CHARACTERISTICS OF SLOPE INSTABILITIES OF THE NILE DEEP-SEA FAN

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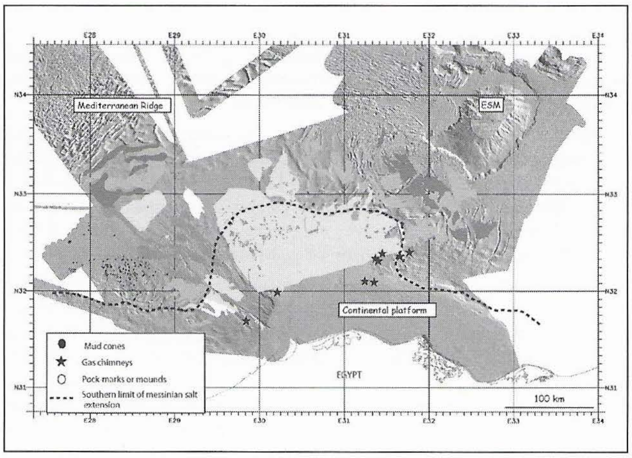
Abstract

The Nile deep-sea fan, turbiditic system reaching a size of about 90 000 km^2 is the locus of multi-scale slope instabilities. Three main types of instabilities have been defined: (1) first order instabilities, related to the generalized gravity spreading of the Plio-Quaternary deep-sea fan on Messinian salt layers. This global spreading is accomodated by numerous localized slides, (2). Second order instabilities. These are corresponding to giant mass movements related either to earthquakes, fluids, eustatism or sedimentary overloading. Finally, (3) third order instabilities, corresponding either to localized levee liquefactions or to thin-skinned slides on the steep slopes of the Eratosthenes seamount.

Key words : Slope instabilities, salt-tectonics, eustatism, fluids, Nile deep-sea fan

The Nile deep turbiditic system, reaching a size of about 90 000 km^2, is the most important terrigenous system of the Mediterreanen sea. It is the place of important slope instabilities, giving rise to mass wasting deposits differing in size and location. These deposits are interfingered between turbiditic units and participate for an important part of the edifice's building. We defined three main type of instabilities, that correspond to three main scales of events (Fig. 1):



(1). **First order instabilities** related to the regional gravity spreading and gliding of the Plio-Quaternary sedimentary cover above thick Messinian mobile evaporites. These regional movements are accomodated by frequent readjustements of proximal extensional faults and distal contractional folds, leading to localized slides. The resulting mass deposits are settled at the foot of growth faults or the flank of folds. They are generally thin, not exceeding a few meters in thickness, but extremely frequent. They appear as acoustically transparent or chaotic bodies on 3-5 kHz profiles. These are frequently interfingered between bedded deposits. These instabilities are reccurent and their location can be roughly predicted: they appear in all areas where salt is thick enough to allow gravity movements.

(2). **Second order instabilities** corresponding to giant mass movements not related to salt-tectonics. One recent instability of this type, more than 12100 km^2 in surface, is particularly well imaged in the central province of the Nile deep-sea fan (1). This slope area exhibits rough and chaotic small-scale reliefs, together with linear furrows (e.g., channels), disconnecting individual sedimentary flows. On 3-5 kHz profiling, this area displays a creeping sedimentary cover whose maximum thickness is of about 30 meters, slowly gliding on the top of a a debris flow. This debris flow has been cored and shows numerous mud clasts. On top of this creeping area, numerous high reflectivity patches, corresponding to pockmarks, have been observed on backscatter imagery. Pockmarks and gas chimneys have also been observed in the vicinity of the failure area. The association between those destabilized deposits and pockmarks suggests that both phenomena are probably related.

Giant mass movements have also been active in the past, in the western province of the Nile deep-sea fan. This area corresponds to the main active turbiditic pathway and numerous slope failures are observed in its upper slope domain near the head of the feeding canyon (between 800 and 1000 meters depth). A detailed analysis based on the interpretation of high resolution seismic data allowed to define at least eight imbricated slumps that evolved downslope to large debris flows. The four main basal slumps that we defined exhibit a volume of 1900 km^3 and are covered by recent stacked channel-levees units. Smaller scale debris-flows are inter-fingered within these constructional units and led to numerous channel migrations and avulsions characterised by typical HARP's seismic facies. The slope failures corresponding to these giant destabilizations are localized very nearby gas chimneys, suggesting the importance of fluids in these phenomenons. Also, important sediment overloads, eustatic varaiation and the tectonic activity of the Cairo-Alexnadria trend may be important additional factors trigerring these destabilisations. A tentative stratigraphic correlation suggest that these imbricated slope failures, are active at least since 250 000 years. This area clearly not reached its equilibrium and seem to be potentially reactivated: numerous extensional faults upslope the last incisions suggest further retrogressive evolution of these slumps.

(3) finally, less impressive **third order slope instabilities** have been defined. Some of them are associated with ponctual liquefactions of channel levees in the mid-slope domain. These events sometimes led to channel avulsion. Small slides have also been observed in another context, on the sides of the Eratosthenes seamount, piece of continental crust involved in the subduction near Cyprus, bounding the northeastern part of the Nile deep-sea fan. The sides of this seamount are very steep and "thin-skinned" slides are numerous. Slope failures are concave and deformation toes convex. These slides seem to be related both to the steepness of the sides of the seamount and to extensional tectonics.

To conclude, different types of instabilities, corresponding to different stimulations have now been defined on the Nile deep-sea fan area. Their relative importance in terms of volume has now to be defined more quantitatively and the potential relationship between giant slope instabilities and fluids has to be investigated. Also geotechnical measures on cores will be performed. This will be the basis of proper risk assessment studies.

References

1 - Loncke, L., Gaullier, V., Bellaiche, G. and Mascle, J., 2002. Recent depositional patterns of the Nile deep-sea fan from echo-character mapping. *AAPG bulletin*, 86/7: 1165-1186.