Life in polar impact-shocked rocks — an analog for micro-habitats at the Martian poles

Conference or Workshop Item

LIFE IN POLAR IMPACT-SHOCKED ROCKS – AN ANALOG FOR MICRO-HABITATS AT THE MARTIAN POLES.
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Introduction: We describe the colonization of shocked gneissic rocks from the Haughton impact structure in the Canadian High Arctic (75°N) [1] as a potential analog for habitats at the Martian poles for speculative indigenous life or contaminants that have already been transferred to Mars by vehicles such as the crashed Mars Polar Lander.

We have used 16s RNA sequencing and SEM to demonstrate the presence of a diverse heterotrophic community of microorganisms throughout the rocks, including spore-forming *Bacillus* spp., which are a known genus of microorganisms to be found on spacecraft surfaces [2]. The low nitrate and phosphate abundances in the polar desert and probably the low leaching rate of organics into the rocks mean that these communities are likely to be nutrient stressed and may spend most of their time in a dormant state. Many of these organisms phylogenetically match psychrophilic species, suggesting adaptation to low growth temperatures.

As well as heterotrophic components, the rocks are also colonized by photosynthetic organisms. Cyanobacteria of the genera *Chroococcidiopsis* and *Dermocapsa* inhabit the rocks as endolithic bands from the surface to a depth of ~5 mm where light levels are sufficient for photosynthesis [1].

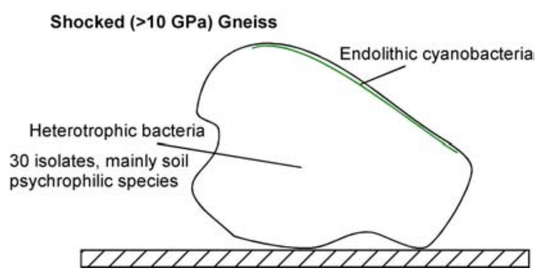

Figure 1. Impact shocked gneiss provides a habitat for a diversity of microorganisms adapted to survival in the terrestrial arctic.

The organisms grow as biofilms on the surfaces of impact fractures and are attached to the rocks in a polysaccharide matrix. The organisms probably enter the rocks after wind deposition onto the surface of the rocks and leach into the subsurface of the rocks with water that penetrates into the inter-connected microfractures. Both phototrophic and heterotrophic components derive their water from snow-melt and rain during the brief ~1.5 month growing season and remain frozen and dormant during the 24 hr darkness of polar winter when temperatures drop to -45°C. We have shown that water can be retained within the rocks for many days after a precipitation event or snow-melt.

During the 24 hr light of polar summer the organisms are protected from UV radiation by the overlying rock and they gain the advantage of thermal heating of the rock [3]. We have shown using sections of rock overlying monolayers of *Bacillus subtilis*, that 0.5mm of rock is sufficient to reduce microbial inactivation by one order of magnitude. The implications of this data are that under 1.5 mm of rock, the damage experienced by micro-organisms entrained into a similar microhabitat on Mars would be similar to that on the exposed surface of present-day Earth under the protection of the ozone column, demonstrating the effectiveness of the endolithic habitat as a refugium from Martian UV radiation.

Using thermisters embedded into the rocks, we found that at a depth of 1 mm the temperatures rose to 10°C higher than the air temperature [3]. Thus, the communities within the rock may experience substantially higher temperatures in the micro-climate than in the external macro-climate, consistent with observations of Antarctic endolithic communities [4].

The similar obliquity of Mars and Earth, and thus the requirement for any potential Martian polar life (indigenous or contaminant microorganisms) to be able to survive the dark Martian polar winter, makes the study of terrestrial polar microorganisms and their modes of survival of special interest as analogs to guide life detection strategies at the Martian poles. Because the Martian surface has a large number of impact craters, which compared to the Earth, are unsubducted and relatively uneroded, understanding the growth and survival of microorganisms within a polar impact structure can yield important insights into the ability of microorganisms to take advantage of impact habitats in the polar regions of Mars.

References: [1] Cockell, C.S., Lee, P., Osinski, G., Horneck, G., Broady, P. (2002). Meteoritics and Planetary Science, 37, 1287-1298. . [2] Fike, D., Cockell, C.S., Pearce, D., Lee, P. (2003). International Journal of Astrobiology, **1**, 311-323. [3] Cockell, C.S., McKay C.P., Omelon, C. (2003). International Journal of Astrobiology, 1, 305-310. [4] McKay, C.P. & Friedmann, E.I. (1985). *Polar Biology* **4**, 19-25.