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Diamond-bearing root beneath the southern territories of Arkhangelsk region (European part of Russia): Evidence from Cr-Pyrope geochemistry

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In this study, we present the major- and trace-element composition for 145 Cr-pyrope grains, recovered from heavy mineral concentrate from samples collected from modern river and stream sediments in the south of Arkhangelsk region, for evaluation the composition of lithospheric mantle and its suitable for formation and preservation of diamonds. This region is of particular interest due to their location within the ancient Karelian craton, the presence of significant amount of Kimberlite Indicator Minerals (KIMs, Shchukina and Shchukin, 2018) and the lack of any known nearby magmatic bodies, including kimberlites. Based on CaO-$Cr2O_3$ content (Sobolev et al., 1973), pyropes are presented by lherzolitic (95 %) and harzburgitic (5 %) varieties. Based on chondrite-normalized rare-earth element patterns (REEn) and Y-Zr contents, pyropes can be classified in five principle groups. (I, Lz1, 32%) - depleted pyropes of lherzolitic type with low concentrations of $Cr2O_3$ (0.7 – 3.5 wt.%) – are enriched in heavy REE (HREE) up to 60 - 90 × chondritic in Yb, and show progressive decrease from HREE to light REE (LREE) with fractionated middle REE (MREE)-HREE patterns (Ybn/Smn > 4). These pyropes have residual nature with no signs of metasomatic influence. (II, Lz2, 36%) – lherzolitic pyropes with flat HREE-MREE patterns (Ybn/Smn = 1-4; Ybn = 5-40 × chondritic) and low-to-moderate $Cr2O_3$ content (0.6-5.6 wt.%). These garnets are in equilibrium with clinopyroxenes in peridotites and re-equilibrated by silicate melt. (III, Lz3, 9%) – lherzolitic pyropes with humped REE profiles – show progressive increase from LREE to MREE with a top in Sm-Eu (9-49 × chondritic) and decrease from MREE to HREE (Ybn = 4-24 × chondritic). Lz3 pyropes have a wide range of $Cr2O_3$ content (1-9 wt.%). These garnets were formed under the influence of silicate melt with high Zr/Y ratio. (IV, Lz4 and Hz, 22 %) – lherzolitic and harzburgitic pyropes with sinusoidal REE patterns (Smn/Ern >1) – are predominantly high-$Cr2O_3$ (5-12 wt.%) pyropes with portion of low-to-moderate-$Cr2O_3$ (1-4 wt.%) varieties. These pyropes were formed under the influence of carbonatite metasomatism. (IV, Lz5, 1%) – exsolved pyropes of lherzolitic type – have low $Cr2O_3$ content (2.7 wt. %) and low REE concentrations in the range of 0.05-3 × chondritic. These pyropes were exsolved from high temperature orthopyroxene upon cooling. The presence and ratio of pyropes of different geochemical groups evidence that the lithospheric mantle beneath the southern area of the Arkhangelsk region is similar to that beneath the main diamondiferous kimberlite regions worldwide, and is also suitable for formation and preservation of diamonds. The high percentage of diamond-associated pyropes, i.e. with humped and sinusoidal REE profiles (Lz3, Lz4 and Hz), emphasizes the likelihood that diamond-bearing kimberlites are located within this area. This work was supported by the Russian Science Foundation under Grant No. 17-77-10008.

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