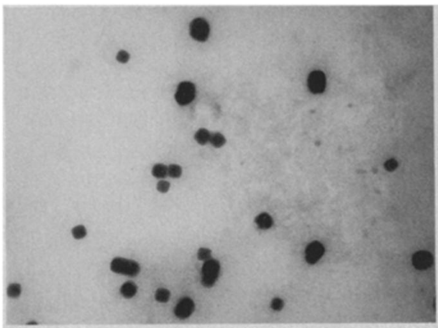
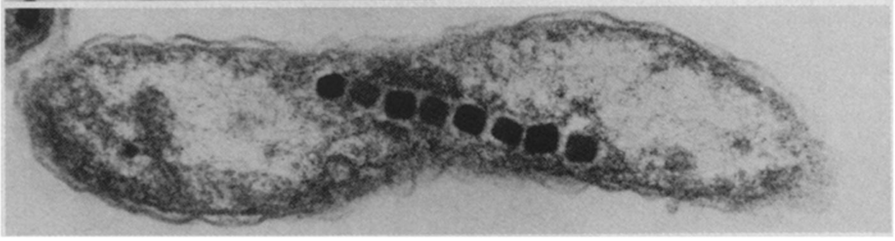
SCIENCE NEWS of the week

Tiniest Fossils May Record Magnetic Field



Kirschvink and Chang

Left: When magnified 91,000 times by an electron microscope, magnetite particles reveal shapes that bear an uncanny likeness to those formed by magnetic bacteria. Below: Within a bacterial cell, magnetite particles are formed by the organism. The bacteria use the magnetite to identify the earth's magnetic field. Equipped with a sense of direction, the organisms are able to locate food supplies.



R. Blakemore

When researchers study the magnetism recorded in marine sediments, what they in fact measure are the properties of magnetite particles far smaller than can be seen by the unaided human eye. Scientists from the California Institute of Technology in Pasadena now propose an explanation for these particles: They say that the magnetite grains are the same size and shape as those found in bacteria that produce the mineral. The bacteria use the magnetite to direct themselves downward toward their food supply (SN: 4/16/80, p. 267). Thus, the strong magnetic signals in some sediments may be due to biological activity. What's more, the researchers suggest, these particles, so small that hundreds of them could line up across the width of a single human hair, are the smallest fossils preserved.

Every few hundred thousand years or so, the earth's magnetic field flips, for reasons still poorly understood. The record of these reversals is duly logged in the magma that flows from spreading centers on the seafloor, and in the soft cushion of sediments that over millions of years builds up on the oceanic crust. The magnetism of some sediments is more stable than others. If a magnetite grain is large, its magnetism is likely to change with the flux of the earth's magnetic field. The most stably magnetized particles are so small that they can hold a single magnetic domain. Within a domain, all magnetic alignments within the atom are parallel. In larger grains, there is room for more than one domain, each with a characteristic alignment, making the degree and stability of magnetization much less than it could be, given the large size of the particle.

Last week in Indianapolis at the annual meeting of the Geological Society of America, Joseph Kirschvink of Caltech described a study he conducted with Shih-Bin Chang, also of Caltech. He explained that inorganic magnetite particles, such as those precipitated from chemical solutions or from molten rock, normally are octahedral, or eight-sided. The particles formed by bacteria occur in three types, he says. Some are hexagons, or six-sided prisms; some, from New Zealand, are teardrop-shaped; and some are cubes. Kirschvink says that when examined under the magnification afforded by a high-resolution electron microscope, the single-domain magnetite grains made in bacteria are shown to be "precisely the size and shape of the crystals that make the magnetic record."

Kirschvink and Chang say that the biologically formed magnetite grains can be distinguished from inorganic grains by their shapes and sizes and by the low concentrations of titanium. (Magnetite emitted at volcanoes is much higher in titanium content.) Another potential test, Kirschvink told SCIENCE NEWS, may be to measure the ratios of oxygen isotopes to see if they differ among the various crystal forms.

Rob Van der Voo, who studies paleomagnetism at the University of Michigan in Ann Arbor, says that if the particles are of biological origin, it may help illuminate a quality of the magnetic record that long has puzzled scientists. The transition during which the magnetic field reverses may take thousands of years. During part of this time, he says, the earth's magnetic signal is very weak. If the particles are formed by bacteria, during the time of transition the organisms would be confused. Without unambiguous magnetic poles, the bacteria would be unable tell up from down, and hence, would be unable to locate their food supply.

"We don't understand very well what keeps them going during that time, but people have argued that in sediments, you find not only a weak signal where the field reverses, but also a low magnetite content," Van der Voo says. "One of the strongest arguments is to say it is because at that time, there were not as many bacteria that produced this magnetite." When the magnetic field builds up in the opposite sense, he says, the bacteria again would form healthy colonies, and normal magnetite production would resume.

The Caltech team hopes that the magnetite particles, tentatively dubbed "magnetofossils," may be useful in studies of early earth history. By painstaking laboratory methods, the researchers have removed the particles from cores of sediments extracted during the Deep Sea Drilling Program. Biogenic magnetite particles have been identified in sediments from the Eocene period, about 50 million years ago. Kirschvink says they also are trying to extract the particles from much older silica-based rocks, including some formed during the Precambrian period, which ended about 570 million years ago. He says that fine-grained magnetite grains are present, but removing them is difficult. The rocks are so hard that the process of removing the silica also destroys the magnetite.

He does not think that the presence in rocks of the particles, if they can be shown to be of biological origin, will be particularly useful as a marker for specific geologic periods because the bacteria appear to change little over time. However, he says, "If we could find evidence that the particles were indeed biologic," it would show that the organisms had developed to the point where they could produce the mineral. The presence of the bacterial magnetite also could contribute information about the prevalence of free oxygen in the early earth atmosphere.

Richard Blakemore, of the University of New Hampshire in Durham, has found that bacteria in his laboratory cultures require small amounts of molecular oxygen in order to form magnetite. However, if the bacteria lived in conjunction with Precambrian bacterial communities such as the layered structures called stromatolites, Kirschvink says, it might not necessarily mean that the whole ocean was oxygenated, but that the bacteria lived in a micro-environment where free oxygen was available. The prevailing view is that free oxygen started forming on earth about 2.3 billion years ago, and that by 1.7 billion years ago was abundant enough to support organisms that required it for respiration and metabolism. —*C. Simon*