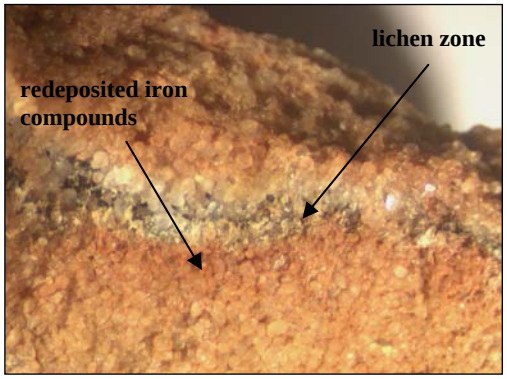
CRYPTOENDOLITH ALTERATION OF ANTARCTIC SANDSTONE SUBSTRATES: PIONEERS OR OPPORTUNISTS? R. L. Blackhurst[1], M. J. Genge[1], A. T. Kearsley[2] , and M. M. Grady[2], [1]IARC, Department of Earth Sciences and Engineering, Imperial College London, Exhibition Road, London, SW7 2AZ, U.K, (rebecca.blackhurst@imperial.ac.uk), [2]IARC, Department of Mineralogy, The Natural History Museum, Cromwell Road, London, SW7 5BD, U.K.

Introduction: Lichen dominated cryptoendolithic communities from the Dry Valleys of Antarctica have been the subject of much research over recent years owing to their potential as analogues of Martian life-forms. This is primarily owing to the stress tolerant nature of the microorganisms, remarkable adaptive achievements and the similarities between the Antarctic Dry Valley ecosystems and conditions pertaining at the Martian surface. Endolithic microbial communities have a photosynthetic primary producer, so translucent rocks through which sunlight can penetrate are their only suitable substrate. They also favour colonization of rocks which either have a porous structure or are weathered and permeated by fractures, as they are reported not to penetrate the substrate by solution [1]. The predominant rock-colonizing organisms are cryptoendolithic lichens [1]. They form conspicuous multi-coloured zones under the surface of the Beacon Sandstones. All zones are produced by filamentous fungi (mycobionts) and unicellular green algae (phycobionts), which together form a symbiotic lichen association.

Figure 1: Colonized Beacon Sandstone sample BP2 showing upper lichen zone. Field of view 2cm

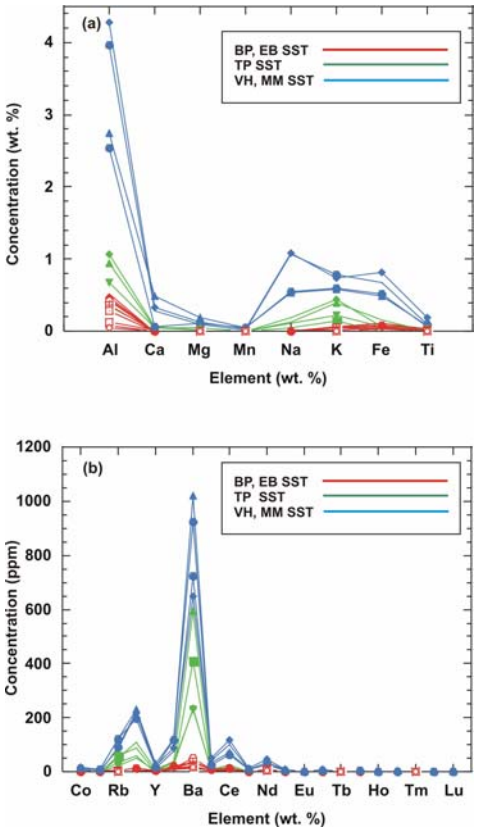


Cryptoendolithic lichens interact with the substrate they have colonized by producing oxalic acid [2]. They can mobilize iron compounds, which results in their inhabited zone being leached of iron-bearing minerals, causing the thin crust above this zone, and rock substrate a few millimetres below it, to appear darker owing to redeposition of iron at these levels, leaving a white zone in the rock [3] (fig.1). The oxalic acid also dissolves the cementing substance between the crystals in the colonized zone leading to exfoliation of the surface crust resulting in loss of biomass [3].

We have been investigating the possible effect these microbes have on the overall chemistry of the sandstones they inhabit. Our interest lies in whether these microbial communities can alter the chemistry of more hostile substrates to favour their survival. Aluminosilicates and silicates are easily degraded by fungi as silicate minerals are readily attacked by the oxalic acid they produce [4]. Though the communities have been reported not to penetrate the substrate by solubilization and favour colonization of rocks which have a pre-existing porous structure [1], they have the means for mineral dissolution and could therefore inhabit a less porous substrate and modify it to create more favourable conditions (a motive). The detection of elemental variations and the nature and extent of any elemental disparity could add value to the potential role of cryptoendolithic communities as suitable analogues of "Martian" microorganisms and as biomarkers when considering future *in situ* analysis of Martian surface materials and Mars sample return rocks.

Previous Work: Utilizing ICP-AES and ICP-MS techniques we conducted a major, minor and trace element study of a suite of colonized and uncolonized sandstones collected by a British Antarctic Survey expedition to Terra Nova Bay and the McMurdo Base during the Antarctic summer of 1995-1996 [5]. The results of this analysis have shown significant elemental disparity between sandstones that are colonized by the cryptoendolithic microorganisms and those that are not (Fig. 2a, b). Complimentary to the chemical study, electron microscopy was employed to determine accurate percentages of each mineral phase present in the different sandstones. To achieve this we mapped the major elemental composition of characteristic areas within each specimen. Phase map analysis showed significant disparity in mineral composition between the different samples and highlighted that the samples fall into three distinct categories in terms of mineralogical maturity; mature (colonized), intermediate (colonized), and immature (uncolonized). The chemical data also showed this trend in terms of elemental concentrations with the intermediate samples appearing to be the medial representatives of the specimens of sandstone (fig.2a, b).

Figure 2: Elemental concentrations in colonized sandstones (mature, red and intermediate, green) compared to uncolonized sandstones (immature, blue). (a) Major elements measured by ICP-AES; (b) minor element concentrations measured by ICP-MS.



The un-normalized major, minor and trace element data (Fig. 2) revealed sizeable differences in the concentrations of elements between colonized and uncolonized samples, and seem to indicate that the cryptoendolithic microorganisms had altered the chemistry of their host rocks. The intermediate samples have higher elemental concentrations compared to their colonized counterparts (Fig 2a, b); phase map analysis shows that these samples have different mineral abundances from the other colonized samples, lying in effect between these and the uncolonized samples. The results may indicate that the microorganisms undertake mineral weathering in order to change the substrate to one that is more favourable. The intermediate samples may represent a median stage of a biogenic weathering process, not yet having reached the mineralogical maturity of the other colonized sandstones when they were collected. But from this dataset, we cannot determine whether this depletion is secondary, i.e., the result of cryptoendolith action, or whether it is a primary feature of the different rock types. The significant elemental disparity between the mature colonized, intermediate colonized and immature uncolonized specimens may not simply be explained just by organism activity, and overall differences in mineralogy may provide a stronger argument. Chemical, rather than biological weathering may be the alteration process. These intermediate samples may have been at an earlier stage of this weathering process, but were still suitable for colonization, having the pore space required by the colonists. In order to take account of inherent differences in mineralogy between the rocks from different locations, further study will examine in greater detail the major elemental compositions of the individual layers in each sample.

Current Analysis: The prepared samples were all derived from close to the outer edge of each rock – rather than the unaltered interior. Thus a 'like with like' comparison within individual specimens was not possible. Several layers can make up these rocks, a siliceous crust, colonized upper lichen zone, a microalgal zone, a red layer formed of redeposited iron compounds and the deeper rock substrate, which is presumably unaltered. New maps of major elemental compositions are currently being created, but of different layers through the profile of the samples. This will allow comparison of differences in mineralogy between each layer in an individual sample. By comparing phase map analysis of colonized layers and uncolonized layers in the same sample and the chemistry of these individual layers, we may be able to ascertain whether the cryptoendoliths do interact further with their substrate.

Discussion: This further study on the cryptoendolith habitat may confirm whether chemical differences are a result of secondary alteration by endoliths 'digesting' the rocks, or are purely a reflection of primary differences in mineralogy of the sandstones. Are these microorganisms limited to colonization of rocks with pre-existing maturity, porosity and permeability or, as pioneers might the endoliths be able to infiltrate substrates that are not ideal but have adequate pore space, then once established they may be able to adopt a euendolithic role and alter the substrate to increase its habitability.

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