Biomarker preservation in Antarctic sandstone after space exposure outside the International Space Station

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Abstract

Cryptoendolithic microbial communities, discovered in the extremely cold, hyper-arid McMurdo Dry Valleys of Antarctica (Friedmann 1982), the most similar terrestrial environments to Mars surface (Wynn-Williams and Edwards 2000; Onofri et al., 2004), have been considered as a candidate in supporting the search of life in Mars exploration. In such harsh conditions, microorganisms grow in airspaces among mineral grains and show some adaptations, as the accumulation of protective pigments and compatible solutes, assuring their survival. In the frame of the Lichen and Fungi experiment (LIFE, P.I. Silvano Onofri; Onofri et al. 2012, 2015), small samples of these communities, were exposed to space, in the EXPOSE-E facility for 1.5 years, with an exposition to vacuum (10-7 to 10-4 Pa) (Horneck et al., 2010), galactic cosmic radiation (≤190mGy) (Berger et al., 2012), and the full spectrum of solar extraterrestrial electromagnetic radiation to which cryptoendolithic microorganisms demonstrated to survive (Scalzi et al., 2012). The search for trace of extant or extinct life is one of the main goals of the future space mission beyond Earth. The future rover missions

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ExoMars 2020 (ESA-Roscomos) and Mars 2020 (NASA) are exploring chemical and biological indicators of life, called biomarkers. A good biomarker must have a biogenic origin and thus must unequivocally be identified as possible trace of life. The detection of biomarkers on Mars was the aim of BIOMEX (BIOlogy and Mars Experiment) project, in which has been investigated the alteration of different biomarkers, after exposure to space and Mars-like conditions outside the International Space Station. In this contest, the aim of this work was to characterize fungal biomarkers from these exposed rock samples, with different approaches: i) Raman spectroscopy and InfraRed analyses, which has been considered excellent tools for the detection of inorganic and organic molecules, such as microbial pigments and ii) -omics approaches, as lipidomic and metabolomic techniques, performed to detect biological macromolecules and to determine their stability after space exposure. The focus of lipidomics and metabolomics has been on biomarker discovery, with the aim of identifying metabolites that are correlated with environmental exposures. The results suggest that microbial molecules can be detected through different techniques. In particular, our attention was focused on pigments, such as melanin and carotenoids that maintain their stability also after 1.5 years of space exposure. These results are of importance for the upcoming life-detection missions on Mars finalized for the search for past, extant or extinct life outside the Earth.