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Geodynamic and geochronological Approach to the Formation and Evolution of the Early Earth's Crust

E. Galimov, **E. Bibikova**

V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, Moscow, Russia, bibikova@geokhi.ru

For several decades we have studied the geochronology and early evolution of the Ukrainian and Baltic Shields. The results permit us to distinguish in the Achaean history three consecutive stages, which were common both for the Ukrainian and the Baltic Shields, although their manifestation was not synchronous. Those stages are – the formation of ancient cores consisting of tonalite-komatiite association (ca 3.7 Ga on Ukrainian and ca 3.3 on the Baltic Shield); formation of greenstone belts (3.3-3.0 Ga and 2.9-2.7 Ga correspondingly) and the emplacement of subalkaline granitoids (2.95-2.9 and 2.75-2.7 Ga). The analysis of data for other cratons shows that the similar succession is a general characteristic of all ancient cratons.

We found that the crust evolution is in a good agreement with the recently proposed model of the redox evolution of the earth's mantle [Galimov, 2005]. According to Galimov [2005] after early formation of about 95% of the core, the core-build proceeded at the expense of the mantle FeO. That brought about the gradual oxidation for about 150-300 Ma of the initially highly reduced mantle. By the end of this stage the mantle was dry and CO_2-rich. The process of mantle oxidation became a driving force for the ascent of the first plums formed at the core-mantle boundary. Our model of the crust formation is as follows:

Nearly simultaneously with the core formation the melting of the hot, dry, CO_2-rich mantle produced the first basaltic (or/and andesitic) Earth's crust. At about 4.3 Ga this crust may cover the whole of the Earth's surface with possibly small water basins on it. At the beginning the crust was not stable and the processes of its recycling into the mantle, proceeded for nearly 500 Ma. At this stage resurfacing of the Early Earth took place.

Next step in formation of the crust was connected with the operation of the first hot

mantle plums. These plums, formed deep in the mantle, ascending, reached the bottom of basaltic crust. The typical for the ancient crust association of basalts, komatiites and tonalites was formed in this process and the complementary creation of lithospheric keels took place. They have stabilized the position of ancient nucleus. The process of continental crust formation started at about 4.2 Ga but the main stage occurred at 3.8-3.6 Ga. The complimentary formation of tonalitic crust and mantle keels explains the enriched character of the earliest tonalitic crust and the depleted nature of lithospheric mantle. Plume tectonic predominated at this stage.

During the next stage the shallow watering of the mantle occurred that induced the earliest greenstone belts formation (3.5-3.1 Ga). The formation of depressions (geosynclines) took place near the margins of ancient nucleus, where basaltic crust was not supported by lithospheric keels and the association of komatiites, andesities and boninites filled these depressions together with continental and marine sediments.

The subduction processes with deep watering of the mantle started only after 3.0 Ga when the crust became thick enough. The best example of greenstone belts formed in plate tectonic geodynamic conditions are numerous greenstone belts of the Superior craton in Canada and of the Karelian craton, Baltic Shield. All geophysical and geochronological data confirm their origin in frame of plate tectonic geodymanics. The further deeper penetration of water into the mantle produced partial melting and fluid rich magmatism, which mobilized alkaline elements and resulted in the formation of subalkaline granites –sanukitoids and syenites at 2.9 - 2.5 Ga on different cratons. The plate tectonic became predominant.

[1] Galimov E.M. (2005) *Earth Planet. Sci. Let*. **233**, 263-276.