Monazite, xenotime, and anatase associated with exceptional cellular preservation in early Neoproterozoic lakes.

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Paleontological sites of exceptional preservation (Konservat Lagerstätten) are a rare feature of the geological record. They become increasingly rare the older the deposits get, and yet are of major importance since they record a more accurate picture of past ecosystems than regular fossil assemblages do. Here we report the first occurrence of exceptional cellular preservation associated with Rare Earth (RE) phosphates monazite and xenotime, and/or anatase (TiO_2), from the ~1 000 Ma Torridon Group, Scotland.

Thin sections from the Torridon Group contain a number of coccoid microfossils possessing an organic intracellular body (ICB) and highly refringent minerals. High spatial resolution electron microscopy reveals that the ICBs are made of carbon, and traces of nitrogen, pointing to a biological origin. They are always located sub-centrally within the cell, and are not attached to the cell wall. Most of the volume of these fossils is mineralised by clays or francolite. However the highly refringent minerals are monazite, xenotime or anatase. Anatase crystals appear to have no systematic position in the cell or spatial relationship with ICBs, in contrast to monazite and xenotime, which are always formed around ICBs. When enclosed in a RE phosphate crystal, ICBs usually present a granular texture, whereas a massive appearance characterises the preservation in anatase.

The specific position within the cell of the RE phosphates, combined with their low solubility, points to very early precipitation after cell death, with the intracellular contents acting as a nucleation site, and the RE and P ions sourced from the decaying cell. Anatase formation is also interpreted to be early, based on the low mobility of Ti, but is not as tightly controlled by the locus of decaying cell content. Cell contents can be preserved by both minerals, each of them enabling preservation with a slightly different morphology.

This study is a powerful demonstration of the relevance of applying high-resolution electron microscopy techniques to understanding the precise spatial and temporal relationships between minerals and fossils.