Searching for subterranean-adapted microorganisms as part of the ESA CAVES and PANGAEA Astronaut training programs for planetary exploration

Ana Miller*†[1], Ana T. Caldeira[1], Jo De Waele[2], Ilenia D'angeli[3], Samuel Payler[3], Franci Gabrovšek[4], Loredana Bessone[3], and Francesco Sauro[2]

[1]HERCULES Laboratory, University of Évora – Évora, Portugal
[2]Department of Biological, Geological and Environmental Sciences, Italian Institute of Speleology, Bologna University – Bologna, Italy
[3]European Astronaut Centre (EAC), European Space Agency (ESA) – Cologne, Germany
[4]Karst Research Institute – Slovenia

Abstract

Caves on Earth are catching the attention of the space agencies for testing new approaches to planetary science investigations. These subterranean environments could protect astronauts from the high levels of cosmic radiation and extremes of temperature during human missions to the Moon and Mars. As these celestial bodies are likely to contain caves and a record of secondary mineralization, studying secondary mineral deposits and associated microbial life in caves on Earth can help us to better understand where to look on Mars's subsurface. In this sense, the development of procedures and of portable instruments able to perform non-invasive, in-situ analysis has provided an impressive impulse not only for the terrestrial geological field, but also for the next generation of planetary surface explorations. In the framework of the CAVES and PANGAEA astronaut training programme organized by the European Space Agency (ESA), microbiological samples have been collected inside volcanic and carbonate rocks caves with the aim of studying subterranean-adapted microorganisms and to compare them and their respective dwelling with the recently discovered exoplanet biosignatures.

This study comprises the most comprehensive technological efforts to characterize microbial life and microbe-mineral interactions in caves. In this sense, improved sampling methodologies and a wide range of both laboratory and handheld analyses for microbial species detection and classification have been performed. Analytical instruments include high-throughput portable flow cytometer, handheld ATP luminescence and next generation sequencing, using the Illumina Mi Seq platform, of the 16S rRNA gene to identify microbial communities associated with the secondary mineral deposits. In addition, the suitability of these cave speleothems as biosignature repositories was investigated by field emission scanning electron microscopy with energy dispersive X-ray spectroscopy (FESEM-EDS).
Our data indicated that the microbial mats and secondary mineral deposits found in the

*Speaker
†Corresponding author: anamiller@irnas.csic.es

caves contain highly specialized mineral-utilizing microorganisms able to promote biomineralization processes. In addition, this study showed that deep caves offer a challenging subsurface environment for astrobiological research and planetary science explorations.