Resolving the microbe-meteorite interface of the extreme thermoacidophile Metallosphaera sedula at nanometer scale

Denise Koelbl*[1], Tetyana Milojevic†[1], Mihaela Albu[2], and Adrienne Kish[3]

[1]University of Vienna – Austria
[2]Graz Centre for Electron Microscopy – Austria
[3]Unité Molécules de Communication et Adaptation des Microorganismes (MCAM), Muséum National d'Histoire Naturelle – MNHM – France

Abstract

Denise Kölbl1, Mihaela Albu2, Adrienne Kish3, Tetyana Milojevic1*
1Extremophiles/Space Biochemistry Group, Department of Biophysical Chemistry, University of Vienna, Althanstrasse 14, A-1090 Vienna, Austria.
2Graz Centre for Electron Microscopy, Graz, Austria
3Unité Molécules de Communication et Adaptation des Microorganismes (MCAM), Muséum National d'Histoire Naturelle, CNRS UMR 7245, Paris, France

*Corresponding author: tetyana.milojevic@univie.ac.at
Exploration of microbial-meteorite interactions highlights the possibility of bioprocessing of extraterrestrial metal resources and reveals specific microbial fingerprints left on extraterrestrial material. In the present study we provide our observations on the microbial-meteorite interface of the metal respiring thermoacidophile *Metallosphaera sedula*. The H5 ordinary chondrite Northwest Africa 1172 ((NWA 1172) was actively colonized by the cells of *M. sedula*. We applied analytical spectroscopy and ultrastructural methods to decipher interactions between genuine extraterrestrial material and a chemolithotrophic microorganism. First observations of *M. sedula* grown on NWA1172 revealed round-shaped, irregular cocci which were characterized by the presence of electron-dense dark areas along the cell membrane (S-layer) and extensive dark accumulations in the cytosol. A close insight by means of ultrastructural analysis via Scanning Transmission Electron Microscopy (STEM) coupled to spectroscopic techniques (energy-dispersive X-ray spectroscopy (EDS), electron energy loss spectroscopy (EEL)), provided information on metal acquisition by *M. sedula* and subsequent cellular metal localization. Elemental maps acquired by STEM-EDS showed abundant C, O, N, S, Cu, P, Fe, Al, Co and K content in *M. sedula* cells; Cu, K, Cl, Fe, Al and P signals were localized both on the cell surface and intracellularly; Si accumulations produced strong intracellular signals, which correspond to the dark electron dense areas of the TEM image. EELS measurements acquired locally on the cell surface (point analysis; beam diameter of 1 Å) demonstrated that *M. sedula* is bearing a mixed valence iron distribution with dominant Fe2+ species. Furthermore, Electron Paramagnetic Resonance (EPR) measurements were performed to (1) identify paramagnetic species in NWA 1172 and to (2) investigate the impact of *M. sedula* on NWA 1172 with a possible effect on the oxidation state of paramagnetic

*Speaker
†Corresponding author: tetyana.milojevic@univie.ac.at

species. Accumulation of Fe3+ species was detected after growth on NWA1172, which might be the consequence of extensive Fe2+ oxidation of the minerals mediated by iron-oxidizing *M. sedula.* Our investigations validate the ability of *M. sedula* to perform the biotransformation of meteorite minerals and provide the next step towards an understanding of meteorite biogeochemistry.