Simulations of the early Earth's subaerial weathering

Alexey A. Novoselov[1] and Nadezhda A. Alfimova[2]

[1]*Vernadsky Institute, RAS, Kosigina St. 19, Moscow, 119991, Russia, elevfaniy@rambler.ru*
[2]*Institute of Precambrian Geology and Geochronology, RAS, nab. Makarova 2, St. Petersburg, 199034, Russia, n.a.alfimova@ipgg.ru*

As early as liquid water originated on the Earth's surface (at least 4.4 Ga [e.g. *Mojzsis et al., 2001*]) the weathering processes should be started. The subaerial weathering was in a strong relation with early Earth's environmental conditions. Thus the preserved weathering crusts may be a source of information about the early atmosphere composition and climate particularities. This investigation was implemented to research the chemical weathering processes on the early Earth's surface and to understand the possibility of the environmental conditions reconstruction by dint of the study of ancient weathering crusts composition.

Weathering processes on the Earth's surface occur at low temperature, therefore they are characterized by incompleteness of chemical reactions. For simulation of these processes the numerical approach described in [*Zolotov, Mironenko, 2007*] has been applied. Thermodynamic calculations with accounting of mineral dissolution kinetics were implemented on a basis of complex GEOCHEQ (thermodynamic data base derived from SUPCRT92) [*Mironenko et al., 2008*].

The iterative "washing" of basalt by rainwater at early Earth's surface conditions was simulated. We modeled a system including the next elements: O-H-K-Mg-Ca-Al-C-Si-N-P-S-Na-Fe. Used Archean basalt sample (a weathering protolith analogue) consists of 42.7 wt.% albite, 28.1 wt.% chlorite, 21.2 wt.% augite, 4.2 wt.% microcline, 2.1 wt. % quartz, and 1.8 wt.% magnetite. Modeling system was CO_2 open and the carbon dioxide partial pressure varied from $4 \cdot 10^{-4}$ up to 1 bar. A few series of calculations were implemented with methane contained atmosphere. The surface temperature was 15°C and 80°C. The value of rainwater was suggested 400, 1000, and 4000 mm per year.

According to the received data the methane presence in CO_2 atmosphere doesn't influence on the weathering crust composition. The carbonate minerals deposit at the CO_2 content of atmosphere upper the modern one in the course of the initial stage of weathering process. Their forming limits by the magnesium and calcium concentrations of solution and the water-rock ratio into the weathering substratum. The carbonates are the most stable at low quantity of atmospheric precipitates. During the consecutive weathering crust evolution they dissolve completely and remove from the substratum. The resulted weathering crust consists from amorphous silica, iron oxides and clay minerals. The received results have been compared with the compositions of Archean and early Proterozoic weathering crusts [*Alfimova, 2007*]. The weathering of the reviewed samples took place due to moderate humidification and temperature conditions under the carbon dioxide containing atmosphere.

We thank Dr. M.V. Mironenko (Vernadsky Institute) for providing programs and consultations.

References

1. Alfimova N.A., The early Precambrian weathering crusts of Karelia. Geological structure, chemical composition, and forming conditions. PhD thesis // St. Petersburg, 2007, 18 p.;
2. Mironenko M.V., Melikhova T.Yu., Zolotov M.Yu., Akinfiev N.N., GEOCHEQ_M: Program complex for thermodynamic and kinetic modeling of geochemical processes in rock-water-gas systems. Version 2008 // Vestn. Otdelenia nauk o Zemle RAN, 2008, V. 26;
3. Mojzsis, S.J., Harrison, T.M., and Pidgeon, R.T., Oxygen-isotope evidence from ancient zircons for liquid water at the Earth's surface 4,300 Myr ago // Nature, 2001, V. 409, pp. 178 – 181;
4. Zolotov M.Yu., Mironenko M.V., Timing of acid weathering on Mars: A kinetic-thermodynamic assessment // J. Geophys. Res., 2007, 112, E07006.