micro-indentation hardness values are 383, 404 kg/mm² for a 25 g load and 630 kg/mm² for a 15 g load.

Tellurantimony is a new mineral with the composition $Sb_{1.91}Te_3$. The name is for the composition, Sb_2Te_3, in analogy with tellurbismuth, Bi_2Te_3, with which it is isostructural. The mineral is hexagonal ($R\bar{3}m$); the unit-cell is *a* 4.258, *c* 30.516Å. The strongest lines on the *x-ray* powder pattern are 3.156(10), 2.348(7), 2.129(8), 1.980(7), 1.767(6), 1.577(5), 1.468(4), 1.359(5)Å. The mineral occurs in altaite as lath-shaped crystals up to 175 microns wide and 350 microns long, but more frequently as laths up to 40 microns wide. Under reflected light the mineral shows weak pleochroism with colours from pink to cream. Anisotropism is moderate, varying from pink to dark grey. Reflectance measurements at 470, 546, 589 and 650 nm gave 65.1, 63.6, 63.8 and 63.7%. Micro-indentation hardness values range from 39.6-61.3(av. 49.8) kg/mm² with a 25 g load.

Subsequent to the initial study, an antimonian mattagamite and an unknown Ag-Sb telluride were identified. The antimonian mattagamite occurs rimming pyrrhotite in contact with altaite and contains up to 29.5 weight per cent antimony. The antimony content has been found to vary inversely with iron. The unknown telluride occurs as a 15 micron bleb along an altaite-pyrrhotite grain boundary. Microprobe analysis gave a formula of $Ag_{0.9}Sb_{1.0}Te_{2.0}$.

Introduction

The new minerals described here occur in a small zone of telluride ore within the Mattagami Lake mine in the Matagami area, Quebec. This type of telluride zone is not known to occur elsewhere in association with the type of massive sulphide deposit which forms the main orebody.

Samples from the telluride zone were obtained by one of us (R.I.T.) during a visit to Mattagami Lake mine on October 5, 1971. *X*-ray powder pattern identification of the bright metallic mineral in these samples proved it to be altaite. Two new telluride minerals, tellurantimony and mattagamite, were detected during subsequent microscopic and electron microprobe study of a number of polished sections. Additional specimens were subsequently very kindly supplied by geologists at the mine.

The new minerals and names were approved by the Commission on New Minerals and Mineral Names, I.M.A. The name mattagamite (MA TOG A-MIT) is proposed for the locality, Mattagami Lake, Quebec, and is to be applied to the end member $CoTe_2$; the analyzed material is a ferroan mattagamite. The name tellurantimony is for the composition, Sb_2Te_3, in analogy with tellurbismuth, Bi_2Te_3, with which it is isostructural. Type material is preserved in the National Mineral Collection, Geological Survey of Canada, Ottawa, and the mineral collections of the Royal Ontario Museum (ROM M31956, M31957, M31958), Toronto, Ontario.

The Mattagami Lake mine is in Galinee Township, 5 miles southwest of the town of Matagami, Quebec. The main orebody is a large zinc-rich deposit of the stratiform massive sulphide type in Archean volcanics which range from rhyodacite to andesite in composition (Roberts 1966; Sharpe 1968). This type of Zn-Cu (Pb-Ag) massive sulphide deposit is of widespread occurrence in the volcanic belts of the Precambrian Shield, and a volcanogenic origin is widely accepted. The magnesian metasomatism, as represented by chlorite, talc and tremolite in the alteration zone of the deposit (Roberts 1966), is a common characteristic of this type

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of deposit. About 8.5 million tons had been mined at the Mattagami Lake mine to the end of 1969 and reserves were then about 17.3 million tons grading 9.6% Zn, 0.69% Cu, 1.08 oz/ton Ag and 0.012 oz/ton Au (Financial Post, Survey of Mines 1971).

The telluride zone in the mine occurs on the 825 sub-level and the 870 level. A drill intersection which assayed 4.94 oz/ton Ag for a length of 13 ft may indicate an extension of the zone down to the 925 sub-level. The telluride zone is only about one foot wide and has been traced for a length of about 100 ft and vertically for about 60 ft. The zone is conformable with the schistosity of the rock and some ore minerals are disseminated in the sheared rock for a short distance on either side of the main body. The telluride zone occurs partly within massive sulphide ore and partly within chloritized porphyritic metarhyolite. The contact between the massive sulphides and the chloritized porphyritic metarhyolite is described as gradational, with sulphides occurring more in the form of stringers in the latter unit. The telluride zone lies beneath and roughly parallel to a post-ore metadiabase dike which strikes northwest and dips 70° to the northeast. The telluride zone may have been truncated (displaced ?) by the metadiabase dike above the 825 sub-level and also below the 925 sub-level. From the general relationships described above, it seems that the telluride zone was formed within the general alteration pipe which marks a hydrothermal vent system in the footwall rocks. Such alteration pipes are known to occur immediately beneath many massive sulphide deposits of the type represented by the main orebody (Gilmour 1965; Roscoe 1965).

Mineralogy and Textures of the Telluride Ore

Assay data give some idea of the mineralogy of the zone. Samples of the telluride ore have assayed as high as 8.26% Zn, 11.06% Pb, 1.13% Cu, and 16.82 oz/ton Ag. A representative sample of the material contained 11.54 oz/ton Ag and 0.021 oz/ton Au.

The gangue in the telluride ore is generally very rich in talc, although chlorite in place of talc is present in some specimens. Magnetite is commonly a prominent constituent of the ore; Roberts (1966) has noted for the mine generally that magnetite is a common constituent of magnesium (talc)-rich schist. Altaite is the most common ore mineral in the telluride zone, but sphalerite and chalcopyrite are abundant in some specimens. Other opaque minerals that are present are cobaltite, pyrrhotite, pyrite, hessite, and the new minerals tellurantimony and mattagamite.

The magnetite occurs as equant grains that are rounded and irregular to subhedral in shape, and as composite grains with subhedral form against silicate gangue and other minerals. Inclusions of altaite, cobaltite and gangue are common. Chalcopyrite and sphalerite are present in small amounts in most specimens, but in certain specimens both minerals are much more abundant. Chalcopyrite shows either a mutual boundary relationship with altaite, or gives the appearance of having crystallized earlier. Sphalerite contains fine blebs of chalcopyrite which are generally interpreted as having formed by exsolution. Cobaltite is a relatively abundant mineral in the ore. It forms rounded and subhedral grains about 0.1 to 2 mm in diameter and also occurs as very small scattered to tightly-packed equant grains in an altaite matrix. In a number of cases skeletal cobaltite grains in altaite were observed. Pyrrhotite is a common, but not abundant, constituent that occurs, in part, as lenticular masses along the schistosity. In general the pyrrhotite shows textural relationships similar to those of chalcopyrite, and contains cobaltite and altaite inclusions. Pyrite in equidimensional grains of medium to large size are relatively abundant in some specimens. In a few cases small grains of pyrite were observed in pyrrhotite and chalcopyrite. Hessite is a rare constituent of the ore, but is the phase accounting for the silver indicated by the assay results. The largest grains of hessite, up to 470 microns long by 55 to 115 microns wide, were observed in relatively large areas of massive altaite. Although largely surrounded by altaite, these large grains are often in contact with chalcopyrite. Grains of hessite about 20 by 5 microns and ranging down to a few microns across are more common.

Tellurantimony commonly occurs as lath-shaped grains in an altaite matrix. At least scattered small laths of the mineral appear to be present in all large masses of altaite. Mattagamite was found in only one specimen, which contained fairly abundant chalcopyrite and sphalerite. A number of polished sections were prepared from this specimen.

Optical, Physical and Chemical Properties

The samples were mounted in cold-setting plastic, polished on lead laps and lightly buffed on a cloth lap using minus 0.2-μ alumina. The reflectance values were obtained with a Leitz MPE microscope photometer equipped with a Dumont, type-6467 photomultiplier tube, two six-volt storage batteries connected in parallel, and a Veril B200 continuous-band interference filter. A calibrated silicon specimen (N2538.42) issued by I.M.A. Commission on Ore Microscopy, was used as a reference standard. The microhardness values were determined with a Leitz Durimet hardness tester equipped with polarizing filters and rotating stage.

The compositions were determined using a Materials Analysis Company model 400 electron-probe microanalyzer. Pure metals were used as standards and corrections were applied using Edition VII of the program by Rucklidge (1967).

X-ray diffraction powder data were obtained by the film method using a 57.3 mm Gandolfi camera. Material suitable for single crystal study was not available. However, the powder patterns are identical to the synthetic members from which the unit cell dimensions were determined. Synthetic $CoTe_2$ and $FeTe_2$ were formed by reacting high-purity elements in evacuated quartz tubes. X-ray data for pure Sb_2Te_3 are listed in PDF 15-874.

Mattagamite

The mineral occurs as equidimensional and rarely as blade-like grains isolated in altaite (Fig. 1), and as irregular rims on pyrrhotite and chalcopyrite in contact with altaite (Fig. 2). The rims range from a few microns to 30 microns in width whereas the largest equidimensional grain is 110 microns. Hessite is sometimes associated with the mattagamite rims. In reflected light under oil immersion, the colour is violet, particularly in contrast to the pink of cobaltite. Anisotropism is weak, varying from a pinkish-violet to greyish-violet. Microhardness determinations and reflectance measurements for the four standard wavelengths are given in Table 1.

The results of the electron-probe microanalysis for the three largest grains are given in Table 2. The average formula for mattagamite is $Co_{.54}Fe_{.37}Te_{2.00}$.

TABLE 1. REFLECTANCE AND MICRO-INDENTATION HARDNESS

	Mattagamite		Tellurantimony	
Wave-length	Range of 9 measurements	Mean	Range of 13 measurements	Mean
470 nm	51.7-54.3	53.1	60.4-71.1	65.1
546 nm	50.0-52.6	51.4	59.8-67.9	63.6
589 nm	50.3-52.6	51.7	61.5-67.9	63.8
650 nm	50.8-53.9	52.7	61.5-68.7	63.7
Micro-indentation	VHN_{15}=630		VHN_{15} (8 grains): 40.2-73.9 (av. 54.9)	
hardness (kg/mm^2)	VHN_{25}=383,404		VHN_{25} (5 grains): 39.6-61.3 (av. 49.8)	

The x-ray diffraction data for mattagamite and synthetic $CoTe_2$ are given in Table 3. Tengnér (1938) determined the structure of synthetic $CoTe_2$ to be orthorhombic, like $FeTe_2$, with *a* 5.31, *b* 6.31, *c* 3.89Å, whereas $FeTe_2$ (frohbergite) has *a* 5.29, *b* 6.27, *c* 3.86Å (Berry & Thompson 1962). For synthetic $CoTe_2$ prepared in this study the unit cell parameters obtained with 114.6 mm Debye-Scherrer camera and refined by a least-square computer program are *a* 5.305, *b* 6.289, *c* 3.866Å. The pattern of mattagamite was not suitable for unit cell determinations.

Tellurantimony

The mineral occurs in altaite as lath-shaped crystals up to 175 microns wide and 350 microns long, but more frequently as laths 40 microns wide and less (Figs. 3, 4). In reflected light, with oil immersion, the mineral shows weak pleochroism with colours from pink to cream. The mineral in contact with cobaltite has a creamy pink appearance, whereas cobaltite appears darker pink. Anisotropism is moderate, varying from pink to dark grey. Reflectance and microhardness measurements are given in Table 1. In at least some orientations the mineral has a greater polishing hardness than the host altaite. Twinning perpendicular to the elongation axis of the laths was commonly observed.

Electron-probe microanalyses of tellurantimony are given in Table 2. The formula for tellurantimony is $Sb_{1.91}Te_{3.00}$ or ideally Sb_2Te_3. Using metal standards, it is not possible to determine whether the mineral has a slight deficiency in antimony as suggested by the analysis.

TABLE 2. ELECTRON PROBE MICROANALYSES

Mattagamite

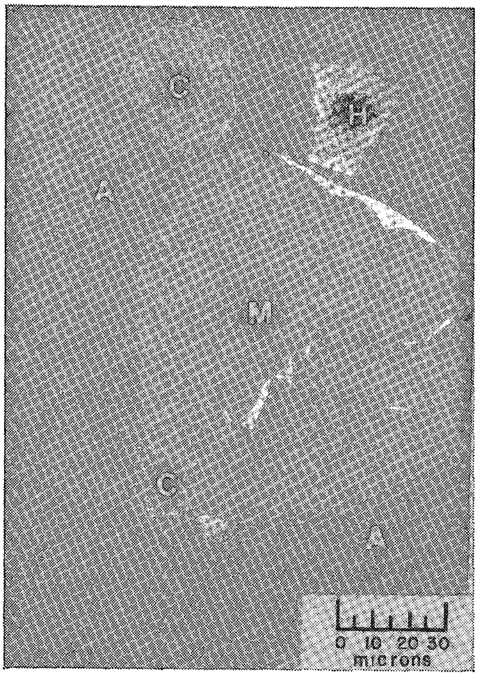
Grain size	60μ	40μ	110μ	Av.
Co	11.1	9.8	9.9	10.3
Fe	6.0	7.0	7.1	6.7
Te	82.6	82.4	82.3	82.4
Total wt. %	99.7	99.2	99.3	99.4

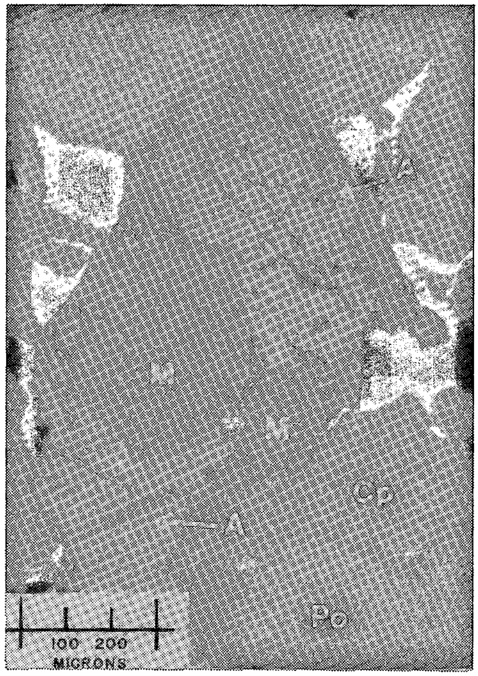
Formula $Co_{.54}Fe_{.37}Te_{2.00}$

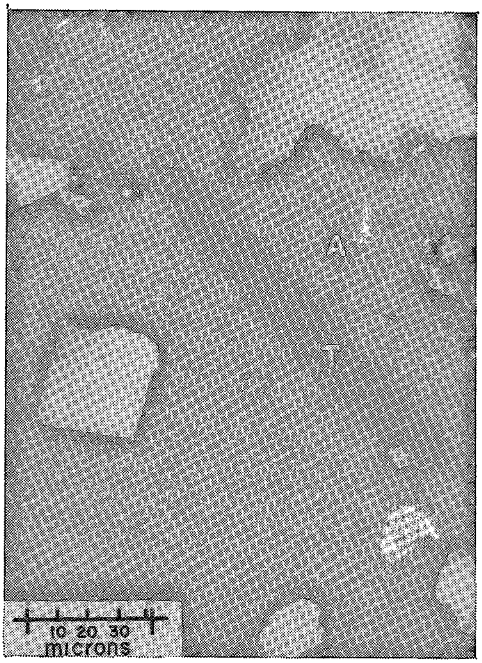
Tellurantimony

	Av. (8 grains)	Range
Sb	37.5	35.8-38.2
Bi	0.3	0.2- 0.3
Te	61.8	61.0-62.6
Total wt. %	99.6	

Formula $Sb_{1.91}Te_{3.0}$







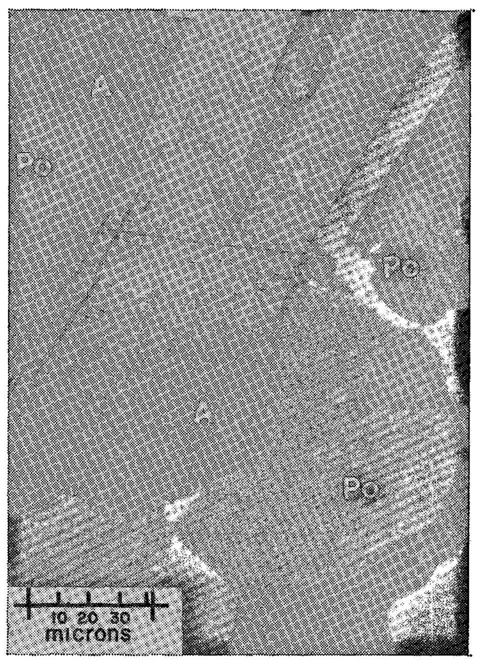


FIG. 1. Large equant grain of mattagamite (M) in altaite (A) with associated euhedral crystals of cobaltite (C) and hessite (H).

FIG. 2. Mattagamite (M) as an equant grain in altaite (A) and as a partial rim between chalcopyrite (C) and altaite, and between chalcopyrite and pyrrhotite (PO). The dark areas are pits. Scale should read 10 and 20, not 100 and 200.

FIG. 3. Typical lath of tellurantimony (T) in altaite (A). The bright areas are internal reflections from gangue minerals. Nicols partly crossed.

FIG. 4. Laths of tellurantimony (T) in altaite (A) with pyrrhotite (PO) grains at various degrees of extinction. Nicols partly crossed.

The *x*-ray diffraction data for tellurantimony are given in Table 3 and compared with those of synthetic Sb_2Te_3, with which it is identical. The unit cell dimensions for tellurantimony obtained with a 57.3 mm Gandolfi camera using Fe-filtered Co radiation and refined by a least-square computer program are *a* 4.258, *c* 30.516Å.

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TABLE 3. X-RAY DIFFRACTION DATA OF MATTAGAMITE AND TELLURANTIMONY

	Synthetic $CoTe_2$ *a*=5.305, *b*=6.289, *c*=3.866A°			Mattagamite		Synthetic Sb_2Te_3* *a*=4.262, *c*=30.450A°				Tellurantimony *a*=4.258, *c*=30.516A°	
hkl	$d_{calc.}$ A°	$I_{est.}$	$d_{meas.}$ A°	$I_{est.}$	$d_{meas.}$ A°	hkl	$d_{calc.}$ A°	I/I_1	$d_{meas.}$ A°	$I_{est.}$	$d_{meas.}$ A°
011	3.293	3	3.294	3	3.31	003	10.1500	2	10.16		
-	-	1/2	3.224			006	5.0750	4	5.08		
101	3.124	4	3.125			009	3.3833	6	3.383	2	3.389
111	2.798	8	2.805	10	2.805	014	3.3212	2	3.321	1	3.327
120	2.705	10	2.707	8	2.703	015	3.1565	100	3.157	10	3.156
200	2.653	3	2.667			017	2.8144	<1	2.815	1	2.810
210	2.444	1	2.449			018	2.6497	2	2.651	1	2.659
121	2.216	1	2.225			01.10	2.3489	35	2.349	7	2.348
211	2.066	6	2.071	6	2.066	01.11	2.2146	6	2.215	1	2.211
220	2.027	2	2.034			110	2.1310	25	2.130	8	2.129
130	1.950	4	1.949			00.15	2.0300	4	2.030	1	2.030
-	-	1/2	1.904			01.13	1.9777	4	1.977	7	1.980
012	1.848	5	1.850	4	1.843	116	1.9648	2	1.964		
221	1.796	3	1.800			01.14	1.8739	4	1.875	2	1.869
112	1.745	4	1.751			119	1.8013	2	1.804		
310	1.702	3	1.708			025	1.7662	10	1.766	6	1.769
230	1.645	3	1.644			00.18	1.6917 }	2	1.692	1	1.699
040	1.572	8	1.572	3	1.583	01.16	1.6915 }				
202	1.562	1	1.564			028	1.6606	<1	1.661		
320	1.541	3	1.547			01.17	1.6115	2	1.611		
212	1.516	3	1.518	2	1.514	02.10	1.5783	8	1.578	5	1.577
321	1.432	1	1.438			01.18	1.5378	2	1.537		
141	1.404	2	1.406			01.19	1.4700	8	1.470	4	1.468
132	1.373	1	1.379			00.21	1.4500	2	1.450		
240	1.352	5	1.357	2	1.354	01.20	1.4075 }	2	1.408	1	1.408
400	1.326	2	1.330			02.14	1.4072 }				
410	1.298	2	1.300			125	1.3598	8	1.3597	5	1.359
003	1.289	3	1.283			11.18	1.3249	2	1.3249	2	1.327
331	1.276	1/2	1.271			12.10	1.2683	6	1.2683	2	1.266
411	1.230	2	1.239			01.23	1.2462	2	1.2462		
042	1.220	5	1.213	2	1.205	030	1.2303	2	1.2303	1	1.230
322	1.205	1	1.200					2	1.2102		
340	1.175	6	1.170	2	1.168			<1	1.1988	1	1.196
123	1.163	1/2	1.163					2	1.1742		
203	1.159	1/2	1.155							1	1.008
213	1.140	3	1.148							1	0.994
341	1.124	3	1.128							1	0.969
242	1.108	4	1.114	2	1.108					1	0.959

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x-ray work, L.J. Cabri for synthetic work, R. Pinard for the photomicrographs and P. O'Donovan for the polished sections.

APPENDUM: Antimonian mattagamite and an unknown Ag-Sb-telluride

In the course of preparation and study of additional polished sections of the altaite-rich specimens collected from a drift on the 825 ft level of the Mattagami Lake mine, electron microprobe analyses revealed that in many cases the new mineral mattagamite is also antimony-bearing. In nearly all equant grains of mattagamite isolated in altaite, the mode of occurrence for which compositional data were originally obtained, antimony was not detected. However, in its other mode of occurrence, as rims on pyrrhotite in contact with altaite, mattagamite contains antimony and as much as 29.5 weight percent has been measured. The antimony content of mattagamite has been found to vary inversely with its iron content. A semi-logarithmic plot of the compositional data is presented in Figure 5. It can be seen that an approximately inverse exponential relationship exists between the antimony and iron contents of the mineral. The roughly linear relationship for the composition of grains analyzed in section G (Fig. 5) indicates that when the iron content exceeds

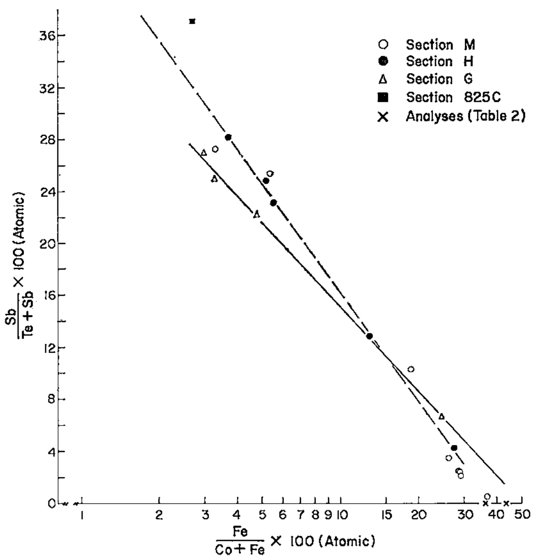

FIG. 5. Semi-logarithmic plot showing the inverse relationship between the iron and antimony contents of mattagamite. The compositions measured for grains in individual polished sections are distinguished and the compositional relationships for sections G and H are approximately represented by the solid and dashed lines, respectively.

Fe/Co + Fe × 100 = 50 atomic percent, antimony is absent. This would represent an iron content of 8.93 wt%. This value may be high since the analysis of mattagamite in the earlier study gave 7.1 wt% Fe, with no antimony.

Similarly a plot with Sb/Te + Sb × 100 on the logarithmic scale indicates that iron is not present when this ratio exceeds 30 to 39 atomic percent (that is, a maximum of about 30.7 wt% Sb). However, the antimony-rich mattagamite in section 825 suggests that the most antimony-rich phase may have Sb/Te + Sb × 100 = 50 atomic percent (about 39.5 wt% Sb). The highest antimony content measured for the mineral is 29.5 wt%.

In addition, another unknown telluride has been identified in the ore. The mineral occurs as a small bleb (15 microns) along the contact of pyrrhotite and altaite. The mineral is anisotropic and has a pinkish tint. Electron microprobe analysis gave Ag 20.1, Sb 25.3, Te 53.2, total 98.6wt%, equivalent to the formula $Ag_{0.9}Sb_{1.0}Te_{2.0}$. The mineral is too sparse for proper characterization of the phase.

The new compositional data of mattagamite indicate that while, in atomic proportion, cobalt always exceeds iron and tellurium always exceeds antimony, the measured compositions are for relatively iron-rich (ferroan mattagamite), antimony-rich (antimonian mattagamite), and intermediate solid solution phases. That is, the postulated ideal composition of mattagamite, $CoTe_2$, is not closely approximated. It seems likely that in antimony-deficient assemblages one may expect compositions nearer the ideal.

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