Spinel Formation During Thermomechanical Erosion of Footwall Basalt Beneath a Sulfide Melt Pool at the Komatiite-Hosted Ni-Cu(-PGE) Moran Deposit, Kambalda, Western Australia

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Trough-like features at the base of channelized komatiite lava flows are known from many Ni-Cu(-PGE) sulfide deposits around the world. These embayments usually host the sulfide mineralization at their base and in so-called pinch-out zones, where the sulfide has a basal and upper contact with the older substrate in the flanks of the troughs. The origins of both the embayments and associated pinch-outs are still under debate. The alternative explanations are (1) preexisting topographic relief of the komatiite's substrate, (2) purely tectonic control of the trough formation, or (3) formation due to thermomechanical erosion of the komatiite into the substrate.

The Moran deposit, host to ca. 50 kt Ni, is located on the eastern flank of the Kambalda dome in the Kalgoorlie terrane of the Yilgarn craton in Western Australia. The 2.7 Ga volcanosedimentary succession was intruded by magmatic dikes and metamorphosed to upper greenschist to lower amphibolite facies. Despite this overprinting, well-preserved textures were encountered, suggesting that widespread melting of the footwall Lunnon Basalt occurred during the emplacement of the komatiite and sulfide lava.

Melting textures are observed along most of the basal contact of Moran, in the form of subrounded silicate clasts, rare subspherical silicate melt droplets, and sulfide-silicate emulsions, which are all rimmed by skeletal Cr-rich spinel. In the pinch-out zone, Cr-rich spinel is also observed at the upper contact to the Lunnon Basalt, partly creating plume-like textures in the upper sulfide layer and partly growing as dendrites from the upper contact downward into the sulfides. No tectonic evidence of structural formation of the pinch-out has been observed, and is precluded by the delicacy of the spinel textures. Numerous vesicles, usually rare in the Lunnon Basalt, are found in some of the hanging-wall basalt immediately adjacent to the Cr-rich spinel, suggesting that remelted basalt had floated to the top of the sulfide melt.

Representative samples were taken from the basal contact and from the upper contact in the pinch-out zone, and were imaged in 3D using a medical X-ray tomographic scanner at resolutions of about 200 µm. Chemical maps of polished surfaces were made at 40-µm resolution using the desktop Bruker Tornado™ system.

The widespread presence of Cr-rich spinel suggests it was growing from the sulfide melt close to contacts with molten basalt; we suggest that the Cr and Fe were derived from the sulfide melt, and oxygen from the basaltic melt. Analyses of textures from the contact of older basalt to younger sulfide melt in the Moran deposit, Kambalda, shows for the first time that the sulfide-hosting trough was accentuated by widespread melting of substrate basalt. Furthermore, in upper contacts of the pinch-out zone, the disposition of Cr-rich spinel and the nature of the contacts indicate a primary magmatic origin of pinch-out zones on the basal flanks of the Moran trough.