ISOTOPIC AND GEOCHEMICAL COMPOSITION OF THE KOMATIITES SOURCES: IMPLICATIONS FOR ARCHAEAN MANTLE PLUME EVOLUTION OF THE BALTIC SHIELD

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Many aspects of crust formation and evolution of the crust-mantle system of the Baltic Shield through Archaean and Proterozoic times are relatively well known (Huchma, 1986; Timmerman & Dely, 1995; Gaal & Gorbatschev, 1987; Lobatch-Zshuchenco, 1993; Dely et al., 1993). At the same time many problems of composition and evolution of the mantle remain a subject of discussion. In fact our knowledge of the Archaean and Proterozoic mantle is in many ways no better than is our knowledge of Venus and Mars.

In order to understand the geochemical and isotopic evolution of the Archaean upper mantle of the Baltic Shield, geochemistry of incompatible and rare earth elements, oxygen isotopic composition, Sm–Nd and Rb–Sr systematics of komatiites (PK) from 11 greenstone belts of the Kola peninsula, Karelia and E Finland have been studied. From our data we conclude that:

— based on the U–Pb zircon and Sm–Nd isochron whole-rock age, the greenstone belts could be subdivided into three groups: i) 3.05–2.9 Ga; ii) 2.9–2.8 Ga; iii) 2.8–2.7 Ga;

— PK with $\varepsilon_{Nd}(T)$ from +3.7 to +2.6 represent the greenstone belts of the assumed age group 2.8–2.9 Ga; their mantle source has overall REE content (particularly HREE) 0.4–2.0 x chondrite; the fact that 7 data points form a good linear array with MSWD = 3.6 favours the hypothesis that PK from the Kola peninsula (Polmos–Poros and Ura–Guba belts), North (Hizovaara belt) and West Karelia (Kostomuksha belt) originated in a time span of 2.79 ± 0.31 Ga and that the isotopic characteristics of their respective mantle sources were similar (ε_{Nd} = +3.4); the T_{DM} model age of 2.79 ± 0.31 Ga is equal within errors to the Sm–Nd whole-rock isochron age of 3.15 ± 0.15 Ga of PK + TH from the Ura-Guba belt and 2.81 ± 0.6 Ga from the Kostomuksha belt and U–Pb isochron zircon ages, which are thought to represent the time of volcanism in this greenstone belt; it must be noted that these samples are depleted in LREE to different degrees, but have similar (flat) HREE distribution patterns; if such LREE heterogeneity is not reflected by ε_{Nd} values of the rocks, it could mean that LREE depletion occurred not long before the magma generation;

— two samples from Hautavaara and Palaj–Lamba belts have considerably lower ε_{Nd} values (+1.7 and +1.3, respectively); in the light of Zr, Ti and Y concentrations it can be assumed that mantle reservoir with which this PK reequilibrated, was “enriched”;

— the most depleted ε_{Nd} values (+4.2 to +4.9) were observed in PK from the Kamennoozero (E. Karelia) and Sovdozero (C. Karelia) belts; such high ε_{Nd} value might be explained by depletion of the mantle source by removal of significant masses of the continental crust, represented by adjacent gneisses of Vodlozero region with U–Pb zircon age of 3.14 ± 0.03 Ga and Sm–Nd model age > 3.3 Ga (ε_{Nd} = -2 to +1) and gneisses from conglomerate pebbles of Oster belt with T_{DM} model age > 3.2 Ga; in this case, it might be expected that in the other parts of the Baltic Shield a smaller volume of continental material had been extracted from the mantle before 2.9 Ga.

We assume that all these features could be best explained in the context of mantle plume evolution.

Early stage (3.05–2.90 Ga) — the melting of a mixture of heated surroundings (moderate DM) and cooled source material (undepleted) in the head of the mantle plume produced the PK of Eastern and Central Karelia, characterized by high Al_2O_3 = 6–10 %, moderately low FeO = 6–13 %, low TiO_2/Zr and Y/Zr ratios, slightly depleted $(Ce/Sm)_N$ = 0.66–0.73, “normal” overall HRRE = 2.0–3.0 x chond. and with high ε_{Nd} +4.2.

Middle stage (2.9–2.8 Ga) of the mantle plume lateral spreading produces the PK of Kola and N Karelia with high MgO = 36–28 %, FeO = 10–20 %, chondritic Y/Zr ratios, flat REE patterns $(Ce/Sm)_N$ = 0.92–1.09, “chondritic” overall HREE content (0.3–2.1 x chondrite), moderate high ε_{Nd} = +2.6 to +3.7, and moderate to low $^{87}Sr/^{86}Sr$ = 0.704–0.701. These PK were probably derived from the nearly chondritic source in the hot axial zone.

Late stage (2.8 - 2.7 Ga) - the melting of a heated high DM surroundings in a tilted plume head produced the E Finland PK: $(Ce/Sm)_N$ = 0.27–0.57; overall HREE = 3.3–5.0 x chondrite; low TiO_2/Zr and Y/Zr ratios.