POCK-MARKS, GAS CHIMNEYS AND MUD-VOLCANOES: EVIDENCES FROM THE NILE DEEP-SEA FAN

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Abstract

Recent geophysical surveys on the Nile deep-sea fan (PRISMED II, Fanil) have revealed the existence of numerous pock-marks, mud-volcanoes or gas chimneys, all indicating fluid ascensions such as gas or mud-flows. Fluid releasing processes are observed in different settings, associated to large scale destabilizated sedimentary masses, growth-fault footwalls, or deep-seated tectonics. Fluid escapes might be trigerred by high sedimentary influxes generating overpressure processes in deep reservoir-layers by sedimentary overloading.

Key-words : Nile deep-sea fan, fluids, gas chimneys, pock-marks, mud-volcanoes, sedimentary overloading.

The Nile deep-sea fan's physiography, and shallow structure, have recently been imaged in detail during two recent scientific surveys (PRISMED II in 1998, and FANIL in 2000), Figure 1. Multibeam swath bathymetry and acoustic imagery, seismic reflection data, HR seismic profiling and a few piston-cores have allowed to discover numerous probable gas and fluid sea-bottom escapes, and mud volcanoes.

- Pock-marks have been well-imaged by backscatter data (highly reflective patches) in two domains: Firstly, within the Central deep-sea fan's province, between the Rosetta and Damietta onshore areas. There, they chiefly characterize the upper slope, between 1000 and 2500 meters where they seem to be related to slope destabilization processes and huge debris flows. Pock-marks have also been detected along the upper slope of the Eastern Nile deep-sea fan, at water depth ranging from 750 to 1000 meters.

- Numerous sub-marine conlets similar to mud volcanoes (300 to 1000 meters in diameter on average) have been discovered along the lower slope, within the Western Nile deep-sea fan's province. These features are not randomly distributed, but appear clearly located at the foot of growth fault systems that characterize most of the middle slope domain in this area. Within this sub-domain, huge sub-circular depressions, 5 to 10 kilometers in diameter, where several mud cones are emplaced, look like "calderas". Some of them are bounded by circular rims indicating probable collapse processes. We suspect that these features reflect areas of intense fluid and mud escapes (mud volcanoes), due to sedimentary overload above overpressured reservoirs. This overload may results from the activity of growth faults rooting within underlying Messinian salt layers. A thining of the sealing salt layer at the growth faults footwalls might be responsible for ascension of overpressured fluids and gas-saturated clay through the overburden. The conlets show often more reflective centers, or even flows, that might be associated with sedimentary dispersal by mud-flows. This may be an alternative explanation for their depressed morphology.

- Several features, similar to gas chimneys already discovered by industry, have also been observed, chiefly along the Eastern Nile deep-sea fan upper slope, where they appear as sub-circular and flat bathymetric features, bounded by depressed and faulted rims. These features reach diameters up to 4.5 kilometers and are characterized on seismic data by poorly reflective columnar bodies. They appear quite uniform on bathymetric data but show on acoustic imagery highly refective flows that may indicate to mud-flows. Finally, these gas chimneys are clearly emplaced nearby tectonic features that bound thickly sedimented grabens. Such a structurally controlled pattern may trigger fluid ascensions and is common in the nearby accretionary Mediterranean ridge (Figure 2).

The Nile deep-sea fan appears as an area releasing huge quantities of fluids (may be chiefly gas) as a consequence of several concurrent mechanisms such as sedimentary overload, growth faults activity, and potential activity of deep-seated tectonics.

We also notice that this process seems to be quite recent given the morphological expression of all releasing features.

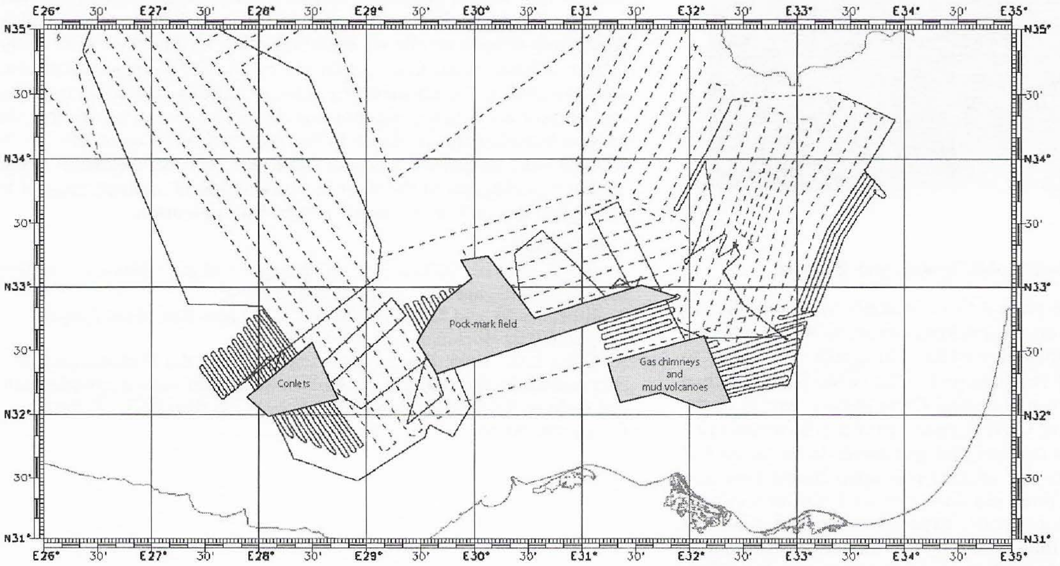
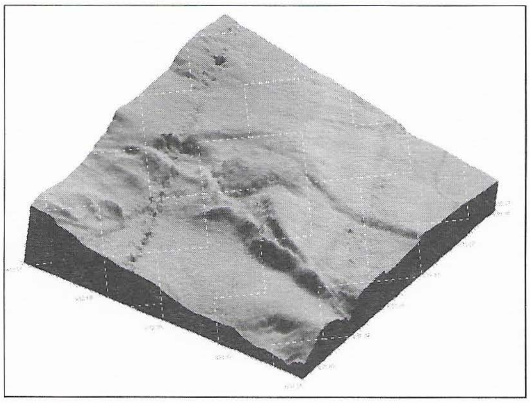
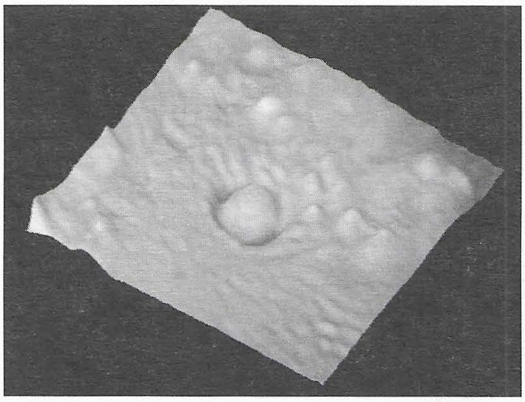


Figure1: Track-lines of the Prismed II (dotted) and Fanil (plain) surveys recently acquired along the Nile deep-sea fan (Multibeam swath bathymetry and acoustic imagery, seismic reflection data, HR seismic profiling and a few piston-cores). Areas displaying pock-marks, conlets or gas chimneys are indicated.



Structurally controlled gas chimney, Eastern Nile-deep sea-fan.



Structurally controlled mud volcanoe, Mediterranean ridge.

Figure 2: Shaded bathymetry of structurally controlled gas chimneys and mud-volcanoes, respectively belonging to the Easternmost Nile deep-sea fan province and to the Mediterranean accretionary ridge.