Investigating life on land 1 billion years ago.

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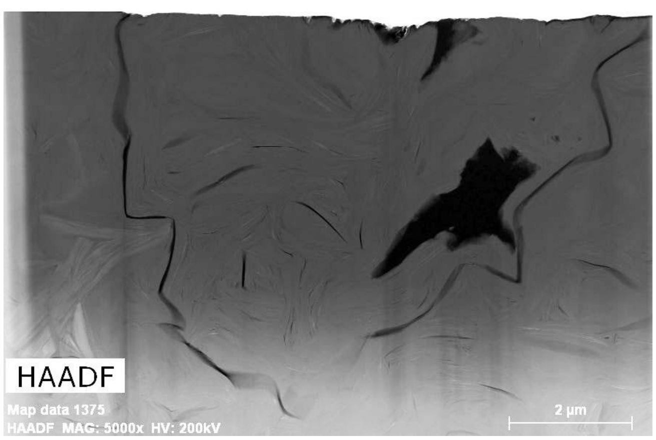
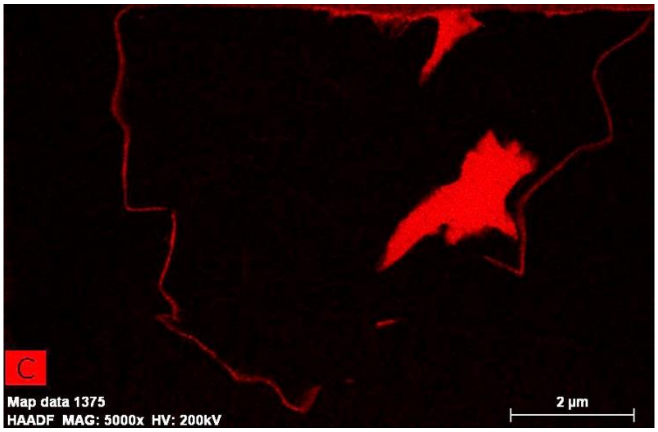
Life has been present on Earth for at least 3.5 billion years, however the fossil record for the first ~3 billion years is extremely scarce. Furthermore the vast majority of organisms were microscopic and showed simple morphologies, making early life investigation more difficult. Given that important evolutionary transitions occurred during this time, for example the evolution and diversification of Eukaryotes from prokaryote precursors, it is important to search for the best preserved fossils and apply state of the art techniques to them in order to try to discover when, where and how such evolutionary events occurred. Distinguishing different domains of life (e.g., prokaryotes versus Eukaryotes) requires analytical techniques with excellent spatial resolution in two and three dimensions, in order to accurately analyse key features of the cells such as cell wall architecture, biochemistry, signs of multi-cellularity and specific types of cell contents.

Here we present the study of exceptionally preserved 1 billion-year-old fossils from the Torridon Group of northwest Scotland. These microfossils are preserved in phosphatic nodules from lake deposits, providing precious insights into early life on land. Many fossils have retained some of their organic walls and cellular contents, which is a rather rare feature in the Precambrian (time period before 542 million year ago). The cell contents have various sizes, shapes and opacities, and occur in a variety of different cell morphologies. Of interest is whether this variety reflects true taxonomic diversity (i.e. many types of organisms) or whether some or all of these features are taphonomic (i.e., due to differential degradation of the cells prior to fossilisation). We will present data from correlative light microscopy, 2D & 3D electron microscopy (SEM and TEM), and NanoSIMS ion mapping, which enable us to compare and contrast the structure and chemical composition of the different cell content morphotypes with that of their cell membranes and walls. These analyses have allowed us to build up a 'spectrum of preservation' database whereby the effects of taphonomic degradation can be recognised within clusters of identical cells. Future work will build on these results and combine them with organic geochemistry biomarker work to determine the true diversity of eukaryotic organisms in lake environments 1 billion years ago.





Cross sections through a Torridon microfossil showing an outer cell membrane and preserved cellular content. Top panel: high angle annular dark field STEM image. Both cell membrane and cellular content appear in black. Bottom panel: carbon distribution, EDS. Red areas indicate presence of carbon. Both images show the same area.

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