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The Pen Duick Escarpment off Morocco: A promising biogeochemically active carbonate mound laboratory (MiCROSYSTEMS)

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Carbonate mud mounds, found in marine environments from shallow- to deep-water settings, span from Proterozoic to recent times. During the past decades, numerous active venting fields were discovered in deep marine environments and became a subject of extensive study for marine scientists. Mound building seems to be a fundamental but still enigmatic strategy for life. Various arguments suggest that microorganisms are playing a major role in the reef development, mound formation and biodiversity. Therefore, it is important to evaluate the microbial mediated processes of carbonate precipitation.

Cold-water coral reefs thriving on carbonate mounds were discovered in the late 1990's off western Ireland. An exploratory cruise of RV Belgica in 2002 off Morocco has led to the discovery of apparently juvenile mounds in water depths of 500-600 m, topping a cliff - the Pen Duick escarpment - flanked by giant mud volcanoes. Subsequent cruises have confirmed the colonization by deep-water corals and have unveiled extensive fields of seep-related carbonate crusts in the off-reef regions. Long cores taken in 2004 indicate that the 'Pen Duick' mounds, in which microbial action was demonstrated by a strong emission of hydrogen sulphide, may be considered as giant biogeochemical reactors. The mound sediments were dated 2 kyrs B.P. at the surface and 20 kyrs B.P. in a depth of 6 mbsf.

A 450 cm long gravity core, coming from one of these juvenile mounds, was sampled and analyzed for mineralogy, stable isotopes composition, geochemistry, and micro-

bial communities. Most of the sediment consists of calcite (coccoliths), quartz and dolomite. At a depth of 4 mbsf, we found hardened nodule-like structures, embedded in grey mud containing cold-water coral pieces. The presence of 20-30% of dolomite, in the carbonate phase, suggests a microbial influence during mineral formation. Preliminary results of the pore water geochemistry indicate a reactive sulphate – methane interface at 3.8 mbsf. In this layer we focused our studies on the microbial communities, such as methanogens, methanotrophs and sulphate reducers. The trend of the $\delta^{13}C$ values in digenetic carbonate supports the assumption of microbial activity in this section of the core. In order to define the primary microbial community involved in carbonate precipitation, we did direct culturing, DNA isolation and PCR analysis of three functional genes, the α subunit (mcrA) of the methyl-coenzyme M reductase (MCR), the α subunit (pmoA) of the particulate methane monooxygenase (MMO) and the α and β subunits (dsrA and dsrB, respectively) of the dissimilatory sulfite reductase (DSR). These enzymes are involved in methanogenesis, methanotrophy and sulphate reduction biochemical pathways, respectively. In summary, our initial results demonstrate that the Pen Duick carbonate mound can be considered as a natural laboratory in which to study cold-water coral ecosystems associated with microbial activity.