FLUID SEEPS OF THE NILE DEEP SEA FAN : FIRST RESULTS OF THE NAUTINIL (2003) DIVE EXPEDITION

J.P. Foucher [1] *, J. Mascle [2] , J. Woodside [3], A. Boetius [4] and the NAUTINIL Shipboard Scientific Party

[1] IFREMER, DRO/GM, B.P. 70, 29280 Plouzané cedex, France
[2] UMR 6526 Geosciences Azur, B.P. 48, 06235 Villefranche-sur-Mer, France
[3] Vrije Universiteit, De Boelelaan 1085, 108[1] HV Amsterdam, The Netherlands
[4] Max Planck Institute for Marine Microbiology, Celsiusstr. 1, 28359 Bremen, Germany

Abstract

Fluid seeps of the Nile deep sea fan were investigated with research submersible *Nautile* during the Nautinil expedition (2003). Dive observations revealed active manifestations of gas emanation and brine seepage through the summits of several mud volcanoe and pockmarks along the continental slope between depths of 500 and 3000 m. Densely distributed bacterial mats and filaments are associated with brine seeps. Authigenic carbonate crusts and chemosynthetic fauna are numerous in pockmarks.

Key-Words: Eastern Mediterranean, Nile fan, Fluid seeps, Mud volcanoes, Submersible dives

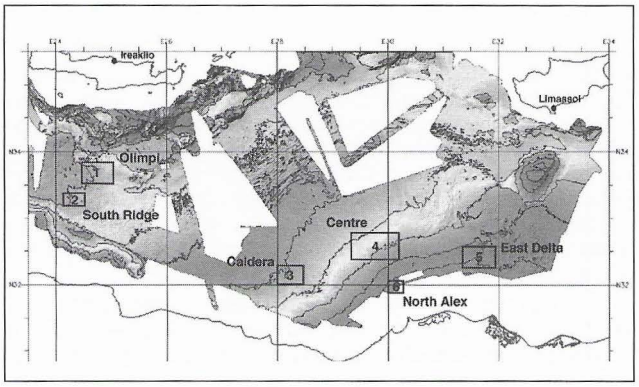
The Nile Fan is one of the largest deep sea fans in the world. It was built mainly in the past several million years since the Messinian salinity crisis and covers a segment of the ancient (late Jurassic to early Cretaceous) passive margin of Egypt. It is characterised, among other things, by the presence directly on the sea floor of numerous potential fluid-escape structures along the continental slope between depths of 500 and 3000 m. Several of these structures were investigated with research submersible *Nautile* during the Nautinil expedition that took place from 3 September to 3 October 2003 aboard the research vessel *L'Atalante*, starting and ending at Iraklion (Crete). Most of these structures were found to host active fluid seeps.

Fluid seepage target areas on the Nile deep sea fan exhibit diverse geophysical signatures and morphologies which facilitate their identification using surface geophysical data. These can be classified most simply as (a) sedimentary build-ups and flattened cones, often inferred to be mud volcanoes, varying from several hundreds to more than a kilometre in diameter and several tens of metres high, some situated either at the centre or periphery of large circular depressions with the appearance of volcanic calderas, and (b) high reflectivity patches inferred to be pock-marks, without apparent morphologic signature at the scale of the multibeam bathymetry.

Seven dives focused on four mud volcanoes situated directly over gas chimneys high on the continental slope of the Egyptian margin (Zones 5 and 6). Previous sampling had indicated unstructured sediment supersaturated in gas, thus confirming the interpretations based on seismic reflection data and implying strong degassing activity. Nautinil submersible observations demonstrated active seepage on the summits of the four visited volcanoes, where a rough topography suggests explosive gas eruption. Several seafloor spots of dark, reduced sediment, often covered with whitish bacterial mats, were interpreted as areas with high seepage rates. Large geothermal gradients, with mud temperatures as high as 45°C at 9 meters below the sea floor in the Isis mud volcano, attest to an overall vigorous seepage activity through the four visited mud volcanoes.

Nine dives with their numerous *in situ* samples were aimed at a detailed analysis of three mud volcanoes situated near or within a large caldera of nearly 8 km diameter and located at 3000 m depth in a region of the deep sea fan where underlying Messinian salt deposits, previously forming a veritable cap rock, were ruptured by gravity tectonics and thereby facilitated the rise of underlying fluids to the sea floor (Zone 3). Active brine flow, forming brine ponds, with extensive microbiological manifestations, was observed to be a main characteristics of the Cheops and Chefren mud volcanoes.

Three dives carried out on the pock-marks of the central Nile fan lead to a better understanding of the significance of these features (Zone 4). Authigenic carbonates occur on the seafloor as isolated chimneys or massive pavements. They are made of Mg-rich calcite and aragonite and are often found to be associated with chemosynthetic fauna (tube worms). Observations suggest a long-lasting seepage activity.



As part of Nautinil, three dives were also completed on the Mediterranean ridge (Zones 1 and 2), allowing for a comparison of seepage properties in two distinct tectonic provinces of the eastern Mediterranean sea to be made.

Nautinil is the first phase of a series of three marine expeditions planned for Mediflux, a project within the framework of the cooperative European programme Euromargins, itself part of *Eurocores*, a vehicle for financing research launched in 2001 by the European Science Foundation (ESF). *Mediflux*, a 4-year project begun in 2003, is based on cooperation among diverse institutes and university laboratories in France (Ifremer, IFP, and several CNRS associated universities including Géosciences-Azur and Lodyc), the Netherlands (NIOZ, University of Utrecht, and the Vrije Universiteit of Amsterdam), and Germany (the Max Planck Institute in Bremen). *Mediflux* is dedicated to multidisciplinary analysis of seafloor fluid seeps (cold seeps) and their associated deep environments.