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Cryptoendolith communities in Antarctic dry valley region sandstones: Potential analogues of Martian life-forms

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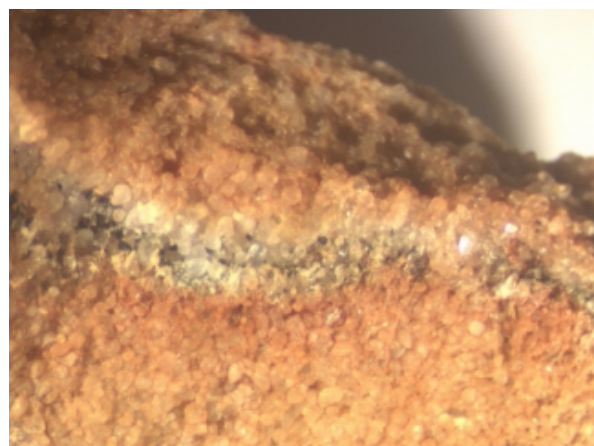
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CRYPTOENDOLITH COMMUNITIES IN ANTARCTIC DRY VALLEY REGION SANDSTONES: POTENTIAL ANALOGUES OF MARTIAN LIFE-FORMS. Rebecca L. Blackhurst¹, A. Verchovsky², K. Jarvis¹ and M. M. Grady³, ¹Dept. of Geological Sciences, Kingston University, Kingston, Surrey KT1 2EE, U.K. (K0019383@kingston.ac.uk), ²PSSRI, The Open University, Walton Hall, Milton Keynes MK7 6AA, U.K. ³Dept. of Mineralogy, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K. (mmg@nhm.ac.uk).

Introduction: Cryptoendolithic communities colonizing sandstones in 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. Interest in them stems from the similarities between the Antarctic cold desert ecosystems, representing some of the most extreme of terrestrial environmental habitats, and the conditions pertaining at the Martian surface [1]. Cryptoendolithic microbial communities occur in the interstitial spaces of certain translucent sandstones [2, 3] and extend down to 10mm below the rock surface (**Figure 1**). They primarily consist of symbiotic or free living lichen and cyanobacteria and their presence is identified by three coloured zones in the profile of the substratum: 1) black pigmented lichen; 2) white lichen, predominantly hyaline fungi; and, 3) microalgae (green algae and/or cyanobacteria) [4].

Figure 1: Cryptoendolithic community in sandstone from Battleship Promontory, Antarctica (sample BP2). Field of view: 2cm.



The stress tolerant nature of the microbes, particularly the cyanobacteria which possess a remarkable suite of survival mechanisms, has resulted in the suggestion that they might be the type of micro-organisms that could have flourished at the surface of an early Mars. Previous studies have included Fourier Transform Raman spectroscopy in the near infrared (1064nm), to characterize a variety of key pigments and biomolecules produced by the communities. Raman spectroscopy has thus been identified as a useful

tool that could be instrumental in detecting traces of past or present life in martian surface materials [1].

It is clear from the distinct coloured biotic zones that the endolithic communities change their host rock. We are, therefore, investigating the possible effect these microbes have on the chemistry of the sandstones they inhabit. Utilizing ICP-AES and ICP-MS techniques, we are undertaking a major, minor and trace element study of the different layers within the sandstones, to establish if, or how, these microbes influence or directly affect the chemical composition of the rocks. The chemical study is complemented by measurement of the abundance and stable isotopic composition of carbon in the different layers. If elemental or isotopic variations are detected, then the nature and extent of these effects could add value to the potential role of cryptoendolithic communities as biomarkers when considering future *in situ* analysis of Martian surface materials and Mars sample return rocks.

Samples and Field Setting: The cryptoendolithic habitat is widespread throughout the Devonian quartzite sandstone of the Beacon Supergroup extending from Victoria Land through the Transantarctic Mountains [4]. The rocky outcrops, snow cover and ambient temperatures of ca -25° C characterize the Dry Valley regions, with strong katabatic winds blowing off the Polar plateau; the relative humidity is 0% [5]. Several samples of cryptoendolithic communities were collected by a British Antarctic Survey expedition to Terra Nova Bay and the McMurdo Base during the Antarctic summer of 1995–1996 [5]. We have started the project by examining cryptoendolithic-bearing rocks collected from the Battleship Promontory (BP) region (76° 55'S 160° 55'E; altitude 1000m). They will be compared with non-endolithic sandstones collected from neighbouring regions.

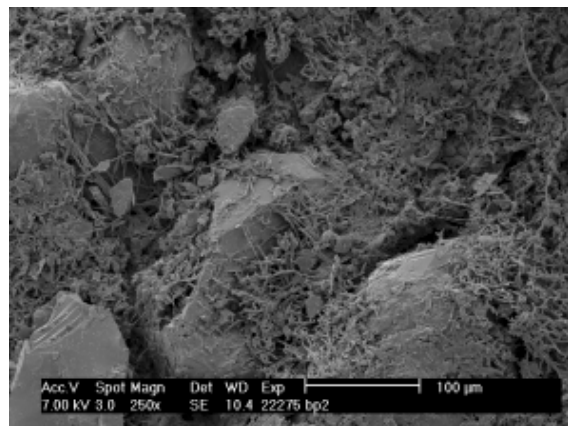
Sample Preparation and Analysis: A sample of BP sandstone, designated BP2, was broken into two pieces. One was mounted and polished for optical and electron microscope observations, whilst the second (**Figure 1**) was used for hand-picking grains for chemical and isotopic analysis.

Mineralogy: Petrographic study of the samples indicated uniform examples of quartzite sandstones. They are fairly homogenous and predominantly quartz dominated (90%) with plagioclase feldspar (6%) and some biotite mica (4%) identified. Samples in general

are moderately well sorted and range from fine to coarse sand.

Microscopy: Images and quantitative major and minor elemental analysis on carbon-coated probe mounts were obtained using a Jeol 5900LV SEM operating at 20kV and 1nA, with a working distance of 10mm. Small pieces of each of the main samples were selected and coated in Au/Pd for analysis with a Phillips XL30 SEM operating at 7kV with a working distance of 10mm. The Phillips XL30 scanning electron microscope was used to detect and identify the microbes in the samples. A thin white layer containing grains coated by a black pigment could be seen in sample BP2 with the naked eye (**Figure 1**). At magnifications as low as x250, fungal hyphae were identified (**Figure 2**). Filamentous and non-filamentous microbes densely populated this layer of the sample. The filamentous microbes clung to and in some cases completely encased many of the quartz grains. There were also non-filamentous microbes whose shapes, like flattened spheres, resembled blood cells. These were not as abundantly distributed throughout the layers as the filamentous microbes.

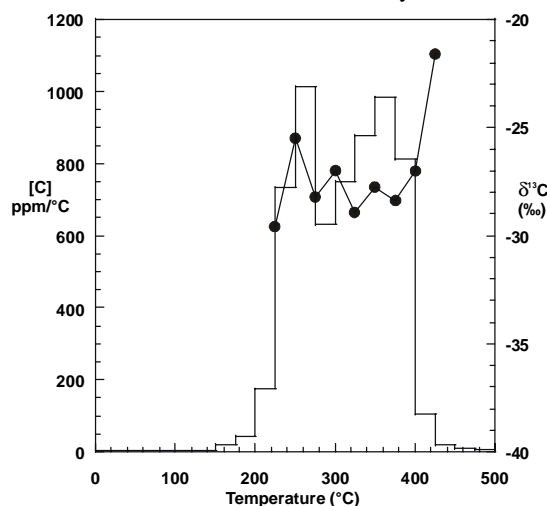
Figure 2: SEM image of filamentous microbes on quartz grains in BP2



Carbon isotope analysis: was undertaken by high resolution stepped combustion-mass spectrometry, using the recently refurbished MS-86 static vacuum system at the Open University. The main sandstone matrix of BP2 was analysed, as were several black grains picked from the dark layer of BP2. The red-coloured main sandstone was, essentially, carbon free, containing < 0.1 wt. % organic carbon. In contrast, the black grains consisted of ~ 15.2 wt. % carbon, with total $\delta^{13}\text{C}$ of -27.6‰. All of the carbon in the sample was organic in nature, and combusted below 400°C (**Figure 3**); there were no carbonates from terrestrial weathering, as is often the case in Antarctic rocks. The organic material was not a single component: the bi-

modal nature of the release, with maxima in yield at 275°C and 375°C, plus the variation in $\delta^{13}\text{C}$, indicate the complex nature of the organics.

Figure 3. Abundance (histogram, scaled on the LHS) and isotopic composition (circles, scaled on the RHS) of carbon released on combustion of 0.4 mg of the black layer from BP2. Errors in isotopic composition are smaller than the size of the symbol.



Implications: Cryptoendolith communities have emerged over the last few years as potentially important tracers for exobiological life detection. Similarities between the extremes of the Antarctic desert environment and conditions on the Martian surface have suggested that cryptoendoliths might be suitable analogues for past or present life on Mars. Most approaches to this comparison have characterized the biological signatures exhibited by the micro-organisms [e.g., 1]. We have started a search for elemental and isotopic effects produced by cryptoendoliths in a suite of quartzites from the Dry Valley region of Antarctica. If our investigation into the chemistry of the sandstones provides evidence that demonstrates a determinable influence by the microbes on the rock chemistry, then the value of these communities as biomarkers will be enhanced. Hence, using the behaviour, characteristics and influences of these terrestrial extremophiles, an important astrobiological profile may be compiled to be used as a guide for future exobiological research.

References: [1] Wynn-Williams D. D. and Edwards H. G. M. (2002) *Icarus*, 144, 486-503. [2] Friedmann E. I. (1982) *Science*, 215, 1045-1053. [3] Johnson C. G. and Vestal J. R. (1989) *Geomicrobiol. J.*, 7, 137-153. [4] Russell N. C. et al. (1998) *Antarctic Sci*, 10, 63-74. [5] Edwards H. G. M. et al. (1997) *J. Raman Spectrosc.*, 28, 685-690.