For ancient deep-sea plankton, a long decline before extinction

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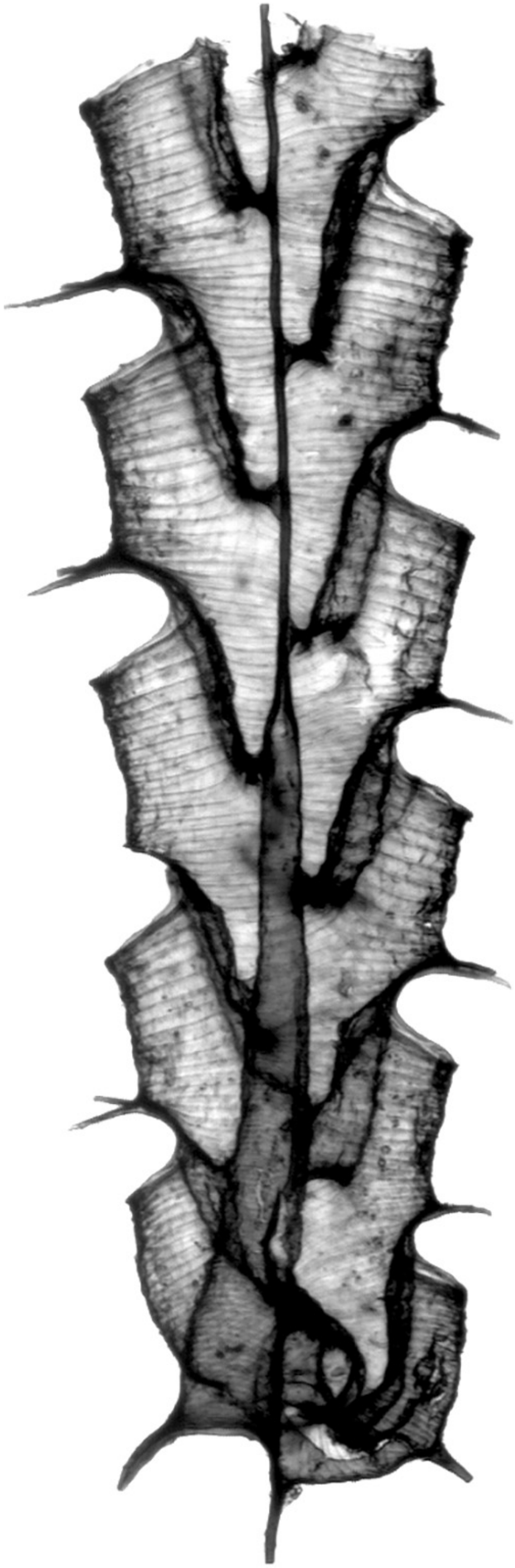


A microscope image of *Paraorthograptus kimi*, a doomed species of deep-water graptolite. Once common, this species was among those that disappeared during the end-Ordovician mass extinction. Credit: Michael Melchin

A new study of nearly 22,000 fossils finds that ancient plankton communities began changing in important ways as much as 400,000 years before massive die-offs ensued during the first of Earth's five great extinctions.

The research, published July 18 in the Early Edition of the *Proceedings of the National Academy of Sciences*, focused on large zooplankton called graptolites. It suggests that the effects of environmental degradation can be subtle until they reach a tipping point, at which dramatic declines in population begin.

"In looking at these organisms, what we saw was a disruption of community structures—the way in which the plankton were organized in the water column. Communities came to be less complex and dominated by fewer species well before the massive extinction itself," says co-author H. David Sheets, PhD, professor of physics at Canisius College and associate research professor in the Evolution, Ecology and Behavior graduate program at the University at Buffalo.

This turmoil, occurring in a time of ancient climate change, could hold lessons for the modern world, says co-author Charles E. Mitchell, PhD, professor of geology in the University at Buffalo College of Arts and Sciences.

The shifts took place at the end of the Ordovician Period some 450 million years ago as the planet transitioned from a warm era into a cooler one, leading eventually to glaciation and lower sea levels.

"Our research suggests that ecosystems often respond in stepwise and mostly predictable ways to changes in the physical environment—until they can't. Then we see much larger, more abrupt, and ecologically disruptive changes," Mitchell says. "The nature of such tipping point effects are hard to foresee and, at least in this case, they led to large and permanent changes in the composition of the oceans' living communities.


.50 millimeter

A microscope image of *Styracograptus tubuliferus*, an ancient, deep-water graptolite that belonged to a lineage of graptolites that later disappeared during the end-Ordovician mass extinction. Credit: Charles E. Mitchell

"I think we need to be quite concerned about where our current ocean communities may be headed or we may find ourselves at the tail end of a similar event—a sixth mass extinction, living in a very different world than we would like."

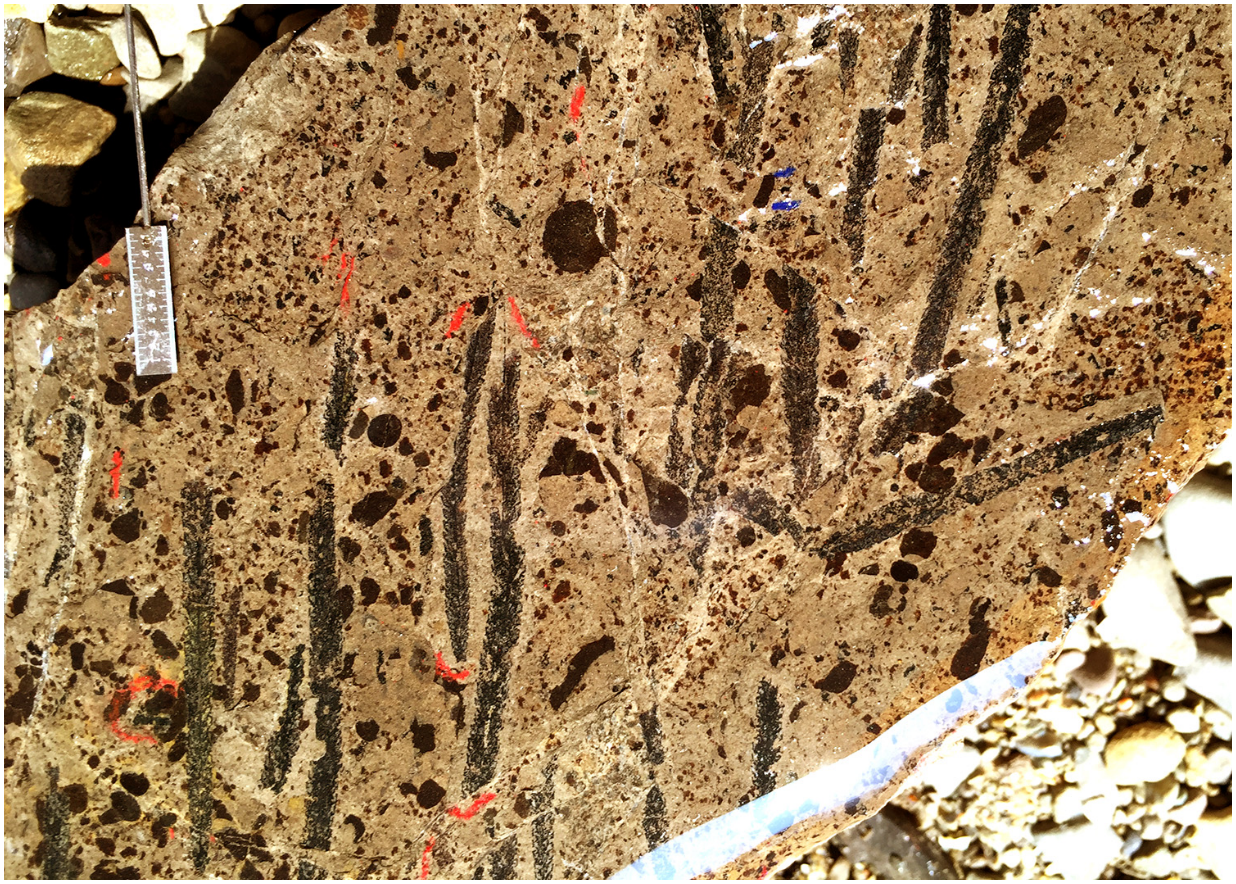
The study was a partnership between Canisius, UB, St. Francis Xavier University, Dalhousie University and The Czech Academy of Sciences.

A long slide toward oblivion

In considering mass extinction, there is perhaps the temptation to think of such events as rapid and sudden: At one moment in history, various species are present, and the next they are not.

This might be the conclusion you'd draw if you examined only whether different species of graptolites were present in the fossil record in the years immediately preceding and following the Ordovician extinction.

"If you just looked at whether they were present—if they were there or not—they were there right up to the brink of the extinction," Sheets says. "But in reality, these communities had begun declining quite a while before species started going extinct."



A slab of rock from a study site in Nevada harbors many specimens of Metabolograptus extraordinarius, a shallow-water graptolite species, which together with some close relatives, replaced all the formerly dominant species following the end-Ordovician mass extinction. Credit: Charles E. Mitchell

The research teased out these details by using 21,946 fossil specimens from areas of Nevada in the U.S. and the Yukon in Canada that were once ancient sea beds to paint a picture of graptolite evolution.

The analysis found that as ocean circulation patterns began to shift hundreds of thousands of years before the Ordovician extinction, graptolite communities that previously included a rich array of both shallow- and deep-sea species began to lose their diversity and complexity.

Deep-water graptolites became progressively rarer in comparison to their shallow-water counterparts, which came to dominate the ocean.

"There was less variety of organisms, and the rare organisms got rarer," Sheets says. "In the aftermath of a forest fire in the modern world, you might find that there are fewer organisms left—that the ecosystem just doesn't have the same structure and richness as before. That's the same pattern we see here."

The dwindling deep-sea graptolites were species that specialized in obtaining nutrients from low-oxygen zones of the ocean. A decrease in the availability of such habitats may have sparked the creatures' decline, Sheets and Mitchell say.

"Temperature changes drive deep ocean circulations, and we think the deep-water graptolites lost their habitats as the climate changed," Sheets says. "As the nature of the oceans shifted, their way of life went away."

More information: H. David Sheets et al, Graptolite community responses to global climate change and the Late Ordovician mass extinction, *Proceedings of the National Academy of Sciences* (2016). DOI: 10.1073/pnas.1602102113

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