Early differentiation of the Earth and the Moon: Evidence from development of tectonic-magmatic processes on these planetary bodies

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Tectonic-magmatic processes on the early stages of the Earth's and the Moon's evolution. Comparative study of tectonic-magmatic development of the Earth and the Moon showed that the main feature of the lunar magmatism is its closeness to the Paleoproterozoic magmatism of the Earth. On the Moon are lacking both analogs of the terrestrial Archean type of activity, when formation of granite-greenstone terranes occurred, and the Phanerozoic subduction-related magmatism.

Tectonic-magmatic evolution of the both bodies had begun after solidification of the magmatic oceans, which were brought to formation of primordial sialic crust on the Earth and anorthositic on the Moon, and passed through two main stages. At the early stages of the Earth's evolution mantle-derived magmas were represented by low-Ti komatiite-basaltic series in the Archean and by siliceous high-Mg (boninite-like) series (SHMS) in the early Paleoproterozoic, derived consequently from slightly and highly depleted ultramafic mantle sources. According to experimental data, plume heads were spreaded at the depths about 300-150 km without essential deformations and disruptions of the crust. Predominated type of geodynamics was plume-tectonics (Bogatikov et al., 2000).

The critical change of the Earth's geological evolution occurred 2.2-2.0 Ga ago, when continental-oceanic stage has begun run. Formation of geochemically enriched mantle sources, presumably associated with mantle metasomatism, was characteristic for this stage. Fe-Ti picrites and basalts appeared for the first time in large quantities; MORB-type basalts began to play essential role. At the same time the archaic plume tectonics was changed for the Phanerozoic-type plate tectonics. We suggest that appearance such type of endogenic activity was linked with ascending of the mantle plumes of a new generation which have arisen on the boundary of the outer liquid core and the silicate mantle. For the plumes it is characteristic a presence of specific fluids, enriched in Fe, Ti, alkalies, P, Ba, Zr, LREE, etc. As a result, material of these plumes was lighter than previous ones and the plumes could reach more shallow levels. Extension of their heads could lead to disruption of the ancient continental crust and formation of the oceanic crust.

The most ancient magmatism of the Moon's *highlands* was begun from low-Ti melts of the magnesian suite 4.45-4.0 age (Snyder et al., 2000), which were rather close in composition of rocks, their mineralogy and geochemistry to the early Paleoproterozoic terrestrial SHMS magmatism. About 3.9-3.8 ago it was changed by basaltic *mare* magmatism, appeared simultaneously with formation of the *maria* depressions and lunar mountains. It is assumed that origin of *maria* was related to catastrophic impact events

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High-pressure mineral assemblages in shocked chondritic meteorites: A window to constituents in Earth's Transition Zone and Lower Mantle.

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Minerals in Earth's transition zone and lower mantle are mainly inferred from high-pressure experiments, and mineral inclusions in diamonds. Shocked chondritic meteorites display shock-melt veins that contain a variety of high-pressure polymorphs of natural minerals. Dense phases include: ringwoodite, wadsleyite, majorite, magnesiowüstite, $NaAlSi_3O_8$ hollandite (and jadeite + SiO_2 glass), akimotoite (ilmenite-structured $MgSiO_3$) and Mg-silicate perovskite [1-4]. Many of these phases are inferred to constitute the major components of Earth's transition zone and lower mantle. The analogy of the dense phases in meteorites to deep Earth gains relevance if we assume a chondritic bulk Earth. Based on their formational mechanisms, dense phases in shock-melt veins can be classified in two settings:

(1) Polycrystalline aggregates of high-pressure minerals result from solid-state phase transitions in coarse-grained polymineralic clasts. They consist of ringwoodite, wadsleyite, majorite, and occasionally akimotoite and Mg-silicate perovskite. These phases display nearly identical chemical characteristics with their parental olivine, and orthopyroxene, respectively. **(2)** High-pressure liquidus phases, such as majorite-pyrop$_{ss}$, magnesiowüstite, hollandite-structured polymorph of $NaAlSi_3O_8$ and occasionally akimotoite, result from crystallisation of the silicate melt at high-P (17-26 GPa) and T (2000- 2300° C) [1]. The resulting assemblage provides constraints on the pressure-temperature crystallisation history of the melt vein. The presence of jadeite + dense SiO_2 glass, instead of $NaAlSi_3O_8$ hollandite may signal an upper limit of the pressure to 20 GPa at which this pair solidified; i.e. the P-T stability field of $NaAlSi_3O_8$ hollandite was either not reached, or crystallization in the vein was active during a steep decompression path.

The liquidus assemblage can reveal crucial information on the behaviour of Na and K in silicate melts and their possible crystal/liquid partitioning and fractionation in the transition zone and Earth's lower mantle. In the veins, Na partitions to majorite, perovskite, magnesiowüstite and occasionally to akimotoite [1-4], whereas K partitions to the $NaAlSi_3O_8$ hollandite [1-4].

References

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