When Earth greened over

A thick, green carpet of photosynthetic life, on the scale of that seen today, exploded across Earth 850 million years ago — much earlier than thought — a new study suggests.

The matting — a mixture of algae, mosses and fungi — would have fixed atmospheric carbon into the soil, which would then have washed into the seas for burial, according to the study (L. P. Knauth & M. J. Kennedy *Nature* doi:10.1038/nature08213; 2009). With lower levels of carbon to react with, global levels of oxygen would have risen. The greening of ancient Earth could thus be indirectly responsible for the sudden evolution, beginning about 600 million years ago, of larger respirating animals with oxygen-hungry cells, say geologists Paul Knauth of Arizona State University in Tempe and Martin Kennedy of the University of California, Riverside.

"This is a profound event," says Kennedy. "It explains the rise of oxygen, and the timing of that rise."

The evidence the researchers provide is indirect: data compiled from thousands of samples of carbonate rock, such as limestone, that originally formed in ancient shallow seas. Analysis of carbon and oxygen isotopes in these rocks revealed that the influence of the freshwater run-off into these seas was as important in ancient times as it is today in forming carbonate rocks.

Because terrestrial plant life leaves indelible isotopic marks in modern carbonate rocks, the authors surmise that some sort of photosynthetic life — at the same global scale — was responsible for similar measurements they found in ancient rocks. In rocks older than 850 million years, they find starkly different isotopic signatures, which they interpret as an absence of carbon-rich material in freshwater run-off, and thus an absence of photosynthetic life on land.

H.STRAND/CORBIS

Did a green carpet of algae, mosses and fungi cover Earth 850 million years ago?

The study contradicts other work that looks to the oceans, rather than land, to justify the same isotopic data. Other researchers argue that the oxygenation of Earth and the explosion of animals 600 million years ago arose from sudden and drastic changes in ocean water chemistry around the same time (D. A. Fike *et al.* *Nature* 444, 744–747; 2006). The changes in ocean chemistry have been attributed to episodic releases of methane from ocean vents, and periods of 'snowball Earth', extreme glacial epochs when Earth may have been so cold that oceans froze over.

But Knauth and Kennedy say the isotopic records in the carbonate rocks reflect more than just the chemistry of the global oceans. They argue that most carbonate rocks undergo further stages of alteration where freshwater run-off is important.

There are problems with the new theory, says Paul Falkowski, a geochemist at Rutgers University in New Brunswick, New Jersey — most notably that there isn't much evidence for widespread plant life until around 400 million years ago. The hard tissues of vascular plants evolved around this time, but the softer tissues of mosses and fungi that came before would have been preserved less easily. Work with molecular clocks — which use genetic differences to estimate the timing of speciation — does suggest that terrestrial plants evolved from the types of plants that Knauth and Kennedy call for, around the time that they suggest.

But to have the effect on the carbonate record that they see, the ancient photosynthetic life would have needed to be operating on the scale that it is today — a worldwide carpeting of green. And that should have left something for posterity, says Nick Butterfield, a palaeobiologist at the University of Cambridge, UK. "In order to have a significant impact it has to be everywhere, all over the place," he says. "And it can't be, unless it has seeds and cuticles and adaptations for covering vast amounts of the terrestrial surfaces. If you've got those adaptations you can't avoid turning up in the fossil record." ■

Eric Hand