OBSERVATIONS ON OCCURRENCES OF AWARUITE IN LAPLAND

by

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Awaruite is a naturally occurring stainless steel nickel-iron alloy with an average Ni content of 72.4 wt%. Most commonly, it is found as an accessory mineral in serpentinized cumulate units of ophiolite complexes (Filippidis 1985). Awaruite is a cubic mineral with saturation magnetization of 120 Am^2/kg at room temperature (magnetite: 90–92 Am^2/kg). The density of awaruite is between 7.8 and 8.2 g/cm^3. Awaruite shows a silver white colour with higher reflectance than pyrite in polished sections and it is a relatively soft mineral with Mohs hardness between 5 and 6 and Vickers hardness from 265 to 380 kg/mm^2. Occurrences of awaruite had been considered as mineralogical curiosities until the discovery of potentially mineable awaruite enrichments in serpentinized harzburgite, dunite and peridotite of obducted ophiolite complexes of Palaeozoic and Mesozoic age in British Columbia, Canada (Lovén & Meriläinen 2011). The economic interest in this mineral is that a substantial reduction in the environmental impact and cost of stainless steel production can be achieved by the direct use of awaruite concentrate in steel mills.

Occurrences of awaruite in Lapland are reported in Papunen and Idman (1982). However, details of exact localities are not mentioned. The database of Papunen's original report on the nickel potential of Lapland (Papunen 1976) lists occurrences of awaruite at the following localities: Tarpomapää, Allivuotso-Ivalon Matti and Kuusi-Lomavaara. Our SEM-EDS-supported petrographic work confirmed the occurrence of awaruite as an early product of alteration of Ni-bearing olivine to magnetite and serpentine minerals at the Kuusi-Lomavaara locality (Fig. 1A): the texture and paragenesis correspond to the most common type of awaruite formation process (Klein & Bach 2009). Pentlandite partially replaces the early magnetite-awaruite association, suggesting that a weak sulphurization overprinted awaruite formation at the Kuusi-Lomavaara locality (Fig. 1a).

Taking into account the characteristics of the awaruite-bearing rocks at Kuusi-Lomavaara and other localities worldwide, we selected further samples of serpentinite from Lapland to check for the presence of awaruite according to the following criteria: no carbonate-talc-chlorite alteration, a sulphur content of less than 0.1 wt%, a relatively high (>0.05 wt%) nickel content and relatively high

(>4000) magnetic susceptibility values. Polished thin sections of samples from ten serpentinite occurrences of Lapland, which were available from the work reported in Papunen (1976) and from other Ni(-Cu-PGE) exploration projects of GTK, were subjected to SEM-EDS-supported petrography and MLA studies. Our work resulted in the recognition of two localities where the presence of awaruite was detected in more than 10% of thin sections that were subjected to detailed studies.

Serpentinite forms several small lensoid bodies in the host gneiss in an approximately 700-m-long NE–SW-oriented zone at Pahtajärvi in northern Lapland (Marmo 1960). The serpentinite bodies are locally altered to soapstone and also contain 1–2-cm-thick subparallel magnetite-antigorite veinlets in some places. The major mass of serpentinite without carbonate-talk alteration and magnetite veining consists of antigorite and chrysotile, with a few needles of tremolite and remnants of olivine. Awaruite partially or almost completely replaces round-irregular grains of millerite, which are randomly disseminated in serpentine minerals. Ni-rich magnetite replaces awaruite along grain boundaries (Fig. 1b). Millerite also encloses inclusions of pentlandite, heazlewoodite and gersdorffite. The most typical grain size of awaruite is between 10 and 50 microns, but its grain size is less than 10 microns in sections with low awaruite contents.

The Värriöjoki intrusion forms a large ellipsoid body of approximately 4 km x 2 km in an Archaean gneiss-amphibole-chlorite schist complex in eastern Lapland. The major mass of the intrusion consists of relatively fresh dunite with a serpentinized peridotite and pyroxenite zone a few tens of metres thick along its contacts with the country rocks. Awaruite mostly occurs in an approximately 1000-m-long narrow zone of metaperidote along the southern margin of the intrusion. Awaruite exclusively forms thin rims along the perimeters of 50–100-micron composite pentlandite–Ni-rich magnetite aggregates (Fig. 1c). Awaruite rims occasionally also contain millerite and nickeline grains (Fig. 1d). The textural and mineralogical characteristics of awaruite occurrences are consistent with the formation of awaruite by desulphurization of primary rock, forming pentlandite and hydrothermal millerite at Värriöjoki and Pahtajärvi, respectively.

The preliminary results presented here are insufficient for outlining the economic potential of awaruite in Lapland. However, our observations suggest that awaruite is not an uncommon mineral in some serpentinite bodies in Lapland, and it is expected that new occurrences will be discovered by refinement of targeting criteria on the basis of further mineralogical-textural, geochemical and petrophysical studies.

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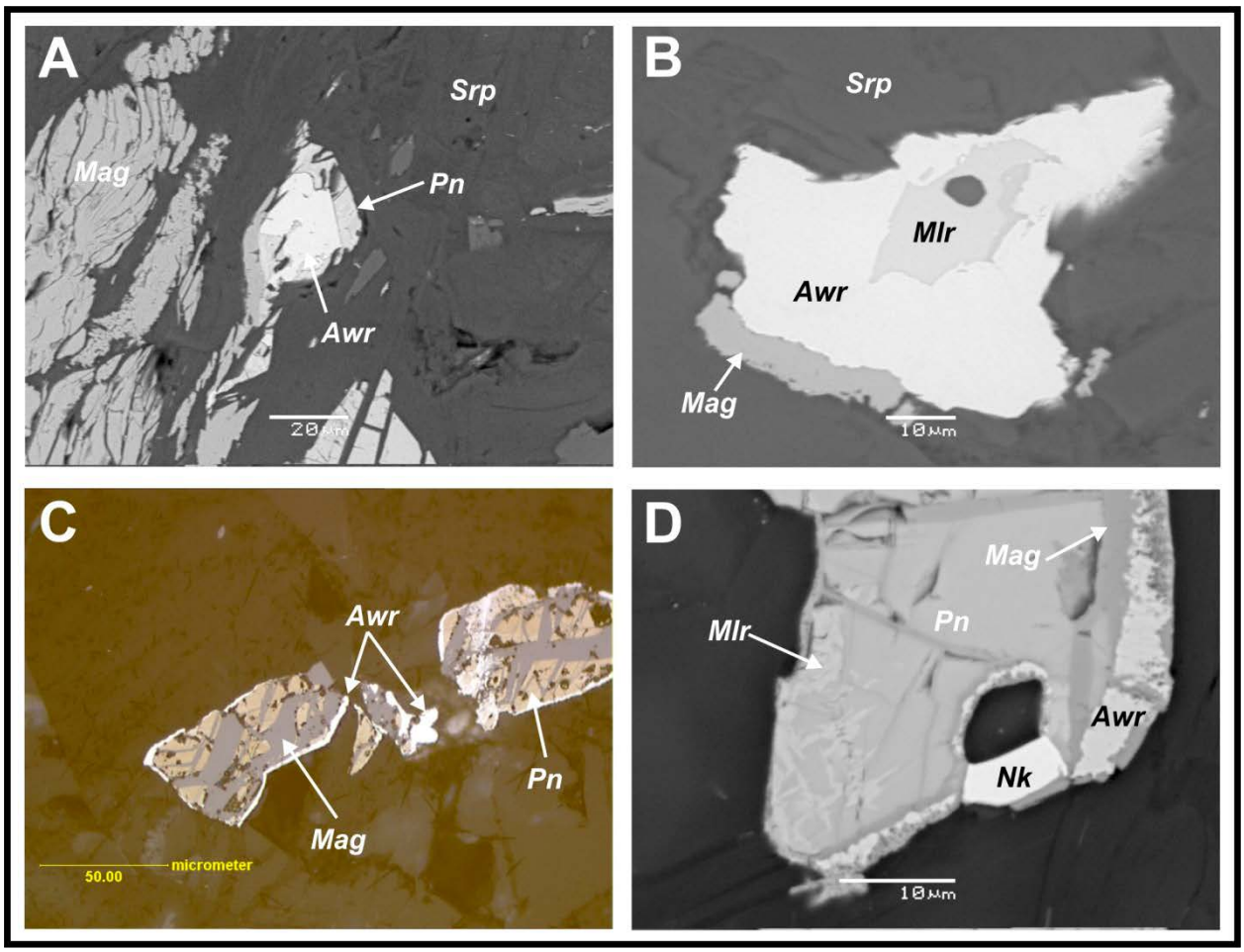

Fig. 1. Textural varieties of awaruite occurrences in serpentinites in Lapland. Mineral abbreviations: Awr – awaruite; Pn – pentlandite; Mlr – millerite; Nk – nickeline; Mag – magnetite; Srp – serpentine mineral. (a) Awaruite corroded by magnetite and pentlandite, Kuusi-Lomavaara locality. (b) Awaruite replacing millerite and a magnetite rim on awaruite, Pahtajärvi locality; (c) Awaruite rims on a pentlandite-magnetite aggregate, Värriöjoki locality. (d) Millerite and awaruite replacing a pentlandite-magnetite aggregate and nickeline in the awaruite rim, Värriöjoki locality.