EPSC Abstracts
Vol. 5, EPSC2010-33, 2010
European Planetary Science Congress 2010

Role of tectonomagmatic processes for surface environmental changes and evolution of biosphere on terrestrial planets: evidence for evolution of life on the Earth

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Abstract

It is known that the Earth's ecological systems in the Middle Paleoproterozoic were subjected to fundamental change, which finally led to the appearance of multicellular organisms. Though life has been already existed in the Paleoarchean [7], the multicellular organisms appeared only in the middle Paleoproterozoic (~ 2.0 Ga ago) [6]. The first cardinal change in tectonic evolution of the Earth occurred at 2.45 Ga, when the Earth entered a cratonic stage, which was marked by vast eruptions of lavas of siliceous high-Mg series accompanying by great glacial epoch. However, this stage did not lead to significant changes in bioorganic world represented at that time by abundant and diverse microfossils existing since Archean, which was possibly related to the geochemical signatures of this magmatism, in particular, low contents of many biophile elements. Then, within period from 2.35 to 2.0 Ga, a cardinal change in the type of magmatism occurred: the early Paleoproterozoic siliceous high-Mg magmas derived from depleted mantle gave place to the geochemically-enriched Fe-Ti picrites and basalts, similar to the Phanerozoic within-plate magmas. New type of magmas was characterized by elevated and high contents of Fe, Ti, Cu, P, Mn, alkalis, LREE, and other incompatible elements (Zr, Ba, Sr, U, Th, F, etc.). At the boundary of 2 Ga, the plume tectonics was replaced by plate tectonics, which led to gradual replacement of ancient sialic continental crust by secondary oceanic (mafic) crust.

That time was marked by the appearance of first fungi [2]. These organisms not only caused the decomposition of organic matter, but served as active agents of biological weathering, playing an important role in biogeochemical cycle of biophile elements, including aforementioned metals and other elements (primarily, Fe, Cu, Zn, Co, Ni, and P), and correspondingly their supply in the World Ocean. A large-scale influx of alkalis in the World Ocean presumably neutralized its water, making it more suitable for the life, while input of Fe-group metals, P, and other trace elements, which are required for metabolism and fermentation, rapidly expanded the possibility for the development of biosphere. The manifestation of this geochemically enriched magmatism is correlated with the first finds of eucaryotic heterotrophic organisms at ~ 2 Ga, for example in the black shales and phosphorites of the Paleoproterozoic Pechenga complex, Kola Peninsula [5], and with rapid evolution of organic life, especially photosynthesizing cyanobacteria. For instance, a significant increase in amount of spheromorphides and remains of filamentous algae is observed in the Upper Jatulian deposits (~ 2.0 Ga) of Karelia [1]. The vital activity of the new organisms significantly increased the oxygen content in atmosphere, which was marked by the formation of cupriferous red beds at all Precambrian shields, generation of the first hydrocarbon deposits (shungites, Karelian craton), and phosphorites with age of 2.06 Ga on the Indian and Kola cratons [3].

Thus, a fundamental change in tectonomagmatic activity acted as the trigger for environmental changes and biospheric evolution, supplying a qualitatively new material on the Earth's surface. Data available on Venus and Mars suggest that their tectonomagmatic evolution also followed similar scenario. Two major types of morphostructures,

which are vast plains, composed by young basaltic flows, and older lightweight uplifted segments with a complicated topography (*tesseras* on the Venus and *earths (terras)* on the Mars), point to the two-stage evolution of these planets. The presence of drainage systems on Mars and valleys on Venus assumes the existence of liquid water at the early stages of their development. Like on the Earth, red beds and global glacials appeared on the Mars at the middle stage of it's evolution, and may be at this period ancient microorganisms existed on Mars [4]. Powerful eruptions of gigantic volcanoes of Tharsis and Elysium, probably, led to fall of temperature and disappearance of liquid water on Mars. In contrast to Mars, on Venus appeared speeded up greenhouse effect, which also led to dry and very hot surface.

Acknowledgements

The study was executed within the framework of the complex program of basic research of the Presidium of the Russian Academy of Sciences "Origin of Biosphere and Evolution of Geo-biological Systems" (subprogram II) and was supported by the Russian Foundation for Basic Research, projects 08-04-00484 and SS-4207.2008.5**.**

References

[1] Akhmedov, A.M. and Belova, M.Yu.: Position of Microfossils in the Generalized Proterozoic section of teh Baltic shield and their relation with metallogenic specialization of host sedimentary complexes, 55th Session of Paleontological Society, St. Petersburg, 2009.

[2] Belova M.Yu., Akhmedov A.M.: Petsamomyces, A New Genus of Organic-Walled Microfossils from the Early Paleoproterozoic Coal-Bearing Deposits, Kola Peninsula, Paleontol. Journ., No 5, pp.3-12, 2006.

[3] Melezhik V.A., Fallick A.E., Hanski E.J. et al.: Emergence of the aerobic biosphere during the Archean-Proterozoic transition: challenger of future research, GSA Today, Vol. 15, pp .4-11, 2005.

[4] McKay D.S., Gibson E.K., Thomas-Keprta K.L., et al.: Search for past life on Mars: possible relic biogenic activity in Martian Meteorite ALH 84001, Science, Vol. 273, pp. 924-930, 1996.

[5] A. Yu. Rozanov, Prasinophyceae (Green Algae) from the Lower Proterozoic of the Kola Peninsula, Paleontol. J., No. 4, pp. 90-93, 2008.

[6] Sayutina, T.A. and Vil'mova E.S., Problematic fossils Udokania Leites from the Proterozoic deposits of Transbaikalia, Paleontol. J., no. 3, pp. 100-105, 1990.

[7] Schidlowski M. A: 3.800-million-year isotopic record of life from Carbon in sedimentary rocks, Nature, Vol. 333, pp.. 313-318, 1988.