Climate change and the rise of atmospheric oxygen

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Today's climate change pales in comparison with what happened as Earth gave birth to its oxygen-containing atmosphere billions of years ago. By analyzing clues contained in rocks, scientists at the Carnegie Institution's Geophysical Laboratory have found that the initial rise of oxygen (O_2) was transitory and that its final emergence may have been linked to volcanoes and catastrophic glaciations.

"Rocks contain fingerprint-like clues to the past environment through specific variations in elements such as sulfur," explained Carnegie researcher Shuhei Ono. "Our Earth didn't start out with oxygen in the atmosphere. It probably contained methane and hydrogen, but no oxygen. We think that there were microbes in the oceans, before the oxygenated atmosphere, which would have used methane for energy. Measuring sulfur isotopes--different versions of the atom with the same number of protons, but a different number of neutrons--in rock samples provides a sensitive way to monitor ancient oxygen levels. Oxygen first appeared on the surface of the Earth when microbes developed the capacity to split water molecules to produce O_2 using the Sun's energy. This is a bit advanced biochemistry, but we think this biological revolution emerged sometime before 2.7 billion years ago," he continued.

Ono looked at sulfur isotopes from South African drill-core samples covering the time interval from 3.2 to 2.4 billion years ago. Around 2.9 billion years ago, the methane-dominated atmosphere provided a greenhouse effect and kept the planet warm. His analysis suggests that when oxygen first appeared in the atmosphere, around that time, it would have reacted with the methane, destabilizing the atmosphere and triggering the Mozaan-Witwatersrand glaciation.

The oxygen atmosphere wasn't here to stay, however. "It was a raucous time," stated Carnegie's Andrey Bekker. "Volcanoes peppered the Earth's surface, belching gases and particulates into the atmosphere. That material rained back to the surface and oceans, affecting ocean chemistry and the ocean and atmospheric cycles. We looked at sulfur isotopes in shale and pyrite from Western Australia and found that between 2.47 and 2.463 billion years ago oxygen levels started to rise. But the intense volcanic activity made it almost disappear again. Despite these fits and starts, our oxygen atmosphere prevailed in the end."

The work is presented in several talks at NASA's Astrobiology Science Conference (AbSciCon) 2006 in Washington, D.C., March 26-30. See http://abscicon2006.arc.nasa.gov/ for details.

Source: Carnegie Institution