Oldest fossils of large seaweeds, possible animals tell story about oxygen in an ancient ocean

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These images are part and counterpart of a macroscopic Lantian fossil, probably a seaweed, with differentiated morphologies including a distinct root-like holdfast to secure the organism on sea bottom, a conical stem, and a crown of ribbon-like structures. Scale bar is 1 centimeter. Credit: Photo by Zhe Chen

Almost 600 million years ago, before the rampant evolution of diverse life forms known as the Cambrian explosion, a community of seaweeds and worm-like animals lived in a quiet deep-water niche under the sea near what is now Lantian, a small village in Anhui Province of South China. Then they simply died, leaving some 3,000 nearly pristine fossils preserved between beds of black shale deposited in oxygen-free waters.

Scientists from the Chinese Academy of Sciences, Virginia Tech in the U.S., and Northwest University in Xi'an, China report the discovery of the fossils and the mystery in the Feb. 17 issue of *Nature*.

In addition to perhaps ancient versions of algae and worms, the Lantian biota – named for its location – included macrofossils with complex and puzzling structures. In all, scientists identified about 15 different species at the site.

The fossils suggest that morphological diversification of macroscopic eukaryotes – the earliest versions of organisms with complex cell structures -- may have occurred only tens of millions of years after the snowball earth event that ended 635 million years ago, just before the Ediacaran Period. And their presence in the highly organic-rich black shale suggests that, despite the overall oxygen-free conditions, brief oxygenation of the oceans did come and go.

"So there are two questions," said Shuhai Xiao, professor of geobiology in the College of Science at Virginia Tech. "Why did this community evolve when and where it did? It is clearly different in terms of the number of species compared to biotas preserved in older rocks. There are more species here and they are more complex and larger than what evolved before. These rocks were formed shortly after the largest ice age ever, when much of the global ocean was frozen. By 635 million years ago, the snowball earth event ended and oceans were clear of ice. Perhaps that prepared the ground for the evolution of complex eukaryotes."

The team was examining the black shale rocks because, although they were laid down in waters that were not good for oxygen-dependent organisms, "they are known to be able to preserve fossils very well," said

Shuhai. "In most cases, dead organisms were washed in and preserved in black shales. In this case, we discovered fossils that were preserved in pristine condition where they had lived – some seaweeds still rooted."

The conclusion that the environment would have been poisonous is derived from geochemical data, "but the bedding surfaces where these fossils were found represent moments of geological time during which free oxygen was available and conditions were favorable. They are very brief moments to a geologist," said Xiao. "but long enough for the oxygen-demanding organisms to colonize the Lantian basin and capture the rare opportunities."

The research team suggests in the article in Nature that the Lantian basin was largely without oxygen but was punctuated by brief oxic episodes that were opportunistically populated by complex new life forms, which were subsequently killed and preserved when the oxygen disappeared. "Such brief oxic intervals demand high-resolution sampling for geochemical analysis to capture the dynamic and complex nature of oxygen history in the Ediacaran Period," said lead author Xunlai Yuan, professor of palaeontology with the Chinese Academy of Sciences.

Proving that hypothesis awaits further study. The rocks in the study region are deposited in layered beds. The nature of the rock changes subtly and there are finer and finer layers that can be recognized within each bed. "We will need to sample each layer to see whether there is any difference in oxygen contents between layers with fossils and those without" said co-author Chuanming Zhou, professor of palaeontology with the Chinese Academy of Sciences.

More information: The paper, "An Early Ediacaran Assemblage of Macroscopic and Morphologically Differentiated Eukaryotes," by Xunlai Yuan and Zhe Chen of the Chinese Academy of Sciences; Shuhai Xiao of Virginia Tech; Chuanming Zhou, also of the Chinese Academy of

Sciences; and Hong Hua of Northwest University in Xi'an, appears in the Feb. 17 issue of *Nature*.

Provided by Virginia Tech

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