IMAGING OF THE BIOLOGICAL CONTAMINATION OF METEORITES: A PRACTICAL ASSESSMENT. A. Steele[†], F. Westall[†], D.T. Goddard[!], D. Stapleton[*], J.K.W. Toporski[*], D.S. McKay[†].† Mail code SN. NASA, Lyndon. B. Johnson Space Center, Houston. Texas, 77058, USA. * Department of Geology, University Of Portsmouth, Portsmouth. PO1 2DT. UK. ! BNFL,, Springfields Site, Preston.UK. andrew.steele@easyney.co.uk

During our investigation we have now imaged fresh fracture surfaces in four Antarctic chondrites, Murchison, Nakhla, and ALH84001. These samples represent the two main types of meteorite find sites, ice fields and deserts. On all but two of the Antarctic chondrites we have detected terrestrial fungi and bacteria (1-4). Frequently throughout the history of meteoritics, contamination has been a serious problem. However, the ice field meteorites were considered to be in a near-natural state. Only since McKay et al (1996) have more detailed investigations of the possible sources of contamination in the Antarctic become important and been undertaken (5). In the particular case of ALH84001, a terrestrial organism went undetected by all the techniques that claim to be able to detect life. Why then had it taken so long to classify the actual sources of contamination on these meteorites?. There are several answers summarised as follows:

- Little impetus for the research;
- Ignorance of the diversity of Antarctic microbes.
- Little research on how some meteorites became contaminated;
- Near-exclusive use of thin sections;
- Imaging parameters
- Heterogeneity.

Their was little impetus for the research

It was only with the debate on life on ALH84001 that the issue of contamination from Antarctica came out of a backroom and was given serious thought, mostly by researchers seeking to discredit the work of McKay et al. (1996).

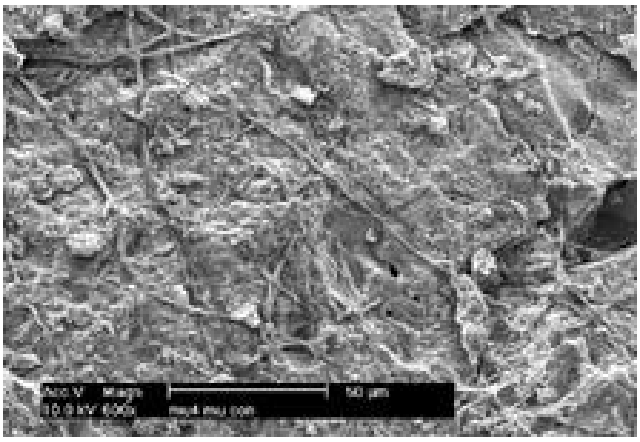
Ignorance of the diversity of Antarctic microbes.

It is only within the last 15 years that serious studies on the nature of Antarctic microbiota have been undertaken. Before this Antarctica was seen as a pristine wilderness. Almost every major common microbial species has found a foothold in Antarctica, including bacteria fungi, algae cyanophyta and lichens.

Little systematic research was conducted to follow up the reasons why some meteorites were contaminated.

The death of a meteorite for organic analysis, is to whisper 'contamination'. Upon the mention of the word the meteorite is discarded. The mechanisms and reasons for the contamination have therefore been slow to emerge. Storage methods of samples may be critical. Figure 1. Shows a chip of Murchison meteorite that when initially imaged 12 years earlier had no sign of contamination. From that time it has been kept within a sealed container. Very little research has been conducted on the contamination of meteorites in storage.

Figure 1. A sample of Murchison meteorite showing extensive Fungal contamination. (Bar - 50μM)



The use of thin sections

Most of the techniques for studying meteorites are based within the experiences gained through terrestrial geology. However the use of thin sections makes the detection of organisms in cracks extremely difficult if not impossible. It only the increased use of SEM of whole chip surfaces which has allowed the finding of these organisms.

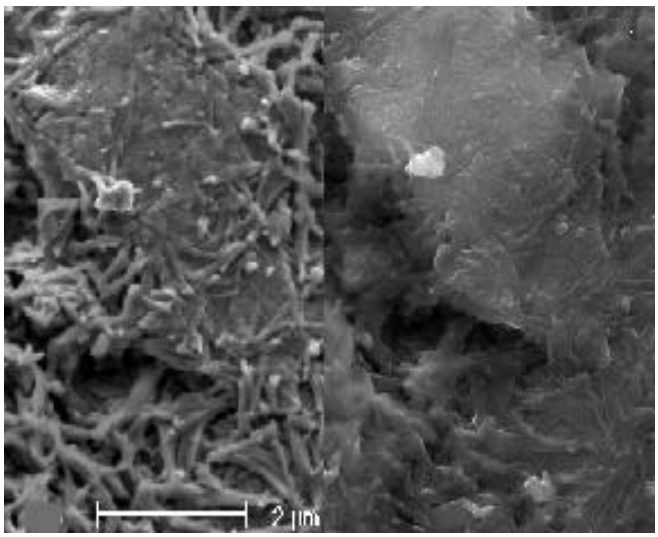
Imaging parameters

Figure 2 shows the same area of ALH84001 covered with a suspected bacterial contaminant (2). Image (A) is taken at 3 kV and the contaminating organism is clearly visualised. However, in image (B) taken at 15 kV the organism is reduced to the level of indistinct –marks on the surface that could appear as interesting mineral phases or missed by lower resolution microscopes than the Philips XL40S Field emission SEM that was used to take these images. Therefore low kV imaging is recommended. Furthermore biological materials require specialised sample preparation to ensure the preservation of cellular structure during SEM. Although none of the samples shown to be contaminated so far (except Murchison) received this preparation, in each case less hardy structures than those observed may have been destroyed. A further compromise would be the use of field emission environmental electron microscopes.

Heterogeneity

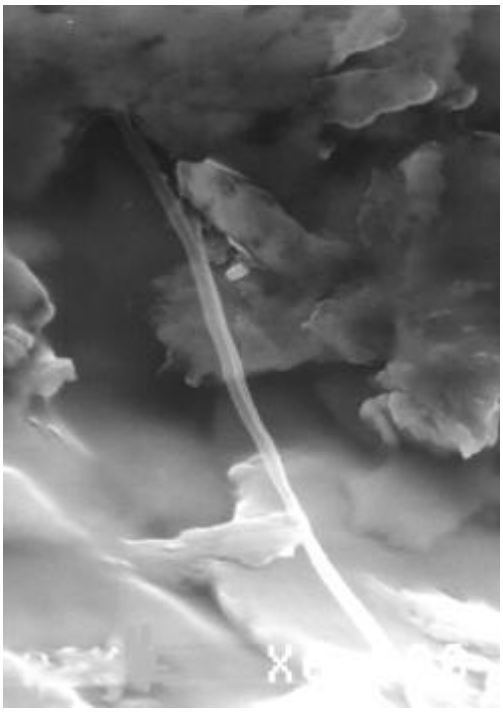
The one overriding predictable factor in the colonisation of any substrate by microorganisms is the seeming random nature of attachment (6). Therefore prior knowledge of the contamination of a particular sample is almost impossible. Image 3 shows a fungal hyphae from the centre of the Nakhla meteorite, which probably infiltrated through cracks little bigger than its own 1 μm diameter (The terminus of the organism is beyond the bottom of the image). However, for each chip of meteorite found with contamination on there are several which do not show signs of any colonisation. The solution to this is the development of a rapid screening mechanism to ensure that the samples are clear of contamination before any experimentation begins. This would be particularly advisable when using techniques that rely on the bulk isolation of material from whole chips. It is the contention that terrestrial contamination would have a negative C^{13} value. However if the organic chemicals within the meteorite were already at a negative value than interpretation of these results would be masked by the rational that it therefore must be terrestrial. It is a catch 22 situation with no seeming way out. The only answer at the moment lies in treating contaminated meteorites as a tool to observe and characterise the effects of biological activity on extraterrestrial materials. This would allow the skills which are needed to unravel the question of extraterrestrial microbial life to be honed.

Figure 2. Bacterial contaminant of ALH84001. A) 3 kV, B) 15kV.



(A) **(B)**

Figure 3. SEM image of a suspected fungal hyphae emerging from a mineral face on the Nakhla meteorite. (x6600, Hyphal diameter = @ 1 μM)



References

1. Steele, A. et al., (1998). Abstracts of the 61st Meteoritical society meeting, Dublin.
2. Steele, A. et al., (1999). Abstracts of 30th LPSC. Imaging of an unknown organism on ALH84001.
3. Steele, A. et al., (1999). Abstracts of 30th LPSC. Contamination of Murchison Meteorite.
4. Toporski J. et al., (1999). Abstracts of the 30th LPSC. Contamination of the Nakhla meteorite.
5. McKay et al. (1996). *Science*. **273**. 924 – 930.
6. Steele, A. (1996) PhD. University of Portsmouth UK.

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