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The giant cold-water coral mound as a nested microbial/metazoan system: physical, chemical, biological and geological picture (ESF EuroDiversity MiCROSYSTEMS)

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The MiCROSYSTEMS project under the ESF EUROCORES EuroDiversity scheme is a holistic and multi-scale approach in studying microbial diversity and functionality in a nested microbial/metazoan system, which thrives in deep waters: the giant cold-water coral mound. Studies on prolific cold-water coral sites have been carried out from the canyons of the Bay of Biscay to the fjords of the Norwegian margin, while the Pen Duick carbonate mound province off Morocco developed into a joint natural lab for studying in particular the impact of biogeochemical and microbial processes on modern sedimentary diagenesis within the reef sediments, in complement to the studies on I0DP Exp. 307 cores (Challenger Mound, off Ireland).
Major outcomes of this research can be summarized as follows.
• IODP Exp. 307 on Challenger Mound had revealed a significant prokaryotic community both within and beneath the carbonate mound. MiCROSYSTEMS unveils a remarkable degree of compartmentalization in such community from the seawater, the coral skeleton surface and mucus to the reef sediments. The occurrence of such multiple and distinct microbial compartments associated with cold-water coral ecosystems promotes opportunities for microbial diversity in the deep ocean.
• New cases of co-habitation of cold-water corals and giant deep-water oysters were discovered in the Bay of Biscay, which add a new facet of macrofaunal diversity to cold-water coral reef systems.
• The discovery of giant, ancient coral graveyards on the Moroccan mounds not only fuels the debate about natural versus anthropogenic mass extinction, but these open frameworks simultaneously invite for the study of bio-erosion and early diagenesis, in particular organo-mineralization, and of the possible role and significance of these thick, solid rubble patches in 3D mound-building and consolidation.
• The assessment of the carbonate budget of a modern cold-water coral mound (Challenger Mound) reveals that only 33 to 40 wt % of carbonate is derived from corals and suggests a selective enrichment of the hemipelagic carbonate fraction, compared to adjacent sediment drift deposits.
• The detection of allochthonous fluids, in particular brines, in the pore space of the surficial mound sediments on the Pen Duick Escarpment hints towards the presence of salt deposits deep underneath, and simultaneously provides the first direct evidence of advective fluid transfer from the deep, throughout the mound substrate and the full mound height. Potential stratigraphic pathways leading from the deeper basinal realms directly to the mound setting have been imaged in a spectacular way through high-resolution pseudo-3D seismic imaging. Geophysical signatures of free gas accumulations have been detected a few hundreds of meters below the mound base, but low concentrations of methane and the absence of lipid biomarkers from methane-dependent prokaryotes suggest low fluxes of methane-derived carbon and thus very small rates of anaerobic oxidation of methane (AOM) in the immediate mound subsurface. Local changes in the sediment biogeochemistry are most likely dictated by slow

diffusive fluid transfer, operating in a heterogeneous way in the subsurface.

• Cultivation experiments with sediments from microbially active mound zones have allowed to study microbially induced carbonate precipitation and provide a tool for the interpretation of carbonate mineralogy. The development and operation of a continuous high-pressure bioreactor (100 bars) allows to simulate in an ex situ mode the impact of environmental parameter changes onto the functioning of relevant microbial communities.

• The detected influx of sulfate in mound sediments implies that bacterial sulfate reduction can be the dominant anaerobic carbon mineralization process. Groundwater flow modeling suggests that currents impinging on the escarpment and the flanks of an exposed mound can account for a significant influx and transport of sulfate through convective fluid transfer within the mound sediments. Oceanic currents consequently provide not only a major control on the external flux of nutrients to the mound-building communities, but they also potentially drive internal flow in the mound. The extant hydrodynamic climate of the mound setting is documented through long-term lander deployments and CTD stations: the current records reveal a significant tidal and seasonal variability. The past environmental record over the last 400 ka is documented in a most comprehensive sedimentary archive, sampled with long cores at the foot of the Pen Duick Escarpment during the MD169 'MiCROSYSTEMS' cruise in July 2008.

• MiCROSYSTEMS has significantly contributed to the successful submission of IODP proposal 673-Full, which should (i) document the whole-mound architecture and the mound setting on Pen Duick Escarpment as well as a most comprehensive stratigraphic record on a reference site at the foot of the escarpment, (ii) reveal the full spatial pattern in microbial diversity, activity and functionality throughout the mound and underneath, and (iii) unravel the plumbing system of a mound and the dynamic interaction between advective, convective and diffusive transfers of organic and inorganic compounds, which impact on biogeochemical equilibria, microbial activity and early diagenetic processes.