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Active pockmarks, mounds and slope instabilities on the Nile margin:

In situ observations, geophysical, sedimentological and geochemical evidence

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Recent MEDIFLUX actions on the Nile deep-sea Fan (Nautinil 2003 and Mimes 2004 expeditions) have investigated fluid seeping structures and their relationship with slope instabilities. Pockmarks and mounds, characterized by high reflectivities on multi-beam data, are particularly abundant in the central province of the Nile cone, between 1700 and 2500 m water depth. In this area, sediments are completely destabilised by mass-wasting processes (i.e. creeping; Loncke et al., 2002, 2004).

The submersible Nautile was used to gather video and still-camera imagery, map the surrounding microbathymetry and sample carbonate crusts, sediments, fluids and associated organisms. A methane sensor (METS, Capsum) was used to provide some qualitative indication of enhanced methane concentrations in bottom-waters along each dive transect. Additional 3.5 kHz profiles, EdgeTech deep-tow sidescan sonar data and Kullenberg sediment cores were also collected in this active area. The mineralogical, geochemical and isotopic composition (δ^{18}O, δ^{13}C, ^{87}Sr/^{86}Sr, ^{143}Nd/^{144}Nd) of carbonate crusts has been analysed to gain further insights into their mode of formation. In particular, high-resolution profiles of major elements and isotopes have been performed along crusts cut perpendicular to their growth banding.

Two types of structures have been identified during the Nautile dives: 1) small circular

pockmarks of variable diameter (3-20 m) and 2) massive carbonate pavements corresponding to large mounds ($\sim$400 m long and $\sim$3 m high). Acoustic sidescan sonar record of the water column has revealed that gas plumes are present above some of these structures. Methane anomalies have been also detected in bottom-waters using the Capsum sensor, along each dive transect. They occur over large depressions showing signs of intense bio-activity, in the immediate vicinity of carbonate mounds. Interestingly, on 3-5 kHz profiles, these depressions correspond to areas where sediments have been thinned up by creeping processes. In addition, two major observations were made from the analysis of sediment cores: 1) numerous figures of fluid ascents are visible within the sedimentary cover, and 2) the upper part of the underlying debris-flow deposit is highly compacted.

All these observations question the role of slope instabilities upon the formation of carbonate build-ups and the overall fluid seepage activity in the central province of the Nile deep-sea fan. Our observations suggest that the surface of debris-flow deposits act as a decollement layer, most probably, where fluids can migrate preferentially. The pathways for gas-rich fluids ascending to the seafloor are clearly controlled by the internal structure of the destabilized sedimentary cover (i.e. thinned areas). Finally, geochemical analyses of carbonate crusts indicate a shallow source for methane-rich fluids and provide additional constraints on their formation processes.