Effects of Serpentinization on Dunite-Hosted Disseminated Ni Sulfide Ore, Agnew-Wiluna Belt, Western Australia

Martin Gole*

Martin Gole & Associates, Perth, Western Australia, Australia

*E-mail, mgole@westnet.com.au

The Agnew-Wiluna greenstone belt hosts komatiite-hosted disseminated Ni sulfide deposits at Mount Keith, Honeymoon Well (Hannibals, Harrier, and Corella deposits), West Jordan, and Yakabindie (Six Mile and Goliath North deposits). Metamorphic grade varies from low grade in the north to low amphibolite in the south. Disseminated mineralization (>0.37% Ni in totally serpentinized dunite) located below the olivine isograd (Mount Keith, Honeymoon Well, West Jordan) has complex, strongly zoned sulfide assemblages, shows a wide range in Ni/S (averages of five deposits 1.2–2.0), and has a high proportion of mineralization with low Cu (28–51% of mineralization with <40 ppm Cu). Sulfide assemblages include pentlandite-pyrrhotite-chalcopyrite ± pyrite, pentlandite ± chalcopyrite, pentlandite-heazlewoodite (or millerite), heazlewoodite or millerite only, and, rarely, heazlewoodite-native Ni. Deposits that are located above the olivine isograd (Yakabindie) are dominated by less complex assemblages and have lower Ni/S (averages of two deposits 0.76–1.04) with a lower proportion of low-Cu mineralization (5–7%).

In serpentine-hosted deposits, the sulfide zonation is reflected by reductions in whole-rock S, Cu, Fe, and Zn over the whole range of Ni grade (i.e., 0.37–~2%). Evidence for mobility of these elements is seen in the presence around deposits of Fe-Cu-Zn sulfides and magnetite in veins and a halo of elevated S. Although there is uncertainty as to the original bulk composition of the mineralization, it is proposed that variable loss of these components from sulfide assemblages and the whole rock was initiated by highly reduced conditions that were produced during low fluid/rock ratio serpentinization. Ratios of Ni to PGE and, with some exceptions, Co are unaffected by the alteration. Consumption of H_2O resulted in Cl, a component of the fluid, being concentrated sufficiently to stabilize iowaite as part of lizardite-rich assemblages. Some serpentinites containing pentlandite-pyrrhotite-chalcopyrite ± pyrite assemblages have exceptionally high Cl contents (up to >2% Cl), whereas rocks containing heazlewoodite or millerite-only assemblages and with low whole-rock S, Cu, Fe, and Zn contents have lower Cl contents (mostly <0.6%). Chlorine is hosted by relatively abundant iowaite, Cl pyroaurite with small amounts in woodallite, and Cl stichtite.

In the latter stages of serpentinization when the olivine hydration rate declined and after expansion and associated fracturing of the ultramafic sequence, a more fluid dominated environment formed and allowed carbonate-bearing fluid to gain variable access to the mineralized rocks. In places, this drove Cl from iowaite (to form CO_2-bearing pyroaurite) and caused variable leaching of components from original magmatic assemblages to those assemblages stable at prevailing f_{O_2} and f_{S_2} conditions. Mass transfer was made possible via metal chloride complexes and H_2S with fluids driven by D2 deformation associated with the metamorphism (M2). This produced a complex sulfide assemblage zonation within the deposits, reflecting variable timing, compositions, and flow rates of fluids over an extended period involving serpentinization and a later recovery period where fluids adjusted compositions from the highly reduced conditions imposed by the serpentinization.