Samsonov A.V., Stepanova A.V., Salnikova E.B., Larionova Yu.O., Egorova S.V., Larionov A.N., 2016. Mafic Dyke Records of Paleoproterozoic Mantle Plume Activity in the Karelian Craton: U-Pb Baddeleyite/Zircon Geochronology and Sr-Nd Isotopic Data. *Acta Geologica Sinica* (English Edition), 90(supp. 1): 118-119.

Mafic Dyke Records of Paleoproterozoic Mantle Plume Activity in the Karelian Craton: U-Pb Baddeleyite/Zircon Geochronology and Sr-Nd Isotopic Data

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Mafic dykes preserved important information on mantle melting regimes in the early Earth history. Despite the fact that a large volume of geochronological data for mafic dykes was recently received, several important issues remain unresolved. How prolonged each pulse was? Do variations in the deep of melting occur within single event? What were the melting triggers and did early Earth geodynamics style differ from Phanerozoic? New age, Sr-Nd isotopic, and geochemical data for the mafic dykes in the Karelian Craton, Eastern Fennoscandian Shield give answers to some of these questions.

The Karelian Craton is a large fragment of Archean continental lithosphere that preserve a lot of mafic dykes of age 2.50-1.96 Ga (Vuollo and Huhma, 2005; Stepanova et al, 2014, 2015). U-Pb dating results for baddeleyite (ID TIMS) and zircon (SIMS) from mafic dykes and sills in the Karelian Craton (Russia) allow us to recognize several discrete magmatic events of ages 2.50, 2.45, 2.41, 2.31, 2.21, 2.13, and 1.98-1.96 Ga separated by ca. 50-150 Ma amagmatic periods. The duration of recognized events did not exceed 10-20 Ma, and fit into the age measurement errors (± 1 rel.%) that is comparable with fast-erupted Phanerozoic LIPs. The recognized events have distinct isotopic and geochemical features.

The 2.45 Ga mafic magmatic rocks show a wide variation in trace element and Sr-Nd isotopic composition. Intensively contaminated high-Mg low-Ti rocks that volumetrically prevail, probably originated via high-degrees of deep-seated melting of mantle source. Low-Mg low-Ti mafic rocks probably reflect a fractional crystallization of the high-Mg melts. The third component of the 2.45 Ga event is represented by high-Ti low-Mg dolerites with low degrees of crustal contamination that probably originated via relatively low degrees of mantle melting at shallow depths. The obtained data suggests that 2.45 Ga mafic magmatic rocks were originated via simultaneously melting of mantle at various degrees and different depths. Such characteristics are similar with Phanerozoic LIPs related with mantle plume arise.

For the 2.41 and 2.31 Ga magmatic events in the Karelian Craton only low-Mg dolerites with moderate amount of Fe and Ti have been studied. We suggesst that these rocks represent strongly evolved residual liquids of primary high-Mg plume-derived melts that have not been found yet.

The 2.13 Ga event includes high-Ti enriched and MORB-type tholeiitic dykes which are widespread on the Karelian Craton, show strong similarity with Phanerozoic syn-breakup basalts of Afar and NAIP (Barrat et al, 2003; Waight and Baker, 2012) in trace-element geochemistry and Nd isotopic compisition, and probably indicate a stage of continental breakup of Archean lithosphere.

The 1.96-1.98 Ga event is partly similar to 2.45 Ga. It consists of small amount of high-Mg rocks (Puchtel et al, 1998)and volumetrically prevail low-Mg, high-Fe-Ti mafic rocks with PGE mineralization.

The results of our investigation of the mafic dykes in the Karelian Craton indicate a strong similarity of Paleoproterozoic and Phanerozoic LIPs in terms of melts composition, variations in degree and depths of mantle melting, and events duration. Considerable differences in volume of high-Mg melts, and extent of crustal melting related recognized for the ca. 2.45 Ga event could be caused both deep erosion of Archean crustal complexes, and relatively low lithosphere thickness of the Karelian Craton in the beginning of the Early Paleoproterozoic.

Research is supported by Russian Science Foundation, grant № 16-17-10260.

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