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Lewis and Clark Fund for Exploration and Field Research in **Astrobiology**
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Project Title: Paleoenvironmental Significance of Microbialites From the Upper Triassic, Southwestern United Kingdom, and Relevance to the End Triassic Mass Extinction

Project Report

The Upper Triassic Mass extinction event is considered one of the 'big five' mass extinctions of the Phanerozoic. The extinction was likely caused by extensive volcanism associated with the opening of the Atlantic Ocean known as the Central Atlantic Magmatic Province (CAMP). Warming, mass wasting, and etc likely lead to a series of cascading events that that ultimately had a major impact on the environments and marine and terrestrial organisms living at the time.

In this research expedition I set out to the southwestern United Kingdom to investigate a layer of rocks that formed in very close association with the end-Triassic extinction event. The rocks are known as the Cotham Marble microbialites and they extend from the just north of Bristol southward into the Lyme Regis. On this trip I visited some of the major localities known to contain the microbialite structures: Lower Woods Nature Reserve, Manor Farm Quarry, Stowey Quarry, and Pinhay Bay in the southern coast. We also visited well-studied Triassic-Jurassic sections that do not contain the microbialite unit: St. Audries Bay, and Lavernock Point in south Wales in order to compare the lithologies across the different sections. Finally as I was lodging in Bristol, I visited the site where the microbialites were first discovered and described—Cotham House near the University of Bristol—and was able to the access museum specimens from the Bristol Museum and Art Gallery.

Analyses of the samples collected involved examination of textures of polished rock slabs, petrography, and analysis of stable isotopes.

Key findings:

I found that although the rock samples have a very laterally extensive distribution, their textures/phases of growth can be traced for tens of kilometers. The significance of this feature is that the formation of the microbialites resulted from nonlocal processes.

Petrographic analyses revealed the presence of putative microbial fossils previously undescribed in the Cotham Marble microbialites. For many years these rocks have been considered 'algal' in origin but evidence of microbial fossils have not yet been shown. Here we demonstrate the presence of putative bacterial fossils restricted to the dendritic portions of the microbialites that likely indicate they were some of the primary agents in constructing them. We complement and corroborate this information with organic carbon analyses that show that the dendrolites contain elevated organic carbon content compared to the interstitial fill.

Petrographic analyses also revealed the presence of abundant clusters of algal prasinophyte cysts likely belonging to the genus *Tasmanites*. *Tasmanites* is considered a disaster taxon that blooms during times of environmental crisis. A striking observation is that other Triassic-Jurassic sections across Europe also record peaks of prasinophytes during the Triassic Jurassic extinction interval, indicating a widespread environmental phenomenon likely in response to the environmental crisis associated with the mass extinction.

Finally, stable isotopes reveal that the microbialites record lighter organic and inorganic carbon stable carbon isotope values than overlying and underlying sections. A negative carbon isotope excursion has been recorded across several Triassic-Jurassic sections around the world and is used as a stratigraphic marker to mark the placement of the end-Triassic extinction. Our data indicate the microbialites record what is known as the initial carbon isotope excursion thus suggesting they capture carbon cycle perturbations recorded in several other end-Triassic sections around the world.

Two key findings resulted from this work: 1.) I was able to demonstrate the likely origin of the Cotham Marble microbliates and suggest that their growth was likely controlled by environmental factors. 2.) The occurrence of widespread microbialites, together with abundant *Tasmanites*, and the stable carbon isotopes all indicate the microbialites coincide with the end-Triassic mass extinction and therefore could reflect a widespread environmental response that allowed microbial mats with unique complex branching morphologies to extend and cover a vast area (~2,000 km^2) as a result of the mass extinction.

These findings have been accepted for publication in the journal *Palaios* and preliminary findings were presented at the 2013 Geological Society of America National Conference and at the 2013 American Geophysical Union Fall meeting.

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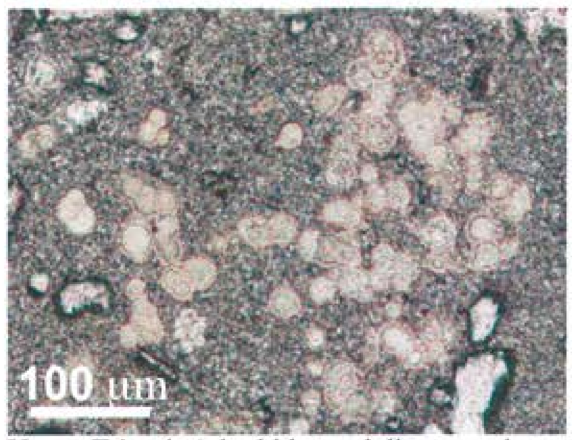
Jurassic
Blue Lias Formation

'Cotham Marble'

Outcrop photo of the Triassic-Jurassic Boundary at Lower Woods Nature Reserve South Gloucestershire, United Kingdom.

Polished piece of the 'Cotham Marble' microbialites.

Field photo of Michael Lewis and Yadira Ibarra at Stowey Quarry sampling Upper Triassic microbialites. photo credit: Sarah Greene



Upper Triassic 'algal blooms' discovered within microbialite samples. photo credit: Yadi Ibarra

Triassic-Jurassic Boundary beds of Lavernock Point South Wales. photo credit: Sarah Greene

At the Triassic-Jurassic Boundary of Charton Bay, Lyme Regis, Dorset Coast.

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