Holes in the evidence or evidence in the holes?

Nicola McLoughlin explains how microscopic tubes in ancient rock may provide the earliest evidence for life on Earth.

The author examining microbial mats at an iron rich hot spring site the 'paint pots' in the Canadian Rockies 2004.

Microbes that live in rocks are called endoliths. They can survive in extremely inhospitable conditions, such as Antarctic dry valleys, meteorite impact craters, and perhaps even lived below the surface of early Earth. Some endoliths live in natural rock cavities. Others munch their way through rocks, leaving behind them a network of tubular holes or microborings – rather like wood-worm in your best furniture. Many fungi, algae and cyanobacteria adopt this mode of life and produce microtubular cavities or 'swiss cheese' textures in rocks, shells and bones. Scientists recently discovered that such rock-eating microbes even inhabit volcanic lavas formed on the deep, dark ocean floor. Here they create twisted and coiled microborings many times their body length. We don't yet fully understand how these endolithic organisms make their living, but presume they get shelter and perhaps nutrients from the rock. Researchers have recently suggested that microscopic tubes in 3.5 billion-year-old lavas from South Africa could be the oldest fossil remains of life. The team I work with have been investigating how such claims can be tested, by examining microtubes in similar-aged rocks from Australia.

These rocks come from the hot, arid Pilbara region of North West Australia. This gold mining district contains some of the world's oldest rocks. We found microtubes in a silica-rich rock, or chert, that formed on an ancient wave-washed beach almost three and a half billion years ago. The challenge back in the lab was to establish how old the microtubes are, and whether or not they were made by microbes. The tubes are over 40 micrometres long, but only eight wide (around a tenth of the width of a human hair), so all our investigations relied on microscopes.

The microtubes can't be older than the rock, and that is a maximum of 3.48 billion years old. This age is calculated by radiometric analysis, which uses the constant 'clock work' decay of lead isotopes in zircon crystals within the rock. But microbes may have eaten into the rock well after it formed, and so the microtubes could be much younger. To test this, we examined thin sections or slices of the rock, to look at how minerals grew, and how this relates to the microtubes' distribution. Our work so far suggests that the tubes occur in the earliest phases of mineral growth, ie when the rock was

> We found microtubes in a rock that formed on an ancient wave-washed beach three and a half billion years ago.

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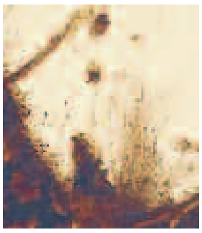
Fossil Fact File

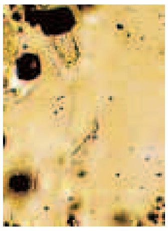
Fossil Fact: microbial microborings

The microscopic tubes in the margins of this volcanic glass fragment of an underwater lava from the south-west Pacific were probably produced by rock-munching microbes.



Fossil Frauds: Apex chert microfossils

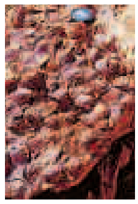
Segmented carbon filaments from the c.3.465 billion year old Apex chert of Western Australia were once interpreted as fossil microbes. Our team in Oxford showed they were non-biological graphite artefacts that formed along the edges of silica crystals in a volcanic rock.



Fossil Fakes: ambient inclusion trails

A hollow microtube created when an iron sulphide (pyrite or fools gold) crystal moved under high fluid pressures through rock. This tube wasn't made by microbes.

Fossil Fiction: Stromatolites?



Stromatolites are finely layered rock mounds that may have required a 'sticky' microbial mat to form. But this 3.4 billion year old example from Western Australia contains no decayed organic remains, and inconclusive geochemical signatures. Instead, non-biological crystal growth may explain its shape.

deposited, or first buried.

But did microbes make the microtubes? They are at least the right size. The average width of the tubes fits many known microbes. Unfortunately, these soft-bodied micro-organisms decay rapidly and are only preserved in rocks under exceptional conditions. It is highly unlikely that we will find microbes in our microtubes or other very ancient examples, but this does not mean that life was never there and hasn't left behind more subtle clues.

> Many microbes produce microtubular cavities or 'swiss cheese' textures in rocks, shells and bones.

So is it possible that microbes weren't involved? When crystals in a rock move under high gas or liquid pressure, they can leave behind tubular cavities called ambient inclusion trails. The heating and squashing involved when metamorphic rocks form can be enough, and there are many examples known in cherts. Alternatively, ambient inclusion trails may have biological origins, created by 'biogenic burps' – decaying organic remains can generate sufficient gas pressures to move mineral grains. Some, but not all, of our microtubes do seem to be ambient inclusion trails, as they have terminal crystals that match the tube diameters. Some are radially arranged in starburst patterns, perhaps around centres of decaying organic remains.

We're now analysing the material within and around the microtubes for further clues about their origin. For example, if microtubes are produced by endoliths seeking nutrients, or perhaps trace metals from the rock, levels of these should be lower around them. Alternatively, if they are 'biogenic burps', we might hope to find concentrated levels of decayed organic matter and carbon at the centre of the starburst patterns. Making these measurments is a real challenge, given the very small size of the microtubes. But by using a state-of-the-art secondary ion mass spectrometer that can take samples a few nanometres apart (billionths of a metre), we have obtained exciting preliminary results. Carbon lines some of the tubes, and this may be decayed microbial remains. Next, we'll look for carbon isotope variations that suggest life. We may also have found the world's oldest phosphates infilling some of the tubes, and as phosphorous plays an important role in biological systems, we are analysing these in detail.

Our research shows up the potential holes, or uncertainties, in claims that rock-munching microbes were the earliest organisms on our planet. But by chewing the evidence over more, we hope to develop endolithic microborings as a new tool in the search for early life on Earth, and perhaps beyond.