SHORT TERM MORPHOLOGY EVOLUTION OF NICE CONTINENTAL SLOPE (LIGURIAN SEA)

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Abstract

Time series bathymetric data acquired between 1991 and 2011 have been used to evaluate the morphological evolution of Nice continental slope (South East of France, Ligurian Sea). This quantitative analysis highlights alternation between low morphological variations and erosional events with consequent volumes lost at shallow water depth (0-200m). On the basis of local seismic data, hydrogeological analysis and previous sedimentological analysis, we try to define the triggering erosive mechanism on a few years period.

Keywords: Ligurian Sea, Geohazards, Bathymetry, Continental slope, Geomorphology

Due to the urbanisation growth in the coastline, a greater assessment and predictive risk ability is becoming paramount regarding natural hazard generated in marine environment. Erosion and evolution of continental slopes through time are mainly due to sedimentary process such as submarine failures. This fast morphological evolution is featured by large landslides scars and deposits (volumes can exceed several hundreds of km3). Those large-scale failures have a strong impact but their return period is about several thousand years or more [1]. At smaller time scales, small failures with a volume of several hundreds of m3 are much more common. These failures lead to: (a) regressive motion of continental slope towards the coastline and (b) the deposition of high-frequency turbidites in the deep basins. This small-scale phenomenon acting on short time scale is significant, but is still difficult to detect.

The continental slope offshore the city of Nice (South East of France, Ligurian Sea) has been studied to address the problems of small-scale failures morphology, recent landslides triggering and volumes that could be remobilised during a failure event. Nice is located between the Southern Alps flank and the Northern continental slope of Ligurian sea (western Mediterranean). Cohesionless sediments on oversteepening slopes are affected by moderate seismicity and anthropogenic constructions extended offshore. Moreover, the few but violent Mediterranean rainfalls have an impact on sediments stability because of groundwater outflow. Such as a natural laboratory, this Ligurian margin is characterized by numerous submarine landslides [1]. The most recent and mediatized was initiated in October 16th 1979. This event partially destroyed the new international airport complex of Nice and triggered a 2m tsunami. Thus we focused our study on this high vulnerability area affected by recent instability to define and understand actual erosion process.

Identification of potential areas where slope movements could be triggered requires data with high spatial resolution. For this purpose we have used all the very high resolution multibeam bathymetry dataset acquired between 1991 and 2011. HD Bathymetric data was collected in the frame of different projects: EM1000 Ifremer (spatial resolution 10m, 1991), Creocean (1m, 1999), AUVGEO (2m, 2006), Haligure (1m, 2009) and MRIS (1m, 2011). The covered zone varies according to each of these cruise but data are common on an area from the coastline to 300m seaward and comprise the 1979 scars in front of Nice-côte-d'Azur Airport. Maps comparisons have been done for each time step, using two different techniques: (a) ArcGIS 3D analysis tools "Cut fill" which calculates the volume change between two surfaces pixel by pixel, and (b) an isobaths location comparison each 10m deep to highlight the regressive erosion.

Those methods have revealed the current evolution in space and time of the submarine morphology at shallow water depth (0-200m). Moreover it has provided the specific background to quantify erosion processes of the last 20yrs. Regarding to space evolution, areas of major sedimentation are principally located on gentle slopes (<7°). Moreover, our analysis shows some exceptions of sedimentation on bigger slopes for example the infilling of former thin channels and slide scars. They are rapidly filled and failure morphology could disappear from the sea floor in less than 5years. Biscara et al. (2012) [2] had the same filling results for Gabon slope in about 15-20years. Areas of major erosion failures have been determined mostly on slopes bigger than 10°. They define a scarp and its associated evacuation channel. The airport contours and the 1979 scarp show slow erosion processes. Nevertheless the main repartition of sedimentation/erosion leads us to say that the 1979 scar is still slowly moving. However, it appears that it is not currently the most active zone on the top slope. With these investigations we have established a high-precision quantification of sedimentation and erosion rates along different time intervals. Between 1991 and 2011, alternation between periods of low morphological variations and periods of failure events with consequent volume losses is clearly visible: erosion volumes are multiplied by a factor of 10 during fast periods. Similar small failure event with a return periods of around 5years were highlighted by Smith et al. (2007) [3] in upper Monterey Canyon (California).

Interpretations in term of triggering processes are still in progress using hydrogeological data, regional catalogue of seismic activity and previous sedimentological analysis. Actually such short time variation may be explained: (a) by specific local characteristics such as the presence of sensitive sediment layers reacting to freshwater phreatic inflow due to intense storms on the watershed [4]. For this purpose we are looking at hydrogeological data: rainfall, volumetric flow rates, groundwater outflow. (b) It is also possible that ground motion generated by moderate size earthquakes during the analysed period had a key role in the failure acceleration. In order to analyse this we are using seismological location and PGA values. Finally, (c) sedimentation rates, overload and critical slope can play a fundamental role. It will be initially studied with previous geological and geotechnical research.

These observations and quantifications reveal failure processes that are still quite active and significant over very short periods of time. This whole study is a next step in term of current stability evaluation of the Nice submarine slope which requires the precise identification of slope instabilities, evaluation of their recent and past activity and discrimination of triggering factors.

References

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