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Flood-basalt magmatism of the Vodlozero Block of the Karelian Craton: relations between high- and low-Cr Varieties

Maria Bogina (1), Valeriy Zlobin (2), Evgenii Sharkov (1), and Alexii Chistyakov (1)

(1) Institute of Geology of Ore Deposits, Petrography, Mineralogy, and Geochemistry of RAS, Moscow, Russian Federation (bogina@igem.ru), (2) Geological Institute of RAS, Moscow, Russian Federation

The early Paleoproterozoic (2.5-2.3 Ga) volcanic rocks of the Karelian Craton are ascribed to the large igneous province of the eastern Fennoscandian Shield. They are mainly represented by calc-alkaline low-Ti basalts and basaltic andesites with relatively high SiO_2 and clearly pronounced continental trace element signatures. The compositions of the rocks vary in the different domains of the Karelian craton. In particular, basalts developed in the Central Domain are represented by strongly fractionated varieties (Mg # < 50), which cannot be used to decipher the source composition. Basaltic rocks of the Vodlozero Block are clustered in two groups. The first group is usually developed in the lower parts of the early Paleopoterozoic volcanic sequences and includes the low Cr (< 200 ppm), low Mg rocks similar to the fractionated varieties developed in the Central Domain. They are characterized by high contents of Zr, Y, and REE, and LILE, fractionated REE patterns with (La/Yb)n = 5.44-12.34, (La/Sm)n = 4.4-2.03, and (Gd/Yb)n = 1.36-2.71), and demonstrate negative Ti and Nb anomalies. The second group is represented by more primitive high Cr (up to 1000 ppm) high Mg# (up to 68) basalts with high Ni contents. Such composition is close to the primary non-fractionated mantle-derived magmas and may be used to provide insight into parental melts of continental flood basalts and their crustal evolution. In the spidergrams they demonstrate weak positive Ti anomaly at positive or absent Zr anomaly and negative Nb anomaly. The rocks of the second group are also characterized (with rare exception) by LREE enriched but less fractionated patterns than the first group: ((La/Yb)n up to 7.5, (La/Sm)n = up to 2.8, (Gd/Yb)n = up to 2.0).

High Cr and low Y contents are indicative of relatively high degree of partial melting of a depleted mantle source. These rocks are simulated by sequential fractionation of uncontaminated continental flood basalts leaving Ol residue and lower crustal contamination (rocks with low values of eNd). The percentage of crustal contamination is controlled by Nb/Th ratio. Examination of Nd isotope data revealed that both these types have negative eNd, but high-Cr rocks have slightly more radiogenic Nd isotope composition. A high positive correlation of eNd with Cr and Mg# in combination with similar trace element signatures of these rocks indicates that the rocks were derived from a single magmatic system: low-Cr basalts were derived from high-Cr basalts via fractionation and insignificant upper crustal contamination. A considerable decrease of Cr and Ni with decrease of Mg#, at practically unchangeable $Al2O_3$, TiO_2, CaO, and Na2O suggests that the process was controlled by fractional crystallization of olivine and Cr-spinel. Absence of distinctive increase in V (and Zn) coupled with $Fe2O_3$* behavior points to the insignificant role of Fe-Ti oxide in their evolution. Some part of high-Cr basalts presumably reached surface without significant retention in the crust for fractionation, while others formed a new magma chamber, where it experienced insignificant contamination and fractional crystallization.

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