Microbial interaction with terrestrial and extraterrestrial rocks on the International Space Station

Rosa Santomartino[1], Charles S. Cockell[1], Annemiek Waajen[1], Wessel de Wit[1], Ralf Moeller[2], Petra Rettberg[2], Felix M. Fuchs[2,#], Rob Van Houdt[3], Ilse Coninx[3], Natalie Leys[3], and the BioRock team

[1] UK Centre for Astrobiology, School of Physics and Astronomy, University of Edinburgh, Edinburgh, UK

[2] Radiation Biology Department, German Aerospace Center (DLR), Institute of Aerospace Medicine, Cologne (Köln), Germany

[3] Microbiology Unit, Belgian Nuclear Research Centre, SCK CEN, Mol, Belgium

[#] Present address: Institute of Electrical Engineering and Plasma Technology, Ruhr University Bochum, Bochum, Germany

As space agencies plan to expand human presence in space and to settle on the Moon first and Mars later, developing strategies to achieve this goal in a sustainable way is necessary. These include *in situ* resource utilization (ISRU) and recovering of materials by waste recycling (*1*). Microbe based technologies may be pivotal to the success of human space exploration. Potential roles of microorganisms in space include manufacturing, as building blocks of ecosystems, in waste recycling and in biomining (*2*). Understanding microbial response to space conditions is therefore essential to harness their potential.

The ESA-supported BioRock experiment (2019) and the BioAsteroid experiment (2021) on the International Space Station (ISS) studied microbe-mineral interactions in space, with a view to its potential roles in extraterrestrial life support systems, for instance ISRU, biofilm formation on rock and biomining.

BioRock was performed for three weeks in microgravity, simulated Martian gravity and simulated terrestrial gravity, with three bacterial species (*Sphingomonas desiccabilis*, *Bacillus subtilis*, *Cupriavidus metallidurans*). We investigated biofilm formation and bioleaching of Rare Earth Elements (REEs) (*3*) and vanadium (*4*) from terrestrial basalt rock. The results show differential biofilms formation on the basalt surface, lipidomics profile and bioleaching efficacy for each bacterial species, generally independent from the gravity condition. This is in agreement with the data on final cell concentrations, which showed no difference between the three gravity regimens on the ISS (*5*), indicating that any possible gravity-related effect was overcome by the end of the experiment (21 days).

BioAsteroid added up on these results and expanded our knowledge on microbial behaviour in space, by investigating the interaction of *S. desiccabilis* and the fungus *Penicillium simplicissimum* with meteorite rock (L-chondrite) in microgravity after 19 days. Results show that both microorganisms were able to grow in the presence of meteoritic material and to perform elemental release (e.g., platinum group elements, Cu, Pd) from L-chondritic material under microgravity. *P. simplicissimum* was also able to form mycelium on the L-chondrite in space.

Taken together, BioRock and BioAsteroid provide the first demonstrations of biomining, particularly from extraterrestrial material, on a space station. The results suggest that, in principle, microbial-supported bioproduction and life support systems could be effectively performed in space (e.g. Mars, Moon and asteroids), as gravity will likely not have a negative effect on biotechnological applications and microbial growth. Hence, our data demonstrate a potential role for microbe-mineral interactions in advancing a sustainable establishment of human presence beyond the Earth.

References:

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