Ancient weathering crust-hydrosphere system as environment of prebiotic molecules appearance

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The chemical composition of the earliest biont cytoplasm was probably identical to the environmental composition. In the publication [1] has been given a supposition that the intracellular liquid's physico-chemical parameters of modern creatures didn't change. Therefore, the prebiotic terrestrial environment was possibly characterized by predominance of potassium above sodium (K/Na>1) and sufficiently high content of magnesium. However, like it has been shown by our previous calculations that modeled leaching of ancient crust rock (basaltic komatiite) under an carbon dioxide atmosphere, the proportion of potassium and sodium in coexistent solution (ancient hydrosphere) approximates to their proportion in initial rock (i.e. K/Na<1). Thus, a substratum, which may be a potassium donor for ancient water reservoir, should be characterized by considerable potassium content. An ancient weathering crust may be the similar substratum. During study of Karelia's Achaean basalt weathering profiles [2] it has been shown that only sodium was drastically removed from ancient weathering crust, whereas potassium was characterized by inert behavior. On the other hand both elements are removed in modern weathering profiles.
Thermodynamic calculations with kinetic parameters were implemented on a basis of complex GEOCHEQ (thermodynamic data base derived from SUPCRT92) [3]. The interaction between basaltic komatiite and volcanic gas condensate which originated in the course of the degassing during the Earth's crust partial melting has been simulated.
It has been written special code for modeling of weathering crust forming. This code simulates the many waves passage of aqueous solution with constant composition through the same solid block.
Over the calculations it has been used compounds of basaltic komatiite (wt.%, SiO_2 - 48.76, Al_2O_3 - 9.36, Fe_2O_3 - 3.07, FeO - 8.04, MgO - 21.65, CaO - 8.05, Na_2O - 0.90, K_2O - 0.16) [4] and gas condensate of Icelandic volcano Surtsey (mol.%, H_2O - 87.88, H_2 - 3.12, CO_2 - 6.43, CO - 0.39, SO_2 - 2.72, S_2 - 0.1, H_2S - 0.63, HCl - 0.43) [5]. The single calculation duration was 0.05 year. 40 000 waves went throw the modeling komatiitic block. Water-rock ratio was assumed to be 0.016, temperature - 15°C, the carbon dioxide atmosphere pressure - 1 bar.
The results of our simulations demonstrate that sodium, calcium, magnesium and iron are almost completely removed in the course of the initial silicate minerals dissolution. But relative weight of silica and potassium increases. Potassium delivered to the solution participates in the formation of illite. And silica mostly accumulates as amorphous silica.
A drastic change of initial rock volume during the washing one by aqueous solution has been shown. At first stage of solution draining the integral rock volume increases drastically and takes a maximum (140% of initial rock volume) after 6.75 years from weathering start. These transformations are associated with a secondary minerals forming. Then the integral rock volume reduces and it makes up 73% of initial rock volume at the end of computation period. This results from the dissolution of secondary minerals.
The chemical weathering of basaltic komatiite is characterized by three main mineral assemblages (fig. 1):

1. Amorphous silica, carbonates, goethite and pyrite. The integral rock volume increases. The duration is 7 years.
2. Amorphous silica, goethite, montmorillonites and illite. The integral rock volume reduces. All primary minerals are dissolved at the end of this period. Solution pH drastically reduces. The duration of this stage is from 7 to 50 years.
3. Amorphous silica, montmorillonites, illite and goethite. The integral rock volume reduces. The duration of this stage is from 50 to 2000 years.

The weathering crust is formed as a result of the basaltic komatiite washing by aqueous solution in the course of 2000 years. It is eventually consisted from amorphous silica (96.4 vol.%) and illite (3.3 vol.%). The similar basalt chemical weathering mechanism was described in [6].

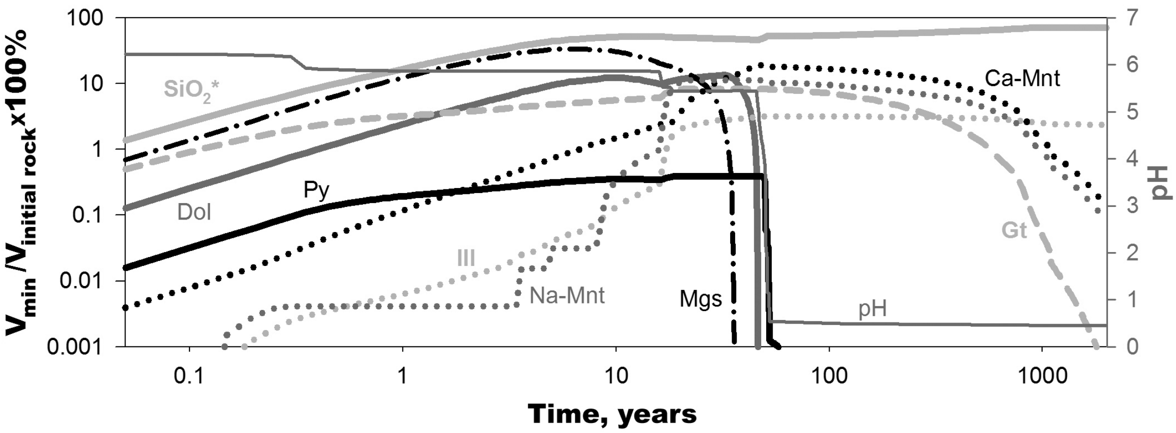

Fig. 1 Secondary minerals of the weathering crust: SiO_2* - amorphous silica, Dol - dolomite, Gt – goethite, Ill – illite, Mgs – magnesite, Ca-Mnt - Ca-montmorillonite, Na-Mnt - Na-montmorillonite and Py – pyrite

At final stage of the weathering crust forming the coexistent solution is characterized by high content of magnesium and predominance of potassium above sodium. Furthermore, it has been observed that K/Na ratio increases with rising of water-rock ratio. It is allowed to conclude that the weathering crust based on basaltic komatiite could be a source of cations for ancient water reservoir with favourable proportion for the origin of life.

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