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The early Paleoproterozoic within-plate boninite-like magmatism: evidence from the Baltic large igneous province, Fennoscandian Shield

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Boninites are typical subduction-related rocks in the Phanerozoic. However, in the Paleoproterozoic they were evolved in within-plate settings, forming large igneous provinces. An example of such province is the early Paleoproterozoic (2.5-2.35 Ga ago) Baltic large igneous province (BLIP) of the siliceous high-Mg (boninite-like) series (SHMS) which located in the eastern Fennoscandian Shield and has about 1000000 km2 in area. It is formed by volcanic sequences (from low-Ti picrites and Mg-basalts via andesites to dacites and rhyolites) in riftogenic structures within Archean Kola and Karelian cratons, dyke swarms and big mafic-ultramafic layered intrusions. Numerous small synkinematic mafic-ultramafic intrusions (Drusite Complex) disseminated within the Belomorian Mobile Belt (BMB), which was a zone of gently tectonic flowage. All of these suggests an existence of a superplume beneath the region, which was drastically differ in composition from the Phanerozoic LIPs.

Boninite-like rocks on their petrography, mineralogy and geochemistry are rather close to the Phanerozoic boninites. For them are typical presence of Mg-olivine, low- and high-Ca pyroxenes, and high-Cr spinel. Moreover, volcanic glass, which form part of extremely fresh lavas (2.41 Ga age) in the Vetreny Belt riftogenic structure, has composition from andesite to dacite (Sharkov et al., 2004). The main difference is an isotopic composition: instead of εNd value from +6 to +8, the Paleoproterozoic SHMS has εNd value -1 to -3, which is presumed contamination of mantle-derived melts by Archean crustal material.

So, the major difference of the BLIP from the Phanerozoic LIPs is a composition of the magmatic melts, which were rather close to subduction-related magmas on their geochemistry, but were generated in the within-plate environment. It suggests that origin of the SHMS magmas was linked with melting of high-depleted mantle and large-scale assimilation of lower crustal material during ascending of the primary mantle-derived high-temperature magmas to the surface.

Detailed studying of the big layered intrusions showed that they are presented transitional magmatic chambers where accumulated portions of fresh magmas, periodically arrived from below. Processes of crystallizing differentiation and mixing of fresh and evolved magmas into solidified chambers occurred here. From here such magmas were arrived to the surface, forming volcanic plateaus. These magmatic systems had been situated above protuberances (local plumes) on the superplume surface, where melting processes occurred as a result of adiabatic decompression.

So, the magmatic systems of the BLIP were characterized by four major levels of activity: (1) the upper part of local plumes where main body of primary mantle-derived melt was generated; (2) the lower crust where mantle-derived melts were contaminated by crustal material and were transformed into the SHMS magmas, (3) the upper crust where transitional magmatic chambers (survived as large layered intrusions), and (4) volcanic plateaus on the surface and subvolcanic sills beneath them.

Origin of the disseminated intrusive magmatism in the BMB obviously was linked with impregnation of the SHMS magmas into a mobile surroundings. As a result, they could not accumulated into a single chamber and each portion solidified independently.

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