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Ancient Creature Fossilized By The Bacteria That Ate It

ScienceDaily (Nov. 18, 2004) — DENVER -- High in the mountains of Antarctica, Ohio State University geologists unearthed the fossil remains of a 180-million-year-old clam-like creature that was preserved in a very unusual way: by the ancient bacteria that devoured it.

And only yards away, they found the first fossil evidence of a completely different kind of bacteria that scientists were unsure even existed as fossils that long ago.

The first find answers one of the most fundamental questions in paleontology -- why some creatures fossilize even though they lack the mineral-rich bones, teeth, or shells that are normally required for the process.

The second find corroborates other evidence that a particular type of bacteria has a very ancient history on Earth.

Loren Babcock, professor of geological sciences at Ohio State, and his colleagues used a scanning electron microscope to examine fossils of tiny arthropods they collected from Antarctica, and discovered that the arthropod fossils were actually composed of clumps of even tinier bacteria fossils.

The scientists suspect that the bacteria feasted on the dead arthropods, then absorbed minerals from their surroundings and turned to quartz, preserving perfectly the shape and texture of the arthropods.

"In essence, the bacteria self-fossilized, and replicated the body of the animal," Babcock said.

They also examined limestone deposits they found nearby, and identified fossils of a different kind of bacteria called archaebacteria. Genetic studies of modern archaebacteria have suggested that this group has existed for billions of years. But fossil remains of archaebacteria have rarely been found, and never been found as fossils in Antarctica, until now.

The geologists presented their results Wednesday at the Geological Society of America meeting in Denver.

Babcock's longtime goal has been to understand a phenomenon called "exceptional preservation," in which soft creatures such as insects and other arthropods -- which normally cannot fossilize -- are somehow preserved. Now he's re-examining other unusual fossils and finding that ancient bacteria were responsible for those cases as well.

"Now it seems almost every situation of exceptional preservation tells the same story," he said.

The story begins 180 million years ago, when lava flows and hot bubbling pools made parts of Antarctica resemble Yellowstone National Park more than the frozen wasteland it is today.

Thermal vents heated some of the water pools to temperatures near boiling -- as high as 80 degrees Celsius (176 degrees Fahrenheit) or more. Only the archaebacteria, which fed on sulfur in the water, survived in that environment.

Nearby, in pools that cooled to 20-30 degrees Celsius (68-86 degrees Fahrenheit) -- temperatures somewhere between a good swim at the beach and bathwater -- lived the arthropod, along with bacteria that were similar to normal eubacteria living today.

Babcock and his team have identified the arthropod as Lioestheria disgregaris, and it appears to have been a bivalved arthropod similar in shape to modern clams. Its shell was made of chitin, a soft, fingernail-like substance that should have disintegrated after the creature died, long before it could fossilize.

But the arthropod had no predators, so when it died of natural causes, the eubacteria decomposed it, forming a gooey coating that reproduced even the tiniest features of the shell. When the bacteria died, their bodies absorbed minerals from the muddy water and turned to quartz.

Later, a volcanic eruption produced lava flows that covered the pools with a layer of basaltic rock. The pools weren't completely obliterated by the overflowing lava, but rather were sealed in pockets that preserved the chemistry in these isolated locations.

Today, only a few sites around the world offer fossils of insects and other soft creatures, and Babcock said that they all share two characteristics: in their time, the creatures had few if any predators to eat them, so their bodies remained intact after death; and some extreme events or special chemistries at the sites enabled the soft shells to change to rock.

With that in mind, he and his colleagues ventured to the Kirkpatrick Basalt in Antarctica in late 2003, betting that conditions there long ago were right for exceptional preservation.

"We didn't really know what to expect," Babcock said. "What we found was the weirdest limestone I've ever seen."

At a mountain site called Carapace Nunatak, about 100 miles from McMurdo Station, they came to a cliff face which had thrust out of the ground, exposing layers of brown volcanic rock with a bold ribbon of tan limestone snaking in-between.

Though the scientists could see arthropod fossils exposed in the rock as they gathered their samples, it wasn't until they returned to Ohio and put the limestone under a scanning electron microscope (SEM) that they saw the fossilized eubacteria. The bacteria look like millions of tiny spheres forming the shape of the arthropod.

When he saw the SEM images, Babcock immediately thought of another experiment in his lab. One of his students, for his thesis project, observed how a dead horseshoe crab decomposes in a water tank. As the horseshoe crab rots, a slimy film of bacteria and fungi forms around it.

Babcock put some of the slime under the SEM, and the arrangement of the modern bacteria looked nearly identical to the fossilized bacteria.

The Ohio State scientists got another surprise when they looked at the limestone under the SEM -- and saw fossilized archaebacteria. Scientists have found living archaebacteria only in very extreme conditions, such as surrounding hot hydrothermal vents at the ocean bottom.

The bacteria's tolerance of heat and its taste for sulfur make it a good candidate for life on the early Earth, and genetic studies have suggested that archaebacteria may have been one of the first forms of life 3.5 billion years ago. The sample the Ohio State scientists found in Antarctica dates back 180 million years, and is the only example of fossil archaebacteria ever found in Antarctica.

Working on this project with Babcock were Alycia Rode, formerly a postdoctoral researcher at Ohio State and now an assistant professor of geological sciences at Ohio University; Steve Leslie, an associate professor of earth sciences at the University of Arkansas at Little Rock; Lara Ford and Katharine Polak, both undergraduate students at Ohio State; and Luann Becker, a research scientist in crustal studies at the University of California, Santa Barbara.

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