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Geochemistry and Geochronology of the Early Paleoproterozoic Volcanism of the Karelian Craton: Petrogenetic and Geodynamic Implications

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The Early Paleoproterozoic time is characterized worldwide by large-scale magmatic, especially volcanic activity, which was related to the onset of global rifting at the Archean-Proterozoic boundary. At the Karelian craton, its volcanic products compose giant nearly submeridional belts several hundreds kilometer long. The Early Paleoproterozoic volcanosedimentary sequences (2-3 km thick) from the bottom upward are made up of coarse-grade mature sediments, predominant pillow-textured and massive lavas, tuffs, and tuffobreccia of basaltic andesites and andesites, which through felsic tuffs grade into quartz porphyries. Two types of basaltic andesites are distinguished. The Type I show MORB-like flat to slightly LREE-depleted or insignificantly LREE-enriched patterns with $(La/Sm)_N$ = 0.7-1.5, and $(La/Yb)_N$ = 0.35-1.3, and minor negative or absent Eu, Nb, and Ti anomalies. The type II rocks show LREE enrichment relative to HREE, $(La/Sm)_N$ = 1.5-3.84 and $(La/Yb)_N$=6.5-11.67, with minor negative to non-existent Eu anomalies (Eu/Eu) = 0.99-1.15, prominent negative Nb and Sr anomalies, and subtle Ti anomaly. Trace element patterns show that the rocks are enriched in LILE relative to HFSE and in LREE relative to HREE. Negative Nb and Ti anomalies could be inherited from a previous subduction event or result from crustal contamination. Nb-Ta-Th systematics can serve in support of the former interpretation, indicating that the rocks exibit "island arc" affinity with low to moderate $(Nb/La)_N$ ratio and extremely low $(Nb/Th)_N$ ratio. HREE patterns are weakly fractionated, and show no significant depletion, indicating that garnet was absent from the source rocks during generation of the primary magma. The relatively low Ni and Cr contents suggest that the rocks undergone significant fractional crystallization from mantle-derived melts. The upper age limit of the mafic rocks is constrained by the U-Pb SHIRMP zircon age of cross-cutting felsic dike at 2416 $\pm$ 16 Ma, and their lower age is limited by the minimal zircon age from underlaying quartzites of 2726$\pm$6.8 Ma. Sm-Nd model age of basaltic andesites account for $\sim$ 2.8 Ga, which in combination with ϵNd from -1.5 to -3 suggests some contamination by crustal material. Rhyolites are represented by high-K subalkaline rocks with high Ba, Rb, Zr contents and LREE-enriched pattern, which is typical of within-plate rocks and similar in shape to that of type II rocks. In petrotectonic diagrams, they demonstrate a dual nature, plotting in the fields of within-plate and island-arc rocks. Their seeming "island arc" affinity is emphasized by negative Nb-Ti anomalies. U-Pb TIMS zircon dating on rhyolites yielded concordant age of 2434 $\pm$ Ma, which within the error is close to the upper age limit of basaltic andesites. In addition, they are similar to basaltic andesites of Type II in trace element and REE pattern shape, but are characterized by higher LILE and LREE contents, and have close ϵNd (about -3). Thus, based on close ages, isotopic-geochemical, and geochemical characteristics, the studied rocks are genetically related and can be combined into a common bimodal series. They were presumably originated via differentiation from MORB-like to subduction-influenced (reworked during previous subduction events) mantle sources and, possibly, experienced variable crustal contamination en route to the surface. In terms of geochemistry, similar rock associations (including siliceous high-magnesian basalts and rhyolites) are widespread at the Archean-Paleoproteorozoic boundary around the world. In particular, the bimodal basalt-rhyolite series of the same age and similar geochemistry were identified at the base of Huronian group in Canada, in the Woongarra Volcanics Formation in Hamersley Basin, Australia, where they also mark the extensional setting. The work was supported by the Russian Foundation for Basic Research, project nos. 07-05-00496, 08-05-00350.