Banded rocks reveal early Earth conditions, changes

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Pictured in 2008, a banded iron formation about 2.5 billion years old near Soudan Underground Mine State Park in Minnesota shows alternating layers of silica-rich (red) and iron-rich (gray) minerals. This type of ancient rock formation dominated the global ocean floors for more than two billion years, but abruptly disappeared 1.7 billion years ago. A study by researchers at the University of Wisconsin-Madison and elsewhere describes a new model of how these ancient rocks formed and what they reveal about the geology, oceans and atmosphere of the Earth's early environment. Photo by: Huifang Xu/UW-Madison

(PhysOrg.com) -- The strikingly banded rocks scattered across the upper Midwest and elsewhere throughout the world are actually ambassadors from the past, offering clues to the environment of the early Earth more than 2 billion years ago.

Called banded iron formations or BIFs, these ancient rocks formed between 3.8 and 1.7 billion years ago at what was then the bottom of the ocean. The stripes represent alternating layers of silica-rich chert and iron-rich minerals like hematite and magnetite.

First mined as a major iron source for modern industrialization, BIFs are also a rich source of information about the geochemical conditions that existed on Earth when the rocks were made. However, interpreting their clues requires understanding how the bands formed, a topic that has been controversial for decades, says Huifang Xu, a geology professor at the University of Wisconsin-Madison.

A study appearing today (Oct. 11) as an advance online publication in *Nature Geoscience* offers a new picture of how these colorful bands developed and what they reveal about the composition of the early ocean floor, seawater, and atmosphere during the evolution of the Earth.

Previous hypotheses about band formation involved seasonal fluctuations, temperature shifts, or periodic blooms of microorganisms, all of which left many open questions about how BIFs dominated the global marine landscape for two billion years and why they abruptly disappeared 1.7 billion years ago.

With Yifeng Wang of Sandia National Laboratories, Enrique Merino of Indiana University and UW-Madison postdoc Hiromi Konishi, Xu developed a BIF formation model that offers a more complete picture of the environment at the time, including interactions between rocks, water, and air.

"They are all connected," Xu explains. "The lithosphere affects the hydrosphere, the hydrosphere affects the atmosphere, and all those eventually affect the biosphere on the early Earth."

Their model shows how BIFs could have formed when hydrothermal fluids, from interactions between seawater and hot oceanic crust from deep in the Earth's mantle, mixed with surface seawater. This mixing triggered the oscillating production of iron- and silica-rich minerals, which were deposited in layers on the seafloor.

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They used a series of thermodynamic calculations to determine that the source material for BIFs must have come from oceanic rocks with a very low aluminum content, unlike modern oceanic basalts that contain high levels of aluminum.

"The modern-day ocean floor is basalt, common black basalt like the Hawaiian islands. But during that time, there was also a strange kind of rock called komatiites," says Xu. "When ocean water reacts with that kind of rock, it can produce about equal amounts of iron and silica" — a composition ideally suited to making BIFs.

Such a mixture can create distinct alternating layers — which range in thickness from 10 micrometers to about 1 centimeter — due to a constantly shifting state that, like a competition between two well-matched players, resists resolving to a single outcome and instead see-saws between two extremes.

BIFs dominated the global oceans 3.8 to 1.7 billion years ago, a time period known to geologists as the Archaean-Early Proterozoic, then abruptly disappeared from the geologic record. Their absence in more recent rocks indicates that the geochemical conditions changed around 1.7 billion years ago, Xu says.

This change likely had wide-ranging effects on the physical and biological composition of the Earth. For example, the end of BIF deposition would have starved iron-dependent bacteria and shifted in favor of microbes with sulfur-based metabolisms. In addition, chemical and pH changes in the ocean and rising atmospheric oxygen may have allowed the emergence and spread of oxygen-dependent organisms.

The new study was partly funded by the NASA Astrobiology Institute, and Xu hopes to look for biosignatures trapped in the rock bands for additional clues to the changes that occurred 1.7 billion years ago and what may have triggered them.

Source: University of Wisconsin-Madison (news : web)