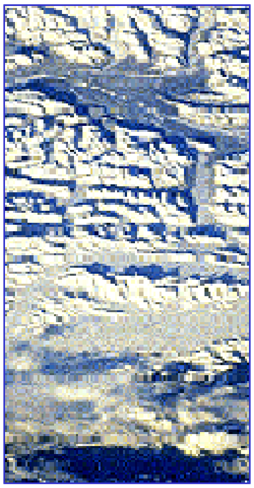


REMNANTS OF THE PAST

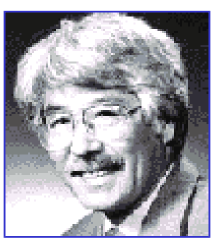
The First Ice Age

Some 2.3 billion years ago, oxygen supported a lot of land-based life on Earth, and then slicked the planet's surface with ice

Geologists have long wondered when oxygen made its debut as a leading gas in Earth's life support system. They knew there were significant amounts present at least 1.2 billion years ago, because evidence suggested that the earliest land-based life--microbial mats and the like--appeared at that time. But two recent studies push the date back nearly twice as far.

Researchers from the Astrobiology Research Center at Pennsylvania State University presented arguments at the annual meeting of the Geological Society of America in Denver on October 26 and October 27 indicating that there was an abundance of oxygen on Earth as long as 2.3 billion years ago. Hiroshi Ohmoto bases his case on a collection of iron-rich rocks in Africa, and James F. Kasting points to the planet's first ice age.

THE RESEARCHERS



OHMOTO

KASTING

Ohmoto, director of the Astrobiology Research Center, worked with Nick Beukes of Rand Afrikaans University to examine iron-rich deposits called laterites. These formations are created when living things decay and release organic acids, which in turn leach iron from upper layers of rock and deposit them as oxides in lower layers. Modern laterites are found mostly in the tropics where organic matter decays most rapidly, and they have the same structure as the ancient ones Ohmoto looked at: an iron-rich layer of rock sandwiched between two iron-deficient ones.

Image: Dupla Aquaristik GmbH

LATERITES. These red soils, now found mainly in the tropics, appear only where oxygen is plentiful enough to support life and to oxidize iron leached from rocks by decaying organic matter.

The first set of laterites the group considered were in Waterval Onder near Pretoria. Because the top two layers there had eroded, though, they focused their attention on core samples drilled by miners nearby in South Africa and Botswana. These specimens showed that the laterite formation in question covered a vast area. And further study revealed that what were thought to be much younger rocks exposed further to the west were actually part of the same formation, which sits on top of the 2.3 to 2.4 billion year-old Hekpoort basalt.

"Because we can trace the basalt all the way across, even to a depth of 2,600 feet, we know that the laterite deposits directly above are only slightly younger than the basalts," Ohmoto notes. For those laterites to have arisen, there must have been enough oxygen in the atmosphere at the time to support life and to convert iron into iron oxide. "Until now, the earliest accepted date for land-based life was 1.2 billion years ago," Ohmoto adds, "but now we can push that back at least another billion years."

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That same life-giving oxygen in the atmosphere also likely caused Earth's first known ice age, Kasting claims. Earlier studies showed that some 2.3 billion years ago (as well as 600 and 750 million years ago) at least six of the planet's seven continents--then huddled together around the equator--were glaciated. Many scientists initially rejected these earlier arguments that Earth had gone through such "snowball" phases.

Assuming that the previous work is correct, however, there are only two ways to explain how ice could have stretched from pole to pole across oceans frozen a half mile deep, Kasting says: Either Earth's tilt (now at 23.5 degrees from vertical) was greater than 54 degrees so that the equator received the least solar energy, or a dearth of greenhouse gases cooled the planet over time.

Kasting bets on the later scenario. "The earliest known 'snowball Earth' occurred around the time that oxygen levels in the atmosphere began to rise," he says. "Before then, methane was a major greenhouse gas in the atmosphere in addition to carbon dioxide and water vapor." But one-hundredth of a percent of today's atmospheric oxygen would have been sufficient to overwhelm the methane, he notes, and carbon dioxide levels would not have been high enough yet to compensate the resulting cooling. Natural volcanic activity could not then generate enough carbon dioxide to melt the glaciers for another 5 to 10 million years.

Ohmoto's and Kasting's accounts of oxygen's role 2.3 billion years ago fill in two gaps about the snowball Earth idea. Not only had it been unclear how glaciers might have encroached upon the equator, but also how the variety of life on Earth could have branched out afterwards--unless it existed beforehand and somehow survived the deep freeze near hot springs or undersea thermal vents. "The biological puzzle of snowball Earth is very interesting," Kasting says. But recently, "events suggest that life was more robust than we thought and that the Earth's climate was much less stable than we assumed."

--Kristin Leutwyler

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