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Within-plate magmatism under condition of abnormally thick sialic crust: Evidence for Proterozoic anorthosite-rapakivi granite complexes of the East-European Craton

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Mid-Proterozoic (1.8-1.5 Ga) large bimodal multistage anorthosite-rapakivi granite complexes (ARGCs) are distinct magmatic assemblages in central part of the East European Craton. ARGCs formation commenced after stabilization of the Svecofennian orogen and relics of its abnormally thick (up to 50-60 km now) crust survived here in many places. Such massifs are practically absent at the eastern part of the craton (Kola-Karelian, Volga-Urals, etc. domains) with normal thickness ($\sim$40 km) of the crust.

The ARGCs formation was accompanied by emplacement of diabase, quartz porphyry and complex dike swarms. Intra-plutonic diabase dikes (Fe-Ti basalts plume-related type), intruding the rapakivi granites, are often crossed in turn by later portions of granites; injections of basaltic melt into granitic magma chambers resulted in magma mingling. It indicates that melted out occurred simultaneously in mantle and crust during ARGC formation.

Geochemical peculiarities of the ARGC rocks are enrichment in alkali (especially in K), Ti, Zn, Pb, and Zr, relatively high concentrations of Be, Sn, In, Y, Nb, Rb, F, Cu, W and Mo, and sometimes – Li and U. Nd value, ranges from -1.2 to +1.6, and relative high Th and Zn contents, most frequently observable in anorthosites, imply that the mafic magmas were considerably contaminated by crustal components.

According to geophysical data, ARGCs represent upper parts of large transcrustal systems, composed by alternation of basic and silicic rocks, which located above rises of the mantle up to 10-20 km high. Such localization of ARGCs, probably evidence that such protuberances were mantle plume heads in time, where melting of their material occurred due to adiabatic decompression. Newly-formed basaltic melts (apparently Fe-Ti basalts, similar in composition to intra-plutonic dike rocks) intruded at different depths into abnormally thick sialic crust of stabilized by then Svecofennian orogen in form of large sills and caused melting of crustal material above them. As a result, complex magmatic systems appeared here.

Partial melting of the crust was the consequence of advective heating from the hot mantle magmas. Due to convection, the main heat loss during solidification was realized through roofs of basaltic sills. Consequently, extensive melting of warmed-up siliceous rocks above them would be occurred, at that thickness of newly formed granitic layer could twice exceed the thickness of basaltic sill (Huppert and Sparks, 1988). During the initial stages relatively cool crustal material at the boundary of basaltic melt and sialic roof involved in convective flows and dissolved in hot basaltic melt, which led to it's enrichment in SiO2 and Al2O3., led to predomination of plagioclase cumulates among the rocks of basic sections. Solidification of such complex chambers were began from hardening of lower basic layers; it led to domination of ascending currents in the upper silicic layer, which was favour to appearance of specific rapakivi textures in granites.

ARGCs are usually associated with large Mid-Proterozoic belts of within-plate felsic volcanism, developed on all Precambrian shields on place of stabilized Paleoproterozoic orogens with thick sialic crust. From such point of view, it was the main reason for existence of such volcanism, because majority of mantle-derived mafic magmas was not reached the surface and secondary felsic melts were predominated. Evidently, ARGCs illustrate structure and processes in transitions magma chambers of such peculiar magmatic systems.

Many investigators suggest that ARGCs are a part of anorthosite-mangerite-charnockite granite (AMCG) suite. However, typical AMCG complexes were commonly developed in mobile zones and undergone by deformation and high-grade metamorphism. In contrast, anorogenic ARGCs are usually localized among stabilized domains and appeared on places where Paleoproterozoic orogens completed their development. So, their tectonic settings can be described in terms of within-plate activity, distinctive from the settings of the AMCG suite.