HEAZLEWOODITE AND AWARUITE IN SERPENTINITES OF THE EASTERN TOWNSHIPS, QUEBEC

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Awaruite of composition approximately Ni_3Fe was shown by Nickel (1959) to be a common accessory phase in most serpentinites of the asbestos-producing belt in the Eastern Townships, Quebec. Nickel demonstrated that awaruite developed during the serpentinization process from nickel and iron already present in these rocks.

Work on the distribution and genesis of native metals in the Muskox intrusion (Chamberlain, *et al*, 1965) indicated that native metals could form by the decomposition of earlier-formed sulphides. For example, pentlandite was shown to decompose to form awaruite plus iron sulphide, and chalcopyrite to native copper plus pyrrhotite. Some native iron may have been formed by the reduction of magnetite. Such reactions suggested that awaruite in the Eastern Townships could also have been formed by the decomposition of primary sulphides. This theory was checked by examination of 44 polished sections made from samples donated by A. S. MacLaren of the Geological Survey, and from samples collected during the 1965 field season*. The observed distribution of awaruite, heazlewoodite and magnetite in these sections is summarized in Table 1.

Magnetite is present in 94 per cent of the sections in amounts exceeding 0.1 per cent. Most sections contain 1 per cent or more. It occurs as threads between ghost olivine or pyroxene crystals, as discrete, weakly euhedral grains, or as rims around primary chromite crystals. It is invariably in contact with serpentine. Magnetite is believed to have formed by reaction of magnesium-iron olivine or pyroxene with water to give magnesium serpentine plus magnetite at temperatures below 550° C. It is commonly associated with either heazlewoodite or awaruite (described below) in the rocks under consideration, but at the extreme ends of the main asbestos belt, it occurs alone in serpentine (Table 1).

Awaruite is present in 30 per cent of the sections examined. Its minute grain size, Ni_3Fe composition, and general association with magnetite have been described in detail by Nickel (1959). In all but one case in the present study, magnetite was found to be present in the same sections, though awaruite was not observed in actual contact with it. The alloy is generally irregular or scalloped in outline. Rarely, it seems to occur as almost perfect cubes a few microns in diameter. A single grain of alloy

*Assistance and cooperation from the many companies visited are much appreciated.

TABLE 1. HEAZLEWOODITE, AWARUITE AND MAGNETITE IN SERPENTINITES, QUEBEC

Sample No.	Phases present in addition to serpentine Magnetite	Alloy	Heazlewoodite	Property
CM65–43	x			Carey-Canadian
–44	x			Carey-Canadian
–45	x			Carey-Canadian
–46	x		x	National Asbestos
–31	x		x	National Asbestos
–32	x		x	National Asbestos
–33	x		x	National Asbestos
–34	x		x	National Asbestos
–35	x		x	National Asbestos
–36	x		x	National Asbestos
–37	x		x	National Asbestos
–38	x		x	National Asbestos
–39	x		x	National Asbestos
–40	x		x	National Asbestos
–41	x		x	National Asbestos
–42	x			National Asbestos
–48	x	x		Johnson (Thetford)
–49	x	x		Johnson (Thetford)
A64 –2	x	x		Johnson (Thetford)
CM65–50	x		x	Beaver
–51	x		x	Beaver
–52	x		x	Beaver
–53	x	x		Beaver
A64 –5	x	x		Beaver
A64 –4	x	x		Lac a la Truite
CM65–54		x		British-Canadian
–55	x	x		British-Canadian
–56	x	x		British-Canadian
–57	x	x		British-Canadian
–58	x		x	Continental
–59	x		x	Continental
–60	x		x	Continental
–61	x		x	Normandie
–62	x		x	Normandie
–63	x		x	Normandie
–64	x		x	Normandie
–65	x			Vimy Ridge
–66	x			Vimy Ridge
–68	x			Nicolet Lake
–69	x			Nicolet Lake
–25			x	Jeffrey
–26	x	x		Jeffrey
–27	x	x		Jeffrey
–28	x	x		Jeffrey
–29			x	Jeffrey
–30	x	x		Jeffrey
A64 –3	x		x	Jeffrey

from the Jeffrey mine (Sample CM65–30) measured almost 1 mm. across. This was the largest grain encountered in the study.

Heazlewoodite is present in 53 per cent of the sections examined. According to Table 1, heazlewoodite occurs in about twice as many sections as awaruite. This is not a true measure of its abundance relative to awaruite because of the uneven distribution of samples. It is, however, a common minor constituent of the serpentinites, and its average grain size of about 30 microns is more than double that of awaruite. Heazlewoodite was recognized on the basis of its cream colour and teal blue to violet anisotropism. Identification was confirmed by x-ray powder pattern. In addition, nine grains were tested for microhardness under 50 gram loads. These range from V.H. 231 to 321, with a mean of 300.

Heazlewoodite was not observed in the same sections with awaruite (Table 1). Heazlewoodite accompanies magnetite in all but 2 of the sections in which it occurs. The two phases were observed in contact in several instances (Figure 1). Textural relations suggest that heazlewoodite and magnetite formed contemporaneously and that they represent an equilibrium assemblage. Similarly, there seems little doubt that awaruite and magnetite formed contemporaneously, as indicated above. The suggestion therefore is that both heazlewoodite and awaruite formed in different zones within the ultramafic bodies as by-products of the serpentinization process. Nickel already present in the rocks almost certainly accounts for the nickel in both secondary phases. On the other hand, it

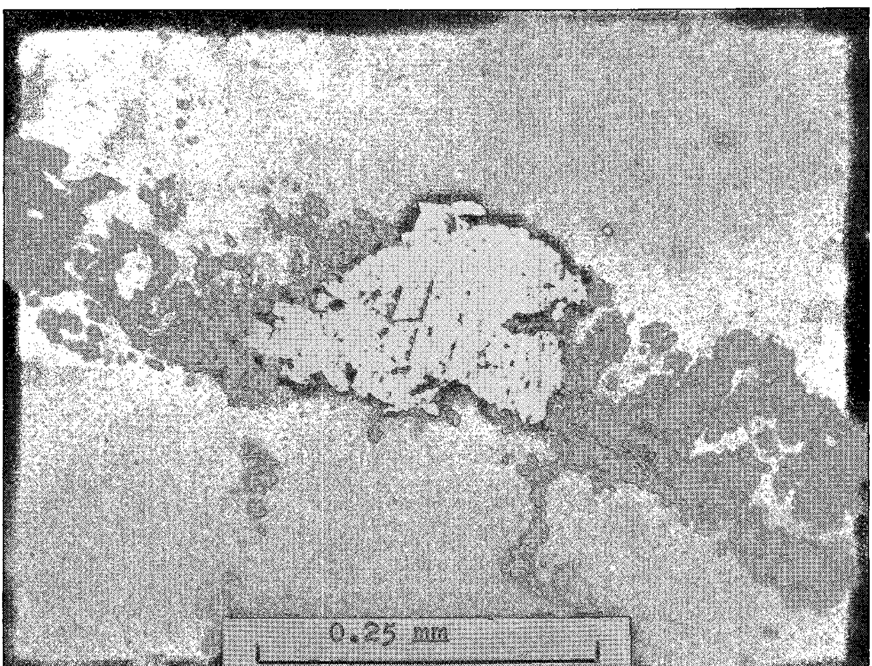

FIG. 1. CM65-59. Heazlewoodite (white) developed in magnetite (grey) within serpentine (black).

seems reasonable that small quantities of sulphur could have moved through these rocks with water during serpentinization. This could be somewhat analogous to the manner in which finely disseminated pentlandite appears to have developed in the "secondary sulphide zone" of the Muskox intrusion (Chamberlain, in press). The process may also be similar to the one mentioned by Naldrett (1965) in which heazlewoodite developed in peridotite at the Alexo property, Timmins, Ontario.

Repetition of the two-phase assemblages magnetite-awaruite and magnetite-heazlewoodite in different zones suggests an antipathy between awaruite and heazlewoodite. It seems more than fortuitous that the two phases were not observed in the same polished sections, yet nothing in the geometry of the phase relations in the Fe-Ni-S system (Kullerud, 1963) suggests that an incompatability exists. If the antipathy is real, it must be related to fluctuating chemical activities of sulphur and/or oxygen in various parts of the system. Such fluctuations did not disturb equilibrium relations between the major phases present (serpentine and magnetite) and probably operated over a narrow, though apparently critical, range.

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TRANSMISSION ELECTRON MICROSCOPY OF FINE-GRAINED ROCKS

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The resolving power of the petrographic microscope has limited the study of rocks to systems in which the grain size is larger than several microns. During the past several years techniques have been developed