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FOREWORD

In 1921, shortly after the organization of the Mineralogical Society of America (December 30, 1919), Professor T. L. Walker (1867–1942) and Professor A. L. Parsons (now emeritus)—both charter fellows and in later years presidents of the Society—founded *Contributions to Canadian Mineralogy* from the Department of Mineralogy and Petrography, University of Toronto. This annual publication was conducted by Professors Walker and Parsons and, since 1941, by Professor M. A. Peacock; and from 1921 to 1948 it has appeared without interruption in the *Geological Series* of the *University of Toronto Studies.* Since the founding of the Walker Mineralogical Club in 1938, the periodical has been sponsored by the Club as well as by the University; and after the union of the Department of Mineralogy and Petrography and the Department of Geology and Palaeontology in 1945, the Canadian journal was issued by the combined Department of Geological Sciences and the Walker Mineralogical Club.

At the November 1948 meeting of the Council of the Mineralogical Society of America, Professor (then President) Peacock reported that the University of Toronto had decided to terminate the *University of Toronto Studies* which, as a whole, had greatly declined, and that no practical way had been found to continue the publication of *Contributions to Canadian Mineralogy* in Canada. In order to preserve the continuity and integrity of the Canadian Journal, the Council agreed to devote a regular issue of the *American Mineralogist* to a collection of papers by Canadian mineralogists, to be assembled and edited by Professor Peacock in consultation with the Editor of the *American Mineralogist.* With this first issue of *Contributions to Canadian Mineralogy* as a part of *The American Mineralogist,* it is a pleasure to assist our Canadian colleagues to publish and distribute their valuable mineralogical results.

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THE TELLURIDE MINERALS AND THEIR OCCURRENCE IN CANADA[1]

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CONTENTS

ABSTRACT

A study of telluride minerals and ores, mainly by microscopic and *x*-ray methods, has led to revised and condensed synoptic descriptions of the telluride minerals and a catalogue of Canadian telluride localities. The mineral descriptions contain new measurements of specific gravity, some new cell dimensions, and numerous new *x*-ray powder patterns, given in tables and reproductions; they also include the available chemical analyses of Canadian materials and summaries of observed occurrences and associations. The topographic list of Canadian telluride localities distinguishes positive identifications by *x*-rays from those based on older methods.

INTRODUCTION

The telluride minerals as a group are rarer than the sulphides and less well known, and consequently they are of special interest to the ore mineralogist. At the same time the tellurides are unusually interesting to the mining geologist and the prospector, as compounds of gold and silver or as close associates and indicators of the precious metals. The four main telluride districts are Nagyág (Transylvania), Kalgoorlie (Western Australia), Cripple Creek (Colorado), and Kirkland Lake (Ontario), and all of these are also important gold producing districts. The telluride min-

[1] Extracted from an unpublished Ph.D. thesis: Descriptive mineralogy of the tellurides —*University of Toronto*, 1946.

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erals of the Transylvanian deposits have been described principally by Schrauf (1878), those of Kalgoorlie by Stillwell (1931), those of Cripple Creek by Genth (1868, 1877), Penfield & Ford (1902), and others, and the Canadian localities have been recorded by Cairnes (1912), Todd (1929), and especially Ellis Thomson (1922–1937).

Until recently the known Canadian telluride localities have been almost confined to Ontario and Quebec. The discovery of a number of bismuth tellurides in British Columbia by Dr. H. V. Warren led to an intensive study of these minerals and the bismuth-tellurium system by Dr. M. A. Peacock (1941; Warren & Peacock, 1945), and as a result the members of this group and their relations are better known. As a student and assistant of Professor Warren in Vancouver and later of Professor Peacock in Toronto, the present writer became interested in the occurrence of tellurides in British Columbia and their persistent association with gold, and this led him to an extended study of these minerals and their occurrence in Canada.

Methods of Study

The study of a species commenced with an examination of hand specimens in daylight, and under the binocular microscope. This revealed such properties as cleavage, colour, tarnish, and lustre, and permitted the determination of hardness, tenacity, and mineral association. Numerous specific gravity measurements were made on selected fragments, with the Berman torsion microbalance, which uses samples of 10–20 mg. The minerals studied are all opaque and therefore polished sections were made to test the homogeneity of the material, to observe the optical properties in reflected light and the behaviour to the standard etch-reagents as recorded by Short (1940), and occasionally to determine paragenetic relationships. Numerous x-ray powder photographs were made to compare known and doubtful materials. Whenever the elements of the unit cell were known or could be determined, the powder pattern was indexed as far as it seemed reasonable, giving standard x-ray powder patterns with every line accounted for.

Telluride minerals often occur in small amount in ore, in intimate association with sulphides and gold. Precise determination is rarely possible in such small areas by the usual microscopic means, as many of the tellurides have similar properties, and numerous errors have been made in identification. In general, there is great need for corroborative evidence in the determination of the rarer minerals in polished sections. Such minerals are often named on the basis of optical behaviour, etch-tests, and micro-chemical tests which are not always sufficient. Mistakes in identification lead to embarrassment to the writers and confusion in the literature. It is hoped that the time is rapidly approaching when all but the commonest ore minerals will be positively identified by *x*-ray means.

The following procedure, based on the methods of Haycock and Harcourt, was used to determine minerals present in areas as small as 20 microns in diameter in a polished section. A needle with a very sharp point was applied to the area in question and a minute quantity detached by slight scraping. A drop of collodion was placed on the scraping and allowed to become almost dry before being collected by the needle and transferred to the point of a finger where it was rolled into a small ball by another finger. This ball was then placed on the end of a thin filament of glass and centered in the *x*-ray camera. The resulting powder pattern on a fraction of a milligram usually served definitely to identify the substance. In some cases, where the area scraped was less than 20 microns in diameter, the pattern of the adjacent mineral or minerals was also present and could often be identified.

Scope of the Present Paper

A full account of the writer's work on the telluride minerals is given in an unpublished Ph.D. thesis, and some of the results of this work have already been published (Thompson, 1946*a*, 1946*b*, 1947; Peacock & Thompson, 1946*a*, 1946*b*). The present paper is restricted to critically revised and condensed synoptic descriptions of all the known telluride minerals, together with a catalogue of occurrences in Canada. The descriptions emphasize the characters that can be determined by simpler means, and most of the information has been confirmed or improved by direct observation. Many new observations, notably measurements of specific gravity, cell dimensions and *x*-ray powder patterns, are included. To save space the indices (*hkl*) and the calculated spacings of the powder patterns have been omitted. The catalogue of Canadian telluride occurrences and associations distinguishes those which have been established by *x*-ray photographs from those based on earlier determinations. An account of a study of the pyrosynthesis of the tellurides is reserved for another occasion, and all discussion of the origin and economic value of the tellurides is excluded from this purely descriptive paper. For convenience the tellurides are grouped according to the principal metal constituents: gold (montbrayite, calaverite, krennerite); gold and silver (petzite, sylvanite); silver (hessite, empressite); copper (weissite, rickardite); nickel (melonite); iron (frohbergite); lead (altaite, nagyagite); mercury (coloradoite); bismuth (hedleyite, joseite, tellurbismuth, wehrlite, tetradymite); and finally the uncertain or discredited tellurides, stuetzite, muthmannite, niggliite, "antamokite" and "goldfieldite" are briefly mentioned.

Material and Acknowledgments

In the examination of any mineral species authentic material is of great importance. I wish to express my thanks to Dr. V. B. Meen of the Royal Ontario Museum of Geology and Mineralogy who kindly placed at my disposal many excellent and typical specimens; to Mr. R. A. Bryce of Macassa Mines for several spectacular specimens of ore from the Robb-Montbray Mine, Montbray Township, Quebec; to Dr. M. H. Frohberg for a large number of specimens from northern Ontario, Quebec and elsewhere; to Dr. H. Hopkins for specimens from the Wright-Hargreaves Mine, Kirkland Lake, Ontario; to Dr. E. P. Henderson of the United States National Museum for type specimens of empressite and "antamokite"; to Professor H. E. T. Haultain for specimens of sylvanite and native tellurium; to Mr. S. A. Pain for an excellent specimen of hessite and petzite; to the several mining companies in Ontario and Quebec for supplying specimens of telluride ores for study; to Dr. H. V. Warren of the University of British Columbia for several specimens of telluride ores. Finally I am much indebted to Professor M. A. Peacock, under whom this work was carried out, for spending much time assisting me in the course of this study and in the preparation of this report.

Mineral Descriptions[3]

Tellurides of Gold

Montbrayite—Au_2Te_3

Triclinic, $P\bar{1}$; $a=12.08$, $b=13.43$, $c=10.78$, $\alpha=104°\ 30\frac{1}{2}'$, $\beta=97°\ 34\frac{1}{2}'$, $\gamma=107°\ 53\frac{1}{2}'$; $Z=12$ (Peacock & Thompson, 1946*b*).

Massive but sometimes with interrupted parting planes. Yellowish-white colour, paler than calaverite, with splendent metallic lustre. Very brittle, breaking with a flat-conchoidal fracture; $H=2\frac{1}{2}$ (C); $G=9.94$.

Polished sections creamy-white like krennerite and distinctly less white than altaite. Reflection pleochroism rarely perceptible; weak to moderate anisotropism (light gray, light yellow-brown, blue-gray). The mineral makes coarse solid mosaics with optically continuous areas often several millimeters in width. HNO_3 (1:1), strong effervescence with a light yellow-brown stain; several small (50 micron) circular areas staining light gray; after the drop has been removed an "alligator-skin" etch-pattern develops leaving the circular areas in relief; HNO_3 (3:2), slower effervescence; surface stains light brown with development of small circular areas similar to the above which are also stained light brown; after the drop has been removed an etch-pattern develops with one prominent direc-

[3] Lattice dimensions throughout this paper are in kX units. New measurements are based on the wavelengths $CuK\alpha_1=1.5374$, $FeK\alpha_1=1.9321$ kX.

tion; an epidermis a few microns thick tends to come off and curl up at the edges; this may be completely removed with hard buffing, the surface again becoming apparently homogeneous; HNO_3 (conc.), very slow effervescence; surface stains uniformly light gray-brown; no etch-pattern develops after the drop has been removed; circular areas absent; HCl, KCN, $FeCl_3$, KOH, $HgCl_2$, negative.

X-Ray Powder Pattern (Peacock & Thompson, 1946*b*; fig. 1)

I	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)
1	5.9	7.48	1	21.3	2.12	2	31.8	1.459
2	9.9	4.47	10	21.65	2.08	½	32.2	1.443
½	10.9	4.07	1	22.2	2.03	½	33.5	1.393
½	11.65	3.81	1	22.9	1.975	½	35.05	1.339
½	12.6	3.52	1	23.8	1.905	1	35.55	1.322
1	13.8	3.22	½	24.45	1.857	2	35.95	1.309
8	15.0	2.97	½	24.75	1.836	½	39.4	1.211
8	15.25	2.92	½	25.5	1.786	2	39.9	1.198
½	18.1	2.47	2	26.6	1.717	1	47.6	1.041
1	18.9	2.37	2	26.9	1.699	½	55.1	0.937
1	19.75	2.27	2	31.05	1.490	1	56.1	0.926

Occurrence: This species was found at the Robb-Montbray Mine, Montbray Township, Quebec, and described in detail by Peacock & Thompson (1946*b*). The gold telluride is abundant in some specimens (about 20 specimens are known to have been preserved) forming equidimensional masses sometimes exceeding 1 cm. in diameter. Freshly broken surfaces show coarsely crystallized aggregates of montbrayite, tellurbismuth, altaite, melonite, gold, chalcopyrite, and pyrite. In polished sections the following minerals are found in contact with montbrayite or enclosed within the gold telluride; altaite, tellurbismuth, petzite, gold, chalcopyrite, melonite, and frohbergite. Altaite, with small amounts of gold and petzite, occurs in thin stringers cutting montbrayite. Tellurbismuth with subordinate altaite and small patches of petzite make ovoid inclusions with a eutectoid structure, irregularly distributed through montbrayite. In total bulk these inclusions might amount to 10 per cent of the montbrayite and in some cases they reach 1 mm. in diameter. In ordinary light the altaite shows as straight or curved bluish-white bands within the tellurbismuth, which is faintly reddish-white by contrast and not easily distinguished from the surrounding montbrayite. Crossed nicols emphasize the anisotropic tellurbismuth, and staining with HCl darkens the bands of altaite. These inclusions have the appearance of exsolution products. Petzite occurs as irregular areas often surrounding and traversing patches of montbrayite, and occasionally cutting altaite, tellurbismuth, and melonite. Subhedral crystals of melonite, with or without partial rims of petzite, occur in montbrayite, but the best crystal outlines are shown by isolated plates of melonite in altaite. The chalcopyrite does not occur in the montbrayite itself but at the boundaries of altaite, tellurbismuth, petzite, and gold with montbrayite. Gold occurs abundantly in areas rich in pyrite and replaces subhedral crystals of the latter. Marcasite, chalcocite, and covellite are present in minor amounts.

Analysis	1	A
Au	44.32	50.77
Ag	0.55	—
Pb	1.61	—
Bi	2.81	—
Sb	0.90	—
Te	49.80	49.23
	99.99	100.00

1. Montbrayite with visible inclusions of tellurbismuth, altaite, and petzite. Anal. Williams (in Peacock & Thompson, 1946*b*).
A. Calculated for Au_2Te_3.

Calaverite—$AuTe_2$

Monoclinic, *C*2/*m*; $a=7.18$, $b=4.40$, $c=5.07$, $\beta=90°\pm30'$; $Z=2$ (Tunell & Ksanda, 1935).

Bladed or lath-like crystals, stout or slender prisms, also massive, granular to indistinctly crystalline. Pale brass-yellow in colour like pyrite, with high metallic lustre; twice observed with a peculiar bronzy-purple tarnish. Very brittle, breaking with a sub-conchoidal to uneven fracture; no cleavage. $H=2\frac{1}{2}$–3 (C); G=9.10–9.40 (R.M.T.).

Polished sections creamy-white with moderate anisotropism (light gray, brown, dark gray), showing moderately coarse-grained mosaics. HNO_3 (1:1) stains light brown with effervescence; after the drop has been removed and the surface dried, an etch-cleavage develops showing one prominent direction; a few small circular areas similar to those developed in montbrayite and krennerite are less affected; HNO_3 (3:2) stains light brown with effervescence; after the drop has been removed and the surface dried a two directional etch-pattern with several relatively unetched circular areas develops; with hard buffing the etch-cleavage pattern and circular areas may be removed, the surface underneath becoming perfectly smooth and apparently homogeneous; HNO_3 (conc.) gives purplish-brown stain and a series of very fine closely spaced lines; HCl, KCN, negative; $FeCl_3$ slowly stains light brown; KOH, $HgCl_2$ negative. These observations on unoriented sections are in good agreement with those given by Short (1937).

X-Ray Powder Pattern (R.M.T.; fig. 2)

I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)
1	8.8	5.02	1	31.8	1.459	2	50.1	1.002
½	11.8	3.76	½	32.5	1.431	3	52.1	0.974
10	14.8	3.01	2	33.9	1.378	2	54.1	0.949
3	15.25	2.92	3	35.1	1.337	½	55.4	0.934
4	20.5	2.19	3	35.9	1.311	½	56.7	0.920
8	21.6	2.09	2	38.05	1.247	4	59.9	0.888
2	21.95	2.06	½	38.8	1.227	1	63.7	0.857
1	22.5	2.01	½	39.4	1.211	1	65.7	0.843
2	23.4	1.936	4	40.05	1.195	1	69.9	0.819
½	24.7	1.840	½	41.5	1.160	1	71.2	0.812
½	25.5	1.786	½	44.65	1.094	1	72.1	0.808
3	26.0	1.754	1	45.4	1.081	1	76.9	0.779
3	27.15	1.685	1	45.9	1.070	1	82.3	0.776
1	30.0	1.537	2	47.2	1.048			
3	30.8	1.501	2	48.4	1.028			

Occurrences: Rhodesia, Western Australia, Philippine Islands, Salvador, New Mexico, California, Colorado. At Kalgoorlie, Western Australia, as small compact masses (2×5 mm.) in a chip of chlorite schist; at the Benguet Consolidated Mine, Antamok, Mountain Province, Philippine Islands, in a specimen of somewhat vuggy quartz with disseminated chalcopyrite, gold, sphalerite, tetrahedrite, galena, calaverite, and pyrite; at Cripple Creek, Colorado, in several specimens of a fine-grained volcanic rock with fine-grained purple fluorite and calaverite as thin laths (1×5 mm.) or disseminated; also as two small crystals. Polished sections from Cripple Creek, Colorado, show calaverite as large irregular lath-like areas in gangue. The mineral contains small inclusions of pyrite and also replaces it; no free gold was observed in the sections.

In Canada calaverite has been identified by x-ray photographs at the Wright-Hargreaves, Bidgood, Macassa, Toburn, Lake Shore, Kirkland Golden Gate, and Upper Canada Mines, Kirkland Lake Area, Ontario, as small compact masses or disseminations in quartz, calcite, or altered porphyry, in association with other tellurides, sulphides, and free gold; at the Miller Independence Mine, Boston Creek, Pacaud Township, in a polished section with chalcopyrite, pyrite, and sphalerite. Also at the Lamaque Mine, Bourlamaque Township, Quebec, in a specimen of white quartz with small plates of tellurbismuth and massive calaverite; at the Louvicourt Goldfields Mine, Louvicourt Township, Quebec, in several specimens of tourmalinized quartz with much free gold and small areas of calaverite and tarnished tellurbismuth in close association with calcite; at the Canadian Malartic Gold Mine, Fourniere Township, Quebec, as massive milky quartz with occasional 1 mm. grains of calaverite; and at the Horne Mine, Noranda, Quebec, in several pieces of greenstone with altaite, petzite, and calaverite in coarsely crystalline masses or intergrown with tellurbismuth.

Calaverite has also been reported from British Columbia, as a brass-yellow telluride (apparently calaverite) from the Engineer Mines, Taku Arm, Tagish Lake, Atlin Mining Division (Cairnes, 1912, p. 193); from Glacier Gulch, near Smithers (Pratt, 1931, p. 56); in Ontario from Painkiller Lake, Beatty Township (Hopkins, 1915, p. 180); the Boston McRae Mine, Pacaud Township (Thomson, 1922, p. 97); from Bigstone Bay, Lake of the Woods (Thomson, 1935, p. 48); from the Teck-Hughes and Sylvanite Mines, Kirkland Lake (Todd, 1929, pp. 81–83).

Calaverite from the Macassa Mine, Kirkland Lake, Ontario, occurs disseminated throughout quartz, also with gold, filling fractures in quartz. Large areas of calaverite often have small particles of gold attached. The calaverite appears to have replaced the fine grained pyrite with which it is associated. The writer's observations are in agreement with those of other workers as to the paragenesis at Cripple Creek, and Kirkland Lake, namely that the sulphides were formed first followed by tellurides and finally gold.

Analyses	1	2	A
Au	39.36	38.55	43.59
Ag	0.30	0.22	—
Pb	5.20	6.49	—
Cu	0.24	trace	—
Fe	0.33	0.70	—
Te	54.32	52.70	56.41
S	0.12	0.55	—
Insol	0.24	0.60	—
	100.11	99.81	100.00

1. Calaverite, Lake Shore Mine, Kirkland Lake, Ontario, with minor altaite; incl. Hg, Bi, Se, none. Anal. Rickaby (in Todd, 1929, p. 77).

2. Calaverite, Wright-Hargreaves Mine, Kirkland Lake, Ontario, with minor altaite, pyrite, and chalcopyrite; incl. Hg, Bi, Se, none. Anal. Rickaby (in Todd, 1929, p. 78).

A. Calculated for $AuTe_2$.

Krennerite—$(Au,Ag)Te_2$

Orthorhombic, *Pbm*2; $a=8.80$, $b=16.51$, $c=4.45$; $Z=8$ (Tunell & Ksanda, 1936).

Highly modified short vertically striated prismatic crystals, cleavage fragments, and grains. Silver-white in colour tarnishing to light brass-yellow. Perfect basal cleavage and uneven fracture. Brittle; $H=2\frac{1}{2}$ (C); $G=8.62$.

Polished sections creamy-white, weakly anisotropic (light gray to dark gray) on a basal section. HNO_3 (1:1) stains light brown with effervescence; after the drop has been removed, a distinct two directional etch-cleavage pattern develops; HNO_3 (3:2) gives a similar stain and etch-cleavage pattern appears but relatively unetched circular areas appear irregularly distributed over the surface; HNO_3 (conc.) stains light brown and develops a few irregular flakes; HCl, KCN negative; $FeCl_3$ stains light yellow; KOH gives light gray-brown tarnish; $HgCl_2$ negative.

X-Ray Powder Pattern (R.M.T.; fig. 3)

I	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)
1	9.4	4.71	3	21.8	2.07	3	31.7	1.463
3	11.25	3.94	1	22.95	1.971	2	33.35	1.398
10	14.60	3.05	1	23.55	1.924	3	34.75	1.348
4	15.05	2.96	3	25.65	1.776	4	35.8	1.314
1	19.15	2.34	½	26.25	1.738	1	37.45	1.264
4	20.1	2.24	3	27.0	1.693	1	38.75	1.228
5	21.35	2.11	3	30.45	1.517	3	39.85	1.199

Occurrences: Transylvania, Western Australia, Colorado. At Kalgoorlie, Western Australia, krennerite was identified as a small cleavage fragment (2×2 mm.) with a particle of attached petzite; and at Cripple Creek, Colorado, in a fine grained volcanic rock, disseminated, and as short striated prisms on one surface.

In Canada krennerite has been reported in Ontario, from the Ashley Mine, Bannockburn Township (Thomson, 1932, p. 27); from the McKenzie Red Lake Gold Mines, Red Lake (Hoiles in Horwood, 1945, p. 166) (the writer examined Hoiles' polished sections but observed only galena and tetradymite); and in Quebec, from the Robb-Montbray Mine, Montbray Township (Thomson, 1928, p. 12) (actually montbrayite), and from the Horne Mine, Noranda (Price, 1934, p. 132). There are no analyses of reported Canadian occurrences.

Tellurides of Gold and Silver

Petzite—Ag_3AuTe_2

Crystal system unknown, usually massive with no trace of crystal form. Bright steel-gray with a mauve tinge to nearly jet-black, tarnishing from bronze-yellow to sooty black. No cleavage but slightly sectile to brittle with a sub-conchoidal fracture. $H=2\frac{1}{2}$ (A+); $G=9.13$ (R.M.T.).

Polished sections galena-white but violet-gray to dull gray in contact with other tellurides, sulphides, or gold; rarely shows triangular pits; isotropic. HNO_3 quickly stains iridescent; HCl stains iridescent; KCN negative; $FeCl_3$ quickly stains iridescent; KOH negative; $HgCl_2$ slowly stains brown.

Petzite is not readily distinguished from coloradoite, empressite, or some types of tetrahedrite in hand specimens. Coloradoite, empressite, and tetrahedrite are quite brittle and show no sign of sectility when tested with a steel needle under a binocular. Petzite is at first slightly sectile but with increasing pressure particles snap off. The brownish-red streak of tetrahedrite helps to distinguish it from petzite. If a purple tarnish is not present on coloradoite, the mineral is indistinguishable from petzite.

X-Ray Powder Pattern (R.M.T.; fig. 4)

I	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)
2	5.9	7.5	1	30.25	1.525	½	43.6	1.114
2	12.1	3.67	1	31.0	1.492	½	44.25	1.101
½	13.6	3.27	1	31.8	1.458	½	44.9	1.089
1	14.9	2.99	1	32.4	1.434	1	46.0	1.069
10	16.1	2.77	1	33.15	1.405	½	47.5	1.043
½	17.25	2.59	2	33.85	1.380	½	49.95	1.004
3	18.35	2.44	3	35.85	1.312	1	51.1	0.988
3	19.4	2.31	1	36.5	1.292	½	53.1	0.961
5	21.3	2.11	1	37.2	1.271	½	56.7	0.920
4	22.3	2.02	1	39.8	1.200	½	59.3	0.894
3	23.9	1.897	1	41.05	1.170	1	60.9	0.880
2	24.9	1.826	½	42.3	1.142	1	62.35	0.868
1	29.55	1.558	½	43.05	1.126			

Occurrences: Transylvania, Western Australia, Colorado; also reported from New Mexico, California, Oregon, New Zealand, Korea, Siberia, and Asia Minor. Identified at Kalgoorlie, Western Australia, as several small chips associated with coloradoite and krennerite; at Gold Hill, Boulder County, Colorado, as a compact mass 10×10 mm.; and at the Red Cloud Mine, Boulder County, Colorado, as a compact mass associated with tetradymite and pyrite.

In Canada, the occurrence of petzite from numerous localities has been confirmed by *x*-ray powder photographs. In British Columbia, at the Hedley Monarch Mine, Osoyoos Mining Division, as minute areas in polished section associated with altaite and hessite. In Manitoba, at the San Antonio Mine, near Bissett, in a specimen of quartz with small areas of calcite containing abundant gold and small grains of petzite. In Ontario at the Ardeen (Moss) Mine, Moss Township, together with hessite, as a massive black crust 5 mm. thick on one surface of vein quartz; at the Lake Shore Mine, Kirkland Lake, as disseminations in quartz porphyry and associated with chalcopyrite and gold; at the Toburn Mine, Kirkland Lake, as a specimen of brecciated quartz and country rock with small areas of petzite and coloradoite associated with pyrite and molybdenite as a film on one surface; at the Upper Canada Mine, Gauthier Township, as small areas in contact with calaverite in sheared porphyry, associated with altaite, chalcopyrite, pyrite, and gold; at the Hollinger Mine, Porcupine district, in several specimens showing petzite as compact masses, small streaks, or disseminated throughout quartz or along cleavage planes of ankerite. In Quebec, at the Canadian Malartic Mine, Fourniere Township, as minute grains in milky quartz, associated with wehrlite, gold, and pyrite; at the Lamaque Mine, Bourlamaque Township, as an intimate intergrowth with a 4 mm. gold crystal; at the Stadacona Mine, Rouyn, as small areas in a quartz calcite gangue; at the Robb-Montbray Mine, Montbray Township, as small amounts in polished sections associated with montbrayite, melonite, frohbergite, altaite, and tellurbismuth; at the Horne Mine, Noranda, Quebec, as several specimens with petzite as a coating or as compact masses associated with calaverite and coarsely crystalline altaite; at the Bevcourt Mine, Louvicourt Township, disseminated with altaite, wehrlite, and gold in massive white quartz; and at the Sullivan Consolidated Mines, disseminated with tellurbismuth in massive white quartz.

Petzite has also been reported in Canada from the Yukon Territory, British Columbia, Ontario, and Quebec. In the Yukon Territory, from the Gold Reef Claim on Gold Hill, Wheaton River district (Cairnes, 1912, p. 192); in British Columbia from the Calumet Claim, Kruger Mountain, Osoyoos Lake, Osoyoos Mining Division, and the Enterprise Claim, Long

Analyses	1	2	3	A
Au	11.10	21.56	23.691	25.42
Ag	49.57	34.86	41.062	41.71
Hg	—	6.90	—	—
Pb	—	0.24	0.071	—
Fe	0.76	0.56	trace	—
Co	0.76	—	—	—
As	1.20	—	—	—
Te	33.62	33.40	32.007	32.87
Insol	2.38	0.80	0.097	—
	99.39	98.32	96.928	100.00

1. Petzite, Hollinger Mine, Porcupine district, Ontario; incl. S, Sb, Ni, trace. Anal. Rickaby (in Walker & Parsons, 1925, p. 40). Perhaps hessite with included gold.
2. Petzite, Sylvanite Mine, Kirkland Lake, Ontario, with microscopic coloradoite; incl. Cu, S, trace, Bi, Se, none. Anal. Rickaby (in Todd, 1929, p. 81).
3. Petzite, Huronian Mine, Moss Township, Ontario (Smith, 1890, p. 439).

A. Calculated for Ag_3AuTe_2.

Lake, Greenwood Mining Division (Hoffmann, 1897, p. 12R); in Ontario from the Labine-Smith Claims, Maisonville Township (Burrows & Hopkins, 1914, p. 35); from the McKenzie Red Lake Gold Mines, Red Lake (Hoiles, in Horwood, 1945, p. 166); the Anderson Farm, Benoit Township (Burrows, 1917, p. 250); the Sylvanite and Wright-Hargreaves Mines in the Kirkland Lake field (Todd, 1929, pp. 80–83); from the Jackson-Manion Mine, Dent Township (Bruce, 1928, p. 30); from Bigstone Bay, Lake of the Woods (Thomson, 1935, p. 48); in Quebec, from the Opasatica district (Harvie, 1912, p. 166; previously reported as sylvanite).

Sylvanite—$AuAgTe_4$

Monoclinic, *P2/c;* $a=8.94$, $b=4.48$, $c=14.59$, $\beta=145°\ 26'\pm20'$; $Z=2$ (Tunell & Ksanda, 1937).

Complex prismatic, thick tabular, skeletal or bladed crystals; imperfectly columnar to granular. Contact, lamellar, or penetration twins giving arborescent forms resembling written characters (graphic tellurium, *Schrifterz*). Silver white colour with brilliant metallic lustre, tarnishing to a light yellow. Cleavage perfect side pinakoidal; brittle; H=2 (C); G =8.24 (R.M.T., Kalgoorlie). Not readily distinguished from native tellurium and krennerite in fresh hand specimens.

Polished sections pleochroic (creamy-white to creamy-gray) often with marked lamellar twinning, and moderately to strongly anisotropic (light gray, brownish-gray to dark violet-gray). HNO_3 (1:1) quickly stains brown, twinning becomes pronounced and a finely irregular and occasionally rectangular etch-cleavage develops when the drop is on the specimen; HNO_3 (3:2) stains through iridescent to reddish-brown with development of a two directional etch-pattern in which one direction predominates; HNO_3 (conc.) stains dark gray-brown, with no etch-cleavage pattern; HCl, KCN negative; $FeCl_3$ leaves a light yellow-brown stain (rubs clean); KOH, HgCl negative. These observations were made on a random section. The following properties are useful in distinguishing sylvanite from calaverite, krennerite, and montbrayite in polished sections: marked pleochroism; lamellar twinning; absence of circular areas on etching with HNO_3; the very quick reaction to various strengths of HNO_3; the fact that an etch-cleavage pattern develops while the drop is on the specimen.

Occurrences: Transylvania, Western Australia, Fiji Islands, Colorado, Oregon. Sylvanite was confirmed at Nagyág, Transylvania, on a specimen of phonolite with single crystals, twins and cleavable masses of sylvanite as a thin film on one surface; at Kalgoorlie, Western Australia, as two small cleavage fragments; and at Vatukoula, Fiji Islands, as

X-Ray Powder Pattern (R.M.T.; fig. 5)

I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)
½	6.0	7.35	1	21.65	2.08	1	34.4	1.361
1	8.7	5.08	3	22.8	1.984	1	34.9	1.344
½	9.8	4.52	1	24.75	1.836	½	35.65	1.319
1	11.15	3.97	2	25.4	1.792	½	37.15	1.272
1	11.6	3.82	½	26.05	1.750	½	38.55	1.233
½	14.1	3.16	1	26.65	1.714	1	39.1	1.219
10	14.65	3.04	½	27.9	1.643	1	40.25	1.190
2	15.0	2.97	½	29.3	1.571	½	42.6	1.136
½	18.1	2.47	2	30.4	1.519	½	45.15	1.084
½	18.75	2.39	½	31.0	1.493	½	47.1	1.049
3	20.0	2.25	½	31.6	1.467	1	48.9	1.020
5	21.0	2.14	1	32.9	1.415	½	50.3	0.999
1	21.3	2.12	1	33.0	1.411			

several specimens of skeletal crystals and cleavable masses in vuggy quartz, associated with native tellurium and pyrite.

No Canadian specimen of sylvanite was available for study. Sylvanite has been reported from the Yukon Territory, Ontario, and Quebec. In the Yukon, from the Gold Reef Claim, Gold Hill, and the Buffalo Hump Group, Mount Stevens, Wheaton district (Cairnes, 1912, p. 192); in Ontario, from the Ardeen (Huronian) Mine, Moss Township, in a Royal Commission Report, but an analysis of this mineral by Smith (1890, p. 439) agrees closely with that of petzite; from Bigstone Bay, Lake of the Woods, and the Dome Mine, Porcupine district (Dana, 1944, p. 340); from the Gold Eagle Mine, Red Lake (McGill in Horwood, 1945, p. 114); from the Howey Gold Mine, Red Lake (Cornford in Horwood, 1945, p. 144); in Quebec, Harvie reported sylvanite from the Opasatica district, Pontiac County in 1910 but later revised his determination to petzite (1912, p. 166); and from the Horne Mine, Noranda (Price, 1934, p. 132).

Tellurides of Silver

Hessite—Ag_2Te

Crystal system unknown; the powder pattern does not index on the monoclinic elements of Tokody (1932, 1934).

Usually massive, occasionally in highly modified, distorted cubic or pseudocubic crystals, compact, or fine granular. Dark lead-gray, usually tarnishing to black, dull gray, or bronze. No cleavage but sectile with an uneven fracture. $H=2\frac{1}{2}$ (A); $G=8.41$ (R.M.T.).

Polished sections light gray, moderately anisotropic with polarization colors, gray, steel-blue, bornite-pink; characteristic confused lamellar twinning. HNO_3 stains iridescent to black; HCl slowly stains black; negative on some areas; KCN on some specimens slowly stain black, on others negative; $FeCl_3$ quickly stains iridescent; KOH negative; $HgCl_2$ tarnishes light brown.

Hessite resembles argentite but the latter yields metallic shavings whereas hessite yields a powder when scratched.

X-Ray Powder Pattern (R.M.T.; fig. 6)

I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)
½	6.2	7.12	7	20.05	2.24	½	28.8	1.596
1	9.8	4.52	2	20.5	2.19	½	29.1	1.581
½	11.9	3.73	6	21.1	2.14	½	29.95	1.540
½	13.1	3.39	1	22.55	2.00	2	32.2	1.443
2	14.0	3.18	½	23.2	1.951	4	33.7	1.385
6	14.85	3.00	½	23.6	1.920	½	35.1	1.337
8	15.6	2.86	½	24.7	1.840	2	36.2	1.302
½	16.0	2.79	½	25.0	1.819	1	37.1	1.274
½	16.65	2.68	1	25.8	1.766	1	38.2	1.243
1	18.35	2.44	½	26.4	1.729	½	40.3	1.189
10	19.5	2.30	1	27.05	1.690			

Occurrences: Altai Mountains (Siberia), Transylvania, Asia Minor, Western Australia, Chile, Mexico, New Mexico, Arizona, California, Colorado, Utah. Hessite was confirmed on a specimen from Botés, Transylvania, in crystalline sphalerite with a few poorly developed crystals of hessite on a group of compact quartz crystals; and from Gold Hill, Boulder County, Colorado, as a 5×5 mm. globular mass.

In Canada the occurrence of hessite has been established by *x*-ray powder photographs from the following localities. In the Yukon Territory from Upper Burwash Creek, as a number of small nuggets of gold and hessite from the placer workings of Mr. G. Loland; and from the Buffalo Hump Group on Mount Stevens, Wheaton River district, as sparse disseminations in quartz with galena. In British Columbia, from the Marble Bay, and Little Billie Mines, Texada Island, as minute amounts in close association with chalcopyrite, bornite, and wehrlite in polished sections; at the Harrison Group, Lindquist Lake, Omineca Mining Division, as microscopic amounts in polished sections; from the Con West property, Taseko Lake, Clinton Mining Division, as small areas embedded in chalcopyrite in polished sections; from the Pellaire Gold Mines property, Taseko Lake, Clinton Mining Division, as several small grains with free gold obtained with the superpanner; from the Lakeview and North Star Claims, Long Lake, Greenwood Mining Division, as compact masses of somewhat granular hessite 20×20 mm. with a few small quartz crystals; from the Boundary District, as a few small isolated fragments; and from the Hedley Monarch Mine, Osoyoos Mining Division, as a $\frac{1}{2}$ mm. area in a polished section, in contact with altaite and petzite. In Ontario, from the Ardeen (Moss) Mine, Moss Township, as grains of hessite and altaite in a gangue of quartz and calcite; and also, together with petzite, as a massive black crust, 5 mm. thick, on one surface of vein quartz with gold and hessite in the form of $\frac{1}{2}$ mm. bronzy to black films partially covering two other surfaces; at the Hollinger Mine, Porcupine district, as thin films on cleavage planes of ankerite; at a prospect in Tisdale Township, Porcupine area, as a specimen of vein quartz with a 4 mm. area of hessite and gold at the contact of a serpentine stringer; and at the Kirkland Lake Mine, Kirkland Lake, as coarsely crystalline calcite with grains of hessite associated with small compact masses of coloradoite, chalcopyrite and tetrahedrite. In Quebec at the Sullivan Mine, Bourlamaque Township, as disseminated grains in quartz and associated with tourmaline, pyrite, chalcopyrite and gold.

Hessite has also been reported elsewhere in Canada, from the Yukon Territory, British Columbia, Ontario, and Quebec. In the Yukon Territory from the Gold Reef Claim on Gold Hill, Wheaton River district (Cairnes, 1912, p. 192); in British Columbia from the Calumet Claim, Kruger Mountain, Osoyoos Mining Division (Hoffmann, 1897, p. 12R); from Liddle Creek, Kaslo River, W. Kootenay district (Hoffmann, 1897, p. 10R); in Ontario, from Gold Creek, Pine Portage Bay, Lake of the Woods (Coleman, 1896, p. 105); from the Powell Claim, Deloro Township (Burrows, 1912, p. 229); from Bigstone Bay, Lake of the Woods (Thomson, 1935, p. 48); from the Toburn (Tough-Oakes) Mine, Kirkland Lake (Campbell & Deyell, in Burrows & Hopkins, 1914, p. 23); in Quebec from the McWatters Mine, Rouyn Township (Hawley, in Thomson, 1935, p. 48); and the Horne Mine, Noranda (Price, 1934, p. 132).

Analyses	1	2	3	4	A
Au..........	2.29	—	0.10	trace	—
Ag..........	60.68	61.01	61.88	62.01	62.86
Te..........	37.33	35.40	—	29.62	37.14
Fe..........	—	—	—	1.76	—
	100.30	96.41		93.39	100.00

1. Hessite, Lakeview Claim, Long Lake, Greenwood Mining Division, B. C. Anal. Guess & Guess (in Hoffman, 1897, p. 12R).

2. Hessite, Gold Creek, Pine Portage Bay, Lake of the Woods, Ontario. Anal. Lawson (in Coleman, 1896, p. 105).

3. Hessite, Powell Claim, Deloro Township, Ontario (Burrows, 1912, p. 229).

4. Hessite, Huronian Mine, Moss Township, Ontario (Smith, 1890, p. 440).

A. Calculated for Ag_2Te.

Empressite—Ag_5Te_3[4]

Massive to finely granular, with no indication of crystal form. Heavy metallic lustre and an almost jet black colour, like petzite but with a slight bronzy cast. No cleavage, but with a finely conchoidal to uneven fracture; $H=3\frac{1}{2}$ (C); $G=7.61+0.01$ (R.M.T.).

Polished sections give a smooth surface which shows strong reflection pleochroism (light gray-mauve to creamy-white, depending on the orientation) and intense anisotropism (white, yellowish green, russet-brown, brown, dark blue). The mineral makes a solid moderately coarse-grained mosaic. HNO_3, slow effervescence and slow iridescent stain which may be removed by hard buffing; HCl, KCN, negative; $FeCl_3$, iridescent stain which remains on buffing; KOH, negative; $HgCl_2$, quick iridescent stain which remains on buffing.

X-Ray Powder Pattern (R.M.T.; fig. 7)

I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)
$\frac{1}{2}$	10.1	4.38	1	20.1	2.24	$\frac{1}{2}$	29.9	1.542
$\frac{1}{2}$	11.2	3.96	10	20.8	2.16	$\frac{1}{2}$	31.8	1.459
1	12.5	3.55	2	21.3	2.12	$\frac{1}{2}$	32.25	1.441
$\frac{1}{2}$	13.1	3.39	1	22.2	2.03	$\frac{1}{2}$	32.65	1.425
$\frac{1}{2}$	13.8	3.22	1	23.5	1.928	2	34.8	1.347
2	14.7	3.03	$\frac{1}{2}$	23.8	1.905	$\frac{1}{2}$	35.8	1.314
$\frac{1}{2}$	15.8	2.82	$\frac{1}{2}$	24.3	1.868	$\frac{1}{2}$	36.6	1.289
1	17.0	2.63	$\frac{1}{2}$	27.6	1.659	$\frac{1}{2}$	37.0	1.277
5	17.6	2.54						

Occurrences: This mineral has been found only in Colorado. A specimen from the Empress Josephine Mine, Kerber Creek District (type locality), is a compact mass of empressite partially covered with a coating of a clay-like material with disseminated yellowish brown sphalerite and finely crystalline pyrite; on one corner is a small area of galena. Established also at the Red Cloud Mine, Boulder County (mislabelled petzite), as sparse disseminations in rock with altaite.

Tellurides of Copper

Weissite—Cu_2Te

Pseudocubic; $a=7.22$ (R.M.T.); $Z=8$.

Massive with irregular fracture. Bluish-black tarnishing to black. No cleavage; $H=3$ (B); $G\approx 6$.

Polished sections light gray with moderate anisotropism (pink, bluish-

[4] This composition is indicated by pyrosyntheses.

gray to blue), like chalcocite. The mineral is sponge-like with gangue filling the cavities. HNO_3 effervesces and stains brown; HCl stains light-brown; KCN stains light-brown; $FeCl_3$ stains brown; KOH slowly stains light-brown; $HgCl_2$ stains light-brown.

X-Ray Powder Pattern (R.M.T.; fig. 8)

I	θCu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)
2	6.1	7.23	5	22.7	1.992	1	34.3	1.364
10	12.15	3.65	2	25.15	1.809	2	35.0	1.340
7	13.85	3.21	1	26.0	1.754	½	37.0	1.277
1	16.4	2.72	1	28.4	1.616	1	39.8	1.201
2	17.45	2.56	½	29.15	1.578	2	40.3	1.189
2	19.7	2.28	½	29.9	1.542	1	42.3	1.142
2	20.7	2.17	3	32.1	1.447	½	43.0	1.127
4	21.6	2.09	½	32.9	1.415	½	45.0	1.087

Occurrences: Colorado, Japan. The only material available for study was a small chip of tarnished weissite disseminated through gangue, from the Good Hope Mine, Vulcan, Colorado. This mineral has not been found in Canada.

Rickardite—Cu_3Te_2

Tetragonal, *P4/nmm*; $a=3.97$, $c=6.11$ (Peacock); $Z=1$.

Not observed with crystal form; massive with an irregular fracture. Deep purplish-red tarnishing to a purplish-brown. Brittle with $H=3\frac{1}{2}$ (B); $G=7.54$.

Polished sections give a finely pitted surface; purplish-red with strong reflection pleochroism (blue-gray to purplish-red), and intense anisotropism (white, blue-gray, dark blue, fiery orange). HNO_3 blackens with effervescence; HCl etches gray to brown; KCN slowly bleaches gray; $FeCl_3$ bleaches gray to brown; KOH tarnishes iridescent to black; $HgCl_2$

X-Ray Powder Pattern (R.M.T.; fig. 9)

I	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)
½	7.3	6.05	4	22.8	1.984	½	36.5	1.292
6	13.25	3.35	1	25.05	1.816	½	37.8	1.254
1	14.70	3.03	2	26.85	1.703	½	38.7	1.229
2	15.90	2.81	½	27.5	1.665	½	39.5	1.209
4	17.65	2.54	1	30.2	1.528	3	41.7	1.156
½	18.5	2.42	2	32.75	1.421	1	43.3	1.121
10	21.8	2.07	2	33.2	1.404	1	45.2	1.083
1	22.0	2.05	1	35.05	1.339	½	48.0	1.034

slowly tarnishes purple. The mineral has a fine-granular appearance with crossed nicols but large irregular lath-like areas extinguish simultaneously. Readily distinguished by its colour and anisotropism.

Occurrences: Colorado, Arizona, Salvador, Australia, Japan. The foregoing properties were obtained on a compact lens of tarnished rickardite, 30×10 mm., in quartz from the Good Hope Mine, Vulcan, Colorado.

In Canada, Price (1934) lists rickardite? amongst the telluride minerals occurring at the Horne Mine, Noranda, Quebec, but without details.

Tellurides of Nickel and Iron

Melonite—$NiTe_2$

Hexagonal, $C\bar{3}m$; $a=3.835$, $c=5.255$; $Z=1$ (Peacock & Thompson, 1946*a*).

Rounded tabular hexagonal crystals and foliated masses. Light steel-gray to tin white with a reddish cast, tarnishing through yellow to bronze-red and light-brown. Cleavage eminent basal, giving highly flexible flakes. H=2 (B); G=7.72.

Polished sections light pink, particularly striking against the pure white of tellurbismuth; distinctly coppery coloured when observed in reflected light under a binocular. Stands out in relief against altaite, tellurbismuth, and montbrayite. Moderately anisotropic (grayish mauve to yellowish brown). HNO_3 instantly effervesces and stains black; HCl, KCN, negative; $FeCl_3$ slowly stains light-brown and brings out scratches (rubs off); KOH, $HgCl_2$, negative.

X-Ray Powder Pattern (Peacock & Thompson, 1946*a*; fig. 10)

I	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)
1	8.4	5.26	2	29.0	1.586	½	42.6	1.136
1	13.4	3.32	6	29.85	1.544	½	43.9	1.109
10	15.85	2.81	1	33.2	1.404	2	45.3	1.081
3	17.0	2.63	1	35.9	1.311	1	48.8	1.022
5	22.0	2.05	2	38.9	1.224	1	50.2	1.001
5	23.7	1.912	1	39.8	1.201			

Occurrences: Colorado, California, South Australia.

In specimens from the Cresson Mine, Cripple Creek, Colorado, melonite was observed as flat thin bronzy tarnished plates in intimate intergrowth with calaverite and gold.

In Canada, the occurrence of this rare telluride has been established at the Robb-Montbray Mine, Montbray Township, Quebec, and described in detail (Peacock & Thompson, 1946*a*). Here the nickel telluride occurs as small patches (up to 20 mm. wide) associated with rich compact masses of altaite, tellurbismuth, montbrayite, pyrite, chalcopyrite, and gold, or disseminated through rock. In polished sections it occurs as small rounded and distorted hexagonal sections sometimes enclosing and sometimes enclosed in an intergrowth of altaite and tellurbismuth. Also as thin selvages, together with frohbergite, surrounding chalcopyrite, and intimately associated with chalcopyrite, petzite, gold, montbrayite, and frohbergite. At the Wright-Hargreaves Mine, Kirkland Lake, Ontario, as a small area (3×3 mm.) in contact with gold in prophyry; at the Toburn (Tough-Oakes) Mine, Kirkland Lake, associated with altaite and petzite in polished section; and at the Macassa Mine, Kirkland Lake, as small (2×2 mm.) areas in contact with gold in brecciated vein material.

Frohbergite—$FeTe_2$

Orthorhombic, *Pmnn*; $a=3.85$, $b=5.28$, $c=6.26$; $Z=2$ (Thompson, 1947).

Not observed in hand specimens. Polished sections pink; purplish pink against melonite which appears yellowish-pink by contrast. Strongly anisotropic (orange-red to inky blue). H=C+ G=7.98 (calc). HNO_3, rapid effervescence and a black etch; HCl, KCN, $FeCl_3$, KOH, $HgCl_2$, negative.

X-Ray Powder Pattern (R.M.T.; fig. 11)

I	θ(Fe)	*d*(meas.)	*I*	θ(Fe)	*d*(meas.)	*I*	θ(Fe)	*d*(meas.)
3	17.1	3.29	4	31.65	1.841	1	49.4	1.273
2	18.0	3.13	½	32.65	1.791	1	52.3	1.221
10	20.2	2.80	1	33.75	1.739	2	53.55	1.201
7	20.95	2.70	½	34.65	1.699	2	56.2	1.163
1	21.45	2.64	3	37.9	1.573	1	58.25	1.136
½	23.3	2.44	1	38.45	1.554	½	59.6	1.120
½	25.75	2.22	½	39.1	1.532	3	61.0	1.105
5	27.95	2.06	2	39.75	1.511	½	62.85	1.086
½	28.65	2.01	2	45.85	1.347	2	64.4	1.071
3	29.95	1.935	½	47.1	1.319	1	70.7	1.024

Occurrence: This new mineral was recognized and described as small areas in association with altaite, tellurbismuth, montbrayite, melonite, petzite, chalcopyrite, pyrite, marcasite, sphalerite, chalcocite, covellite, and free gold in several polished sections of ore from the Robb-Montbray Mine, Montbray Township, Quebec (Thompson, 1947). It occurs most commonly as complete or embayed zones up to 50 microns wide surrounding chalcopyrite and making contact with altaite, gold, or melonite; less commonly as small irregular areas in gold, petzite, or chalcopyrite; once noted as an intimate intergrowth with gold, petzite, and montbrayite.

Tellurides of Lead and Mercury

Altaite—PbTe

Cubic, *Fm3m; a*=6.430 (R.M.T.); *Z*=4.

Rarely in cubes and octahedrons but usually finely granular to massive. Tin white with a grayish-green cast and high metallic lustre, tarnishing bronze-yellow, bright blue-green, dull blue-gray to black; once observed tarnished bronze-red. Cleavage cubic, usually poor but sometimes perfect. Somewhat sectile; H=3 (C); G=8.19 (R.M.T.).

Polished sections pure white, but bluish against tellurbismuth which has a pink cast, and white against galena which appears mauvish-gray by contrast; isotropic. HNO_3 effervesces and stains iridescent to dark gray; HCl tarnishes iridescent; KCN negative; $FeCl_3$ quickly tarnishes iridescent; KOH, $HgCl_2$ negative.

X-Ray Powder Pattern (R.M.T.; fig. 12)

I	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)
1	11.9	3.73	2	28.6	1.606	2	49.1	1.017
10	13.8	3.22	5	32.3	1.439	2	52.6	0.968
8	19.7	2.28	4	35.9	1.311	1	59.3	0.894
1	23.5	1.928	1	42.6	1.136	2	63.4	0.860
3	24.5	1.854	2	45.9	1.070			

Occurrences: Altai Mountains (Siberia), Transylvania, Burma, Western Australia, Chile, California, New Mexico, Colorado, North Carolina. At Nagyág, Transylvania, altaite was observed as irregular inclusions in coarse nagyagite with rhodochrosite; at Las Cruces, New Mexico, as disseminated nests in coarsely crystalline barite; at the Empress Josephine Mine, Kerber Creek district, Colorado, as small inclusions in empressite; at the Red Cloud Mine, Boulder County, Colorado, as disseminated grains associated with pyrite and tarnished empressite in porphyry.

In Canada, the occurrence of altaite has been confirmed by *x*-ray powder photographs in Yukon Territory, at Upper Burwash Creek, associated with hessite, gold, and hedleyite, in polished section; in British Columbia, at the Charley Group and Hido Group (Pellaire Mines Ltd.), near Taseko Lake narrows, Clinton Mining Divisions, in vuggy limonitic quartz associated with hessite, gold, and several sulphides; near Glacier Lake, New Westminster Mining Division, as small nests in float of limonitic vein-calcite; at the Hedley Monarch Mine, Osoyoos Mining Division, associated with hessite and petzite, in polished section; in Manitoba, at Copper Lake, as grains in quartz; in Ontario, at the Ardeen (Moss) Mine, Thunder Bay district, with hessite in a quartz-calcite gangue; at the Kirkland Golden Gate Mine, Swastika, as a finely crystalline mass associated with calaverite and free gold coating one surface of white pyritic quartz; at the Lake Shore, Macassa, Toburn (Tough-Oakes), Kirkland Lake, Wright-Hargreaves, Teck-Hughes, Sylvanite, Bidgood, and Upper Canada Mines, Kirkland Lake Area, as disseminated grains or compact masses up to 40×15 mm., embedded in dark silicified rock, quartz, or altered syenite porphyry, and associated with coloradoite, petzite, calaverite, melonite, pyrite, molybdenite, chalcopyrite, and gold; at the Dome Mine, South Porcupine, as scattered grains associated with pyrrhotite in quartz; in Quebec, at the Robb-Montbray Mine, Montbray Township, in solid rich masses of tellurides, sulphides, and gold, with altaite in substantial masses, usually intergrown with tellurbismuth and altering to an earthy blue-gray coating; at the Horne Mine, Noranda, with petzite and calaverite in coarsely crystalline masses, or intergrown with tellurbismuth; and at the Bevcourt Mine, Louvicourt Township, disseminated with petzite wehrlite, and gold in massive white quartz.

In addition, altaite has been reported in Canada by Hoffmann (1895, p. 29; 1897, p. 10), Cairnes (1912, p. 197), Todd (1929, p. 74), and Thomson (1937); in British Columbia at the Lakeview Claims, Long Lake Camp, Greenwood Mining Division; from the Rhoderic Dhu Claim in the same camp; from Liddle Creek, Kaslo River, W. Kootenay district; and from the Pay Roll Mine, near Cranbrook, Fort Steele Mining Division; in Ontario, from the Three Ladies Mine, Lake of The Woods district; and the Ashley Mine, Bannockburn Township; at the Gold Eagle Mine, Red Lake (McGill, in Horwood, 1945, p. 114); at the Howey Gold Mine, Red Lake (Cornford, in Horwood, 1945, p. 144); at the McKenzie Red Lake Gold Mines, Red Lake (Hoiles, in Horwood, 1945, p. 166); and at the Chambers-Ferland Group, Schreiber (Thomson, 1923, p. 39).

Analyses	1	2	3	A
Pb	49.72	61.26	57.33	61.91
Au	0.01	—	1.10	—
Ag	2.09	—		—
Cu	—	0.20	1.60	—
Fe	0.63	0.64	1.63	—
Te	39.57	36.84	35.66	38.09
S	—	0.29	1.95	—
Insol	7.84	0.46	0.38	—
	99.86	99.69	99.65	100.00

1. Altaite, Lakeview Claim (mean of two analyses), associated with hessite, gold, native copper, native tellurium. Anal. Johnston (in Hoffmann, 1897, p. 11).

2. Altaite, Lake Shore Mine, spherical masses associated with coloradoite; incl. Hg trace, Bi, Se, none. Anal. Rickaby (in Todd, 1929, p. 74).

3. Altaite, Lake Shore Mine, associated with chalcopyrite in nests and veinlets; incl. Hg, Bi, Se, none. Anal. Rickaby (in Todd, 1929, p. 75).

A. Calculated for PbTe.

Nagyagite—Au(Pb, Sb, Fe)$_8$(Te, S)$_{11}$

Tetragonal, $P\bar{4}$; $a=4.14$, $c=30.15$ X; $Z=1$ (Berry, 1946).

Squarish basal plates and folia with rectangular striations; also granular massive. Blackish lead-gray with high metallic lustre. Cleavage basal, giving bent flexible flakes; H$=1\frac{1}{2}$ (B−); G$=7.49$.

Polished sections difficult to make; gray-white distinctly anisotropic (lead-gray to dark blue) showing twinning; often intergrown with altaite. HNO_3 slowly stains iridescent; HCl, KCN, $FeCl_3$, KOH, $HgCl_2$ negative.

X-Ray Powder Pattern (R.M.T.; fig. 13)

I	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)
½	12.2	3.64	3	18.5	2.42	3	24.9	1.826
½	13.05	3.40	½	19.5	2.30	2	28.85	1.702
10	14.75	3.02	½	20.55	2.19	½	27.7	1.654
½	15.2	2.93	4	21.7	2.08	3	30.7	1.506
6	15.8	2.82	½	22.0	2.05	1	31.7	1.463
1	16.9	2.64	1	23.8	1.905			

Occurrences: Transylvania, Japan, Western Australia, New Zealand, Fiji Islands, California, Colorado, North Carolina, Montana.

In Canada, nagyagite has been reported from British Columbia and Ontario, but these occurrences require confirmation. Kemp (1898, p. 317) reported nagyagite from the Olive Mabel Claim, Gainor Creek, Lardeau Mining Division, B. C. Coleman (1896, p. 106) speaks of "a telluride of lead, probably nagyagite, having been obtained at the Huronian Mine [Moss Township, Thunder Bay district, Ontario] as reported by Dr. Ellis of the School of Science, Toronto."

Coloradoite—HgTe

Cubic, $F\bar{4}3m$; $a=6.440$ (R.M.T.); $Z=4$.

Crystals unknown, usually massive and sometimes granular. Bright iron-black tarnishing to a diagnostic dull purple, which distinguishes it in hand specimens from petzite and tetrahedrite. No cleavage, but brittle with a sub-conchoidal fracture. H$=2\frac{1}{2}$ (C); G$=8.10$ (R.M.T.).

Polished sections pinkish-gray, resembling tetradedrite; isotropic. HNO_3 slowly stains brown, some areas almost negative; HCl, KCN, negative; $FeCl_3$ tarnishes iridescent; after cleaning with HCl, the surface shows moderate anisotropism (dark brownish-red to blue-gray); KOH, $HgCl_2$, negative. Distinguished from other tellurides in polished section by its pinkish-gray colour and resistance to etching with HNO_3.

Occurrences: Colorado, California, Western Australia. At the Smuggler Mine, Boulder County, Colorado, tarnished coloradoite was observed in

X-Ray Powder Pattern (R.M.T.; fig. 14)

I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)
10	11.9	3.73	4	35.8	1.314	½	55.9	0.928
1	13.8	3.22	3	38.3	1.240	1	58.5	0.903
9	19.7	2.28	1	42.5	1.138	2	63.3	9.860
7	23.3	1.943	3	45.0	1.087	1	66.5	0.839
2	28.5	1.611	1	49.1	1.107			
3	31.3	1.479	½	51.6	0.982			

a chip of gangue; at Kalgoorlie, Western Australia, as small chips with attached petzite, and krennerite, both free and attached to gangue.

In Canada, coloradoite has been found only in Ontario and Quebec, and has been confirmed at the Lake Shore Mine, Kirkland Lake, Ontario, as compact masses up to 20×30 mm. associated with altaite; at the Wright-Hargreaves Mine, Kirkland Lake, as compact masses with gold, embedded in quartz; at the Toburn (Tough-Oakes) Mine, Kirkland Lake, as lenses up to 10×5 mm. associated with altaite, pyrite and chalcopyrite in quartz stringers in syenite porphyry; at the Bidgood Mine, Kirkland Lake, as compact masses of exceptional size associated with calaverite, altaite, gold, and molybdenite in brecciated quartz; at the Kirkland Lake Mine, as small compact masses embedded in coarsely crystalline calcite and associated with hessite, chalcopyrite, and tetrahedrite; and at the Hollinger Mine, Timmins, as several fragments of coarsely crystalline calcite with films of hessite, coloradoite, tetrahedrite, and chalcopyrite.

In addition coloradoite has been reported from the Teck-Hughes and Sylvanite Mines, Kirkland Lake (Todd, 1929, pp. 82–83); from the Ardeen (Moss) Mine, Moss Township (Thomson, 1931, p. 52); and the Robb-Montbray Mine, Montbray Township, Quebec (Thomson, 1928, p. 13).

Analyses	1	A
Hg	58.55	61.14
Pb	1.60	—
Te	39.10	38.86
Insol	0.25	—
	99.50	100.00

1. Coloradoite, Lake Shore Mine, with a small amount of altaite; incl. Au, Ag, Bi, Se, Cu, Fe, S, none. Anal. Rickaby, in Todd (1929, p. 80).

2. Calculated for HgTe.

Tellurides of Bismuth

Hedleyite—Bi_7Te_3

Hexagonal, $R\bar{3}m$; $a=4.46$, $c=118.8$; $r=39.68$, $\alpha=6° 26'$; $Z=2$ (Warren & Peacock, 1945).

In plates giving flexible and slightly elastic folia; occasionally a hint of crystal form. Tin-white with an iron-black tarnish; perfect basal cleavage H=2 (A); G=8.91.

Polished sections white, slightly anisotropic (light to dark gray) on nearly basal section. HNO_3 effervesces and quickly turns gray; fumes give brown iridescent tarnish; HCl, KCN, negative; $FeCl_3$ stains brown to iridescent; KOH, $HgCl_2$ negative.

X-Ray Powder Pattern (Peacock; fig. 15)

I	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)
1	10.1	4.38	1	21.4	2.11	3	32.8	1.419
½	12.3β	3.26	3	22.8	1.984	2	33.6	1.389
10	13.7	3.25	3	24.7	1.840	2	36.0	1.308
5	19.0	2.36	4	28.3	1.621	1	36.65	1.288
4	20.15	2.23	4	31.3	1.480			

Occurrences: This species was described by Warren & Peacock (1945) from the Good Hope mineral claim, Hedley, British Columbia. Hedleyite occurs as thick plates often intercalated with joseite B, native bismuth, and gold, and associated with arsenopyrite, molybdenite, and pyrrhotite, in quartz and skarn. A second occurrence of this rare mineral was established at Upper Burwash Creek, Kluane Lake district, Yukon Territory. A polished section of a nugget of gold and hessite showed small amounts of altaite and several laths of a bismuth telluride in the hessite; these laths gave the hedleyite pattern.

Analyses	1	2	A
Bi	80.60	81.55	79.3
Te	18.52	17.60	20.7
S	0.12	0.04	—
	99.24	99.19	100.0

1, 2. Hedleyite, Hedley, British Columbia. Anal. Eldridge (in Warren & Peacock, 1945). In anal. 1 also spectrographic Sb 0.05, Pb 0.01, Cu 0.01.

A. Calculated for Bi_7Te_3.

Joseite A—$Bi_{4+x}Te_{1-x}S_2$

Hexagonal, $R\bar{3}m$; $a=4.24$, $c=39.69$; $r=13.45$, $\alpha=18°\ 08'$; $Z=1$ (Peacock, 1941).[5]

Sheets and plates with occasional straight edges yielding soft, flexible,

[5] Following Peacock (1941, p. 102) the general formula $Bi_{4+x}(Te, S)_{3-x}$, omitting Se as unessential, is accepted for joseite. The two types of joseite noted by Peacock, $Bi_{4+x}Te_{1-x}S_2$ and $Bi_{4+x}Te_{2-x}S$, have been recognized in further specimens and they are here denoted as joseite A and joseite B, respectively.

inelastic folia; meagre evidence of crystal form. Silver-white colour with high metallic lustre tarnishing lead gray, iridescent, steel-blue to iron-black. Perfect basal cleavage; H=2 (A–B); G=8.10.

Polished sections less white than galena with hardness B on basal sections, and A on transverse sections. Basal sections nearly isotropic; transverse sections moderately anisotropic in greenish-gray to dark greenish-gray. Etch-reactions: HNO_3 effervesces and etches dark gray; HCl stains light gray; KCN negative; $FeCl_3$ stains pale blue-gray; KOH negative; $HgCl_2$ negative.

X-Ray Powder Pattern (Peacock, 1941; fig. 16)

I	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)
2	10.1	4.38	½	25.0	1.819	2	39.45	1.210
2	12.3	3.61	½	25.6	1.779	½	40.8	1.176
½	13.0β	3.09	3	26.15	1.744	½	47.4	1.044
1	13.45	3.30	1	27.7	1.654	1	48.5	1.026
10	14.5	3.07	½	28.4	1.616	2	49.9	1.005
2	17.4	2.57	3	30.0	1.537	½	51.5	0.982
5	20.1	2.24	2	33.05	1.409	1	53.5	0.956
5	21.4	2.11	3	34.85	1.345	1	54.6	0.943
1	22.0	2.05	1	36.2	1.302	½	57.9	0.907
1	23.0	1.967	2	38.1	1.246	2	66.9	0.836
2	23.95	1.894	½	39.0	1.221	2	70.4	0.816

Occurrences: Brazil, Spain, England. In Canada, joseite A has been positively identified in British Columbia at Glacier Gulch, Hudson Bay Mountain, near Smithers, where it occurs as coarse plates up to ½ inch wide and 2 inches long, sometimes intergrown with bismuth and joseite B; and at the Windpass Mine, near Chu Chua, where it is intimately associated with bismuthinite.

Analyses	1	2	A
Bi	79.3	82.7	81.4
Te	12.2	12.0	12.4
S	6.0	6.0	6.2
Se	none	none	—
Au	trace	—	—
Insol	trace	—	—
	97.5	100.7	100.0

1. Joseite A, Glacier Gulch, Hudson Bay Mountain, near Smithers, Omineca Mining Division, B. C. Anal. Forward (in Warren & Davis, 1940, p. 110).

2. Joseite A ("auriferous tetradymite," ROM, M 17255), Glacier Gulch, Hudson Bay Mountain, near Smithers, Omineca Mining Division, B. C. Anal. Meen (in Peacock, 1941, p. 92).

A. Calculated for Bi_4TeS_2.

Joseite B—$Bi_{4+x}Te_{2-x}S$

Hexagonal, $R\bar{3}m$; $a=4.33$, $c=40.75$; $r=13.81$, $\alpha=18°\ 02'$; $Z=1$ (Peacock, 1941).

Identical with joseite A in most physical properties, and distinguished only by accurate specific gravity measurements. G=8.3.

X-Ray Powder Pattern (R.M.T.; fig. 17)

I	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)
2	9.8	4.52	4	19.6	2.29	2	29.4	1.566
1	12.05	3.69	5	20.8	2.16	1	32.2	1.443
½	12.7β	3.16	1	21.3	2.12	2	34.0	1.375
½	13.05	3.40	½	22.2	2.03	1	37.1	1.274
10	14.1	3.16	2	23.3	1.943	1	38.1	1.246
1	16.95	2.64	3	25.6	1.779			

Occurrences: Brazil. In Canada the occurrence of joseite B has been confirmed in British Columbia at Glacier Gulch, Hudson Bay Mountain, near Smithers, where it is associated with bismuth and joseite A; and at the Good Hope mineral claim, near Hedley, Osoyoos Mining Division, where it occurs as coarse plates often intergrown with native bismuth and associated with hedleyite, pyrrhotite, arsenopyrite, molybdenite, and gold, in quartz and skarn.

Analysis	1	A
Bi.	75.14	64.4
Te.	19.25	22.7
S.	3.64	2.9
Pb.	0.68	—
Fe.	0.52	—
Insol.	0.30	—
	99.53	100.0

1. Joseite B, Glacier Gulch, Hudson Bay Mountain, near Smithers, Omineca Mining Division, B. C. Anal. Forward & Lyle.
A. Calculated for Bi_4Te_2S.

Tellurbismuth—Bi_2Te_3

Hexagonal, $R\bar{3}m$; $a=4.375$, $c=30.39$; $r=10.44$, $\alpha=24°\ 11\frac{1}{2}'$; $Z=1$ (Peacock, in Peacock & Berry, 1940, p. 67).

Plates and foliated masses with splendent metallic lustre; colour lead gray with a pinkish cast, tarnishing dull gray, black, or iridescent. Perfect basal cleavage yielding flakes slightly less flexible than those of tetradymite; inelastic, and somewhat sectile; H=2 (B); G=7.81±0.10.

Polished sections pinkish-white in reflected light, with hardness A transverse to the cleavage and slightly harder on cleavage surfaces.

Weakly anisotropic (yellow to dark gray). The author was unable to duplicate his etch-reactions on *x*-rayed specimens of tellurbismuth; however, the mineral, like all the bismuth tellurides, is always positive to HNO_3 and $FeCl_3$. It is felt that these minerals cannot be distinguished with certainty on the basis of etch-reactions.

Tellurbismuth is frequently intergrown with tetradymite or altaite. Frondel (1940) showed that "vandiestite" was a mixture of tellurbismuth and hessite. Harcourt (1942, p. 106) gives a list of powder spacings and intensities for "vandiestite" from Colorado. These spacings and intensities agree very closely with patterns of an intergrowth of tellurbismuth and altaite from the Robb-Montbray Mine, Montbray Township, Quebec.

X-Ray Powder Pattern (R.M.T.; fig. 18)

I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)
1	8.75	5.05	½	29.45	1.568	1	43.45	1.118
½	11.75	3.77	4	31.15	1.486	½	44.75	1.092
10	13.85	3.21	½	31.95	1.450	1	45.85	1.071
½	16.55	2.69	2	33.05	1.410	2	47.35	1.045
8	18.95	2.37	2	33.45	1.394	½	47.75	1.038
1	20.15	2.23	1	35.05	1.339	½	48.55	1.025
4	20.55	2.19	2	36.35	1.297	½	49.15	1.016
4	22.25	2.03	1	37.35	1.267	1	50.6	0.995
½	22.65	1.996	1	38.05	1.247	½	52.85	0.964
3	25.15	1.809	1	39.95	1.207	½	53.95	0.951
1	26.95	1.696	1	40.4	1.186	½	55.85	0.928
3	28.55	1.608	2	41.65	1.157	1	56.65	0.920

Occurrences: Japan, New Mexico, Georgia, Montana, California, and Sweden. At Boliden, Sweden, as a coarsely crystalline compact mass (40×30 mm.) of tellurbismuth and tetradymite.

In Canada, tellurbismuth has been positively identified in the Yukon Territory, British Columbia, Ontario, and Quebec. In the Yukon Territory, as several flat plates from the placer workings of Mr. G. Loland, Upper Burwash Creek, Kluane Lake district; in British Columbia, from the Hunter Group, Khutze Inlet, Skeena Mining Division, as several plates of tellurbismuth; from the Ashloo Mine, near Squamish, Vancouver Mining Division, as several plates of tellurbismuth; and from the Hedley Yuniman Gold Fields Ltd., Bradshaw Creek, Osoyoos Mining Division, as small plates of tellurbismuth and polished sections; in Ontario, from the Ardeen Mine, Moss Township, in a polished section with chalcopyrite and pyrrhotite in calcite; and in a specimen of brecciated vein material with chalcopyrite, pyrite, and tellurbismuth usually in contact with galena; from the Porcupine Reef Gold Mines Ltd., Pamour, in several specimens of milky quartz with some greenish-white talc containing much visible gold, sometimes in subhedral crystals and grains, rarely in contact with minute areas of tellurbismuth and non-magnetic pyrrhotite which has an unusual deep brownish-bronze colour; in Quebec, from the Lamaque Mine, Bourlamaque Township, in a specimen of white quartz with small plates of tellurbismuth and massive calaverite; from the Louvicourt Goldfields Mine, Louvicourt Township, in several specimens of tourmalinized quartz with much free gold and small areas of calaverite and tarnished tellurbismuth in close association with calcite; from the Robb-Montbray Mine, Montbray Township, in a dozen pieces of solid rich aggregates of tellurides, sulphides, and gold with substantial masses of tellurbismuth and altaite; from the Horne Mine, Noranda, in a polished section with tellurbismuth intergrown in part with altaite; and from the Sullivan Consolidated Mines, disseminated with petzite in massive white quartz.

Analyses	1	2	A
Bi	49.7	47.7	52.2
Te	45.1	47.9	47.8
S	none	none	—
	94.8	95.6	100.0

1. Hunter Mine, Khutze Inlet, near Swanson Bay, Skeena Mining Division, British Columbia. Anal. Forward (in Warren & Davis, 1940, p. 110).

2. Ashloo Mine, near Squamish, Howe Sound, Vancouver Mining Division, British Columbia. Anal. Forward (in Warren & Davis, 1940, p. 110).

A. Calculated for Be_2Te_3.

Wehrlite—$Bi_{2+x}Te_{3-x}$

Hexagonal, $R\bar{3}m$; $a=4.42$, $c=29.85$; $r=10.27$, $\alpha=24°\ 51'$; $Z=1$ (Peacock, in Warren & Peacock, 1945).

In foliated masses, massive to finely granular; colour tin-white to steel-gray. Once observed with a peculiar bronzy tarnish. Perfect cleavage giving flexible and slightly elastic folia; H = 2 (B); G = 8.37–8.44.

Polished sections white with weak anisotropism (light to dark gray). HNO_3 stains black; HCl stains light gray-brown; KCN negative; $FeCl_3$ stains iridescent to purplish black; KOH, $HgCl_2$ negative.

Wehrlite may best be considered as a variety of tellurbismuth. It is essentially a solid solution of Bi in Bi_2Te_3 with Bi approximately at the saturation limit (about 60 wt. per cent Bi) found in the artificial system (Peacock, 1945, p. 68), giving a composition near BiTe.

Occurrences: Deutsch-Pilsen (Hungary). In Canada this rare mineral has been positively identified in British Columbia, Ontario, and Quebec.

X-Ray Powder Pattern (R.M.T.; fig. 19)

I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)	I	θ(Cu)	d(meas.)
2	9.0	4.91	3	25.0	1.819	1	42.4	1.140
1	11.6	3.82	3	28.6	1.606	1	44.1	1.105
1	12.4β	3.23	3	31.2	1.484	2	45.65	1.075
10	13.8	3.22	4	33.25	1.402	2	47.6	1.041
7	19.0	2.36	2	36.2	1.301	1	50.3	0.999
5	20.4	2.21	1	37.05	1.275			
3	22.7	1.992	2	40.65	1.180			

In British Columbia, at the White Elephant Claim, Okanagan Lake, Vernon Mining Division, in several specimens of white quartz containing a soft massive mineral with a bronzy tarnish (wehrlite) and a soft platy mineral (tetradymite); from the Marble Bay and Little Billie Mines, Texada Island, Nanaimo Mining Division, as several polished sections with wehrlite and hessite in minute amounts, in close association with bornite and chalcopyrite; from the Charlie Vein, Tchaikazan River, Taseko Lake district, as minute amounts in polished sections, associated with galena and hessite; in Ontario from Painkiller Lake, Beatty Township, as a polished section with minute amounts of wehrlite and gold; from the Treadwell property, Painkiller Lake, Beatty Township, as several specimens of white quartz with disseminated wehrlite; in Quebec, from the Canadian Malartic Gold Mines Ltd., Fourniere Township, as thin films on rather glassy quartz, associated with grains of petzite, gold, and pyrite, and at the Bevcourt Mine, Louvicourt Township, disseminated with altaite, petzite, and gold in massive white quartz.

Although there are no analyses of Canadian wehrlite, the occurrence of this mineral in close association with silver-rich minerals like hessite and petzite suggests that the small silver content of the type Hungarian material is combined in included silver minerals.

Tetradymite—Bi_2Te_2S

Hexagonal, $R\bar{3}m$; $a=4.21$, $c=29.43$; $r=10.11$, $\alpha=24° 2\frac{1}{2}'$; $Z=1$ (Peacock)

Commonly as foliated to bladed masses; rarely as acutely rhombohedral crystals; twins (fourlings) are reported. Steel-gray with metallic splendent lustre, tarnishing dull gray, black, or iridescent. Perfect basal cleavage yielding flexible but not elastic laminae; $H=1\frac{1}{2}$ (B); $G=7.3 \pm 0.2$.

Polished sections bright white with weak anisotropism, polarization colours light to dark gray. HNO_3 stains through iridescent to black; HCl negative (2 minutes); KCN negative; $FeCl_3$ stains iridescent; KOH, $HgCl_2$ negative.

X-Ray Powder Pattern (R.M.T.; fig. 20)

I	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)
1	8.95	4.94	½	25.8	1.766	½	40.6	1.181
½	12.2	3.64	3	26.1	1.747	½	45.4	1.080
½	13.75	3.24	4	27.95	1.640	1	47.0	1.051
10	14.35	3.10	1	18.7	1.601	3	49.45	1.012
1	16.2	2.76	1	29.7	1.551	1	51.7	0.979
2	17.25	2.59	½	30.7	1.506	1	53.0	0.962
2	18.25	2.45	2	32.3	1.439	2	54.8	0.941
4	19.7	2.28	1	32.7	1.423	2	57.25	0.914
2	20.8	2.16	2	34.8	1.347	3	59.7	0.980
3	21.4	2.11	4	36.5	1.292	3	66.3	0.839
3	23.05	1.963	2	37.8	1.254	3	69.0	0.823
3	23.65	1.916	½	39.2	1.216			
½	25.0	1.819	4	39.55	1.207			

Occurrences: Hungary, Romania, Sweden, Norway, Japan, Rhodesia, Queensland, New South Wales, Western Australia, Bolivia, New Mexico, Arizona, California, Colorado, Idaho, Montana, Virginia, North Carolina, South Carolina, Georgia. Observed from Boliden, Sweden, as a coarsely crystalline compact mass (40×30 mm.) of tellurbismuth and tetradymite; at the Red Cloud Mine, Boulder County, Colorado, as a compact mass of petzite, tetradymite, and pyrite.

In Canada, the occurrence of tetradymite has been verified at the following localities: in the Yukon Territory, at Dublin Gulch, Mayo district, as a small placer pebble with an embedded subhedral crystal of gold; at the Selwyn River, as a few small cleavage flakes; at Discovery Fork, and the East Fork of Nansen Creek, Carmacks district, as several placer pebbles up to 10 mm. in length; in British Columbia at the Harrison Group, Lindquist Lake, Omineca Mining Division, in a polished section, and in several pieces of vein quartz with flakes of tetradymite; at the White Elephant (Precambrian) Mine, Okanagan Lake, Vernon Mining Division, as several specimens of quartz with flakes of tetradymite; at the Jumbo Mine, Rossland, as a thin film of tetradymite and gold on monzonite; at the Taylor Windfall Mine, Clinton Mining Division; in Ontario, at the Broulan Mine, Porcupine district, as a 3 mm. band with minor gold in massive white quartz; at the McKellar Longworth Mine, Schreiber, in a polished section with chalcopyrite, and gold; and at the McKenzie Red Lake Gold Mines, in a polished section with galena; in Quebec, at the Lamaque Mine, Bourlamaque Township, as a specimen of white quartz with small cleavage flakes of tetradymite; at the Perron Mine, Bourlamaque, as several pieces of coarsely crystalline calcite with films of bronzy tetradymite associated with gold; at the Siscoe Gold Mines, Siscoe, as a specimen of tourmalinized quartz with small areas of calcite with coarse gold rarely in contact with 1 mm. grains of tetradymite; and at the Powell Rouyn Mine, Noranda, as a somewhat decomposed stringer of tetradymite in a dark green pyritized quartzose rock coated on two sides by greenish-black chlorite, pink calcite crystals, pyrite, and free gold.

In addition, tetradymite has been reported from British Columbia, Ontario, and Quebec. In British Columbia, tetradymite was reported from near Liddle Creek, Kaslo River, West Kootenay district (Hoffmann, 1897, p. 10R); the Rhoderic Dhu Claim, Long Lake Camp, Greenwood Mining Division (Kemp, 1898, p. 317); the Nickel Plate Mine, near Hedley, Osoyoos Mining Division (Camsell, 1910, p. 138); Glacier Gulch near Smithers, Omineca Mining Division (Pratt, 1931, p. 56); in Ontario from the Howey Gold Mine, Red Lake (Cornford, in Horwood, 1945, p. 144); from the Toburn Mine, Kirkland Lake (Campbell & Deyell, in Hopkins, 1915, p. 183); the Mikado Mine, Rickard Township (Hopkins, 1915, p. 183); the Hattie, Treadwell, Mayo, Hull, and Cartwright properties near Painkiller Lake, Beatty Township, and the Miller Independence Mine, Boston Creek, Pacaud Township (Hopkins, 1921, pp. 9, 21; this material is tellurbismuth according to Berry—*priv. comm.*); Straw Lake near Fort Frances (Thomson, 1934, p. 33); Bigstone Bay, Lake of the Woods, and the Gold Shore Mine, Red Lake (Thomson, 1935, p. 48); the Hollinger Mine, Porcupine district (Keys, 1940, p. 620); the Chambers-Ferland Group, Schreiber (Thomson, 1923, p. 39); in Quebec, from the

Analyses	1	2	3	4	5	A
Bi	51.85	59.10	60.72	60.88	61.05	59.27
Pb	3.50	—	—	—	—	—
Ag	0.91	—	—	—	—	—
S	4.30	4.85	4.29	4.29	3.65	4.54
Te	36.01	35.90	34.71	34.47	35.10	36.19
Insol	3.52	—	—	—	—	—
	100.09	99.85	99.72	99.64	99.80	100.00

1. Liddle Creek, Kaslo River, West Kootenay district, British Columbia. Tetradymite with minor altaite and hessite; incl. Se, Tl, trace. Anal. Johnston (in Hoffmann, 1897, p. 10R).

2. White Elephant Claim, Okanagan Lake, Vernon Mining Division, British Columbia. Anal. Forward (in Warren, 1946, p. 77).

3, 4. White Elephant Claim, Okanagan Lake, Vernon Mining Division, British Columbia; incl. Se trace. Anal. Williams (in Warren, 1946, p. 77).

5. White Elephant Claim, Okanagan Lake, Vernon Mining Division, British Columbia (tetradymite with minor wehrlite); incl. Se trace. Anal. Williams (in Warren, 1946, p. 77).

A. Calculated for Bi_2Te_2S.

Eureka Mine, Tiblemont Township (Thomson, 1934, p. 35); the Horne Mine, Noranda (Price, 1934, p. 132); and the McWatters Mine, Rouyn Township (Thomson, 1935, p. 48). Some of these reported occurrences may refer in fact to other bismuth tellurides.

Uncertain or Discredited Tellurides

STUETZITE—Ag_4Te (?)

A supposed specimen of the uncertain silver telluride stuetzite (USNM, R 442, from Siebenbürgen, Transylvania), was obtained through the kindness of Dr. E. P. Henderson of the United States National Museum. This material gave the *x*-ray powder pattern of bournonite. An attempt to make the compound Ag_4Te by pyrosynthesis resulted in the formation of hessite, Ag_2Te, and excess silver.

MUTHMANNITE—(Ag, Au) Te

No specimen of this mineral was available for study. Analyses have indicated the composition (Ag, Au)Te, but fusions of this composition, with Ag:Au=1:1 and Ag:Au=2:1, gave mixtures of calaverite, $AuTe_2$, and petzite, Ag_3AuTe_2. The specific gravity 5.598 given by Scharizer (1880, p. 605) for muthmannite is apparently too low since it is much lower than that of each of the components.

NIGGLIITE—$PtTe_3$ (?)

This is the name given by Scholtz (1936, p. 184) to a mineral believed to be a platinum telluride, which gave 34.8 per cent Pt on analysis of a single grain weighing a fraction of a milligram. No specimen was available. An attempt to produce $PtTe_3$ by pyrosynthesis gave $PtTe_2$ (not niggliite) and excess Te.

"ANTAMOKITE"

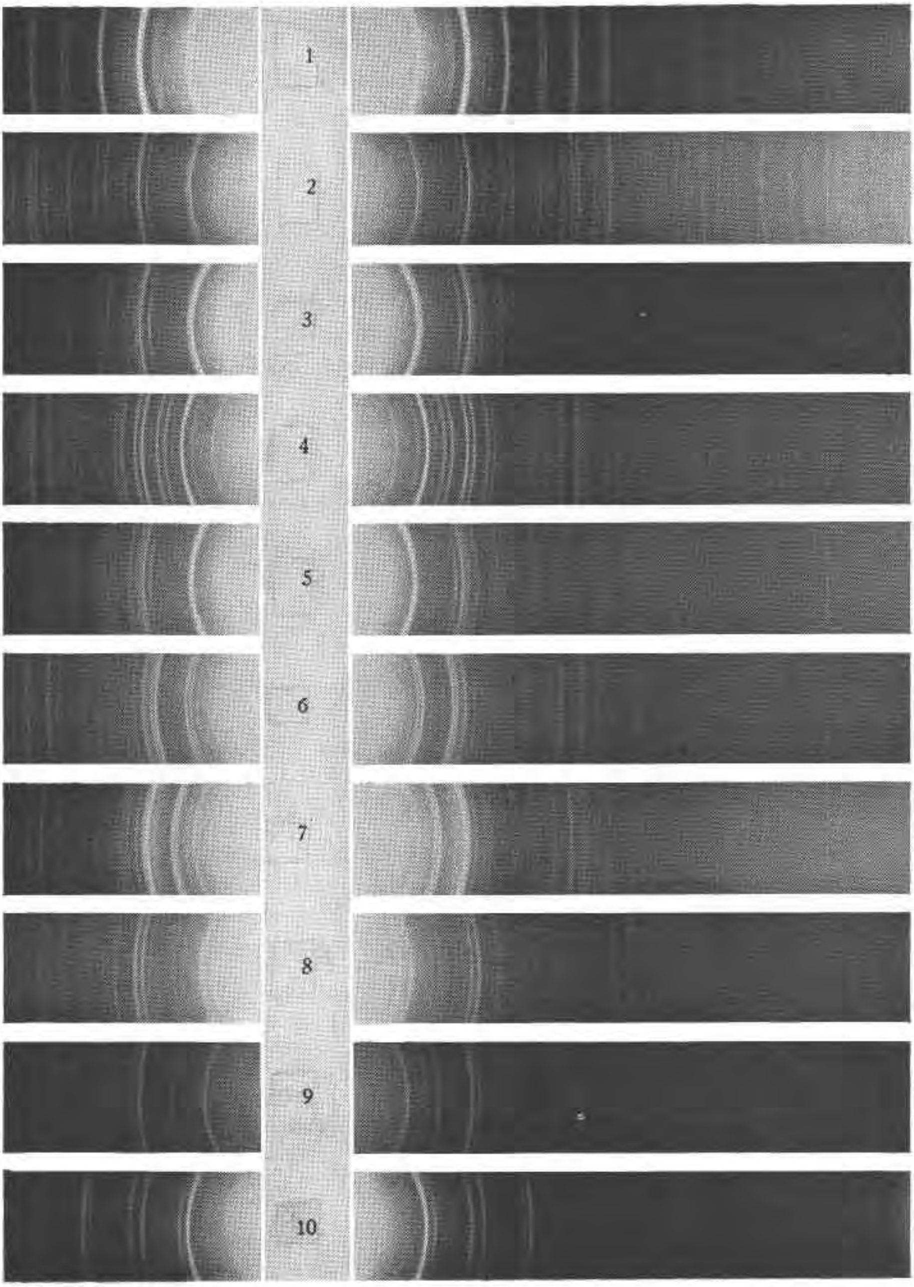
"Antamokite" was supposed to be a new telluride of gold and silver. A recent study of ore from the type locality, the Benguet Consolidated Mining Company Mine, Antamok, Mountain Province, Philippine Islands (Thompson, 1946 *b*), indicated that this material is petzite associated with calaverite.

"GOLDFIELDITE"

This dubious compound of Cu, Sb, Te, and S was recently shown (Thompson, 1946*a*) to be a previously unknown tellurian variety of tetrahedrite, with $a = 10.35$.

X-RAY POWDER PHOTOGRAPHS

The accompanying figures are actual size reproductions of contact prints from *x*-ray powder films taken in a camera of radius $360/4\pi$ mm.



(1° θ=1 mm. on film). Cu radiation (Ni filter) was used in all cases except Fig. 11, for which Fe radiation (Mn filter) was used.

Canadian Telluride Localities

In conclusion it will be useful to give a list of the known Canadian localities for telluride minerals, with the names of the minerals reported at each locality. This list combines published information, derived mainly from the works of Cairnes, Todd, and Ellis Thomson, with the results of the present work. Mineral names marked * are positive identifications based on *x*-ray powder photographs, while names in quotation marks are proved misnomers. It is hoped that this improved list will be useful to prospectors and geologists as well as providing reliable additions to the data of topographic mineralogy.

Yukon Territory

Upper Burwash Creek, Kluane District	*Altaite
	*Hessite
	*Tellurbismuth
	*Hedleyite
Dublin Gulch, Mayo District	*Tetradymite
Selwyn River, Selkirk District	*Tetradymite
East Fork and Discovery Fork of Nansen Creek, Carmacks District	*Tetradymite
Buffalo Hump Group, Mt. Stevens, Wheaton River District	*Hessite
	Sylvanite
Gold Reef Claim, Wheaton River District	Sylvanite
	Hessite
	Petzite

British Columbia

Engineer Mines, Taku Arm, Tagish Lake, Atlin Mining Division	Calaverite
Harrison Group, Lindquist Lake, Omineca Mining Division	*Hessite
	*Tetradymite
Glacier Gulch, Hudson Bay Mountain, Omineca Mining Division	*Joseite A, B
	("tetradymite")
	Calaverite
Hunter Group Claims, Khutze Inlet, Skeena Mining Division	*Tellurbismuth

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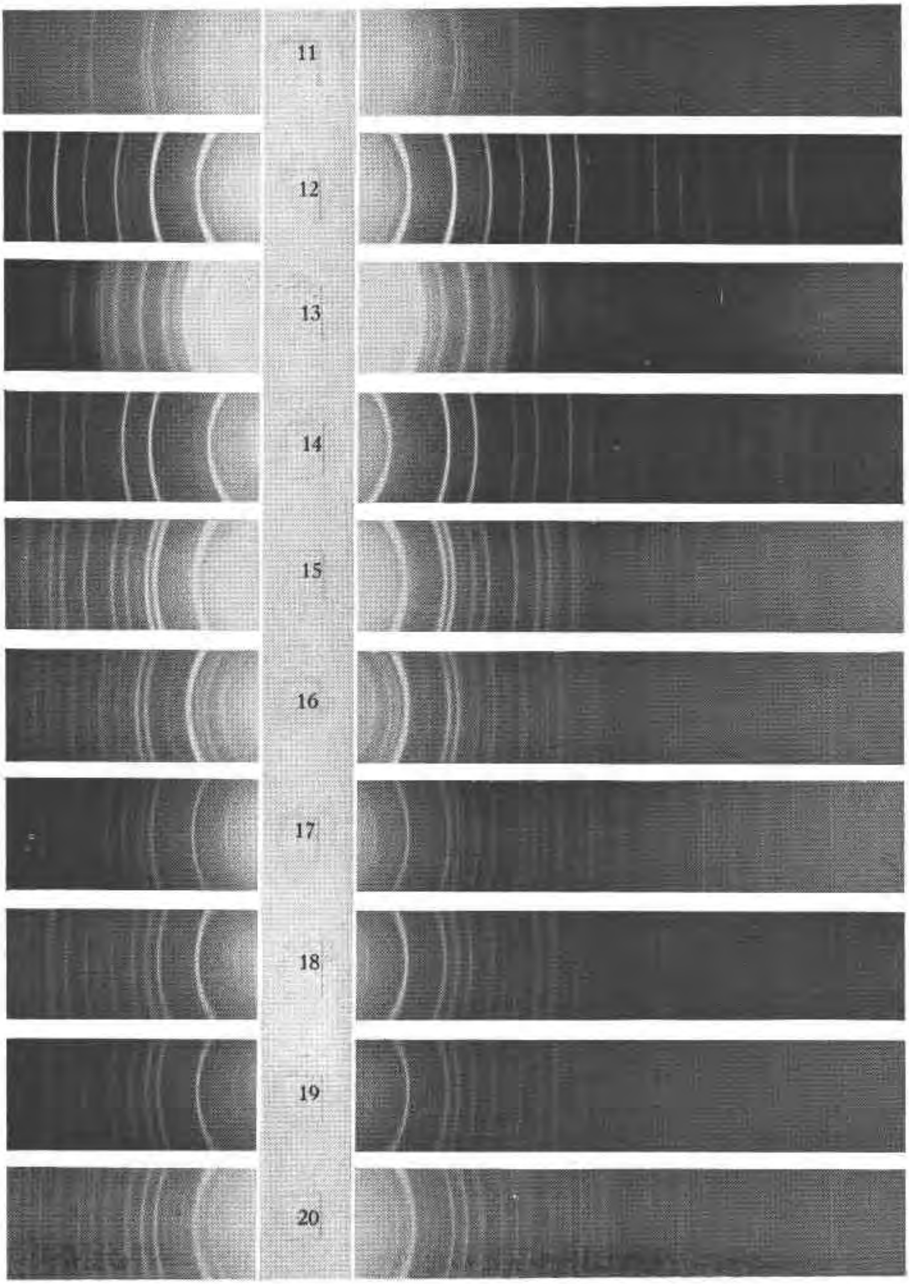
Fig. 1. Montbrayite, Robb-Montbray Mine, Montbray Township, Quebec.
Fig. 2. Calaverite, Cripple Creek, Colorado.
Fig. 3. Krennerite, Cripple Creek, Colorado.
Fig. 4. Petzite, Kalgoorlie, Western Australia.
Fig. 5. Sylvanite, Nagyág, Transylvania.
Fig. 6. Hessite, Botés, Transylvania.
Fig. 7. Empressite, Red Cloud Mine, Boulder County, Colorado.
Fig. 8. Weissite, Good Hope Mine, Vulcan, Colorado.
Fig. 9. Rickardite, Good Hope Mine, Vulcan, Colorado.
Fig. 10. Melonite, Robb-Montbray Mine, Montbray Township, Quebec.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Charlie Group, Taseko Lake, Clinton Mining Division	*Altaite *Hessite *Wehrlite
Hido Group (Pellaire Gold Mines property), Clinton Mining Division	*Altaite *Hessite
Taylor Windfall Mine, Clinton Mining Division	*Tetradymite
Windpass Mine, Chu Chua, Kamloops Mining Division	*Joseite A
Valdez Island, Nanaimo Mining Division	Gold tellurides
Marble Bay Mine, Texada Island, Nanaimo Mining Division	*Hessite *Wehrlite
Little Billie Mine, Texada Island, Nanaimo Mining Division	*Hessite *Wehrlite
Ashloo Mine, near Squamish, Howe Sound, Vancouver Mining Division	*Tellurbismuth
Nickel Plate Mine, near Hedley, Osoyoos Mining Division	Tetradymite
Good Hope Claim, near Hedley, Osoyoos Mining Division	*Joseite B *Hedleyite
Hedley Monarch Mine, Olalla, Osoyoos Mining Division	*Altaite *Hessite *Petzite
Hedley Yuniman Gold Fields Limited, Bradshaw Creek, Osoyoos Mining Division	*Tellurbismuth
Calumet Claim, Kruger Mountain, Osoyoos Lake, Osoyoos Mining Division	Hessite Petzite
White Elephant Claim, Okanagan Lake, Vernon Mining Division	*Tetradymite *Wehrlite
Boundary District	*Hessite
Long Lake Camp, Greenwood Mining Division	
(a) Jewel Mine	Rich tellurides
(b) Lakeview Claims	*Altaite *Hessite
(c) North Star Claim	*Hessite
(d) Enterprise Claim	Petzite
(e) Rhoderic Dhu Claim	Altaite Tetradymite
Jumbo Mine, Rossland, Trail Creek Mining Division	*Tetradymite
Olive Mabel Claim, Gainor Creek, Lardeau Mining Division	Nagyagite

FIG. 11. Frohbergite, Robb-Montbray Mine, Montbray Township, Quebec.
FIG. 12. Altaite, Lake Shore Mine, Kirkland Lake, Ontario.
FIG. 13. Nagyagite, Nagyág, Transylvania.
FIG. 14. Coloradoite, Toburn (Tough-Oakes) Mine, Kirkland Lake, Ontario.
FIG. 15. Hedleyite, Good Hope Claim, Near Hedley, Osoyoos Mining Division, British Columbia.
FIG. 16. Joseite A, Glacier Gulch, Hudson Bay Mountain, near Smithers, British Columbia.
FIG. 17. Joseite B, Good Hope Claim, near Hedley, Osoyoos Mining Division, British Columbia.
FIG. 18. Tellurbismuth, Hedley Yuniman Gold Fields Limited, Bradshaw Creek, Osoyoos Mining Division, British Columbia.
FIG. 19. Wehrlite, Treadwell property, near Painkiller Lake, Beatty Township, Ontario.
FIG. 20. Tetradymite, Selwyn River, Selkirk district, Yukon Territory.

Liddle Creek, Kaslo River, Ainsworth Mining Division	Altaite Hessite *Tetradymite
Pay Roll Mine, near Cranbrook, Fort Steele Mining Division	Altaite

Manitoba

Copper Lake	*Altaite
San Antonio Mine, near Bissett	*Petzite

Ontario

Ardeen (Huronian, Moss, Shebandowan) Mine, Moss Township	*Altaite *Hessite *Petzite *Tellurbismuth Coloradoite Nagyagite Sylvanite
Gold Creek, Pine Portage Bay, Lake of the Woods	Hessite
Three Ladies Mine, Lake of the Woods	Altaite
Bigstone Bay, Lake of the Woods	Hessite Petzite Calaverite Sylvanite Tetradymite
Gold Shore Mine, Red Lake	Tetradymite
Gold Eagle Mines, Red Lake	Altaite Sylvanite
Howey Gold Mine, Red Lake	Altaite Sylvanite Tetradymite
McKenzie Red Lake Gold Mines, Red Lake	Altaite Petzite Krennerite Tetradymite
Chambers-Ferland Group, near Schreiber	Altaite Tetradymite
McKellar Longworth Mine, Schreiber	*Tetradymite
Jackson-Manion Mine, District of Kenora	Petzite
Straw Lake, near Fort Frances	Tetradymite
Anderson Farm, Deloro Township	Petzite
Powell Claim, Deloro Township	*Hessite
Labine-Smith Claim, Maisonville Township	Petzite
Ashley Mine, Bannockburn Township	*Altaite Krennerite
Hattie, Hull, Cartwright, Mayo, and Treadwell properties, near Painkiller Lake, Beatty Township	*Wehrlite ("tetradymite") Calaverite
Miller Independence and Boston McRae Mines, Boston Creek, Pacaud Township	*Calaverite *Tellurbismuth ("tetradymite")

Hollinger Mine, Porcupine District	*Coloradoite
	*Petzite
	*Hessite
	Tetradymite
Dome Mine, Porcupine District	*Altaite
	Calaverite
	Sylvanite
Broulan Mine, Porcupine District	*Tetradymite
Porcupine Reef Gold Mines Limited, Pamour	*Tellurbismuth
A prospect in Tisdale Township	*Hessite
Kirkland Lake Camp	
Kirkland Lake Mine	*Altaite
	*Coloradoite
	*Hessite
Teck-Hughes Mine	*Altaite
	Coloradoite
	Calaverite
Sylvanite Mine	*Altaite
	Petzite
	Coloradoite
	Calaverite
Toburn (Tough-Oakes) Mine	*Altaite
	*Coloradoite
	*Petzite
	*Calaverite
	*Melonite
	Hessite
	Tetradymite
Wright Hargreaves Mine	*Altaite
	*Coloradoite
	*Calaverite
	*Melonite
	Petzite
Lake Shore Mine	*Altaite
	*Calaverite
	*Coloradoite
	*Petzite
Macassa Mine	*Altaite
	*Calaverite
	*Melonite
Bidgood Mine	*Altaite
	*Coloradoite
	*Calaverite
Kirkland Golden Gate Mine, Swastika	*Altaite
	*Calaverite
Upper Canada Mine, Gauthier Township	*Altaite
	*Petzite
	*Calaverite
Mikado Mine, Rickard Township	Tetradymite

Quebec

Opasatica District	Petzite
Robb-Montbray Mine, Montbray Township, Abitibi County	*Altaite
	Coloradoite
	*Petzite
	*Melonite
	*Frohbergite
	*Montbrayite ("krennerite")
	*Tellurbismuth ("tetradymite")
Horne Mine, Noranda	*Altaite
	*Calaverite
	*Petzite
	*Tellurbismuth ("tetradymite")
	Hessite
	Krennerite
	Sylvanite
	Rickardite (?)
	Undetermined pink telluride
Powell Rouyn Mine, Noranda	*Tetradymite
Stadacona Mine, Rouyn	*Petzite
McWatters Mine, Rouyn Township	Hessite
	Tetradymite
Lamaque Mine, Bourlamaque Township	*Petzite
	*Calaverite
	*Tellurbismuth
	*Tetradymite
Perron Mine, Bourlamaque Township	*Tetradymite
Sullivan Mine, Bourlamaque Township	*Hessite
Sullivan Consolidated Mines	*Tellurbismuth
	*Petzite
Siscoe Gold Mines, Siscoe	*Tetradymite
Eureka Mine, Tiblemont Township	Tetradymite
Louvicourt Goldfields Mine, Louvicourt Township	*Calaverite
	*Tellurbismuth
Bevcourt Mine, Louvicourt Township	*Altaite
	*Petzite
	*Wehrlite
Canadian Malartic Gold Mine, Fourniere Township	*Petzite
	*Calaverite
	*Wehrlite

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