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Extreme High-field-strength Element Enrichment in Eclogite Xenoliths from the Jericho Kimberlite, Canada: The Geochemical Complement of Subduction Zone Magmatism

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One of the most enigmatic aspects of subduction zone magmatism is the origin of the depleted high-field-strength element (HFSE) geochemical signature; a hallmark that distinguishes subduction zone magmatism from other oceanic and continental mafic magmatism. There is considerable debate regarding the origin of this unique geochemical signature that hinges on the relative mobility of HFSE during slab dehydration and melting. Here we present geochemical results for a suite of zircon- and rutile-bearing eclogite xenoliths entrained in the Jericho kimberlite, Canada that represent the first known occurrence of mantle-derived material preserving extreme HFSE-enrichment. These xenoliths may provide a key to understanding the petrologic and geochemical nature of the source region for subduction zone magmatism (SZM). The 171.9+/-2.6 Myr Jericho kimberlite (JD-1) is a diamo-diferous pipe that intrudes c.2.6 Gyr and older Archaean granitoid rocks of the central Slave craton, Canada, approximately 400 km north of Yellowknife. Paleoproterozoic (>1.7 Ga) mantle xenoliths up to 30 centimeters in diameter are abundant at Jericho and include eclogite (c.25%), coarse peridotite, porphyroclastic peridotite, megacrystalline pyroxenite, ilmenite-garnet wehrlite and a small proportion of zircon- (2-3%), kyanite- and diamond-bearing eclogite. The eclogite xenoliths investigated in this study are coarse-grained granular varieties that typically contain eclogitic Cr-poor garnet, extensively altered omphacitic (4-8% Na_2O) clinopyroxene with inclusions of amphibole ±barite, and variable amounts of apatite, Ti-phlogopite, high niobian rutile (up to 7 wt% Nb_2O_5), zircon, with traces of carbonate. One of the xenoliths investigated here has the distinctive elevated Na_2O and low-TiO_2 garnet composition typical of eclogitic garnet inclusions in diamond from elsewhere indicating that at least some of the zircon and/or rutile-bearing eclogite xenoliths resided and perhaps originated within the diamond stability field. The most spectacular aspect of the eclogite whole rock geochemistry is the large positive Nb and Zr (plus Hf) anomalies. The high Nb (133-1134 ppm), Ta (5-28 ppm), Zr (1779-4934ppm) and Hf (23-64 ppm) contents are not only extremely enriched for eclogite (2-10 times) but represent some of the most HFSE-enriched mantle-derived material known. We envisage a three-stage evolution for the generation of these unusual eclogite xenoliths prior to final entrainment in the Jericho kimberlite: 1) initial devolatilization of Paleoproterozoic oceanic crust during east-dipping subduction beneath the Slave Craton, possibly including a minor component of high-alumina komatiite; 2) partial melting of this oceanic crust to produce an eclogitic residue with low-SiO_2 and high-MgO contents, and 3) HFSE- and possibly further MgO-enrichment of this residue during H_2O-mediated fluid metasomatism with concomitant growth of rutile, phlogopite and zircon (±apatite, calcite). Such HFSE-enriched residual material provides a perfect geochemical complement to SZM and we conclude that material similar to the Jericho eclogite xenoliths may represent one possible source for generating the HFSE- and Y-depleted nature of some SZM.