SEM IMAGING OF MARTIAN AND LUNAR METEORITES AND IMPLICATIONS FOR MICROFOSSILS IN MARTIAN METEORITES. Derek W. G. Sears† and Timothy A. Kral‡. †Department of Chemistry and Biochemistry and ‡Department of Biological Sciences, University of Arkansas, Fayetteville, Arkansas 72701.

Five lunar meteorites and the martian meteorite ALH 84001 have been examined under the SEM using the equipment and procedures of McKay et al.. Submicrometer ovoids and elongated forms on the surfaces of ALH 84001 were thought by McKay et al. to be ancient microfossils. Although in smaller numbers, we have found similar structures on lunar meteorites. Since the lunar surface is currently the most sterile environment known, and probably always has been, we suggest that the objects described by McKay et al. may not be of biological origin on Mars.

One line of evidence recently used by McKay et al. to argue for ancient biological activity on Mars was the presence in martian meteorite ALH 84001 of objects whose morphology resembles that of terrestrial nanobacteria (1). Nanobacteria are controversial objects with similar morphology to bacteria but are an order of magnitude smaller (2). Since the objects are so small, and the meteorites in question are finds with very large terrestrial ages, there is a question as to whether the proposed microfossils are biological, related to mineral grains in the meteorite, the result of terrestrial weathering or laboratory (e.g. coating) artifacts. To help resolve this question, we examined surfaces of several lunar meteorites and ALH 84001. Our argument is that the moon, with its lack of water, lack of an atmosphere, extreme temperature range and hostile radiation environment, is currently a sterile environment. There is no evidence that it was ever suitable for life. If the lunar meteorites contain objects similar to those in ALH 84001, then it is highly unlikely that the objects seen in the martian meteorite were biological in origin. On the other hand, the lunar and martian meteorites have experienced virtually identical terrestrial histories.

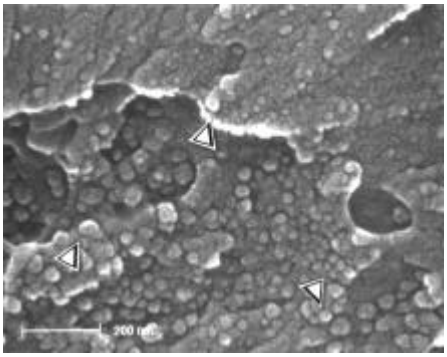
We examined the original and fracture surfaces of five lunar meteorites and the ALH 84001 martian meteorite. ALH 81005 is an anorthositic highland breccia (3) with a terrestrial age of 18.3±3 ka (4) and A/B weathering category (5). MAC 88104 and MAC 88105 are paired anorthositic highland breccias (3) with a terrestrial age of 42.3 ka (4) and an A/Be weathering category (5). QUE 93069 is an anorthositic breccia (3) with a terrestrial age of 5-11 ka (6) and weathering category of A/B (5). Our final lunar meteorite, QUE 94281, is a basalt-rich breccia (3) whose terrestrial age has not been determined and is weathering category Be (5). Martian meteorite ALH 84001 is a coarse-grained orthopyoxenite (7) with a 13 ka terrestrial age (8) and A/B weathering category (5). We used the same SEM and the same procedures as those of McKay et al.

Submicrometer-sized objects were found on many surfaces. Some objects were clearly lying on the surface of the meteorite, some apparently grew out of the surface, while some were located on highly textured surfaces and their relationship to the surface was unclear. We sorted the images into the following morphological classes; areas containing elongated objects, areas containing spheres or approximately spherical objects, areas containing both of these objects and two areas containing long thin strings of material, i.e. “snake-like” features. The martian meteorite contained many ~100 nm long elongated forms, while most of the objects on the lunar samples were ~20 nm approximately spherical (or ovoid) forms, but both forms were found on both

types of meteorite. Examples of the near-spherical forms in the lunar meteorites (Fig. 1a) and ALH 84001 according to McKay et al. (Fig. 2a) are shown below. Sometimes they were located on a heavily textured surface into which the objects appeared to merge, perhaps being a part of it. Often the elongated forms appeared to be segmented.

Examples of the elongated forms in the lunar meteorites (Fig. 1b) and ALH 84001 according to McKay et al. (Fig. 2b) are also shown below. These objects were found in small numbers on lunar meteorites QUE 94281 and ALH 85001, and in large numbers on several faces of ALH 84001. They were either lying on the surface as clearly separate entities or lying long grain or crystal faces with a hint that they were being generated at the edges of crystal faces. These are the elongated forms shown by McKay et al.

We have not attempted to identify the true nature of all the objects we found, although some are clearly the result of processes occurring at the edges of crystals, some are coating artifacts and some are probably surface contaminants. Rather our objective is to point out that original and fracture faces of lunar meteorites, when examined in the same manner as the ALH 84001, contain objects with the same dimensions and structures as those reported by McKay et al., albeit in smaller numbers. Since the lunar meteorites came from the most sterile environment known but have shared the same Antarctic and laboratory history as ALH 84001, we argue that the objects described by McKay et al. may not be due to ancient biological activity on Mars.



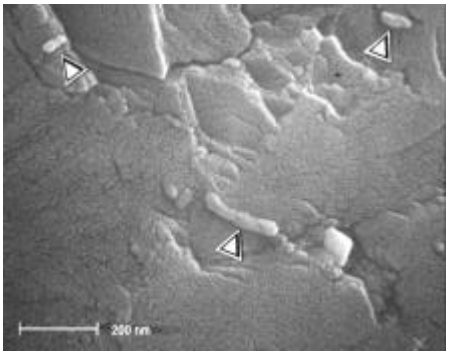


Fig. 1A. (Far left) Ovoid objects on lunar meteorite QUE93069.

Fig. 1B. (Near left). Elongated objects on lunar meteorite QUE 94281.

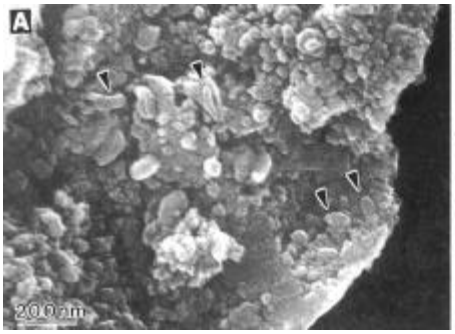


Fig. 2A. (Far left) Ovoid objects on martian meteorite ALH 84001 (from ref 1).

Fig. 2B. (Near left) Elongated objects on martian meteorite ALH 84001 (from ref 1).

(Scale bars on all figures are 200 nm).

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