Geochemical features of high-Mg alkaline rocks and their correlation with geological evolution and structure of the lithosphere (Baltic Shield, Russia)

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The composition of within-plate igneous rocks is indicative of the composition and chemical evolution of their mantle sources. Three occurrences of within-plate anorogenic magmatism exposed in various tectonic blocks of the Baltic Shield have been studied: (1) Arkhangelsk diamondiferous province (Kola craton); (2) Kostomuksha lamproite dyke swarm (Karelian craton); and (3) lamprophyre dykes and plugs in the NW Ladoga area (Svecofennian block) (Fig. 1).

(1) The Arkhangelsk diamondiferous province is located within the Kola craton, at the SE extension of the AR_3 granulite-gneiss complexes of the Kola Peninsula covered by the V-PZ sedimentary rocks of the East European Platform. Dozens of D_3 pipes and sills are composed of kimberlites, melilitites and basalts. Two geochemically distinct groups of ultrabasic rocks can be distinguished and indicate of mantle heterogeneity (Parsadanyan *et al.*, 1996; Makhotkin *et al.*, 1995).

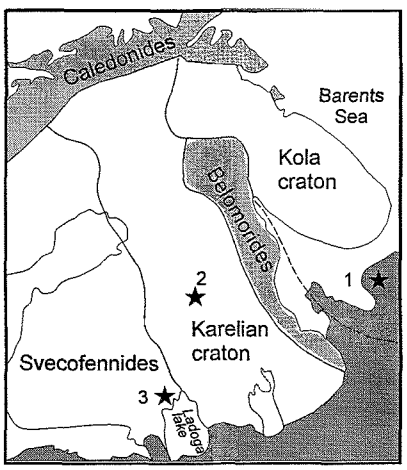

FIG. 1. Localities: (1) Arkhangelsk province, (2) Kostomuksha, (3) NW Ladoga.

The first group comprises diamond-poor and diamond-free kimberlites and *Ol*-melilitites of the Kepina field, which are similar in geochemistry to the South Africa group I kimberlites and *Ol*-melilitites, respectively (Fig. 2). The isotope and geochemical signatures of the Arkhangelsk group I rocks indicate of magma formation from isotopically primitive lower mantle material (BSE) ascended to the upper mantle by plume and enriched in HFSE and *LREE* shortly before the magma generation.

The second group includes diamond-rich kimberlites of the Zolotitsa field, diamond-free *Ol*-melilitites of the Izhmozero field, and *Ol-Cpx*-melilitites of the Onega Peninsula. The Zolotitsa kimberlites are similar in major- and trace-element chemistry to the South African group II kimberlites. The major- and trace-element features of *Ol*-melilitites indicate that they have been formed from the own magma and are not related to differentiation of kimberlite melt. The Arkhangelsk group II kimberlites and *Ol*-melilitites have isotope and geochemical signatures of the enriched mantle EMI with $(T(Nd)_{DM} = 2.0 \pm 0.2$ Ga) (Fig. 3).

(2) The dykes of diamond-bearing *Ol*-lamproites are exposed near Kostomuksha within the Karelian craton and are dated at 1230 Ma (Belyatsky *et al.*, 1997). The *Ol*-lamproites have high MgO (up to 25 wt.%), TiO_2 (2–3 wt.%), K_2O (2–6 wt.%) with K_2O/Na_2O ratio from 5 to 40. Their trace-element patterns are close to that of Western Australian *Ol*-lamproites. However, in contrast to the Western Australian lamproites, they have clear Nd-Sr isotope features of EMI mantle and an older age of source formation ($T(Nd)_{DM}$ = 2.0–2.2 Ga).

(3) The dykes and plugs of calc-alkaline lamprophyres of the NW Ladoga area are located within the Svecofennian block and represented by a

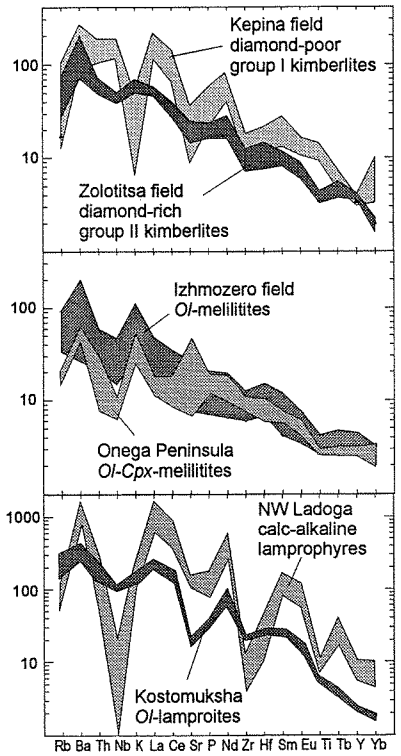

FIG. 2. Trace-elements patterns in rocks normalized to primitive mantle.

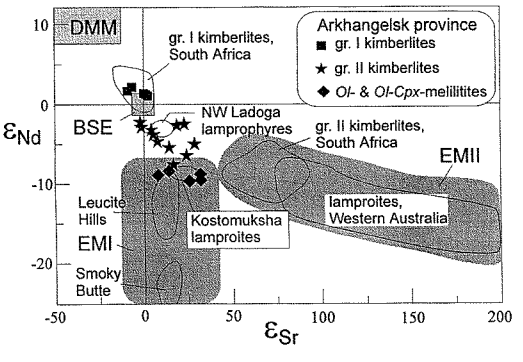

FIG. 3. Isotope composition alkaline rocks of the NW part of Russia.

series from minettes to kersantites with ages ranging of 1700–1600 Ma. Having high Al_2O_3 (12-17 wt.%), total alkalis (5.5–10.5 wt.%) with K_2O/Na_2O 0.4–2.7, and moderate MgO (2.6–8 wt.%) with *mg* = 39–60, they are classified with typical lamprophyres. All rocks are strongly enriched in LILE (particularly in Ba and Sr) and *LREE* and depleted in Ni and Cr (either < 100 ppm), Nb, Ta, and U. Their Nd-Sr isotope composition show that they have originated from the EMI-type source. Relatively high negative åNd values indicate of a small gap between the source enrichment $(T(Nd)_{DM}$ = 2 Ga) and lamprophyre emplacement.

Discussion

All rocks studied have comparable isotope and trace-element features indicative of their generation from the enriched in LILE and *LREE* EMI sources. The normalized trace-element patterns similar to that of island-arc volcanics (positive LILE- and negative HFSE-peaks). Apparently, the EMI reservoir have been generated by ancient (PR_1) metasomatism of subcratonic lithosphere blocks coeval with the new crust formation. These processes were associated with subduction of the Belomorian and Svecofennian palaeooceanic plates under the Kola and Karelian cratons, respectively. The relation of the rock location and their source composition to the PR_1 subduction event is most distinct in the Arkhangelsk province, where there is a regular lateral variation in composition of group II ultrabasites. The following northward sequence of igneous rocks can be revealed: *Ol-Cpx* melilitites of the Onega Peninsula, *Ol*-melilitites of the Izhmozero field, kimberlites of the Zolotitsa field. According to experimental data (Mengel and Green, 1989; Foley, 1994; Yamashita *et al.*, 1995), the *Ol*-melilitites could be derived from *Hbl*-bearing lherzolite of the lithosphere wedge at depths > 120 km, while the kimberlites could originate below 150 km at the base of the lithosphere from *Phl* (±K-*Rht*) lherzolites or hurzburgites. The Early Proterozoic metasomatism of the subcratonic lithosphere of the Kola-Arkhangelsk region was induced by the northeastward subduction of the Belomorian palaeooceanic plate.

Composition of lamproites, richer in K and Mg and poorer in Ca, as compared to the Arkhangelsk group II kimberlites, allow us to suggest that the lithosphere mantle of the Karelian craton was depleted stronger in 'basaltic' components than the Kola-Arkhangelsk subcratonic lithosphere.

Geochemical features of the NW Ladoga lamprophyres show that the enrichment of their sources, like the sources of the Arkhangelsk group II rocks and Kostomuksha *Ol*-lamproites are related to subduction. The occurrence of lamprophyres within the Svecofennian block indicates of relics of Archaean lithosphere under the NW Ladoga area.