Enigmatic fossils are neither animals nor bacteria

Scanning techniques reveal detailed cell structure of debated relics.

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22 December 2011

The unusually complex appearance of a group of 570-million-year-old fossils from Doushantuo, China, has sparked debate among palaeontologists. Researchers haven't been able to decide whether the remains come from animals, bacteria or close relatives of animals that thrived at the dawn of animal evolution. But a team has now used three-dimensional scanning techniques to take a closer look at the fossils — and has decided that in fact, they are none of these.

The Doushantuo fossils look like partitioned sand grains. The partitions resemble animal-cell cleavage and this, as well as structures in the fossils that look like cell nuclei, has led palaeontologists to interpret the fossils as dividing embryos of very early animals. But others argued that they were instead the fossils of *Thiomargarita* — giant sulphur-oxidising bacteria that still exist, can grow to nearly one millimetre in diameter and sometimes look like the cells of other organisms in the fossil record.

Keen to settle the matter, a group led by Philip Donoghue, a palaeontologist at the University of Bristol, UK, and Stefan Bengtson, a palaeontologist at the Swedish Museum of Natural History in Stockholm, used X-ray microscopic tomography to produce three-dimensional images of the interiors of the fossils. The team describes its work in two papers, published in *Science*[1] today and the *Proceedings of the Royal Society B*[2] last week.

Of the 450 fossils scanned, 14 were found to contain structures that look like nuclei. In one of these specimens, three of the eight structures even have the elongated or dumb-bell shape of modern nuclei about to replicate. This hints that the organism died during cellular division.

“We were enthralled to find nuclear division preserved by fossilization. It confirmed that the fossil organisms were not bacteria, but we soon realized that they were not like animals either, as animal nuclei tend to lose their contours during cell division, and these nuclei did not,” says Bengtson.

Swedish Museum of Natural History

X-ray microtomography reveals the shape of the 'cell nuclei' (yellow) in a computer model of a fossil from Doushantuo in China, shown against the backdrop of the rock in which it is found.

Animal, vegetable or mineral?

When the researchers took a closer look, they noticed that specimens which seemed to be in later stages of development contained hundreds of thousands of tiny cells, and that the outer envelopes of these specimens had partly burst open. On the basis of this observation, Donoghue and Bengtson suggest that the creatures are similar to modern mesomycetozoeans, single-celled microorganisms that are neither animals nor bacteria.

Mesomycetozoeans reproduce by creating thousands of spore cells inside a protective envelope that bursts when it is time for them to spread into the environment. Once these cells settle, they create a new envelope and begin replicating again. The idea that the Doushantuo fossils might be similar is causing a commotion in the scientific community.

“A lot of mesomycetozoeans start with a single large cell and then divide like this inside a thick cell wall, so the idea being suggested here is not a bad one. With that said, there are other organisms, like some fungi, that behave in a very similar way. For all we know these could be fungal fossils,” says Iñaki Ruiz-Trillo, a biologist at the Institute of Evolutionary Biology in Barcelona, Spain.

Nicholas Butterfield, a palaeobiologist at the University of Cambridge, UK, agrees with that there are other options. “It is premature to dismiss the possibility that these are developing multicellular organisms. There are intriguing similarities between features of these fossils and the green algae *Volvox*, which are multicellular, albeit of a much simpler type of multicellularity than that found in animals,”

he says.

But there are some who think that the palaeontological community is still a long way from a final verdict. “What isn't widely appreciated is that the Doushantuo rock formation contains billions of microfossils, many of which have no traits that are diagnostic of any living group and contain features that are not of biological origin,” says Jake Bailey, a geobiologist at the University of Minnesota in Minneapolis. “We are still far from understanding the origins of these enigmatic microfossils.”

Nature | doi:10.1038/nature.2011.9714

References

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2. Cunningham, J. A. *et al*. *Proc. R. Soc. B* http://dx.doi.org/10.1098/rspb.2011.2064 (2011).