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Metasomatism and oxidation state of the lithospheric mantle beneath the Rae craton, Canada as revealed by xenoliths from Somerset Island and Pelly Bay

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The Rae craton lies to the east of the Slave craton, to which it was amalgamated at ∼1.9 Ga [1]. The Rae itself is composed of several lithospheric blocks suggesting a protracted geodynamic history. Current geophysical and geochemical data indicate vertical and lateral differences in the mantle root, attesting to this complex development [1,2]. Although the oxidation state of the mantle lithosphere is an important variable that controls the speciation of COHS fluids as well as determining if diamond is stable, no data are currently available. In addition, this parameter can be modified by processes such as partial melting and metasomatic interactions, thus providing further constraints on the geochemical evolution of domains at depth. The aims of this study were 1) to determine the oxidation state of the mantle lithosphere beneath the Rae craton and 2) to link these results with potential metasomatic overprints. We investigated peridotite xenoliths brought to the surface by kimberlite magmas at Somerset Island and Pelly Bay, which also allow us to compare the redox conditions in the central part of the craton (Pelly Bay) with those present at the craton margin (Somerset Island).

Samples from Somerset Island and Pelly Bay include spinel peridotites, garnet-spinel peridotites and garnet peridotites. At Somerset Island, spinel peridotites generally record temperatures (ol-sp) of ∼825-1050˚C, whereas the garnet-bearing samples yield temperatures (ol-gt) mostly >1000˚C (up to ∼1130˚C). Estimated pressures indicate a limited depth range from ∼100-150 km. LA-ICPMS analysis of garnet reveals two different rare earth element (REE) signatures: 1) “normal” signatures representing metasomatically enriched samples, and 2) sinusoidal signatures representing more depleted compositions. The spinel peridotites exhibit a larger range in $\Delta \log f\mathrm{O}_2$ (∼FMQ – FMQ-3.6) than the garnet-bearing peridotites (FMQ-0.5 – FMQ-1.3). At 100-115 km depth, it appears that there are domains with contrasting oxidation state and metasomatic overprint that may represent juxtaposed old and rejuvenated lithosphere [1]

The Pelly Bay suite is limited to 5 samples and all give temperatures <950˚C. The estimated depth range for these samples is from 80-130 km. REE signatures of garnet are either “normal” or indicate only partial melting without any significant metasomatic overprint. The later record $\log f\mathrm{O}_2$ values ∼0.5 log units lower than the enriched samples. The deeper samples with “normal” REE and more oxidised signatures could represent newer, juvenile lithospheric mantle. A spinel peridotite indicates strongly reducing conditions (∼FMQ-4.0) in the shallowest mantle lithosphere.

[1] Liu et al. (2016) Precamb Res, 272

[2] Snyder et al. (2015) Geochem Geophys Geosyt, doi:10.1002/2015GC005957