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Komatiite signature in cratonic mantle websterite from Norway and Siberia

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Garnet-(olivine-)websterite from sub-continental lithospheric mantle (SCLM) occasionally preserves mineral exsolution textures in garnet after Si- and Ti-rich HT precursors (Spengler et al., 2009; Alifirova et al., 2012). We investigated the whole-rock chemistry of six specimens (measured) from orogenic peridotite bodies in western Norway (Ugelvik, Raudhaugene, Midsundvatnet), believed to represent SCLM of the East Greenland craton, and of twelve mantle xenoliths (calculated) from Yakutian kimberlites (Obnazhennaya, Udachnaya, Mir) that penetrated the Siberian craton. The sample set includes olivine-bearing and olivine-absent websterite at each cratonic area and each sample has garnet with exsolution textures.

Magnesia contents are high, 22.7-29.0 wt% (Norway), 15.6-33.1 wt% (Siberia). MgO/SiO_2 versus SiO_2 forms a narrow array apart from mixing lines between dunite and basaltic liquids or products formed by silica-rich fluids, but overlaps the compositional range of komatiite flows from Commondale and Barberton mountain land, South Africa, including spinifex, massive and cumulate subtypes of komatiite (Wilson, 2003; Thompson Stiegler et al., 2010; Robin-Popieul et al., 2012). $Al2O_3/TiO_2$ varies 17-175 and is excepting four samples greater 25 as typical for Al-enriched komatiite (AEK). The oxide ratio range is small for garnet-olivine-websterite (17-35), but large for garnet-websterite (21-175), including extreme values. This duality is repeated in the REE chemistry of the Norwegian samples: garnet-olivine-websterite has moderately fractionated GdN/YbN, 0.73-0.85, garnet-websterite shows extremer values, 0.49-0.65. South African AEK flows also form moderately and extremely fractionated subgroups with GdN/YbN 0.76-0.90 ($Al2O_3/TiO_2$ 25-40, Barberton) and 0.26-0.55 (58-106, Barberton and Commondale), respectively. Each subgroup of AEK and websterite is virtually indistinguishable from one another in REE fractionation and also concentration. Siberian websterite differs with GdN/YbN 0.72-2.14 and up to one magnitude higher REE concentration, consistent with a metasomatic re-enrichment overprinting primary REE signatures (Howarth et al., 2014). The websterite suite has high Cr/Ti (0.6-20.8) at high Cr content (>700 ppm) that overlap those of AEK (0.2-12.9 and >400 ppm), but clearly differ to those of basaltic liquids (<0.13 and <250 ppm; Taylor and Nesbitt, 1998; Ishizuka et al., 2006). Furthermore, websterite Cr and Ti contents mismatch mixing trends of basalt with peridotite. $CaO/Al2O_3$ of websterite, 0.5-2.6, almost resembles that of AEK, 0.04-2.8, whereas experimental batch melts of KR4003 deviate with 0.7-2.1 at much lower $Al2O_3/TiO_2$ of 4-27 (Walter, 1998). Low Zr/Y of 0.1-1.0 (Norway) and 0.4-0.9 (Southern Africa extreme AEK) indicates garnet bearing depleted source regions. Variable Zr/Y of 0.9-4.5 (Siberia) may be due to metasomatism. Although, most of the latter samples share Zr/Hf of the former, 14-28, that may hint on the metasomatic source.

Chemical similarity between websterite and AEK suggests the former to represent the plutonic equivalent of the latter. We therefore interpret websterite to have originated from melts formed by melting of a garnet-bearing depleted mantle. The exsolution texture in the inferred solidus garnet requires websterite to have crystallised in majoritic- and Ti-garnet stability fields, which confirms a thermal anomaly of the order of 1600 °C (Gasparik, 2014). It follows that mantle plume environments contributed to the formation of the oldest SCLM underneath the Greenland and Siberian cratons.