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Structure of different within-plate magmatic system of large igneous provinces

E. Sharkov

Institute of Geology of Ore Deposits, Petrograpgy, Mineralogy and Geochemistry RAS, Petrology, Moscow, Russian Federation (sharkov@igem.ru)

It is generally accepted that formation of continental large igneous provinces (LIPs) is linked with ascending of mantle superplumes. However, it is not clear yet why and how magmatic systems appeared and functionated. It is known that LIPs are formed by numerous magmatic centers, which imply existence of individual magmatic systems beneath them. Such a situation can be explained by presence of protuberances (local plumes) on the surface of extended superplume heads, where processes of adiabatic melting occurred give rise to formation of magmatic systems. Newly-formed melts on their way to the surface pass through complicate system of conduits and transitional magma chambers, where they were undergone by different processes of crystallizing differentiation, mixing, assimilation of wall-rocks, etc. According to data available, three major levels of transitional magmatic chambers, linked by systems of feeder conduits (dikes), occurred within the crust. Each of them is responsible for transformation of a primary melt in different extent:

The lowest level with the largest chambers, located along boundary between upper margin of the plume head and incumbent rigid lithosphere; they are responsible for the underplating phenomenon. Processes of contamination mantle-derived magmas by crustal material can play essential role here, especially in the late Archean and early Paleoproterozoic when they led to appearance of specific mantle-crustal magmas of siliceous high-Mg series (SHMS), which formed large igneous provinces with numerous mafic-iltramafic layered intrusions (Sharkov, Bogina, 2006). It suggests that formation of this series was linked with “floating up” of chambers (batches) of high-temperature ultramafic magmas through the upper part of lithospheric mantle and mafic lower crust by zone refinement mechanism, i.e. by melting material of the chamber’s roof and crystallization at their bottoms. As a result, the primary melt gradually enriched in crustal material; portions of such series of melts periodically arrived into hardening transitional magma chambers of the middle level. Very likely that such structure of magmatic systems was typical also for the earliest Moon’s magnesian suite magmatism, where such type layered mafic-ultramafic intrusions was found (Snyder et al., 1995).

(2) Processes at the middle level are easy to understand on example of large layered mafic-ultramafic intrusions which are represent hardened transition magma chambers. Crystallizing differentiation as well as mixing of periodically arrived into hardening intrusive chambers fresh portions of magmas with evolved melts in it occurred here. Specific type of transitional magma chambers are represented by huge bimodal anorthosite-rapakivi granite complexes (ARGCs), typical for the Mesoproterozoic. They were formed under conditions of unusually thick (70-80 km at the moment) continental crust. Geological, geochemical and isotope data evidence that melting in the mantle and silicic crust occurred here simultaneously above local mantle plumes. It suggests that melting of the crust’s material occurred above sill-like intrusions of basaltic melt which were led to appearance of large magma chambers, where mafic and sialic melts coexisted; such chambers represented now as ARGCs.

By contrast to continental crust, under conditions of thin oceanic crust processes at the low and middle levels of magmatic systems are united, and layered mafic-ultramafic intrusions occurred directly between the ultramafic mantle and rocks of the upper crust, play role of the lower oceanic crust, how it is easily to observe on example of ophiolite associations.

(3) The shallow level - subvolcanic chambers (usually sills), from which melts arrive to the surface, forming individual volcanoes and lava plateaus. Processes of contamination of wall rocks and crystallizing differentiation are very limited here due to small size of bodies and, accordingly, low heat keeping and quickly hardening.

So, primary magmatic melt can reach the surface very rare; as a rule, it had undergone by numerous different transformations on its way.