EPSC Abstracts,
Vol. 4, EPSC2009-112-1, 2009
European Planetary Science Congress,

Development of tectonomagmatic processes on the terrestrial planets as a key for understanding of processes of their formation and evolution

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Abstract

Our knowledge about formation and evolution of the terrestrial planets (Earth, Venus, Mars, Mercury and Moon) based on different physical and geochemical speculations and models. The main disadvantage of such hypotheses is their abstract character and ignoring any data on tectonomagmatic evolution of these planets. At the same time, just this type of data can provide an important information, which is necessary for elaborating of a present-day theory of their formation and evolution. Magmatic processes have carried information about mantle sources in the planets interiors and realize uninterruptedly record of their changing throughout their history. Related tectonic processes express character of deep-seated movements of mantle material. Taking together, they can give possibility to understand how and why evolution of the terrestrial planets occurred.

All of the planets have similar major features: (1) inner structure with iron core and silicate envelope; (2) two major types of morphostructures: highlands, composed by relatively light ancient rocks, and vast lowlands, composed by young basaltic flows. From this follows two-stage evolution of the planets: at the first stages, as a result of directed solidification of magma oceans, their primordial crust, enriched in low-temperature components were formed, and on the second stage, the secondary basaltic crust appeared due to planets' inner evolution.

Such cardinal change occurred on the Earth in interval 2.3-2.0 Ga, when, instead of previous essential magnesian komatiite-basaltic melts, derived from depleted mantle Fe-Ti picrites and basalts, typical for the Phanerozoic within-plate magmatism, began to arrive on the surface. They were enriched in elements of Fe-group, alkali (especially Na), P and other incompatible elements, which promoted processes of metabolism and fermentation and made ecological environment more suitable for the biosphere development and appearance of multicellular organisms. From this particular time new types of sedimentary rocks appeared (red beds, phosphate rocks, hydrocarbons deposits, etc. [2] and biosphere became important geological agent. That sort of change on the Mars led, probably, to appearance of oxidized atmosphere and global glaciations, and, on the contrary, "speed up" greenhouse effect on Venus.

We believe that the ascending of the second generation mantle plumes (thermochemical plumes) were responsible for this change. Such plumes were generated at the core-mantle boundary (CMB) in D" layer. Material of such superplumes reached more shallow levels and extension of their heads led to active interactions with solid rigid lithosphere, divided it on pieces (plates) by oceanic spreading zones, i.e. triggered the processes of plate tectonics which are still active till now on the Earth. Ancient lithosphere has been gradually involved via subduction processes into deep mantle which led to gradually change of the primordial "continental" crust by the secondary basaltic ("oceanic") crust. We suggest that close processes were occurred on Venus and Mars and led to predomination of the basaltic crust on them.

Where was enriched material kept billions years and how it was activated? The established succession of events could be provided only by combination of two independent factors: 1) the terrestrial planets originally were heterogeneous, i.e. formed due to the heterogeneous accretion and 2) the downward heating of them (from the surface to the core) which followed by the cooling of their outer shells. The most probable cause of their centripetal heating was a inward-directed zone/wave of heat-generating deformations, linked with acceleration of the planets rotation around

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axes according to angular momentum conservation law because of gradual compaction of their material and corresponding shortening of their radii. That wave could reach the interior of the planets thus heating deep mantle material and generating first superplumes. Finally, it reached the iron core, melted it and produced secondary thermochemical plumes. These plumes could reach more shallow levels and led to cardinal change of tectonomagamtic activity. As a result, on all terrestrial planets ancient “continental” crust was in different extent substituted by newly-formed secondary basaltic crust and survived as *continents* on the Earth, *earths (terras)* on the Mars and *tesseras* on the Venus among vast planides, composed by basalts. We suggest, that *maria* origin on the Moon was not a result of heavy bombardment and they also appeared above extended thermochemical plume heads like on other terrestrial planets [3].

So, the terrestrial planets represent independent self-propagating systems which origin and development occurred at the same scenario provide for two major stages. Substantial liquid iron core, magnetic field and present-day tectonomagmatic activity survived till now only on the Earth. Liquid core is it’s energetic heart and after it’s solidification tectonomagmatic activity will go to end, how it was occurred on the Moon, Venus and Mars, which are “dead” bodies today.

References

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