TRACE METAL AND MINERALOGICAL PATTERNS IN ENDOLITHIC MICROBIAL COMMUNITIES

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1. Introduction

In nature, microorganisms are known to accumulate trace metals and be instrumental in forming often unusual mineral phases. While this activity has been well studied for individual organisms (reviewed by Schultze et al., 1993), the effect of whole microbial communities on trace metal distribution in natural environments has not been as thoroughly investigated as their participation in mineral formation (Douglas and Beveridge, 1998). Especially in extreme environments, where microorganisms may be the dominant life form, the ability of microbial communities to affect the transport and distribution of trace metals can have important consequences for local geology and geochemistry. We have begun preliminary investigations of endolithic communities from Antarctica, the arid Mono Lake Basin and the Negev desert (Israel) and present our results here.

2. Materials and Methods

Rocks containing endolithic communities, collected during field work in Spring and Fall, 1999 (Mono Basin) and those kindly given by Dr. Imre Friedmann (Negev and Antarctica) were freshly broken to expose the microbial layers. Fragments representing cross sections of the rocks were examined in an environmental scanning electron microscope (ESEM) which allowed examination of UNCOATED and fully HYDRATED specimens. Energy dispersive X-ray spectroscopy (EDS) was used to collect information on elemental abundance in the microbial layers vs. the host rock. We employed a PGT prism light element detector and collected spectra for 100s (live time) from specimens probed with a 20 keV accelerating voltage.

3. Results and Discussion

For all the microbial communities examined, the presence of the community within the host rock was accompanied by a distinct change in texture and elemental proportions. In non-colonised regions, the crystal shape of the constituent mineral grains could be clearly seen. In the regions colonised by microorganisms the mineral grains looked "corroded", with numerous pits, crumbled surfaces, and jagged, indistinct edges.The actual position of the microbial community was discernable as a coating on the mineral surface with occasional filamentous organisms distinguishable. This coating consisted of numerous microbial cells in close spatial proximity covered in extracellular polymers (EPS), a typical characteristic of biofilm or mat communities (Douglas). The EPS also enclosed small mineral precipitates which were formed as a result of microbial activity; either indirect physicochemical weathering due to microbe-induced chemical changes in the microenvironment and/or nascent, generally clay-like, precipitates formed biogenically.

The observable textural differences between the colonised and the non-colonised zones were paralleled by differences in elemental composition, both in terms of relative proportion and segregation of particular elements to specific structures. The regions colonised by microorganisms had a measurably different suite of elements than the host rock. Metallic elements (e.g., Fe, Cr, Ni etc.) were concentrated in the biomass relative to the host rock. Similarly, biologically essential elements (Ca, Mg, K, Cl) were more abundant in the microbial layer. In some case, rare earth elements and metalloids such as Sb and As were also concentrated by the organisms.

4. Conclusions

In extreme environments, such as hot and cold deserts, microorganisms, in the form of microbial communities, are a dominant life form. A common strategy for surviving the harsh conditions is endolithic growth, which puts the biota in close contact with the host rock. This intimate contact maximises the interaction between these two entities, making endolithic systems ideal subjects for geomicrobiological investigations. In the present study microbial cells and their exopolymers were found to concentrate trace metals, possibly derived from their solubilisation of the host rock.

5. References

Douglas, S. and Beveridge, T.J. 1998. Mineral formation by bacteria in natural microbial communities. FEMS Microbiology Ecology. 26: 79-88.

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