Pyritization of shelly fossils, a multidisciplinary case study from the Jurassic Kimmeridge Clay

BENNETT HAWORTH[1], ALEXANDRA V. TURCHYN[1*],
SIMON W. POULTON[2], ALEKSEY SADEKOV [1,3],
NICHOLAS J. BUTTERFIELD[1]

[1]Department of Earth Sciences, University of Cambridge, Cambridge CB2 3EQ. *avt25@cam.ac.uk
[2]School of Earth and Environment, University of Leeds
[3]University of Western Australia, Perth, Australia

Shelly fossils, originally composed of calcite and aragonite often are replaced by iron sulfide (FeS_2) minerals throughout the Jurassic Kimmeridge Clay formation in Kimmeridge Bay, on the south coast of England. The FeS_2 shows preservation of detailed microstructure that presents problems for the traditional mould-and-cast interpretation of pyritization of fossil material. Furthermore, in some cases the aragonite is primary, while the calcite has been largely replaced with FeS_2. Finally, both polymorphs of FeS_2, pyrite and marcasite, are present, suggesting a unique chemical environment allowed the exceptional preservation. Detailed geochemical and mineraological analysis of the pyritized fossils in the Kimmeridge Clay provides unique insight into broader cases of exceptional fossil preservation.

We use bulk geochemistry, laser-ablation-coupled sulfur isotopes, and mineralogical analysis of shell microstructure to suggest that the pore waters alternated between acidic and FeS_2-saturated conditions, allowing mouldic microscale FeS_2 growth. We suggest these alternations in pore fluid conditions resulted from intermittent euxinia in the bay. There are three lines of evidence which support transient euxinia. First, laser-ablation coupled to multi-collector ICP-MS shows that the sulfur isotope composition of all analysed pyritized fossils is identical within the bed, suggestive of a single source of sulfide. Second, bulk iron speciation from the beds with pyritization is different from iron speciation from the beds where the shells are not pyritized, suggesting the sedimentary diagenetic conditions changed how the iron is complexed in the beds. Finally, the disorientation relationship between pyrite and marcasite suggests a fluctuating relationship between acidic conditions that favour marcasite growth and conditions which favour more traditional diagenesis. Variations in shell microstructure, studied via SEM and traditional microscopy, are used to explain why calcitic shell material is replaced while aragonite - theoretically more soluble and thus more prone to replacement - is often not.

This abstract is too long to be accepted for publication. Please revise it so that it fits into the column on one page.