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Carbonate mounds from the Gulf of Cadiz in relation to methane seepage: unrelated phenomena or coupling?

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For more than decade, the formation of carbonate mounds, related ecosystem development and organization/functioning of the entire mound habitats are subjects for a growing amount of studies and discussions. Carbonate mounds from the Gulf of Cadiz are of special interest due to their association with active mud volcanoes within the El Arraiche mud volcano field. Such co-occurrence of ecologically contrasting phenomena anticipates complex biogeochemical interactions between a carbonate mound interior and seeping through hydrocarbon-rich fluids. To get closer in understanding of how methane affects a carbonate mound development in the gulf, a combination of inorganic and organic geochemical techniques was applied to two sedimentary cores collected from summits of Alfa and Beta mounds. These mounds were found at the NW slope of the Gimini MV at the Pen Duick Mound Province. We analyzed vertical distribution profiles of sulfate, sulfide, chlorinity, DIC in combination with hydrocarbon gas measurements and lipid biomarker study. To have estimates of Sea Surface Temperature (SST) during the carbonate mound formation, we applied the TEX86 (TetraEther indeX of tetraethers with 86 carbon atoms; Schouten et al., 2002) and the alkenone-based UK37 index (Müller et al., 1998). The pore-water data revealed the presence of brine inflow, which is consistent with the data of Hensen et al., (2007). The behavior of sulfide distribution profiles and 13C values from dissolved inorganic carbon (DIC) indicated that most of the sulfide and DIC are resulted from the microbial anaerobic oxidation of methane (AOM) processes. In contrast, the analysis of archaeal membrane lipids from distinct clades of AOM-mediating anaerobic methanotrophs showed exceedingly low concentrations of specific biomarkers, which is in contradiction with pore-water and gas chemistry data. Besides, AOM is the main cause for the increase of sedimentary alkalinity that leads to carbonate precipitation. Instead, some sedimentary intervals associated with pore-water-detected AOM zone showed the presence of semi-dissolved coral branches, indicating thus rather acidic intra-environments. In this paper we discuss a potential “consecutive order” of biogeochemical processes in the close subsurface of Alfa and Beta carbonate mounds and outline the importance of careful interpretation of biogeochemical signatures related to past, modern and post seepage episodes.

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