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THE ROLE OF MICRORGANISMS IN CARBONATE DEPOSITION IN AOM SETTINGS

Zoë ROBERTS[1], Richard D. PANCOST[1] and Fiona C. MELDRUM[1]

1. School of Chemistry, University of Bristol, Cantock's Close, Bristol BS8 1TS, UK.

Recent work, combining phylogenetic analyses, lipid biomarker quantification and stable isotopic analysis, indicates that consortia of sulfate-reducing bacteria and archaea work in syntrophy to mediate the anaerobic oxidation of methane (AOM) in methane-rich sediments (Boetius et al., 2000; Pancost et al., 2000). As a consequence of AOM, bicarbonate concentrations are very high in pore waters and bottom waters associated with methane seeps, leading to the extensive precipitation of authigenic carbonate in sediment pore spaces and on the seafloor (e.g. Peckmann et al., 1999). These carbonates are a critical component of carbon cycling at cold seeps as they represent the long-term sequestration of methane-derived carbon.

At present it is unclear how microbial mats become lithified and whether microbial organic matter can serve as a template for carbonate precipitation. Certainly, the abundance of lipid biomarkers in authigenic carbonates (Elvert et al., 2000; Michaelis et al., 2002; Pancost & Damsté, 2003) indicates a close relationship. We employed a multidisciplinary approach to investigate the role of microorganisms in carbonate precipitation incorporating techniques such as biomarker analysis, solid state NMR, SEM and X-Ray diffraction. Samples examined include microbial mats from the Black Sea and carbonate crusts from Kattegat bay, east of Denmark.

For biomarker analysis the mats were subsampled as previous research has indicated that mat composition can vary in both microbial composition and biomarker distributions (e.g. Michaelis et al, 2002). A range of biomarkers was observed including archaeol and hydroxyarchaeol, pentamethylicosane (PMI), crocetane and various dialkyl glycerol diethers (DGDs) with the high abundance of crocetane suggesting that the archaea present are most likely from the ANME-2 group. The distributions of biomarkers differ between mat types (as determined by inorganic carbon content and colour); most strikingly biomarkers are much less abundant in the more lithified mat parts. Crocetane and hydroxyarchaeol are observed in both black and pink/orange mat types, which differs from the observations of Blumenberg et al. (2004). The greater the amount of inorganic carbon present in a sample, generally the less crocetane is present relative to PMI, although the trend is not linear (see fig. 1a). When comparing data between samples of the same mat type, differing absolute abundances are also observed. For example, for three samples of pink/orange, soft mat (i.e. low IC content) abundances of crocetane were 830, 380 and 240 μg/g, while those of PMI were recorded at 380, 90 and 280 μg/g respectively.

X-Ray diffraction analysis of each section has revealed that the carbonate part of the mat is high-magnesium calcite. Analysis of the inorganic part of the mat by SEM also reveals the presence of calcite crystals; in many cases the calcite crystals are present as clusters, many of which appear as triangular prisms of intergrown rhombohedra (fig.1b). This morphology has been reported as typical for calcite crystals grown in the presence of organic additives such as citric acid (Meldrum & Hyde, 2001). This suggests that chemicals present in the AOM consortia directly affect the crystal structure of the calcite precipitated.

Using crystal morphology could therefore be a valuable component in the analysis of ancient carbonates where no external organic matter remains and little biomarker material can be extracted from the carbonate.

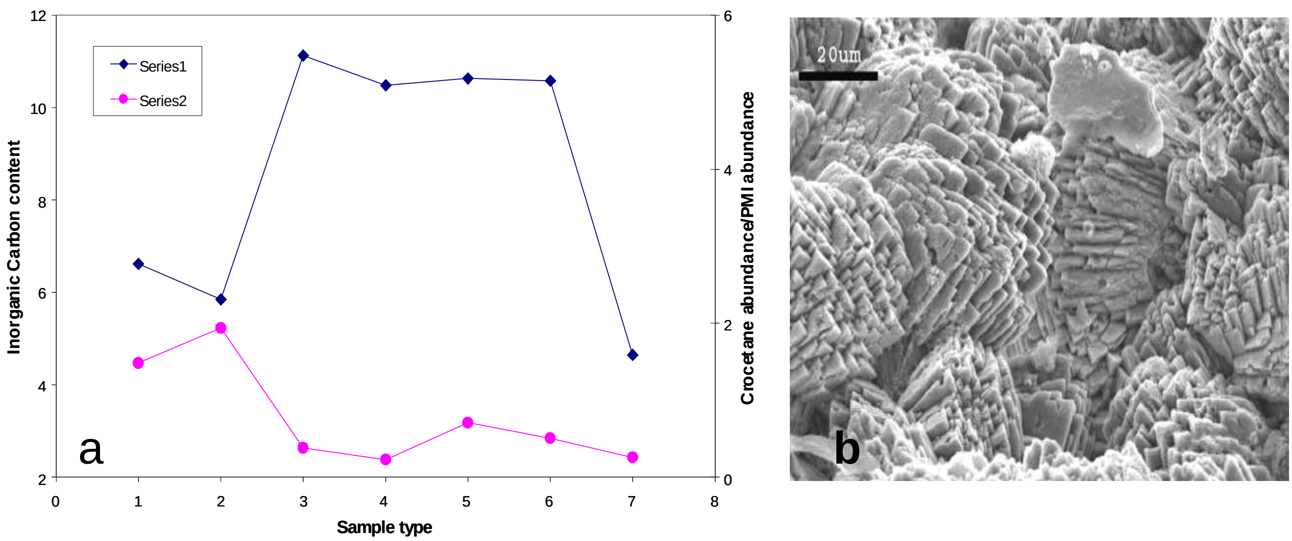

Figure 1. a) Graph illustrating the differences in inorganic carbon content and crocetane/PMI ratio between mat types. Mat types 1, 2 and 7 were soft and fleshy while 3, 4, 5 and 6 were hard and lithified. b) SEM image of the inorganic parts of a mat showing the crystal structure.

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