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Carbonate preservation pathways in cold-water coral mounds

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The aim of this thesis is to contribute to the understanding of the impact of early diagenesis on cold-water coral (CWC) mound fabrics and carbonate preservation pathways in discrete mound structures. Studying diagenetic patterns in mound sediments is important to understand better the intrinsic controls on CWC mound formation through time, and its impact on the palaeoceanographic and palaeoclimatic sedimentary record. Specifically, the leading questions of this thesis are to understand the impact of methane seepage on the mound fabric, the intrinsic and extrinsic controls on seepage in mounds and the significance of methane seepage in mounds. For the purpose of this study, six gravity cores were retrieved from resp. Brittlestar Ridge I (BRI) in the East Melilla Mound Field (EMMF), Alboran Sea and Alpha Mound on the PDE, Gulf of Cadiz in June 2013 during the EUROFLEETS cruise MD194 Gateway 'The Mediterranean-Atlantic Gateway Code: The Late Pleistocene Carbonate Mound Record'. Results from gravity cores from BRI in the Alboran Sea have not been affected by methane seepage and reaffirm the use of CWC mound sediment as environmental records. Results showed that CWC growth re-initiated as early as 14.8 ka BP, coinciding with the start of the Greenland Interstadial 1 (GI-1) and that CWC growth is intimately linked to continental run-off and North Atlantic climate dynamics. Within the context of this thesis, these results confirm that CWC mound sediments which are not too much affected by diagenesis are excellent palaeo-environmental records. Contrary to CWC mound growth in the Alboran Sea, Alpha Mound is known to be a mound clearly affected by methane and therefore provides an excellent opportunity to study the impact of methane on the mound fabric. Research so far has evidenced the presence of anaerobic oxidation of methane (AOM) and its imprint on the fabric, but has not been able to disentangle AOM-related fabrics from fabrics related to other diagenetic processes. This makes it difficult to constrain the carbonate preservation pathways through time in mound sediments. Results from this thesis showed that methane has left a profound impact on the Alpha Mound sediments, which are unique and distinct from other diagenetic features. Lipid biomarker analysis of sediment from Alpha Mound evidenced that a fossil sulphate methane transition zone (SMTZ) is present, where AOM induced the precipitation of a high-Mg calcite cement and caused the semi-lithification of the sediment. Based on the presence of authigenic aragonite needles and bio-erosion features, the semi-lithified interval was likely exhumed afterwards and acted as substrate for renewed CWC larval settlement. Today, the present SMTZ is established below the fossil SMTZ. Moreover, AOM-derived H_2S interacts with other processes higher in the sedimentary column leading up to 40 wt.% Ca-excess dolomite precipitation (but not to lithification of the sediment) thereby overprinting earlier diagenetic signals. Therefore, results show that high-Mg calcite and Ca-excess dolomite in Alpha Mound precipitate under different conditions each having a unique pathway. However, it remains difficult to constrain the global significance and relevance of the impact of methane on CWC mound fabrics because Alpha Mound is likely unique in being subjected to methane so strongly. However, better suited tools (e.g. lipid biomarker and petrographic analysis) need to be applied to other CWC mounds and bioconstructions to exclude the potential involvement of methane through space and time. In addition to more detailed research on CWC mound fabrics, another way to investigate the role of methane on CWC mounds is through simulating changes to mound fabrics in constrained lab environments with the use of versatile experimental flow-through reactor set-ups.

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