Geophysical Research Abstracts, Vol. 8, 04094, 2006
SRef-ID: 1607-7962/gra/EGU06-A-04094

The central Nile deep-sea fan: an example of interaction between fluid ascents and slope instabilities

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Abundant slope failures and fluid seepages are often closely associated on the continental slope of the Nile deep-sea fan and particularly within its central province where superposed mass-wasting deposits are extending over more than 10 000 km2. In this area fluid-related features characterize either as important gas chimneys (1 to 4 km in diameter), or numerous small carbonate mounds and pockmarks (25m to 900 m in diameter). We observe an evolution from upslope to downslope:

(1) Upslope (between 500 and 700 m water depth), gas chimneys are abundant and mostly emplaced along the shelf border on NW-SE and NE-SW fault trends. Many slides initiate from the vicinity of these chimneys, suggesting that they directly participate to the destabilization processes of the central Nile deep-sea fan.

(2) Midslope, (between 700 and 1500 m water depth), the sea bed morphology appears quite rough and slides initiating from the upper slope evolve to transparent superposed debris flows on 3,5 kHz data. In this area, high reflective patches are observed on the backscatter imagery and interpreted as pock-marks and/or mounds. Nautile dives (Medinaut-Mediflux ESF program), carried out on one of these features, indicate that

the high reflectivity correspond to authigenic methane-related carbonate crusts.

(3) Downslope (between 1500 and 2000 m water depth), some debris-flows are draped by a gently folded hemipelagic cover, clearly undergoing creeping processes. Kullenberg cores reveal that the basal debris flow is highly compacted and that the deformed hemipelagic cover shows numerous fluid ascent related structures (fluidized sediments). Nautile dives have been carried out in this area and demonstrate that reflective patches clearly correspond to carbonate crusts, either organized as important mounds (∼400m long and 3 m high) or identified in the centre of circular depressions (∼3-20 m in diameter). Semi-quantitative measurements of methane concentrations in bottom-waters indicate that methane anomalies occur above the thinned areas of the creeping cover. These observations suggest that the sedimentary overloading of a fluid-rich debris flow has induced significant dewatering and that the top of this debris-flow may now acts as a gliding plane along which the sedimentary cover is slowly creeping. Recent debris-flows overlay partly this creeping sedimentary cover, suggesting on-going sedimentary processes in this area.

Our data set stresses clear relationships between fluid escape occurrences and gliding events. Upslope, gas chimneys seem to trigger important and repetitive slope instabilities, which generate debris-flows. Downslope, overloading, compaction and dewatering processes within debris-flow sediments initiate most likely fluid ascents and creeping within the sedimentary cover. In addition to those destabilization processes, the possible migration of gas-rich fluids from deeper sediment layers, may also contributes to overpressures in the sediments of the Central Nile province.