Geophysical Research Abstracts,
Vol. 11, EGU2009-13475, 2009
EGU General Assembly 2009

The Earliest Fossil Evidence for Life on Land and the Freshwater Origin of Algae?

L Battison, M.D. Brasier, and J.B. Antcliffe
Department of Earth Sciences, Oxford University, Parks Road, Oxford, UK, OX13PR

Some 150 years ago, in 1859, Charles Darwin was greatly puzzled by a seeming absence of fossils in rocks older than the Cambrian period. He drew attention to a veritable Lost World that it is now known to have spanned more than 80 per cent of Earth History. And he made a prediction that we here bring again into focus: 'The presence of phosphate nodules and bituminous matter in some of the lowest azoic rocks probably indicates the former existence of life at these periods (Darwin 1859, p.307). His prediction came to fruition in 1899, when Sir Archibald Geikie announced to the world the first discovery of genuine microfossils in Precambrian phosphatic rocks, made by Jephro Teall, Ben Peach and John Horne within the Torridonian rocks of Scotland.

The Torridonian phosphate of NW Scotland has, however, been rather little studied until recently. It is remarkable for its fidelity of fossil preservation, and also for its non-marine depositional setting. Dating to the end of the Mesoproterozoic Era around 1Ga ago, thick packages of fluvial sandstones are found to serve the remains of very ancient intermontane lake ecosystems. Fossil assemblages from terrestrial settings are rarely seen before the Devonian $\sim$ 350 Ma ago. Evidence for freshwater and terrestrial life in the Precambrian has therefore been circumstantial rather than detailed and none has yet come from freshwater phosphate. We here demonstrate that phosphate from $\sim$ 1200-1000 Ma Mesoproterozoic lake sediments of the Torridon Group preserve a remarkable suite of organisms forming a freshwater, terrestrial, phototrophic ecosystem. Ephemeral lakes and streams developed in intermontane basins within the interior of the supercontinent of Rodinia and periodically experienced prolonged desiccation allowing phosphate precipitation.

The microbiology of these lake sediments is being studied in detail, where they are yielding - with the aid of Automontage - fresh evidence for the earliest known terrestrial ecology and lagerstatte. Delicate cellular structures, and even sub-cellular structures, can be preserved with high fidelity in the phosphate. These cells show evidence for life cycles that ranged from resting cysts - sometimes sculptured - to colonial vegetative stages and thence to single celled dispersal stages. Cyanobacteria, eukaryotic protists and algae are all present.

The ecological structure and responses of these Torridon lake communities can be compared with those of modern, mainly acidiphilic, lakes. Together with sedimentary structures and wrinkle mats of demonstrably microbial origin, we can point to the variable development of seasonal eutrophication and stagnation in the photic zone of these ancient lakes. Population statistics of the various morphotypes reveal differences between the assemblages collected from older and younger units of the Torridon Group, attributable to differing lacustrine ecologies. Such exceptional preservation in the Proterozoic is part of an emerging picture of evolving taphonomic styles through time, in which better preservation of cells is found as we go further back into the fossil record. We attribute this remarkable preservation in the Proterozoic to very early diagenesis in a world before the evolution of a sediment Mixed Layer during the Cambrian explosion of the Metazoa.

This evidence suggests that Earth's terrestrial biota and its associated phosphorus cycle were well established on land by $\sim$1000 Ma ago. It also suggests that many algal groups, which today are obligate freshwater denizens, may have originated in freshwater lakes over a billion years ago.