Petrochemistry of the Ntaka Hill Mafic-Ultramafic Intrusion and Implications for Ni-Cu Mineralization

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The Ntaka Hill mafic-ultramafic intrusion is located within the highly deformed Neoproterozoic granulite to upper-amphibolite facies Mozambique belt, in southeast Tanzania. Little is currently understood in regard to the origin, geochemistry, and petrogenesis of both the intrusion and its host Ni-Cu sulfides, and hence this study aimed to use whole-rock geochemistry and petrochemistry (in situ X-ray fluorescence (XRF) mapping) in an attempt to resolve these knowledge gaps.

We identified a number of cumulate (dunite, harzburgite, orthopyroxenite) and non-cumulate (metapyroxenite, melagabbro) lithologies within the intrusion. In the Sleeping Giant prospect, these rock types are encountered as a series of regularly repeating cyclic units consisting of (from base to top) dunite or olivine-rich harzburgite (±nickel sulfides), poikilitic harzburgite (olivine chadacrysts), poikilitic orthopyroxenite, granular orthopyroxenite (cumulates), and non--cumulate "metapyroxenite" whose primary texture has largely been overprinted by an intergrowth of hornblende and Mg-amphibole. At least 12 cycles were observed at Sleeping Giant, and not all cycles are complete.

The XRF mapping confirmed the presence of euhedral orthopyroxene oikocrysts containing anhedral resorbed olivine cores. This, together with macroscopic textures showing dunite dissolution within some pyroxenites, was likely caused by the silicification of the olivine-rich magma during contamination. In addition, XRF mapping identified both normal and reverse Cr-zoning patterns in the pyroxene oikocrysts. The reverse Cr step-zoning is relatively rare, and usually occurs within the more granular olivine orthopyroxenites.

Whole-rock geochemistry of the various lithologies in the intrusion demonstrate that the ultramafic magma had primary liquid compositions of 10 to 15% MgO, suggesting temperatures above that of ambient mantle, indicating a mantle plume source. Trace element plots confirm the ultramafic magma was primitive-mantle derived. More fractionated lithologies, i.e., the non-cumulate metapyroxenite, show high La/Sm, Zr/Ti and negative Nb-anomalies. These are likely due to contamination with the more enriched, sulfidic, arc-like country rocks and/or volcano-sedimentary rocks. The nickel sulfides are found predominantly in rocks with 15 to 25% MgO, suggesting that, although some may have formed early in the system, the majority either formed later or were suspended in the magma until the system evolved to lower MgO contents.

In summary, these observations suggest that the Ntaka ultramafic rocks were emplaced as olivine-chromite-bearing slurries within hot reactive country rock. Highly variable degrees of country rocks assimilation took place as the original sills began to inflate causing stoping and collapse of roof rocks. This en-masse contamination flooded the system with silica and sulfides from the country rocks, leading to sulfide saturation and a shift from olivine to orthopyroxene crystallization. This led to the formation of nickel sulfides and also the orthopyroxene oikocrysts. The high Cr of these orthopyroxenes may be due to resorption and dissolution of the initial chromite crystals. Reversely Cr zoned cumulates may have formed during periods of magma recharge, or during cumulate collapse events at the intrusion flanks, which transported grains back into more primitive magma. A similar process may have transported and upgraded the Ni-Cu sulfides. The final stage of the system involved mechanical mixing of varying components of various suspended crystal loads (and sulfides) due to collapse of deposited cumulate piles on the sill flanks.