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SOPCHEITE: A SECOND CANADIAN OCCURRENCE, FROM THE LAC-DES-ILES COMPLEX, ONTARIO†

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Abstract

Sopcheite, a silver palladium telluride, ideally $Ag_4Pd_3Te_4$, found in copper–nickel sulfide ores of the Monchegorsky pluton, Kola Peninsula, USSR, was first characterized by Orsoev *et al.* (1982). An unnamed mineral of similar composition and with similar optical properties had previously been reported from the Levack West mine, Sudbury area, by Cabri & Laflamme (1976). Three grains of a mineral with similar characteristics, occurring in unusual intergrowths with kotulskite and merenskyite, were found in 1979 in a diamond-drill core from Lac-des-Iles, Ontario. Compositional and quantitative reflectance data suggest the identity of the Levack West mineral and of this second Canadian occurrence with sopcheite. New and more complete reflectance spectra add substantially to the characterization of the mineral.

Keywords: sopcheite, second Canadian occurrence, Lac-des-Iles, Ontario, PGM, $Ag_4Pd_3Te_4$, reflectance spectra, quantitative data.

Sommaire

La sopchéite, tellurure d'argent et de palladium, de formule idéale $Ag_4Pd_3Te_4$, découverte dans le minerai sulfuré Cu–Ni du pluton de Monchegorsky, de la péninsule de Kola (U.R.S.S.), a d'abord été caractérisée par Orsoev *et al.* (1982). Cabri & Laflamme (1976) ont décrit un minéral sans nom, semblable à la sopchéite tant par ses propriétés optiques que par sa composition, provenant de la mine Levack West (dans la région de Sudbury). Trois grains d'un minéral possédant des caractéristiques analogues et se présentant en intercroissances inattendues avec kotulskite et merenskyite ont été trouvés en 1979 dans des carottes de forage du complexe du Lac-des-Iles (Ontario). Les données chimiques et les mesures du pouvoir réflecteur du minéral de Levack West et celles de l'échantillon du Lac-des-Iles étayent l'hypothèse de l'identité de ces deux minéraux à la sopchéite. Les données nouvelles et plus complètes sur le pouvoir réflecteur constituent un apport substantiel à la caractérisation de ce minéral.

Mots-clés: sopchéite, deuxième occurrence au Canada, Lac-des-Iles, Ontario, minéraux du groupe du platine, $Ag_4Pd_3Te_4$, données quantitatives sur le pouvoir réflecteur.

Introduction and Mode of Occurrence

This paper records the second occurrence in Canada, at Lac-des-Iles, Ontario, of a mineral with similar composition and optical properties to the unnamed $Ag_4Pd_3Te_4$, described by Cabri & Laflamme (1976) from the Levack West mine, Sudbury area, Ontario. Compositional data, qualitative optical properties and reflectance spectra for the mineral from both occurrences are compared with those for the silver palladium telluride *sopcheite* (Orsoev *et al.* 1982) from copper–nickel sulfide ores of the Monchegorsky pluton, Kola Peninsula, USSR. We conclude that, in the absence of X-ray data, which could not be obtained owing to the small grain-size, the compositional and optical data are sufficient to demonstrate the probable identity of the Canadian minerals with sopcheite.

The new occurrence of sopcheite is in the Roby zone of the Archean Lac-des-Iles complex, located 80 km north-northwest of Thunder Bay, Ontario. Previously, Watkinson (1975), Cabri & Laflamme (1979), Dunning (1979) and Watkinson & Dunning (1979), using polished sections of drill-core samples and heavy-mineral concentrates, identified a total of eleven platinum-group minerals (PGM) from the Roby zone. These minerals are braggite, vysotskite, kotulskite, isomertieite, merenskyite, moncheite, sperrylite, stibiopalladinite, stillwaterite, sopcheite (reported as unnamed $Ag_4Pd_3Te_4$ in Dunning 1979) and unnamed Pd_5As_2. In addition, Pd occurs in solid solution in melonite, gold and pentlandite

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(Cabri & Laflamme 1979). The PGM occur, with rare exceptions, in disseminated sulfides, and most are associated with nickel minerals.

Sopcheite was found in samples P58–322.1 and P59–520.4, both from the Roby zone, and occurs as small, irregularly shaped areas in close association with kotulskite and merenskyite (Figs. 1, 2). The PGM grains are enclosed in chalcopyrite and pentlandite, which occur in the assemblage chalcopyrite - pyrite - pyrrhotite - pentlandite.

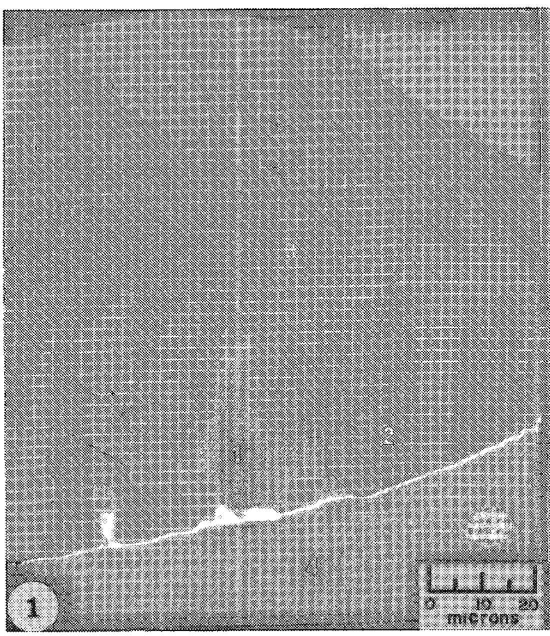
Optical and Chemical Properties

Qualitative optical properties

The qualitative description of the color of very small grains (20 μm or less) is extremely difficult and can be suspect because their appearance will vary depending on the associated minerals. Orsoev *et al.* (1982) described sopcheite in reflected light as grey with a brownish tint and lacking observable bireflectance. In crossed polars, they described it as weakly anisotropic with rotation tints varying from yellowish to bluish. The original description of sopcheite from the Levack West mine (Cabri & Laflamme 1976) agrees well: in plane-polarized light, grey-brown in air and medium brown in oil; in crossed polars, weakly anisotropic.

On re-examination (L.J. Cabri, pers. comm. 1978), it was found to be distinctly anisotropic. We therefore undertook a more detailed examination of the appearance of both the Lac-des-Iles grain and of the two areas from the Levack West specimen measured in the reflectance study. In unfiltered plane-polarized light, with a color temperature of 3000–3300 K, sopcheite from Lac-des-Iles is not visibly bireflectant but is slightly pleochroic from light grey to a light brown-grey. In oil its reflectance is reduced, and the reflectance pleochroism changes to grey to a pink or purplish grey. In crossed polars the rotation tints are moderate to strong from brown to yellow-brown to greenish yellow. In oil the brightness of these tints is enhanced. With polars uncrossed by 3° the sequence of tints is pinkish orange to orange to green to grey-brown.

In plane-polarized light, the two areas in the Levack West grain-mount appear grey to pinkish grey in air and grey to a slightly brownish grey in oil. They differ slightly in their appearance in crossed polars. This may be due to different crystallographic orientations; however, area 2 abuts the mounting plastic, and the background brightness of the plastic interferes with color perception. It also made difficult the accurate determination of the extinction positions of this grain. The anisotropic



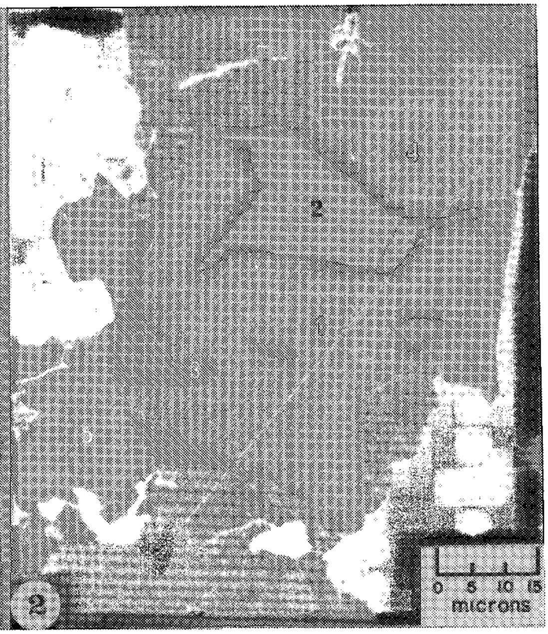


FIG. 1. Sample P58-322.1: sopcheite (1) at margin of a PGM grain, with an intergrowth of kotulskite (3) and merenskyite (2), enclosed in chalcopyrite (4). Partly crossed polars.

FIG. 2. Sample P59-520.4: sopcheite (1) with merenskyite (2) rimmed by kotulskite (3) enclosed in chalcopyrite (4) with some pentlandite (5). Partly crossed polars.

rotation-tints for both areas are not as vivid as those of the grain from Lac-des-Iles, those for area 1 changing from a reddish brown to a paler light brown, and for area 2 from a dark purple-grey to light brown to rich brown. With the polars uncrossed by 3°, the sequence for area 1 is pinkish or brownish grey to greenish grey to brown to purplish brown to grey and, for area 2, dark bluish red or purple to dark grey to brownish yellow.

Allowing for the differences in association, equipment and observers, these results agree reasonably well with the brief descriptions of Orsoev *et al.* (1982) and Cabri & Laflamme (1976).

Quantitative reflectance

The meaurement procedure and the equipment used are the same as described by Criddle *et al.* (1983) except that a SiC standard (Zeiss no. 472), ×40 air and oil objectives with effective numerical apertures adjusted to 0.22, and a prototype photometer-diaphragm (loaned to us by Dr. H. Piller of Carl Zeiss, Oberkochen) were used. The diameter of the illuminated field was ~12 μm and that of the measuring field, ~5 μm.

Measurements made on grains as small as these are at the practicable limit of microscope photometers (and their operators). Three factors, leveling, focusing and determination of extinction positions, demand the utmost care, and even so, it is not possible to guarantee that minute inclusions of other minerals (unresolvable by the eye) would not affect the measurements.

The reflectances were measured at an interval of 10 nm from 400 to 700 nm (Table 1), and color values were calculated for the three CIE-recommended il-

TABLE 1. QUANTITATIVE REFLECTANCE-DATA FOR SOPCHEITE

	AIR						OIL					
	Levack West				Lac des Iles		Levack West				Lac des Iles	
	Area 1		Area 2				Area 1		Area 2			
λnm	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2
400	34.9	39.2	31.58	37.3	38.28	36.15	20.3	24.6	22.5	25.5	27.3	25.1
10	35.2	39.2	32.0	37.3	38.6	36.5	20.9	24.8	22.65	25.2	27.3	25.2
20	35.6	39.2	32.5	37.2	39.0	37.0	21.6	25.1	22.9	25.0	27.4	25.5
30	36.3	39.4	33.2	37.2	39.4	37.7	22.6	25.5	23.3	24.8	27.6	26.0
40	37.15	39.5	34.1	37.3	39.9	38.8	23.8	25.8	23.8	24.7	27.75	26.7
450	38.25	39.8	35.1	37.5	40.3	40.0	25.1	26.1	24.3	24.6	28.0	27.6
60	39.1	40.05	36.1	37.7	40.8	41.2	26.3	26.4	24.9	24.7	28.2	28.5
70	40.5	40.4	37.1	38.0	41.2	42.3	27.3	26.7	25.5	24.75	28.55	29.4
80	41.4	40.6	37.9	38.2	41.7	43.3	28.1	26.9	26.0	24.8	28.9	30.2
90	42.0	40.9	38.6	38.4	42.1	44.1	28.7	27.05	26.5	24.8	29.3	30.9
500	42.6	41.05	39.1	38.6	42.6	44.6	29.1	27.2	26.85	24.9	29.7	31.3
10	42.9	41.2	39.4	38.7	43.05	44.9	29.3	27.3	27.0	24.9	30.1	31.4
20	43.1	41.3	39.6	38.7	43.5	45.0	29.4	27.4	27.0	24.9	30.6	31.4
30	43.1	41.4	39.65	38.8	44.0	44.9	29.3	27.5	27.0	25.0	31.0	31.2
40	43.1	41.6	39.7	38.95	44.4	44.8	29.3	27.7	27.0	25.1	31.4	31.1
550	43.2	41.9	39.7	39.2	44.95	44.8	29.2	27.95	26.95	25.35	31.9	31.05
60	43.3	42.2	39.8	39.5	45.6	44.8	29.4	28.3	27.0	25.7	32.5	31.1
70	43.5	42.6	40.0	39.9	46.3	44.95	29.5	28.8	27.15	26.1	33.2	31.2
80	43.7	43.1	40.2	40.4	47.0	45.15	29.7	29.2	27.3	26.5	33.9	31.4
90	43.9	43.55	40.4	40.9	47.7	45.3	29.9	29.8	27.5	27.0	34.6	31.55
600	44.1	44.0	40.6	41.3	48.3	45.5	30.0	30.2	27.7	27.5	35.2	31.7
10	44.2	44.5	40.8	41.8	48.8	45.6	30.2	30.7	27.8	27.9	35.6	31.8
20	44.3	44.9	40.9	42.2	49.2	45.7	30.4	31.2	27.9	28.3	36.0	31.9
30	44.4	45.3	41.0	42.6	49.5	45.8	30.5	31.7	28.1	28.75	36.3	32.0
40	44.45	45.6	41.2	43.1	49.8	45.9	30.6	32.1	28.2	29.2	36.6	32.15
650	44.6	46.0	41.4	43.6	50.0	46.1	30.8	32.5	28.3	29.8	36.8	32.3
60	44.8	46.45	41.5	44.05	50.2	46.2	30.9	33.0	28.55	30.3	37.0	32.45
70	45.0	46.9	41.7	44.6	50.35	46.35	31.1	33.5	28.8	30.9	37.1	32.6
80	45.2	47.3	41.9	45.1	50.5	46.5	31.35	34.0	29.0	31.4	37.3	32.8
90	45.4	47.7	42.15	45.6	50.6	46.7	31.6	34.5	29.3	31.9	37.4	32.9
700	45.6	48.1	42.4	46.1	50.8	47.0	31.9	35.0	29.6	32.5	37.6	33.2
COLOR VALUES												
Illuminant A												
x	0.455	0.457	0.455	0.457	0.462	0.454	0.457	0.462	0.455	0.460	0.466	0.454
y	0.413	0.408	0.413	0.407	0.410	0.413	0.414	0.407	0.412	0.405	0.410	0.413
Y%	43.6	42.95	40.1	40.3	46.4	45.1	29.7	29.1	27.3	26.5	33.3	31.4
λ_d	582	592	583	594	589	582	583	594	584	600	590	582
P_e%	8.6	6.6	9.1	6.4	11.6	7.8	11.0	9.8	8.0	7.1	14.4	8.2
Illuminant C												
x	0.320	0.320	0.321	0.320	0.326	0.319	0.323	0.325	0.320	0.322	0.331	0.319
y	0.331	0.322	0.331	0.322	0.329	0.330	0.335	0.325	0.329	0.320	0.331	0.331
Y%	43.3	42.5	39.85	39.8	45.6	44.9	29.45	28.6	27.15	26.0	32.6	31.3
λ_d	573	584	573	586	581	572	572	585	574	595	582	572
P_e%	6.5	4.2	6.8	3.9	7.7	6.1	8.6	6.2	5.9	4.0	9.5	6.4

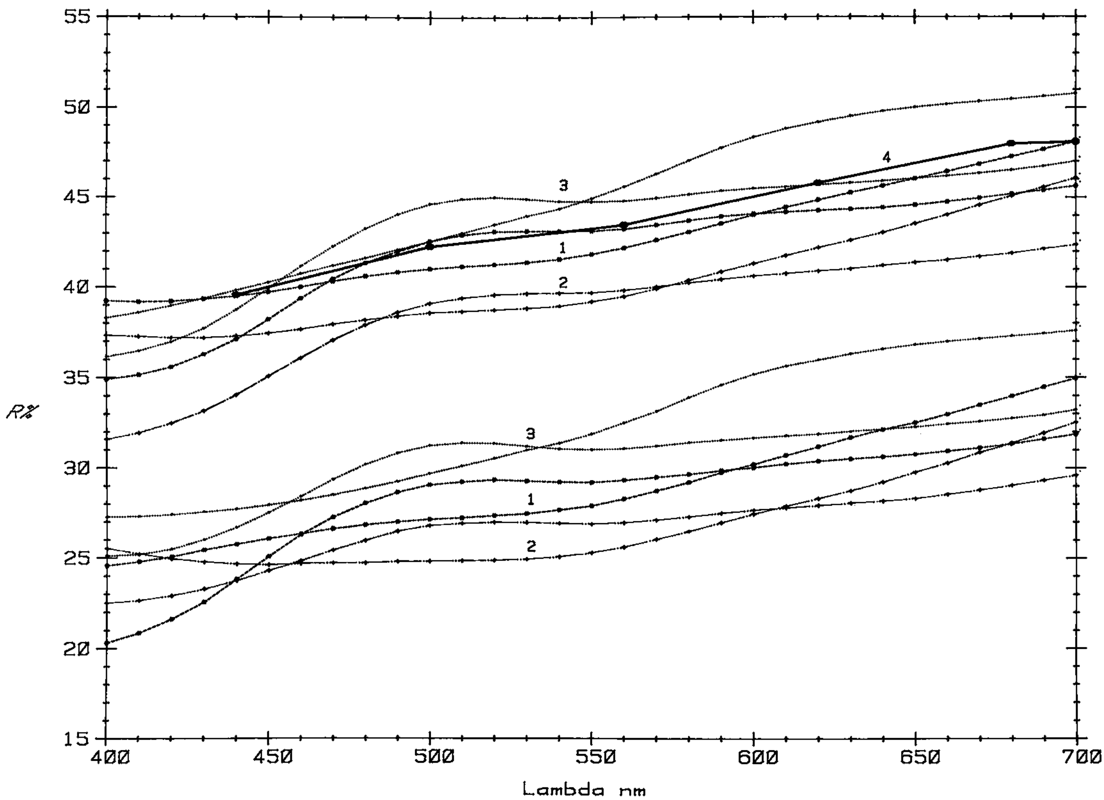


FIG. 3. Reflectance spectra for sopcheite in air and in oil. R spectra (upper group of curves) and ${}^{im}R$ spectra for one grain from Lac-des-Iles and two grains from the Levack West mine, compared with the R spectrum (solid line) of Orsoev *et al.* (1982). The spectra marked 1 and 2 for the areas described in the grain from Levack West, and spectra marked 3 are for the grain from the Lac-des-Iles complex.

luminants (only those for the two illuminants approved by the COM are listed in this Table). It will be seen from this that there are substantial differences between the luminances (Y%) for the two areas measured on the Levack West grain and between these and the grain from Lac-des-Iles. For the sake of brevity these will be discussed in terms of illuminant A: there is a ~3% difference in Y between areas 1 and 2, and a further 2–3% difference between the higher reflecting area 1 and the even higher-reflecting Lac-des-Iles grain. When the spectral curves are plotted (Fig. 3), it is seen that whereas the luminances differ, the dispersion of the reflectance for the two vibration directions measured for the three curves is similar, R_1 and R_2 displaying the same trends, and R_1 crossing R_2 twice in all three cases [labels R_1 and R_2 are assigned on the basis of R_1 having the higher reflectance at 550 nm and not on the basis of higher luminance: see Criddle (1980)]. The similarity of these curves suggests that the minerals are the same; either measurement errors or compositional differences must be responsible for the differences in magnitude. The former was ruled out by remeasurement at 400, 500, 600 and 700 nm, before and after rebuffing; the measurements are reproducible to within 0.3 percentage units. Compositionally, the only difference between the grains (Table 2) is the presence of about 1% bismuth in the Lac-des-Iles grain, not found in the Levack West grain.

Figure 3 also includes the spectral curve in air of the type specimen of sopcheite of Orsoev *et al.* (1982). This curve suggests that the mineral is isotropic, which is not the case; presumably they were unable to measure its bireflectance. The dispersion of the reflectance of the type specimen is similar to the general trend of all three areas reported here, and is bracketed by the curves of the grain from Lac-des-Iles and those of area 1 from Levack West, thus providing convincing proof, when taken with the compositional similarities, of the probable identity of these grains and sopcheite.

TABLE 2. COMPOSITION OF SOPCHEITE

No.	Ag	Pd	Fe	Cu	Ni	Te	Bi	Total
1.	34.4	26.1	-	-	n.d.	39.4	1.0	100.9
2.	34.0	25.8	-	-	"	39.1	0.36	99.26
3.	34.6	25.5	-	-	"	40.6	n.d.	100.7
4.*	33.6	25.2	-	-	"	40.1	"	98.9
5.	32.62	25.26	0.80	0.09	0.03	41.32	0.17	100.29
6.	33.56	23.92	2.13	n.d.	n.d.	42.13	n.d.	101.74

n.d. not detected; *0.29 wt.% As reported by Cabri & Laflamme (1976) but assigned to contamination from adjacent sperrylite. X-ray lines and standards used are as follows: PdLα and TeLα, synthetic PdTe or $(Pd_{0.9}Ni_{0.1})Te_{1.9}$; AgLα, metal; BiLα, synthetic PdBiTe. Corrections for the interference between $PdL_{\beta 1}$ and $AgL_{\alpha 1}$ were done. Raw data processed using a modified version of EMPADR VII computer program of Rucklidge & Gasparrini (1969). Compositions derived from electron-microprobe data and expressed in wt.%. Source of data: 1-3 this study, 4 Cabri & Laflamme (1976), 5-6 Orsoev et al. (1982).

Chemical composition

The composition of the Lac-des-Iles material was determined at CANMET with a MAC-400 electron-probe microanalyzer, operated at 25 kV with a specimen current of approximately 0.03 micro-amperes. X-ray lines and standards used are given in Table 2.

The average results of three microprobe analyses from the Lac-des-Iles material correspond to $Ag_{4.00}Pd_{3.05}(Te_{3.92}Bi_{0.03})_{\Sigma 3.95}$, which is in good agreement with the average composition of the grains from Levack West, $Ag_{3.97}Pd_{3.02}Te_{4.01}$, and with the sopcheite from Monchegorsk, for which Orsoev *et al.* (1982) gave formulae of $(Ag_{3.78}Fe_{0.18}Cu_{0.02}Ni_{0.01})_{\Sigma 3.99}Pd_{2.96}(Te_{4.04}Bi_{0.01})_{\Sigma 4.05}$ and $(Ag_{3.79}Fe_{0.21})_{\Sigma 4.00}(Pd_{2.74}Fe_{0.25})_{\Sigma 2.99}Te_{4.02}$.

CONCLUSION

This study has shown that, although X-ray data were unobtainable for the Ag–Pd–Te minerals from Lac-des-Iles and Levack West mine, Sudbury, comparison of their chemical compositions, qualitative optical properties and quantitative reflectance-spectra with those of sopcheite from the type locality are sufficient to indicate their identity. Hence, the Lac-des-Iles deposit may be taken as the second occurrence of the mineral in Canada.

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