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The reason for a Daly gap in magmatic series of large igneous provinces: geological and petrological evidences

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One of the most important problems of magmatic petrology over the past century is a «Daly Gap» [Daly, 1914]. It describes the lack of intermediate compositions (i.e. andesite, trachyandesite) in volcanic provinces like ocean islands, LIPs, & arcs, giving rise to "bimodal" basalt-rhyolite, basalt-trachyte or basanite-phonolite suites (Menzies, 2016). At the same time, the origin of the bimodal distribution still remains unclear. Among models proposed to explain the origin of the bimodal series are liquid immiscibility (Charlier et al 2011), physico-chemical specifics of melts (Mungal, Martin,1995), high water content in a primary melt (Melekhova et al., 2012), influence of latent heat production (Nelson et al., 2011), appearance of differentiated transitional chambers with hawaiites below and trachytes on top (Ferla et al., 2006), etc. In this case, the bimodal series are characterized by similar geochemical and isotopic-geochemical features of mafic and sialic members. At the same time, some bimodal series are produced by melting of sialic crust over basaltic chambers (Philpottas and Ague, 2009). This results in the essentially different isotopic characteristics of mafic and sialic members, as exemplified by the bimodal rapakivi granites-anorthosite complexes (Ramo, 1991; Sharkov, 2010). In addition, the bimodal basalt-trachyte series are widely spread in oceanic islands where sialic crust is absent.

Thus, it is generally accepted that two contrasting melts were formed in magma chambers beneath volcanoes. Such chambers survived as intrusions and are available for geological study and deciphering their role in the formation of the bimodal magmatic series.

We discuss this problem by the example of alkali Fe-Ti basalts and trachytes usually developed in LIPs. Transitional magmatic chambers of such series are represented by bimodal syenite-gabbro intrusions, in particular, by the Elet'ozero intrusion (2086±30 Ma) in Northern Karelia (Russia). The intrusion intruded Archean granite-gneisses and, like syenite-gabbro intrusive complexes everywhere, was formed in two intrusive phases. The first phase is represented by mafic-ultramafic layered intrusion derived from alkali Fe-Ti basalt. The second phase is made up of alkali syenites, which are close in composition to alkali trachyte. At the same time, syenite and gabbro have close εNd(2080) (2.99 and 3.09, respectively). So, we faced the intrusive version of alkali basalt-trachyte series.

We believe that neither crystallization differentiation, nor immiscible splitting, nor other within-chamber processes were responsible for a Daly Gap. The formation of the latter is rather related to the generation of two compositionally different independent partial melts from the same mantle plume head: (1) alkali Fe-Ti basalts derived from plume head owing to adiabatic melting, and (2) trachytes produced by incongruent melting of upper cooled margin of the head under the influence of fluids, which percolated from underlying adiabatic melting zone. The existence of primary trachyte melts is supported by the finds of “melt pockets” in mantle xenoliths in basalts.