Old rocks breathe fresh air into evolution debate

Justin Ries and colleagues examined the chemical signature of limestone rocks in southern Namibia, Africa.

Marine geologist Justin Ries

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An enduring mystery over what triggered a massive evolutionary jumpstart on Earth half a billion years ago may be closer to being solved, thanks to a new discovery by a UNC marine geologist and his colleagues.

The study, led by marine scientist Justin Ries, relates to what's known as the "Cambrian Explosion," which occurred about 540 million years ago and is considered the greatest evolutionary event in the history of animal life.

For hundreds of millions of years leading up to the event, only relatively simple animals existed. Then, there was a burst of evolutionary activity, resulting in thousands of new, more complex life forms. Several theories have been put forward to explain this delay in diversification– such as the emergence of predators around the time of the Cambrian Explosion, which drove other creatures to develop more sophisticated defenses – but the various reasons remain under debate.

Now, findings by Ries and colleagues published in the August issue of the journal Geology appear to strongly bolster one explanation – that the low oxygen levels of the primordial atmosphere and oceans persisted much longer than previously thought, suggesting it was the alleviation of these low oxygen conditions that ultimately allowed animal life to flourish.

"This period was a game-changer in terms of the evolutionary structure of life," said Ries, an assistant professor in the department of marine sciences in UNC's College of Arts and Sciences. "Our findings are consistent with the idea that it occurred because of major changes in the composition of the ocean and atmosphere at that time."

A hole in the atmospheric change hypothesis has been scientists' belief that relatively high oxygen levels existed on the planet long before the Cambrian period, Ries said. If that was the case and oxygen was key to this evolutionary event, researchers reasoned, why did it take until then for the few initial stems of animal life to expand into the thousands of lineages that emerged?

The new study appears to answer that puzzle. Ries' team examined the chemical signature of limestone rocks in southern Namibia, Africa, that were deposited in the oceans between 553 million and 543 million years ago, just before the Cambrian Explosion.

They found that at that time, sulfate levels in the ancient ocean – and by implication, oxygen levels in the atmosphere – were much lower than previously thought. Scientists are able to use sulfate – a molecule that is dissolved in seawater – as a proxy for the amount of oxygen that existed, because their respective levels vary in proportion with one another (marine sulfate is primarily derived from the oxidation of terrestrial sulfide).

"This implies that the subsequent alleviation of these low sulfate and low oxygen conditions may have led to the intense diversification of animals in early Cambrian time," Ries said.

Along with Ries, the study co-authors are David A. Fike, and John P. Grotzinger, from the California Institute of Technology, Lisa M. Pratt with Indiana University, and Timothy W. Lyons, from the University of California–Riverside.