Simple devices for concentration of microbial life: Experiments in Haughton impact structure

Conference or Workshop Item

SIMPLE DEVICES FOR CONCENTRATION OF MICROBIAL LIFE: EXPERIMENTS IN HAUGHTON IMPACT STRUCTURE. J. Parnell[1], P. Lindgren[1], G.R. Osinski[2], C. S. Cockell[3], P. Lee[4], [1]Dept. of Geology & Petroleum Geology, University of Aberdeen, Aberdeen AB24 3UE, U.K., J.Parnell@abdn.ac.uk), [2]Canadian Space Agency, Saint-Hubert, Quebec J3Y 8Y9, Canada, [3]Open University, Milton Keynes MK6 7AA, U.K., [4]Mars Institute, SETI Institute, NASA Ames Research Center, Moffett Field, CA 94035-1000, U.S.A..

Introduction: The Detection of Microbial Life: If we are to find extant life on another planet, it is most likely to be extremely simple in nature, the equivalent of microbial life on Earth. Accordingly, strategies to detect extant life are focused on analyses for biological signatures in the soil zone. This was attempted in the Viking labeled release experiment on Mars, and more recently has involved development of a range of approaches including high-resolution mass spectrometry, Raman spectroscopy, and molecular probes [1]. These techniques follow an 'instant gratification' approach. We suggest that there is also a value in longer-term experiments, that attempt to concentrate microbial life before making an analysis. By concentrating any ambient microbes, the chance of detecting them will be greater. In some mission scenarios for Mars, deployment of a concentration mechanism for several months is quite feasible.

Encouraging Concentration of Microbial Life: The concentration of microbial life is most likely to be achieved by providing something that they want. This could include an energy source, chemical nutrients, or liquid water. Simple deployment of a nutrient plate might be enough, but has not been attempted. Provision of light energy and moisture could be achieved in a single simple device, using a pair of transparent plates sufficiently close together to allow water to be held between them due to capillary action. Light is a universal energy source, and photosynthesis is probably a widespread response [2], so using a device that provides light has a chance of attracting any microbial life available. Materials can be transparent to various wavelength ranges of light, so harmful ultra-violet irradiation can be excluded.

Experiments in Haughton Impact Structure: We trialled devices of this type in the Haughton Impact Structure, Canadian High Arctic. Pairs of sterilized glass microscope slides were deployed, bound by a paper clip (Fig. 1). A second clip is anchored in the soil and wedges the two slides apart at one end to allow formation of a water film. The insertion of single glass slides in soil is an established technique for sampling of microbial matter in the subsurface [3]. The slides deployed at Haughton were used in a novel manner to attract microbial matter by providing an environment offering high levels of sunlight. This was inspired by the natural colonization of transparent rocks [4] and minerals [5] in the crater by cyanobacteria, most specifically by *Gloeocapsa* [4].

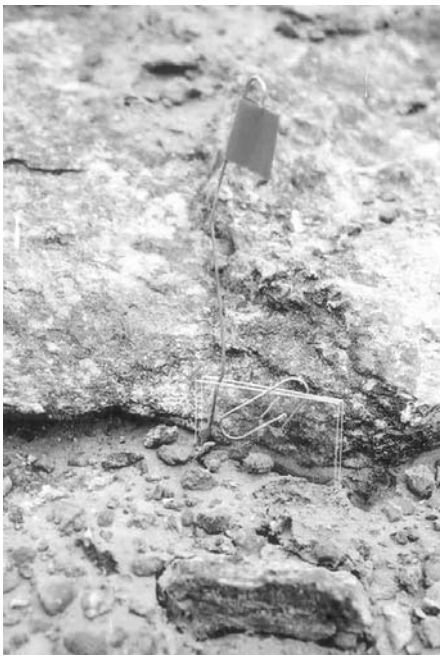

Fig. 1. Field deployment of glass slides bound with one clip and wedged apart with a second. Slides are inserted in soil or rock crevices.

Twelve pairs of glass slides were deployed in July-August 2004. Ten were anchored in soil with varying levels of moisture. The other two were inserted in crevices in bedrock. All were recovered in July 2005, although some glass had broken. For almost all of the intervening period, the slides were covered with snow/ice; one was still encased in ice when recovered. Many slides contained detrital mineral matter (dust), that was probably windblown, either directly onto the slides or more likely through percolating meltwaters. Seven of the slides contained black clots, visible to the naked eye (Fig. 2). Examination of the clots by scanning electron microscopy showed that they consist of cells, that are identical in appearance to those of *Gloeocapsa* studied in transparent gypsum [5]. Most significantly, the cells include numerous tetrads that indicate cell division (Fig. 3), i.e. the cyanobacteria are actively reproducing and colonizing the glass slides.

Some slides also show threads of organic material intermixed with the cells. The ends of the threads are attached to the surface, and appear to be for fixative purposes.

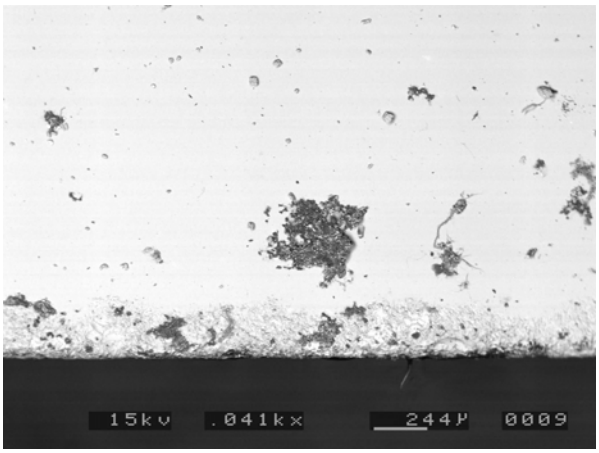

Fig. 2. Sub-millimetre clots of black matter on glass microscope slide after deployment in soil, Haughton Impact Structure. Note thread to right of large clot.

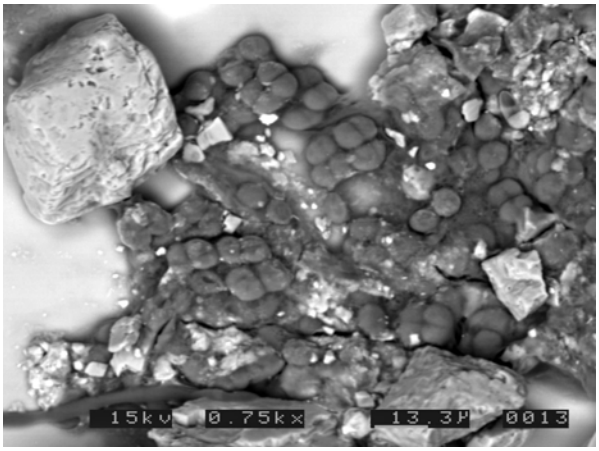

Fig. 3. Close-up of cells on glass slide, showing tetrad morphology due to *in situ* reproduction. Mineral matter (bright) consists of detrital dolomite rhombs.

Discussion: The ready colonization of glass slides should not be a surprise, as biofouling of glass surfaces is a serious problem in several environments [6]. The photosynthetic growth season at Haughton cannot be long, due to snow/ice cover and Arctic winter darkness, but nevertheless the colonization had occurred within a single season. The slides themselves may enhance colonization by providing a convenient exposed surface. The threads attached to the surface may be comparable with extracellular polymeric tendrils observed to help bacteria attach to surfaces [7,8]. Biofilms commonly consist of a mixture of cells and extracellular polymeric matrix [8]. An advantage of the polymeric matrix is that it is highly hydrated, and inhibits desiccation [8]. Microbes can be repelled by glass, but cations in the groundwaters can help to overcome this [9,10]: The Haughton groundwaters contain elevated levels of magnesium and several other cations [11].

Adaptation of Experiments: Several adaptations could be made to experiments, while keeping them simple. Further devices were deployed in July 2005 using polycarbonate with enclosed tubes (offcuts from Canadian Space Agency greenhouse). These will be sampled in summer 2006, but showed substantial condensation of moisture inside the tubes within 24 hours, that may be beneficial to colonization. On Mars, where surface water is limited but fogs and fosting do occur [12], or on similar bodies, the promotion of condensation could be very helpful. Potential nutrients could also be incorporated, as microbes preferentially colonize surfaces that offer nutrients [9]. Devices could be constructed in a spherular or cuboid format for ease of storage and remote deployment. They could also be electronically tagged for relocation. A more sophisticated adaptation would register the incorporation of biomass onto a device.

Conclusion: Simple devices that create environments with high levels of light and moisture could attract any extant microbial life on a planetary surface and hence enhance the possibility of detecting it. Our experience at Haughton shows that such colonization can occur readily.

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