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The petrology and petrogenesis of the Swaldale region, Motzfeldt Center, South Greenland

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Motzfeldt is one of several high-level alkaline plutonic centers that collectively define the mid-Proterozoic Gardar Province of South Greenland. Despite pyrochlore-hosted Ta-enrichment (± Nb-Zr-REE), the petrology, geochemistry and petrogenesis across the center remain to be fully constrained. We present petrological and geochemical data for the Swaldale region, an arcuate band of nepheline syenite and associated intrusives on Motzfeldt's NW margin. Work for this present study was undertaken in collaboration with the license holder, Regency Mines plc.

Swaldale comprises two geochemically distinct magmatic members. The largest, the Motzfeldt Sø Formation (MSF; EuN/Eu*N = 0.35), is a suite of diverse syenite variants that show significant petrological and geochemical heterogeneity. These rocks have a relatively restricted SiO_2 range (57.4-62.9 wt.%) with concurrent variation in (Na+K)/Al (0.75-0.95), Mg/(Mg+Fe) (2.18-19.82) and ΣREE (595.0-3095.9 ppm), emphasizing their evolved but not peralkaline nature. Fractionation is mirrored by pyroxene geochemistry with evolution from aegirine-augite, aegirine-hedenbergite, to aegirine. Accessory pyrochlore, titanite, and zircon are rare; however, anomalous facies of zircon-rich (∼2 wt.%) syenite are observed. Intercumulus fluorite is a common accessory within MSF rocks. Hydrothermal alteration, marked by hematized alkali-feldspar, is pervasive and ubiquitous. Further peraluminous syenite of the Geologfjeld Formation ((Na+K)/Al = 0.74; EuN/Eu*N = 1.60) marks the truncated remnant of an early syenite stock to the north of the MSF. These rocks contain salite, which, in addition to a lower ΣREE and higher Mg/(Mg+Fe) (18.01), demonstrates the less-fractionated nature of this stock in comparison with the MSF.

Sheeted intrusions of peralkaline syenite ((Na+K)/Al = 1.1; Ta = 32.4 ppm) truncate the MSF across central Swaldale. On a mineralogical basis, it is hypothesized that such intrusions reflect outward sheeting of the central Flinks Dal Formation, the last major expression of Motzfeldt magmatism. Further NE-SW dykes of the Igaliku Dyke Swarm and termed 'Big Feldspar Dykes' are present across the region.

The MSF has bulk-rock Ta, Nb, and Zr concentrations of 7.2-22.1 ppm, 156.9-402.7 ppm, and 563.0-13790.0 ppm, respectively. We interpret lesser enrichment in HFSE's over both central and NE Motzfeldt as consistent with the inferred enhancement of HFSE complex solubility in F-rich residual melts. Accordingly, the most evolved and enriched melts are expected towards the top of the Motzfeldt Center where concentrations exceeding 250 ppm Ta are observed (McCreath et al., 2013). This inference is additionally supported by observed changes to Nb/Ta ratios throughout the MSF whereby the solubility of Ta complexes in F-rich melt is greater than Nb.

Our data are consistent with a model whereby MSF melts of the Swaldale region are intermediaries between parental and the most evolved melts of the MSF. Our data supplement previous investigations to constrain fully the abundance and distribution of Motzfeldt Ta-Nb-Zr-REE-mineralization within the Gardar rift.

References:

McCreath, J.A., Finch, A.A., Herd, D.A., Armour-Brown, A., 2013, Geochemistry of pyrochlore minerals from the Motzfeldt Center, South Greenland: The mineralogy of a syenite hosted Ta, Nb deposit. American Mineralogist, v. 98, p. 426-438.