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Elements redistribution between organic and mineral parts of microbial mats: SR-XRF research (Baikal Rift Zone)

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ABSTRACT

In article minerals formation and elements accumulation in microbial mats of some hot springs of the Barguzin basin (Baikal Rift Zone) is discussed. The content of a wide spectrum of elements in microbial mats is studied by means of the method SR-XRF. Regularity of elements accumulation by community depending on geochemical features of hot spring's waters are discussed. These elements are distributed in different ways between organic and mineral substance of the microbial mats. The distribution of K, Mn, Ni, Cu, Zn, Fe is regular, Ca, Rb, Sr are almost totally related with the mats mineral part, while Ga, Ge and Br are accumulated in mats organic substance. Germanium element is concentrated in considerable amounts in the cyanobacterial communities, that develop in sulphideless springs with a higher radon concentration.

1. Introduction

Cyanobacteria appeared at the turn of 3.6 billion years ago and had two number of peaks about 2 and 1 billion years ago [1]. During a long period cyanobacteria prevailed and microbial mats are considered to develop occupying vast areas. At present time microbial mats in some hot springs are the model object of paleogeological processes. The reconstruction of the conditions under which ancient communities developed is only possible providing thorough studies of modern communities. Though cyanobacterial mats, their structure and composition are well studied from the microbiological point of view, their geochemical studies are not sufficient. Barguzin basin in the Baikal Rift Zone with its hot springs is one of those locations where diverse cyanobacterial communities develop dynamically. The Alla, Kuchiger and Umkhei hot springs are connected with the West Barguzin fault (right side of Barguzin basin), the Garga and Uro springs are connected with the East Barguzin one (left side) (Fig. 1). Fractured anisometric granites or grandiorites serve as water reservoirs. Kuchiger, Umhei and Uro springs pass through quarternary unconsolidated deposits; Alla and Garga are discharged directly through fissure zones in slightly modified granites, with travertines forming at the orifice points [2,3]. This work sets forth the first data concerning elements content in microbial mats and their distribution between the organic matter and mineral component.

2. Methods

Waters composition was defined by a complex of methods with the cross-check of the results. The methods applied were those of atom-emission spectrometry, capillary electrophoresis, ICP MS, atomic absorption. To define the species composition of bacteria and cyanobacteria the mat samples were preserved in 4% formalin, non-preserved samples being stored at 4 °C. The microbial mats were layered and then dried under laboratory conditions. Micromorphology and mineral phases qualitative composition research was carried out with the use of the scanning electron microscope Leo 1430VP (Germany) (the operator S.V. Letov, IGM SB RAS). The organic matter of the microbial mat was leached with H_2O_2, heated on a sand bath in order to isolate the mineral component.

The samples of the whole mats, of their mineral component and travertines were analysed via the SR-XRF method. The SR-XRF method was used in practice at the element analysis station VEPP-3 at the synchrotron emission Siberian centre of the Nuclear Physics Institute SB RAS. Energy-dispersive X-ray optical SR-XRF scheme was applied in two modes of the primary monochromatic

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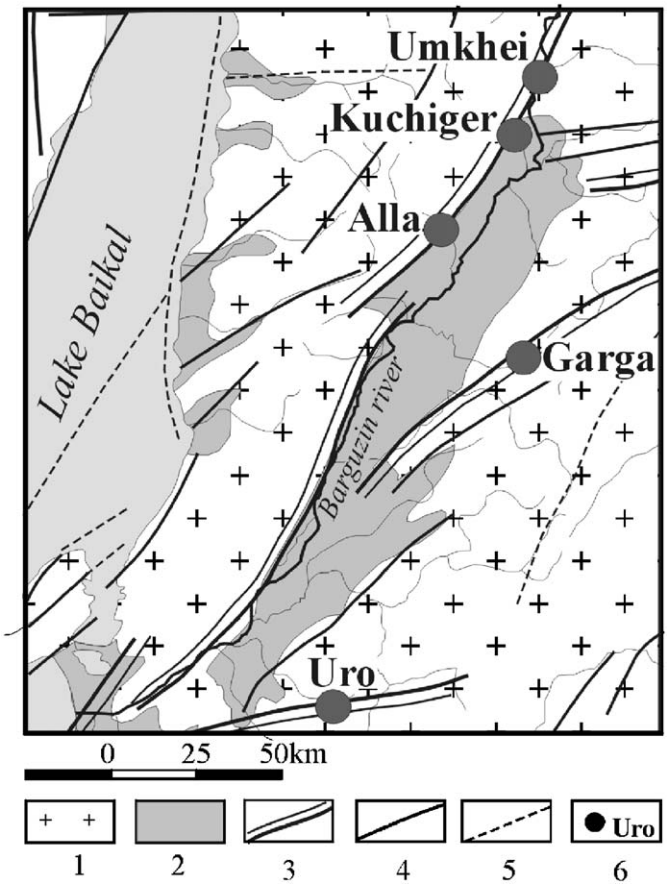

Fig. 1. Hot springs disposition in Barguzin valley. 1—granites, 2—quarternary deposits, neotectonic faults structures, 3—general ($L>80$ km), 4—regional ($L<80$ km), 5—supposed (Atlas of Baikal, 1993) and 6—hot springs under study.

emission 23 and 36 KeV [4]. Processing of issue spectra was carried out by means of program AXIL.

3. Results

From the geochemical point of view the Barguzin valley right bead and left bead hot springs differ a little. All the springs are alkaline silicate hydro-therms with the nitrogen prevailing in the gas composition [5–7]. The Alla, Kuchiger and Umkhei springs waters belong to the same type and represent HCO_3–SO_4–Na according to their major and minor elements composition. These springs are HS^--bearing and low Rn (4 eman) concentrations. The Garga and Uro spring water are characterized by the absence of HS^- in the solution and radon content 30–10 eman. Barguzin basin hot springs distinguishing feature is persistently high F^- (11–16 ppm) and Si (30–40 ppm) concentration. In trace elements composition alkaline, alkaline-earth (Li, Rb, Sr, Cs, Ba) and anionogenic elements (Ge, Mo, W) prevail.

Over a vast area at the Alla river bottom microbial mats are widespread. There are four types of microbial communities pointed out. At the temperatures above 55 °C thermophilic cyanobacteria *Phormidium* spp. and green filamentous bacterium *Chloroflexus* develop. Directly beside the orifice anoxygenic mat called after its prevailing species *Chloroflexus* is being formed [8]. While the temperature lowers down to 40–45 °C *Phormidium* sp. and *Oscillatoria* sp. (the mat *Phormidium*) predominate. As the temperature lowers down to 35 °C (between 35 and 20 °C) genus *Thiothrix*, along with a little number of genera *Oscillatoria* and *Phormidium* and diatoms do develop (*Thiothrix* communities). At the lowest temperatures brown fouling appear, represented by a cyanobacterial mat with *Scytonema* predomination. Genus *Phormidium* (*Scytonema* mat) is represented less.

It might be because of low temperatures (up to 43 °C) in the Kuchiger spring communities that species of *Oscillatoria* genus became *Phormidium* codominants. *Oscillatoria limosa* and *Phormidium foveolarum* prevailed in the microbial communities which developed at the temperature of 43 °C. There was a quantity of diatom algae registered. In a green film that developed along the outflow of the one of numerous streams a maximal species diversity can be pointed. Here large masses of bacteria, cyanobacteria, diatom algae and fungi were found. *Phormidium* spp. made the mat base at that point.

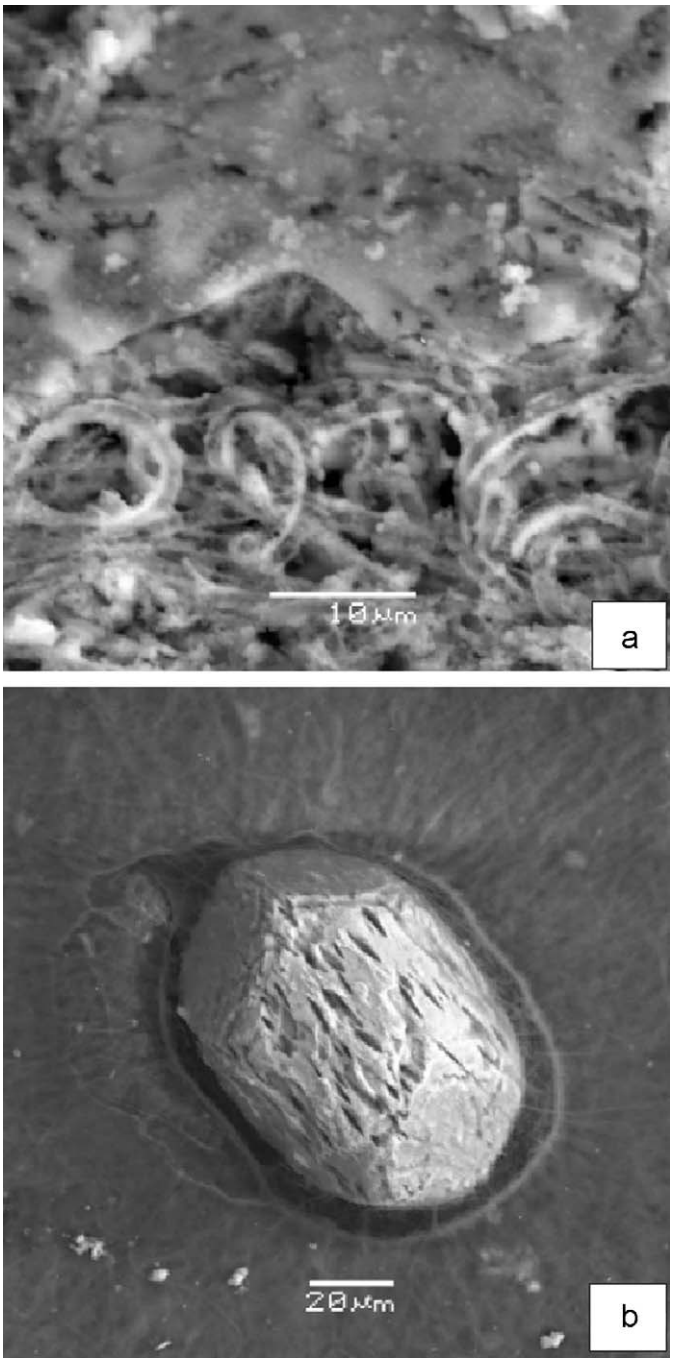

Fig. 2. (a) Amorphous SiO_2 in a microbial mat and (b) calcite forming in a cyanobacterial mat.