Magnetic Microbes in Mono Lake

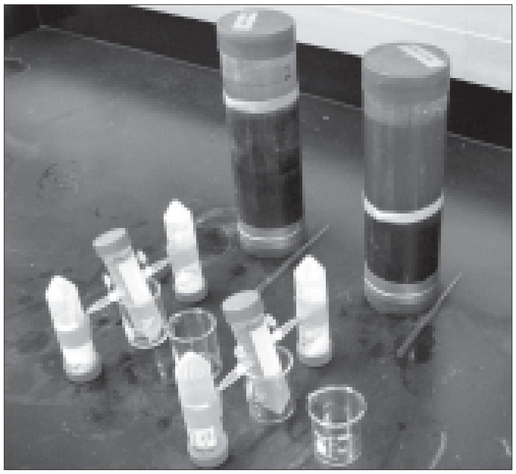
By Cody Nash

Editor's Note: Down at the lake one day, staff member Bartshé Miller ran into Cody Nash. When Cody mentioned that he was studying magnetic bacteria we just had to ask him to write an article so we could learn more!

My experience with Mono Lake began in 2002, when I led a small group of Caltech undergraduate geology students on an expedition to collect magnetic bacteria. We were on a hunt—collecting gallons of water and mud in jars and core tubes collected from the shore all the way to the deepest parts of the lake.

What is it about Mono Lake and magnetic bacteria that brought us there in the first place? Magnetic bacteria are fascinating life forms, creatures only a few thousandths of a millimeter long that synthesize inside themselves near-perfect crystals of magnetic minerals—most commonly the iron oxide magnetite. These crystals are already being used in biotechnology and nanotechnology applications today. Someday, they may lead to novel cancer treatments and data storage devices. The crystals are also preserved in rock record and are distinct enough from magnetic minerals not of biological origin that they can be identified as fossils—magnetofossils! Magnetofossils have been identified in rocks over 500 million years old, and may exist in rocks much older.

In fact, the oldest reported magnetofossils occur in a meteorite from Mars. These putative fossils are highly controversial; if they are real, they may represent the first evidence of extraterrestrial life. The possibility that magnetic bacteria lived on early Mars is what led me to Mono Lake. Mounting evidence suggests that lakes of liquid water existed on Mars early in its history, when the planet was likely warmer and wetter. As Mars transformed into the cold and dry world we see today, liquid water would have pooled in restricted basins. The lakes thus formed would have become more saline and alkaline as the water evaporated or froze and sublimated away. Mono Lake, which is at least 760,000 years old, is one of the oldest evaporitic basins on Earth, and provides an analogous environment to early Mars.



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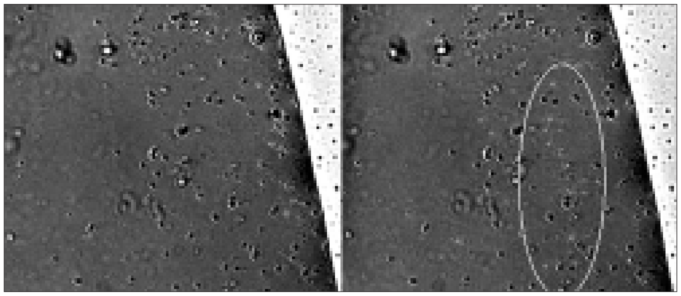
One technique for selecting magnetic bacteria from a sample is the racetrack, shown here. Samples taken from the sediment cores (top right) are placed in the center tube of the racetracks (bottom left). Sterile cotton plugs separate the sample in the main tube from filtered sample water in the smaller horizontal tubes. Magnets create a field across the racetrack such that magnetic bacteria will swim through the plugs into the smaller tubes at a much faster rate than non-magnetic bacteria, hence the term racetrack.



This image shows a before (left), where all of the magnetic bacteria are collected at the edge of a drop (the dark area). On the right is the same drop, a few seconds after reversing the field direction. There is a wave of magnetic bacteria swimming away from the drop that are highlighted by the white circle.

After our first expedition to Mono Lake, we returned to the laboratory and used various methods to extract magnetic bacteria from our samples. Using the tools of modern biology, particularly the polymerase chain reaction, we amplified from the DNA of the bacteria one of the genes most commonly used to identify organisms, the small subunit ribosomal RNA gene. The identity of the magnetic organisms we found in Mono Lake placed them in groups of bacteria in which they had never been observed before. One of the groups, the Archaea, is so distantly related to all of the other known magnetic bacteria that we were very surprised to see them. Strictly speaking, the Archaea are not bacteria at all, but a distinct domain of life, just like the eukaryotic domain to which plants, animals, and fungi belong. It was as if we had discovered mushrooms with wings!

In 2003, I again led a group of undergraduates to Mono. The students got real-life field research experience when the sampling device, a gravity corer, refused to work. We returned home with samples only from the shore and depths to which we could snorkel. We attempted to cultivate the magnetic bacteria in dozens of conditions. While our cultivation experiments did not succeed and our samples ultimately perished, using a microscope, we managed to record on video some small-spiral shaped magnetic bacteria from just under the surface of the sediment.

This year I am returning to Mono Lake as a NASA Planetary Biology Intern, collaborating with researchers at the University of Southern California. Our aim is to rigorously identify and isolate the magnetic bacteria of Mono Lake. It is very exciting, and I look forward to finding out exactly who these magnetos (as we like to call them) are. ❖

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