Ancient environment drives marine biodiversity, study says

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Fossil snails known as turritellid gastropods; they're about 13 million years old. Credit: Shanan Peters

Much of our knowledge about past life has come from the fossil record – but how accurately does that reflect the true history and drivers of biodiversity on Earth?

"It's a question that goes back a long way to the time of Darwin, who looked at the fossil record and tried to understand what it tells us about the history of life," says Shanan Peters, an assistant professor of geoscience at the University of Wisconsin–Madison.

In fact, the fossil record can tell us a great deal, he says in a new study. In a report published Friday, Nov. 25 in *Science* magazine, he and colleague Bjarte Hannisdal, of the University of Bergen in Norway,

show that the evolution of marine life over the past 500 million years has been robustly and independently driven by both ocean chemistry and sea level changes.

The time period studied covered most of the Phanerozoic eon, which extends to the present and includes the evolution of most plant and animal life.

Hannisdal and Peters analyzed fossil data from the Paleobiology Database along with paleoenvironmental proxy records and data on the rock record that link to ancient global climates, tectonic movement, continental flooding, and changes in biogeochemistry, particularly with respect to oxygen, carbon, and sulfur cycles. They used a method called information transfer that allowed them to identify causal relationships – not just general associations – between diversity and environmental proxy records.

"We find an interesting web of connections between these different systems that combine to drive what we see in the fossil record," Peters says. "Genus diversity carries a very direct and strong signal of the sulfur isotopic signal. Similarly, the signal from sea level, how much the continents are covered by shallow seas, independently propagates into the history of marine animal diversity."

The dramatic changes in biodiversity seen in the fossil record at many different timescales – including both proliferations and mass extinctions as marine animals diversified, evolved, and moved onto land – likely arose through biological responses to changes in the global carbon and sulfur cycles and sea level through geologic time.

The strength of the interactions also shows that the fossil record, despite its incompleteness and the influence of sampling, is a good representation of marine biodiversity over the past half-billion years.

"These results show that the number of species in the oceans through time has been influenced by the amount and availability of carbon, oxygen and sulfur, and by sea level," says Lisa Boush, program director in the National Science Foundation's Division of Earth Sciences, which funded the research. "The study allows us to better understand how modern changes in the environment might affect biodiversity today and in the future."

Peters says the findings also emphasize the interconnectedness of physical, chemical, and biological processes on Earth.

"Earth systems are all connected. It's important to realize that because when we perturb one thing, we're not just affecting that one thing. There are consequences throughout the whole Earth system," he says. "The challenge is understanding how perturbation of one thing – for example, the carbon cycle – will eventually affect the future biodiversity of the planet."

Provided by University of Wisconsin-Madison

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