BIOMARKER INSIGHTS INTO THE END-TRIASSIC MASS EXTINCTION IN THE SW UK – AN OVERSIMPLIFIED ICONIC CARBON ISOTOPE EXCURSION

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Introduction

The end-Triassic mass extinction event (~201.5 Ma) resulted in a substantial loss of life globally and allowed for the evolutionary expansion of the dinosaurs. This extinction is linked to volcanic and thermogenic gas release from the emplacement of Earth's largest igneous province, the Central Atlantic Magmatic Province (CAMP). Pulsed CAMP emissions resulted in a doubling to tripling of atmospheric CO_2[1] and a cascading series of catastrophic environmental effects. A distinctive feature of the end-Triassic mass extinction is multiple negative bulk organic carbon isotope excursions (CIEs), the pre-cursor, initial, and main, with the extinction event typically thought to have taken place during the initial CIE. Since outgassed CAMP CO_2 is not isotopically depleted in ^{13}C enough to account for the CIEs, CAMP induced release of isotopically light CO_2 via dissociation of methane clathrates are proposed to account for these negative excursions [2,3].

The St. Audrie's Bay section in the Bristol Channel Basin, SW UK is the most referenced succession containing these CIEs, and typically used in global chemostratigraphic correlations. However, fossil and facies data show the initial CIE occurs during transition from marine to brackish and fresh water conditions, water depth decrease to centimetre scale, and multiple phases of sub-aerial exposure[4–6]. This study applies biomarker abundances and their stable isotopic compositions to investigate whether the initial CIE at the St. Audrie's Bay and neighbouring Lilstock sections (~10km apart) is indeed a global phenomenon or the result of significant but local ecological and environmental changes.

Results & Discussion

Strong evidence exists for microbial mat development during the initial CIE at St. Audrie's Bay and Lilstock. At the onset of the initial CIE, during an interval of sub-aerial exposure (inferred from several levels of desiccation cracks), there is an increase in the C_{31} 2α-methylhopane index, indicative of aerobic cyanobacteria[7]. Subsequently, C_{40} carotenoids indicative of green pigmented green sulfur bacteria (chlorobactane) and purple sulfur bacteria (okenane) also increase[8,9]. During this interval increases in β-isorenieratane, a biomarker of brown pigmented green sulfur bacteria, may be derived from a source other than β-carotane and isorenieratane (typical precursors for β-isorenieratane[10,11]) which show no significant increase during the initial CIE. The importance of cyanobacteria in microbial mats and preservation of okenane and chlorobactane in conditions other than "typical marine" (e.g., basin restriction, subaerial exposure)[12] strongly supports the development of a microbial mat, and not the traditional interpretation of photic zone euxinia which these biomarkers are often associated with. These increases occur in a brackish shallow-water setting in which microbial mats commonly thrive, and were deposited during the low-energy, calcium carbonate-rich

"dead zone" in which no macrofossils (and therefore metazoan grazers) are present[13]. Furthermore, at sections surrounding (but absent at) St. Audrie's Bay and Lilstock is the Cotham Marble; a penecontemporaneous bed containing laminar and thrombolitic stromatolites covering 2000 km^2. Extant microbial mats produce isotopically-depleted lipids compared to planktonic organisms, therefore the initial CIE must be, at the very least, influenced by the formation of a microbial mat.

Compound specific isotope analysis of short, mid and long-chain *n*-alkanes, pristine, and phytane show near-synchronous negative and positive excursions at the initial CIE onset and termination, respectively. This follows the general trend of the bulk organic carbon isotope record, suggesting a source of isotopically light carbon for the initial CIE. However, there is discrepancies between sections and biomarker patterns. At St. Audrie's Bay the initial CIE negative 5.12‰ shift is best represented by a negative shift in phytane (5.12‰), whereas at Lilstock the initial CIE negative 8.05‰ shift it is best represent by a negative shift in the mid to long-chain ($C_{21 - 29}$) *n*-alkanes (4.12 to 6.01‰). At both sections $\delta^{13}C_{phytane}$ most closely follows the bulk organic carbon isotope profile. Some of the largest isotopic shifts in *n*-alkanes occurs at the termination of the initial CIE, with negligible effect on the carbon isotope record. Due to the low total organic carbon values throughout the initial CIE (<1%) minor changes in organic matter input would have significant impact on the initial CIE. We attribute a microbial mat methanogenic bacterial origin for phytane that may be making the major contribution to the bulk organic carbon isotope record during the initial CIE[14]. At Lilstock, odd numbered mid to long chain *n*-alkanes ($C_{21 - 27}$) indicative of bryophytes (mosses) and submerged aquatic plants[15–17] display isotopic values more ^{13}C depleted than phytane. The isotopic signature of phytane likely comprises a mix of sources including microbial mats and phytoplankton. Therefore, the initial CIE during the end-Triassic may be attributed to sources other than those from CAMP-induced atmospheric carbon isotopic changes, highlighting the caution that should be used when undertaking chemostratigraphic correlations among sections where significant water depth fluctuations are apparent.

References

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