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SPECIAL COLLECTION: FROM MAGMAS TO ORE DEPOSITS

A story of olivine from the McIvor Hill complex (Tasmania, Australia): Clues to the origin of the Avebury metasomatic Ni sulfide deposit

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Abstract

Magmatic differentiation and/or assimilation and related segregation of immiscible sulfide liquid are generally believed to be critical processes in the formation of the majority of orthomagmatic Ni sulfide deposits. In recent years, a new class of Ni sulfide deposits formed by metasomatic and/or hydrothermal modification of peridotites has been recognized. The serpentinite-hosted Avebury Ni sulfide deposit (Tasmania, Australia), the largest known non-magmatic sulfide deposit, provides an unprecedented opportunity to understand sources of metals and fluids responsible for this style of economic mineralization. Our study shows that serpentinization of the Ni-bearing olivine in the Cambrian peridotites of the McIvor Hill complex was followed by metasomatic transformation assisted by heat and fluids supplied by the nearby Late Devonian granite intrusion. The role of the above in the formation of an economic concentration of Ni sulfides is supported by (1) abundant Ni-Fe alloys and sulfides associated with serpentinization of peridotitic olivine, (2) metasomatic olivine containing inclusions of serpentine and metalliferous brines, and (3) the Late Devonian age of the Ni sulfide deposit. The Avebury metasomatic olivine is Ni-depleted and enriched in Mn relative to olivine of similar Fo content in nearby unmineralized peridotites, and to olivine in subduction-related mafic magmas generally. The unusual minor element chemistry of olivine is matched by a unique set of olivine-hosted multiphase inclusions composed of fibrous Mg-silicates and various Na-, K-, Fe-, Ca-, Mn-, and Ba-bearing chlorides/hydrochlorides, sulfides, arsenides magnetite, REE minerals, and Fe-Ni alloys.

Peridotite whole-rock Sr-Nd-Pb isotope data and U-Pb dating of metasomatic titanite support earlier suggestions that Ni mineralization is temporally and genetically related with the intrusion of the nearby 360 Ma Heemskirk Granite. It appears that the multiphase inclusions in metasomatic olivine demonstrate chemical signatures of both in situ serpentinites (entrapped alloys, sulfides, arsenides, and magnetite) and distal fluids (enrichment in Pb, Bi, Sn, Sb, Sr, Ba, Rb, Cs, and Ce).

We propose that magmatic olivine in large ultramafic bodies provides almost infinite Ni to replacive serpentinites and constitutes a major reservoir of disseminated Ni mineralization. In the case of Avebury Ni was locally redistributed from olivine in the Cambrian peridotites to mainly Fe-Ni alloys and sulfides during serpentinization in the early Paleozoic. In the Devonian reheating and interaction with a granitic fluid in the contact aureole of the Heemskirk Granite led to de-serpentinization and formation of metasomatic high-Mn, low-Ni olivine with inclusions of serpentine and entrapped alloys, sulfides, arsenides, and magnetite, and metalliferous brines rich in "granitic" elements. Nickel released from serpentinite in this process was re-deposited near the margins of the peridotite to form the Avebury Ni orebody. Our model of serpentinization-related release of Ni from magmatic olivine, in situ precipitation of metallic, sulfide, and arsenide Ni-minerals, and their redistribution and recrystallization in hydrothermal conditions represents an alternative to Ni remobilization from magmatic sulfides.

Keywords: Ni sulfide deposits, peridotites, serpentinization, olivine, granite, metasomatism, geochronology