Nitrogen limitation in extremophilic hydrothermal ecosystems of Yellowstone National Park

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We present the results of ^{15}N assimilation experiments conducted with hydrothermal chemotrophic and phototrophic microbial mats in Yellowstone National Park (YNP), USA. *In situ* ^{15}N incubations were carried out with $^{15}NO_3^-$, $^{15}NH_4^+$, and $^{15}N_2$ during the summer 2009 and 2010 field seasons over a wide range of temperature and pH (50-92°C, pH = 2.1-9.3).

Measured rates of NO_3^-, NH_4^+, and N_2 assimilation vary widely between sites. The highest assimilation rates were generally found in photosynthetic mats. NO_3^--assimilation was detected at some high temperature sites but was conspicuously absent at others, even when these sites exhibited remarkable geochemical simularity. Measurable rates of N_2-fixation were measured in the phototrophic cyanobacterial mats. However attempts to detect N_2 assimilation in high temperature, alkaline, chemotrophic communities were unsuccessful.

NO_3^- assimilation rates determined in 2009 using 1-4 μM initial NO_3^- were generally <10% of 2010 rates using 100 μM initial NO_3^- at reoccupied sites (e.g. Figure 1). These results imply that nitrate assimilation may be strongly understaturated at *in situ* NO_3^- concentrations (<1.5 μM). This suggests that nitrogen limitation may be an underappreciated aspect of hydrothermal ecosystem biogeochemistry.

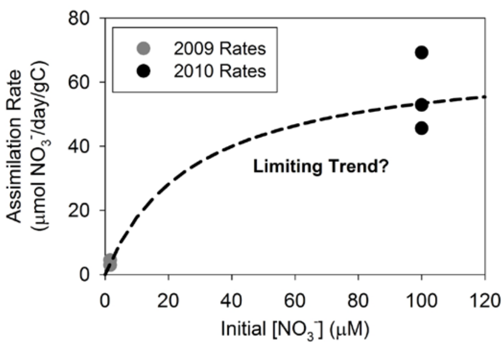

Figure 1: Nitrate assimilation rate as a function of initial NO_3^- concentration at a hot spring near Obsidian Pool, YNP.

Concerning organization of geochemical environment as a study object for geochemistry

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In the light of concepts of theoretical geochemistry the environment is presented by a set of hierarchically ordered and geochemically discontinuous objects such as biosphere or lithosphere which in their part consist of a quantity of the smaller structural units – rocks, gases, proteins. On the molecular level the latter present sets of typical components made of a relatively limited number of chemical elements. In general the environment is treated as the present result of the continuous chemical reactions. However the paradox is that the observed environment can not be interpreted as a result of all the possible chemical reactions. To produce such an object as the World Ocean, or an ore deposit the necessary chemical elements should occur in the corresponding volume, the corresponding form and sufficient quantity. In the other words the physically significant result of interaction of all the substances is characterized by significant masses presented in the particular volume. Therefore the quantity of all the chemical elements present on the Earth may be treated as material bodies of the particular elements such as iron, oxygen or actinium.

Such an approach is logically unrepugnant and permit to formulate an important corollary. All chemical elements and compounds that are in the environment regardless of form, quantity and aggregate state are organized as material bodies which have general and specific properties such as weight, dynamics and space configuration. Furthermore, theirs bodies exhibit characteristics of a three-dimensional fractal.

This assertion does not contradict any of the basic tenets of science and allows us make a more general conclusion. Parameters of the existing geochemical environment at all levels of organization are naturally predetermined by specific interaction of a small number of material bodies, that are stable in time and space and are the basic components of the universe.

If these statements are true (they are at least logically consistent) then the environment can be considered as constantly evolving, naturally organized and well-balanced superposition of special geochemical bodies, which in framework of notions of theoretical geochemistry may become the main object of this science. Such object is in full measure able to provide formal interpretation and comparison of all the existing geochemical data using the means of modern physics and mathematics.