A Geochemical Study of Magmatic Ni-Cu-PGE Sulfide Mineralization Hosted in Mafic Intrusions at Melba Flats, Western Tasmania, Australia

Marcus Phua,[1*] Reid Keays,[1, 2] and David Phillips[1]

[1]School of Earth Sciences, The University of Melbourne, Parkville, Victoria 3010, Australia
[2]School of Earth, Atmosphere and Environment, Monash University, Victoria 3800, Australia

*E-mail, ckphua@student.unimelb.edu.au

Mafic intrusions hosting magmatic Ni-Cu-PGE sulfide mineralization at Melba Flats are located along the eastern margin of the NE–trending Dundas Trough in Western Tasmania. The Melba Flats intrusions occur as a suite of bifurcating sills and dikes that extend over 2-km within the volcanogenic lithic graywackes of the Crimson Creek Formation. Ni-Cu-PGE sulfides at Melba Flats typically occur in two different forms: as disseminated sulfides within the majority of the intrusions and/or as semimassive to massive sulfides that can comprise up to 80% in volume of an intrusion. Although the massive sulfides generally occur at the base of the intrusions, they are also present at various depths throughout the intrusions. Pentlandite, chalcopyrite, pyrrhotite, along with minor millerite and pyrite, are the dominant sulfide minerals associated with mineralization. Historical production of the magmatic Ni-Cu-PGE sulfides at Melba Flats stands at about 10,000 tons with an average grade of 9.7% Ni and 4.7% Cu since its discovery in 1893.

The Melba Flats intrusions were formed by primitive magmas of high-MgO content (14-15%) with a subalkaline tholeiitic affinity. The thicker intrusions are differentiated, with the most primitive magma occurring near the base, and the most evolved at the top, indicating that they had undergone in situ fractionation. Primitive-mantle-normalized REE and extended multi-elements spider diagrams indicate similar petrogenetic patterns between the barren and mineralized intrusions, providing strong evidence that the intrusions are co-magmatic. Primitive mantle-normalized Nb/Th vs. Th/Yb scatter diagrams as well as negative Nb anomalies observed on extended multi-elements spider diagrams further indicate that the magmas had undergone some degree of crustal contamination.

The Ni-Cu-PGE sulfides at Melba Flats contain up to 20.0% Ni, 6.7% Cu, 3320 ppb Pd, 1970 ppb Pt, 112 ppb Rh and 239 ppb Ir. Mantle-like S/Se ratios as well as the high Ni-Cu tenors and PGE contents of the semi-massive to massive sulfides indicate that these sulfides are magmatic in origin and formed at high R-factors during sulfide segregation. On the other hand, crustal-like S/Se ratios as well as the lower Ni-Cu tenors and PGE contents of the disseminated sulfides indicate that these sulfides were formed at low R-factors during interaction with S-bearing crustal rocks. Pd vs. Pt and Pd vs. Cu scatter diagrams clearly highlight the differences between the two contrasting forms of sulfides occurring in the mafic intrusions at Melba Flats. Consequently, the bulk of the data indicate that the semi-massive to massive sulfides were formed at depth before being transported to their current sites by the high-MgO magmas. Significantly during this transportation process, the magmas underwent further interaction with S-bearing crustal rocks, leading to the formation of the low tenor disseminated sulfides.

Based on the hypothesis above, there is a distinct possibility that only a small proportion of the high tenor magmatic Ni-Cu-PGE sulfides that formed at depth were transported to current sites within the mafic intrusions. Hence, it is suggested that a significant amount of magmatic Ni-Cu-PGE sulfides may be concealed at depth at Melba Flats.