WHAT DO FOSSIL BACTERIA LOOK LIKE? EXAMPLES OF 3.5 BILLION-YEAR OLD MINERAL BACTERIA AND THE SEARCH FOR EVIDENCE OF LIFE IN EXTRATERRESTRIAL ROCKS. F. Westall, M. J. de Wit, J. Dann, University of Bologna, Diproval, Via San Giacomo 7, Bologna 40126, Italy.

The recent debate about the evidence of life in Martian meteorite ALH84001 has highlighted the problem of what fossil bacteria actually look like and the interpretation of bacteriomorph structures. Fossil bacteria in terrestrial rocks, especially those from the Archean (>2 billion-years) can act as a guide in the search for cellular fossils in extraterrestrial rocks.

The identification of bacterial fossils in ancient terrestrial rocks has also been beset by controversy and difficulty. In 30 years of investigation of organic-walled, filamentous and spheroid structures, only a few of the many described have finally been accepted as probable bacterial fossils (1,2). Furthermore, experiments to fossilise bacteria, as well as studies of bacterial fossils in younger rocks (<65 million-years) have shown that fossil bacteria are <u>not</u> organic-walled but are, instead, <u>mineral</u> (as in any other dinosaur, shell or fish etc. fossil) (3-8).

What should we be looking for? What are the characteristics of bacteria (both modern and fossil)? Two very important characteristics are size and shape, and distribution. Although there is some variability in the size of modern bacteria, the vast majority have dimensions of about 1 µm. (There has been much discussion of "nannobacteria", especially with respect to structures observed in the Martian meteorite ALH84001. There is biological evidence for nannobacteria (0.1-0.3 µm) in extreme, starvation situations, but none for a mass of nannobacteria under equilibrium circumstances). Bacteria are mostly spherical (coccoid) or rod-shaped (bacillus), but some are curved or spiral. Experimental fossilisations and studies of younger fossils demonstrated that fossil bacteria can appear as hollow or filled mineral crusts, or as moulds (a hollow left in the rock, having the size and shape of a bacterium, after the disappearance of the organism). Generally no organic matter is associated with the bacterial fossils. Thus, bacterial fossils have the same size and shape as the original organisms. Bacteria are seldom found isolated and generally occur in colonies of limited distribution. Thus, fossil bacteria are also seen in clusters.

A recent investigation of Early Archean (3.5-3.3 Ga), terrestrial rocks from South Africa (Barberton Greenstone Belt) has brought to light the oldest mineral bacterial fossils so far discovered (9). The rocks from the surface of the early Earth consist of sediments derived from volcanic material and sediments precipitated chemically from solutions emanating from hydrothermal vents on the seafloor or from evaporites in shallow seas/pools (10). At the same time as the sediments were being depositied, hydrothermal fluids rich in silica filtered through them, altering all the minerals (including the fossil bacteria) chemically to silica, but faithfully reproducing their structures. Thus, associated with the bacterial fossils we find perfectly preserved halite, calcite, pyrite and tourmaline crystals, now pure silica. It has been known for some time that these processes have replaced other rock structures with minute details preserved (e.g. spinifex textures) (10).

The bacterial fossils in these silicified sediments are now embedded in quartz crystals. They range from about 0.65-1 µm in size and have a short, rod-shaped morphology. The fossils occur in clusters and, within each cluster,they all have the same size and morphology. Bacterial mats with bacterial fossils embedded in them have also been preserved. The mats display a ropy structure, showing that they were once soft, organic material. These fossil bacteria and bacterial mats are remarkably <u>similar to modern organisms and mats</u>.

The terrestrial Early Archean (>3.0 billion years) fossils could be used as pointers to identify possible bacteria in extraterrestrial rocks. If we are looking for fossil <u>bacteria</u> in rocks from Mars, for example, they might be expected to be similar to terrestrial <u>bacteria</u>, displaying similat sizes, shapes and distributions. Furthermore, given the fact that the original organic matter making up the organism is not preserved as such, we should be looking for <u>mineral</u> fossils.

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