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# WESTERVELDITE, A CANADIAN OCCURRENCE

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## *Introduction*

Westerveldite, a cobalt-bearing, iron-nickel monoarsenide in the FeAs-(Fe,Ni)As series, was first described by Oen *et al.* (1972) in samples of chromite-nickeline ore from La Gallega, Spain. This note reports a second occurrence of westerveldite, discovered in an assemblage of disseminated arsenides in serpentinized peridotite from a borehole near Birchtree mine, Thompson, Manitoba. The sample used in this study has been deposited at the Royal Ontario Museum, Toronto (ROM M32122).

## *Mode of occurrence*

The disseminated arsenides in the peridotite comprise nickeline, maucherite and rare grains of cobaltite. They occur as ragged aggregates which rarely exceed 5 mm in diameter. Maucherite commonly forms broad rims around grains of nickeline, whereas cobaltite is present as small isolated particles in both nickeline and maucherite.

The westerveldite occurs as a lacy intergrowth with maucherite and more rarely with nickeline (Fig. 1). The grain size of westerveldite ranges from 1 μm to approximately 25 μm in diameter. Individual grains form clusters which commonly follow cracks in maucherite and nickeline. Westerveldite is absent where nickeline is the only arsenide present or where nickeline and maucherite do not display a system of fine cracks. It seems, therefore, that westerveldite is the product of later replacement of maucherite, possibly related to the serpentinization of the host peridotite.

## *Optical properties*

The optical properties of the Birchtree westerveldite are similar to those listed by Oen *et al.* (1972). The colour varies from brownish white to greyish white; pleochroism and anisotropism are distinct in air and strong in oil. The polarization colours are blue and brownish orange.

The reflectance of westerveldite was measured by Dr. L. J. Cabri of the Department of Energy, Mines and Resources, Ottawa. The measurements were made with a 45:1 objective of 0.85 numerical aperture, on an area 3.6 μm square. The reflectance standard was silicon N2538.42 calibrated by the National Physical Laboratory, Great Britain. Table 1 lists the reflectance values obtained for the three sets of readings made.

TABLE 1. REFLECTANCE VALUES OF WESTERVELDITE

| Wavelength | R(max) 1 | 2 | 3 | Mean | R(min) 1 | 2 | 3 | Mean |
|---|---|---|---|---|---|---|---|---|
| 470 nm | 51.0 | 52.0 | 52.6 | 51.9 | 46.1 | 50.7 | 51.5 | 49.4 |
| 546 nm | 49.8 | 50.8 | 51.6 | 50.7 | 47.8 | 49.9 | 50.8 | 49.5 |
| 589 nm | 50.6 | 50.8 | 52.8 | 51.4 | 47.6 | 50.1 | 52.6 | 50.1 |
| 650 nm | 52.8 | 53.0 | 55.7 | 53.8 | 47.2 | 52.7 | 55.7 | 51.9 |

The average reflectance of westerveldite (50.1 at 546 nm) is slightly lower than that of mauche-

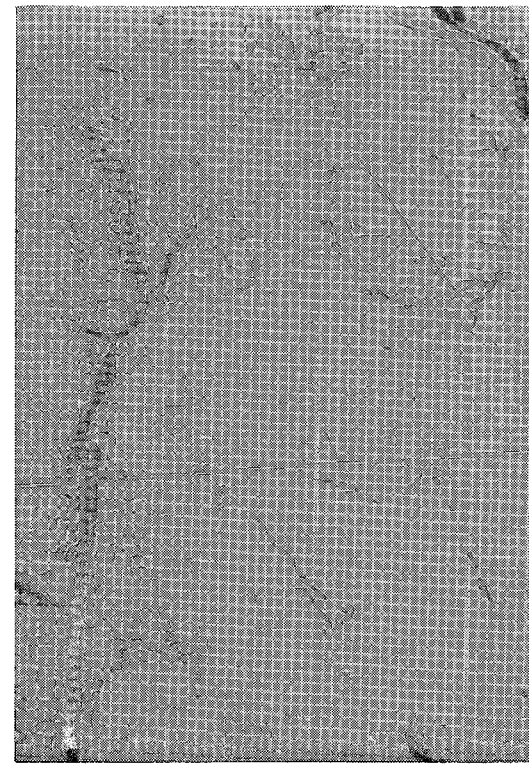

FIG. 1. Photomicrograph (400×) of westerveldite (darkest grey) in maucherite (medium grey) and nickeline (light grey).

rite (53.8 at 546 nm). This agrees with the qualitative observation made by Oen *et al.* on the La Gallega westerveldite.

The Vickers hardness was measured with a Leitz Miniload Tester using a weight of 25 p. The values ranged from 707 to 798 kp/mm². This is slightly harder than maucherite (VH 667 kp/mm²).

### *Chemical composition*

The chemical composition of westerveldite was determined with a Cameca electron microprobe at an operating voltage of 25 kv. Standards were pure Fe, Co, Ni, Sb, As and analysed pyrite. The results were corrected for absorption, atomic number and fluorescence using the data reduction program of Rucklidge & Gasparrini (1969). Table 2 lists the individual analyses and Table 3 gives the average compositions of westerveldite, and associated nickeline, maucherite and cobaltite.

TABLE 2. MICROPROBE ANALYSES OF INDIVIDUAL GRAINS OF WESTERVELDITE*

| Grain number | Weight % Ni | Fe | Co | As | Sb |
|---|---|---|---|---|---|
| 1 | 14.1 | 29.6 | 0.5 | 55.4 | 0.5 |
| 2 | 13.8 | 30.4 | 0.5 | 54.9 | 0.4 |
| 3 | 14.7 | 28.9 | 0.5 | 55.5 | 0.5 |
| 4 | 13.7 | 30.1 | 0.5 | 55.3 | 0.5 |
| 5 | 13.6 | 30.3 | 0.5 | 55.1 | 0.5 |
| 6 | 13.6 | 30.5 | 0.5 | 54.9 | 0.6 |
| 7 | 13.3 | 30.4 | 0.4 | 55.4 | 0.5 |
| 8 | 14.5 | 29.8 | 0.3 | 54.9 | 0.5 |
| 9 | 13.4 | 31.4 | 0.5 | 54.4 | 0.4 |
| 10 | 13.8 | 29.7 | 0.5 | 55.5 | 0.5 |
| 11 | 13.4 | 30.6 | 0.4 | 55.1 | 0.5 |
| 12 | 14.7 | 29.4 | 0.5 | 55.0 | 0.5 |

* Totals ranged from 98.7 to 101.0 wt. % prior to recalculating to 100% using the program of Rucklidge & Gasparrini (1969).

TABLE 3. AVERAGES OF ELECTRON MICROPROBE ANALYSES OF WESTERVELDITE AND ASSOCIATED ARSENIDES

| Wt. % | Westerveldite | Nickeline | Maucherite | Cobaltite |
|---|---|---|---|---|
| Fe | 30.1 | 0.2 | 0.2 | 4.1 |
| Ni | 13.9 | 43.9 | 50.8 | 9.4 |
| Co | 0.5 | 0.4 | 0.5 | 23.2 |
| As | 55.1 | 55.0 | 48.0 | 45.6 |
| Sb | 0.5 | 0.6 | 0.4 | 0.1 |
| S | nd* | nd* | nd* | 17.7 |
| | 12** | 9** | 11** | 6** |

* nd= not detected
**number of grains analysed

The formula calculated for the average composition of westerveldite is

$$(Fe_{0.73}Ni_{0.32}Co_{0.01})_{\Sigma 1.06}As_{1.00}.$$

The range in analytical values can be expressed by the formula

$$(Fe_{0.70\text{-}0.77}Ni_{0.31\text{-}0.34}Co_{0.01})_{\Sigma 1.04\text{-}1.10}As_{1.00}$$

The westerveldite from Birchtree is slightly higher in iron and lower in nickel than the westerveldite from La Gallega for which Oen *et al.* give the average formula

$$(Fe_{0.635}Ni_{0.400}Co_{0.015})_{\Sigma 1.050}As_{1.000}.$$

### *X-ray crystallography*

The westerveldite grains were too small to be isolated for x-ray diffraction analysis. However, a pattern was obtained from a grain composed of nickeline, maucherite and westerveldite. The diffraction lines that could not be accounted for by nickeline and maucherite correspond to the pattern found for the La Gallega westerveldite.

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