Earth's position and orbit spurred ancient marine life extinction

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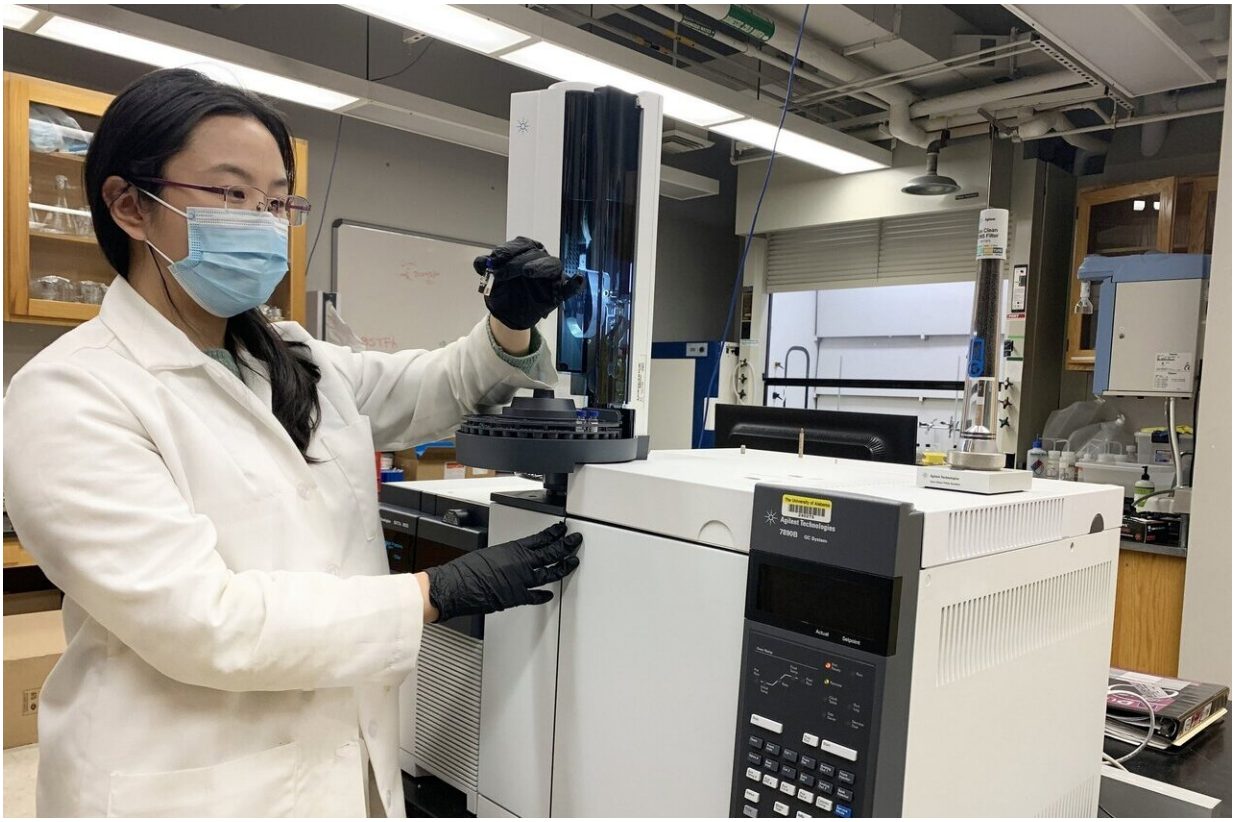

Dr. Man Lu, UA postdoctoral researcher, analyzes molecules in Devonian rocks from Tennessee on a gas chromatography-mass spectrometer. Credit: University of Alabama at Birmingham

Ancient rocks from Tennessee revealed the Earth's rotation and orbit around the sun controlled the timing of oceanic dead zones in a mass

extinction of marine life about 370 million years ago.

Led by researchers at The University of Alabama, the findings have important implications for modern oceans. The results of the study were published online this week in *Earth and Planetary Science Letters*. The study shows that oxygen depletion in the ocean was not permanent during the mass extinction , rather dead zones occurred in periodic episodes regulated by astronomical forcing.

"Studying ancient dead zones helps us understand how modern dead zones caused by human activities shape the evolution of marine ecosystems over a long period of time," said Dr. Yuehan Lu, UA associate professor of geological sciences and corresponding author of the paper.

Dead zones are low-oxygen waters where most marine life die. Today dead zones are known to threaten coastal ecosystem, but they are also thought to be the direct cause of the Late Devonian mass extinction that occurred 370 to 360 million years ago, one of five recorded mass extinctions on Earth.

The research identified a link between what is called astronomical forcing and the mass extinction of shallow marine life during the period. It's the first study of its kind to identify the cycles of land-sea interactions during the event.

"We collected samples at the highest possible resolution, and the sampling strategy allowed us to identify the periodicity linked to astronomical forcing," said Dr. Man Lu, a postdoctoral researcher at UA and lead author of the paper.

During the period of Earth's history known as the Late Devonian there were three major landmasses, with present day North America meshed

with Greenland and much of Europe. It was during this time period that one of the "Big Five" extinction events occurred as massive numbers of marine animals living closer to land, such as trilobites and corals, died in two waves. The reason for these extinctions are still intensely debated.

Astronomic forcing is the slow impact of the changes in Earth's rotation, movement, tilt and orbit around the sun over time, causing cyclic variation in the distribution of solar energy reaching the Earth. Consequently, cyclic changes in climatic patterns occur on the Earth. The phenomenon occurs periodically in what are known as Milankovitch cycles.

The detective work by the researchers involved collecting samples every centimeter and analyzing trace biomarkers left behind on the rock. These biomarkers, also known as "molecular fossils," are sourced from land plants, marine algae and bacteria thriving in low-oxygen environments. They contain core structures that are resistant enough to be preserved over hundreds of millions of years, allowing reconstruction of the environments of land and sea about 370 million years ago.

The research team calculated cycles of biomarkers through time. They found astronomical forcing sets cycles of 17,000 and 21,000 years for marine dead zones by timing the fluxes of materials from land reaching the ocean. Those terrestrial fluxes supply additional nutrients and cause excessive growth of marine algae and bacteria, leading to oxygen depletion in Devonian coastal oceans.

"We discovered that the largest extinction interval during the Late Devonian mass extinction could progress with a series of marine anoxic events whose timing is controlled by the Earth's orbital forcing," said Dr. Takehito Ikejiri, a paleontologist with UA's geological sciences and Alabama Museum of Natural History who worked on this project.

More information: Man Lu et al. Periodic oceanic euxinia and terrestrial fluxes linked to astronomical forcing during the Late Devonian Frasnian–Famennian mass extinction, *Earth and Planetary Science Letters* (2021). DOI: 10.1016/j.epsl.2021.116839