IN-SITU OBSERVATION OF POCK-MARKS FROM THE NILE DEEP-SEA FAN DURING THE NAUTINIL CRUISE: PRELIMINARY RESULTS

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Abstract

Recent geophysical surveys on the Nile deep sea fan have revealed numerous patches of high reflectivity, mainly in the Central province, locus of recent sediment slumps. It has been suggested that those features may correspond to pockmarks linked to gas-rich fluids escaping the seafloor. Here we present preliminary results from the Nautinil cruise, which has taken place on the Nile deep-sea Fan from September 3rd to October 5th 2003. Direct observation of the seafloor with the Nautile submersible has confirmed that these high reflective patches correspond to carbonate concretions associated with cold seeps. Two distinct types of structures have been identified: (1) circular pockmarks with central carbonate chimneys or debris, and (2) massive carbonate pavements of Mg-rich calcite and aragonite. A specific fauna has been observed in association with these seeps.

Key words : pockmarks, cold seeps, carbonate crusts, Nile deep-sea fan

Since 1998, several geophysical surveys (multibeam bathymetry, backscatter imagery, 3-5 kHz profiling, MCS data) have shown that the Nile deep sea fan (NDSF) exhibits various structures characteristic of an active fluid circulation within continental margin sediments. Those structures include mud volcanoes ressembling small cones (100 to 900m in diameter), mud-pies (5 km in diameter), and pockmarks or mounds [1; 2]. Pockmarks and mounds, represent the most widely observed evidence of potential cold seeps on the NDSF. They are particularly abundant in its Central province, between 1700 and 2500 water depth, where they are characterized by distinctive high backscatter patches. In this province, a widespread field of pockmarks coincides with an area of major sediment destabilization, which covers an area of more than 10 000 km^2 [3]. Multibeam bathymetry reveals that this slope area exhibits rough and chaotic small-scale reliefs, together with linear furrows (e.g., channels), disconnecting individual sedimentary flows. The association between those destabilized deposits and pockmarks suggests that both phenomena are probably closely related. Although no clear BSR has yet been observed in this area, the potential presence of gas hydrates remains a possibility which may explain this association between slump deposits and pockmarks.

In september 2003, the NAUTINIL cruise, as part of the Mediflux European program, has allowed the in-situ observation of these highly reflective patches with the Nautile. Three dives on different parts of the central province, between 1700 and 2000 meters depth, have confirmed that high backscattered patches in this part of the Nile cone correspond both to active and extinct cold seeps. More specifically, high-reflectivity signals are induced by massive carbonate concretions, which precipitate from fluids escaping the seafloor. Two distinct sedimentary structures have been observed during these dives:

1) circular pockmarks of variable diameter (~3-15m), where carbonate chimneys (up to ~1m height) and/or infilled burrows have sometimes built up in the central part. Observed pockmarks are coalescent one to each other, covering areas varying from ~30m^2 to 100m^2. Debris of authigenic carbonates and dead shells (pogomorpha tubes, clams, urchins...) accumulate in the central part of all pockmarks. In some pockmarks, carbonate chimneys (composed mainly of magnesian calcite and aragonite) have been identified together with unfilled burrows, covered by manganese oxides. Carbonate chimneys are ~1m height and are composed of several distinct layers of aragonite (up to 10). Unfilled burrows almost certainly formed within the first few cm below the sediment/water interface initially. Therefore, the presence of these burrows on top of one carbonate chimney suggests that these chimneys may have formed within the sediment similarly. From this above consideration, it would be expected that freshly precipitated carbonates form from the base of the chimney. Then, winnoying of the soft sediment around the freshly emplaced carbonates would bring this aragonitic layer 'out of' the sediment and allow the chimney to "grow". Living fauna (pogomorpha worms, urchins) can be observed at the base of the carbonate chimney.

2) massive carbonate pavements of aragonite, covering larger areas (> ~100m^2) of the seafloor. As a matter of fact, high-reflectivity signals can also be associated to massive carbonate pavements, sometimes covered by pelagic sediments. No fauna has been observed on their surface. Those carbonate slabs are intensively fractured in ~m^2 size pieces. This has allowed us to examine some fresh cuts across the pavements. It consists mainly of "*gruyere-like*" magnesian calcite (i.e., calcite scattered with mm- to cm-size holes). Whereas the surface of the pavements has been intensively oxidised (i.e., brownish ochre color), fresh cuts of aragonite are greyish. Underneath the pavements, living fauna (pogomorpha worms, urchins, clams, galatheas, mussels) are extremely important.

The discovery of these cold seeps associated with authigenic carbonate precipitates demonstrate that sub-circular patches of high-reflectivity almost certainly correspond to areas where gas-rich fluids escape the seafloor. While circular pockmarks must be linked to localised fluid vents, massive carbonate pavements most likely correspond to more diffused flow of gas from the seafloor.

Several push-cores have been taken and carbonate samples have been grabbed. In the near future, a better characterization of those authigenic carbonates (mineralogy, geochemistry, dating) will bring additional constraints on how pockmarks may form in such cold seep environments. In addition, geochemical analyses on sediments sampled by the push-cores will help determining the gas source (biogenic or thermogenic?) and the eventual presence at depth of gas hydrates.

References

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