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Sr/Ca and Mg/Ca ratios in sediments from the Niger fan: Evidence for past episodes of gas hydrate dissociation?

G. Bayon (1), C. Pierre (2), G.M. Henderson (3), J. Etoubleau (1), M. Voisset (1), E. Cauquil (4), Y. Fouquet (1) and The NERIS Team

(1) Département Géosciences Marines, Ifremer, Brest, France, (2) Université Pierre et Marie Curie, LOCEAN, Paris, France, (3) Department of Earth Sciences, University of Oxford, UK, (4) TOTAL, Paris, France (Germain.Bayon@ifremer.fr)

We report Sr/Ca and Mg/Ca ratios for sediments recovered from cold seeps on the Niger deep-sea fan. Our aim has been to investigate the dynamic of gas hydrates in this area over the last few thousand years and longer. This study is directly relevant to the current effort at better understanding how the oceanic gas hydrate reservoir may respond to climate change. In cold-seep areas, authigenic minerals (i.e. aragonite, Mg-calcite, dolomite) precipitate typically from the oxidation of methane-rich fluids. This occurs at the sulfate-methane interface (SMI), and commonly forms discrete millimeter-size concretions in gas hydrate-bearing sediments. Here, we use Sr/Ca and Mg/Ca ratios as proxies for the presence of aragonite (Sr-rich) and Mg-rich carbonates in sediments.

The NERIS Project is a joint collaboration between Ifremer and TOTAL, investigating the geological risk linked to the presence of gas-rich fluids within Niger fan sediments. Two expeditions (NERIS 1 & 2) have taken place on fluid venting areas of the Niger deep-sea fan in 2003 and 2004. Sediments, massive gas hydrates and numerous carbonate crusts have been collected from active seeps, from water depths of 1200m to 2000m. Interstitial waters from sediments were extracted on-board for geochemical analyses, immediately after sampling. Here, we focus more specifically on one sediment core recovered at 1200 m water depth. In this 7-meter-long core, massive gas hydrates have been observed from 4 m depth. The present-day SMI in this core is located just above the gas hydrate horizon, as estimated from the sulfate profile in pore waters. We present high-resolution profiles along this core for major elements and stable isotopes (δ^{18}O, δ^{13}C).

Sr/Ca and Mg/Ca exhibit large variations along the core, reflecting a varying proportion of each sediment constituent (terrigenous material; biogenic carbonates; authigenic aragonite; and Mg-carbonates). A mixing model of these 4 end-members reveals that discrete concretions of authigenic carbonates occur within a well-defined sediment layer, between 30 cm and 170 cm depth. The carbon isotopic composition for the bulk carbonate fraction of the sediment also exhibits drastic changes along the core, from present-day seawater-like δ^{13}C values for surficial sediments down to highly negative values ($\sim$ -30 ‰ PDB) for sediments between 30 cm and 170 cm. This confirms that the carbonate fraction within this latter sediment layer is dominated by methane-derived authigenic carbonates.

When did this concretion-rich sediment layer form and what is its overall significance for the dynamic of gas hydrates in this area? We will address those questions using an age model for that core and direct U/Th dating of aragonite concretions. First results show that the base of the concretion-rich sediment layer corresponds to the last deglaciation period ($\sim$ 12,000 yr BP). This suggests that climate change in this area, presumably an increase of the bottom-water temperature, may affect the dissociation of gas hydrates, leading to the formation of authigenic carbonates.