Plankton key to origin of Earth's first breathable atmosphere

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Researchers studying the origin of Earth's first breathable atmosphere have zeroed in on the major role played by some very unassuming creatures: plankton.

In a paper to appear in the online Early Edition of the Proceedings of the National Academy of Sciences *(PNAS)*, Ohio State University researcher Matthew Saltzman and his colleagues show how plankton provided a critical link between the atmosphere and chemical isotopes stored in rocks 500 million years ago.

This work builds on the team's earlier discovery that upheavals in the earth's crust initiated a kind of reverse-greenhouse effect 500 million years ago that cooled the world's oceans, spawned giant plankton blooms, and sent a burst of oxygen into the atmosphere.

The new study has revealed details as to how oxygen came to vanish from Earth's ancient atmosphere during the Cambrian Period, only to return at higher levels than ever before.

It also hints at how, after mass extinctions, the returning oxygen allowed enormous amounts of new life to flourish.

Saltzman and his team were able to quantify how much oxygen was released into the atmosphere at the time, and directly link the amount of sulfur in the ancient oceans with atmospheric oxygen and carbon dioxide.

The result is a clearer picture of life on Earth in a time of extreme turmoil.

"We know that oxygen levels in the ocean dropped dramatically [a condition called anoxia] during the Cambrian, and that coincides with the time of a global extinction," said Saltzman, associate professor of earth sciences at Ohio State.

In a paper in the journal Nature just last month, the same researchers presented the first geochemical evidence that the anoxia spread even to the world's shallow waters.

"We still don't know why the anoxia spread all over the world. We may never know," Saltzman said. "But there have been many other extinction events in Earth's history, and with the exception of those caused by meteor impacts, others likely share elements of this one – changes in the balance of oxygen and carbon dioxide in the atmosphere and oceans."

"By getting a handle on what was happening back then, we may improve our understanding of what's happening to the atmosphere now."

Something enabled oxygen to re-enter the oceans and the atmosphere 500 million years ago, and the study suggests that the tiny plant and animal life forms known as plankton were key.

Plankton may be at the bottom our food chain today, but back then, they ruled the planet. There was no life on land at all. And aside from an abundance of trilobites, life in the oceans was not very diverse.

Not diverse, that is, until a geologic event that scientists call the Steptoean Positive Carbon Isotope Excursion (SPICE) occurred. In previous work, Saltzman and his collaborators showed that the SPICE event was caused by the burial of huge quantities of organic matter in ocean sediments, which pulled carbon dioxide from the atmosphere and released oxygen.

The more oxygen plankton encounter in their cells, the more selective they become for the light isotope of carbon in carbon dioxide, and absorb it into their bodies.

By studying isotopes in fossilized plankton contained in rocks found in the central United States, the Australian outback, and China, the researchers determined that the SPICE event happened around the same time as an explosion of plankton diversity known as the "plankton revolution."

"The amount of oxygen rebounded, and so did the diversity of life," Saltzman explained.

Other researchers have tried to gauge how much oxygen was in the air during the Cambrian, but their estimates have varied widely, from a few percent to as much as 15-20 percent.

If the higher estimates were correct, then the SPICE event would have boosted oxygen content to greater than 30 percent – or almost 50 percent richer than today's standard of 21 percent.

This study has provided a new perspective on the matter.

"We were able to bring together independent lines of evidence that showed that if the total oxygen content was around 5-10 percent before the SPICE, then it rose to just above modern levels for the first time after the SPICE," Saltzman said.

The study has some relevance to modern geoengineering. Scientists have begun to investigate what we can do to forestall climate change, and altering the chemistry of the oceans could help remove carbon dioxide and restore balance to the atmosphere. The ancient and humble plankton would be a necessary part of that equation, he added.

"When it comes to ancient life, they don't sound as exciting as dinosaurs, but the plankton are critical to this story."

Provided by The Ohio State University

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