TRIGGERING MECHANISMS OF A MAJOR DEBRIS FLOW OFF THE EBRO MARGIN, NW MEDITERRANEAN: THE BIG'95

R. Urgeles [1] *, G. Lastras [1], M. Canals [1], D. Leynaud [2], N. Sultan [3]

[1] GRC Geociències Marines, Departament d'Estratigrafia , Paleontologia i Geociències Marines, Facultat de Geologia, Univ. de Barcelona, Spain - * urgeles@ub.edu

[2] Departement of Geology, University of Tromsø, Norway

[3] Département Géosciences Marines, Direction des Recherches Océaniques, IFREMER, Plouzané, France

Abstract

Geophysical, geotechnical and sedimentological data from the continental slope and rise off the Ebro margin, NW Mediterranean, are presented from an area that has undergone a major instability event, known as the BIG'95. The data depict accurate details of the debris flow deposit, the scar area and subjacent structure, and reveal the nature of both failed and unfailed sediments. Such an extensive data set allows to obtain a clear picture of the sequence of events that initiated the failure of this landslide. These included as major factors the existence of low shear strength materials and the growth of a volcanic structure beneath the headwall area.

Keywords: Debris flow, NW Mediterranean, geotechnical properties, triggering mechanisms

During the last decade a large effort has been put towards understanding the sediment processes and dynamics along the Ebro margin, NW Mediterranean, with a special emphasis on landslide driven processes. Such effort has included the collection of full coverage multibeam bathymetry and derived backscatter, high- and very high-resolution 3.5 kHz parametric and airgun seismic reflection profiles, deep-towed TOBI and MAK1-M sidescan sonar, and 17 cores which have been dated and several parameters have been analysed from, such as grain size, density, water content and undrained shear strength.

Such effort has made evident that the Ebro continental slope and rise are dominated by meandering channel-levee complexes, which evolve upslope into canyons and downslope merge into one single, mid-ocean type channel, the Valencia channel. It is also clear from the extensive multibeam data set that the Ebro slope is constituted by relatively little-incised canyons compared to its northwards Catalan margin counterpart, which also has a much narrower shelf.

Such a pattern is disrupted near the centre of the Ebro continental rise, where channels have been wiped out by a large, 2000 km^2, 26 km^3 mass-wasting event known as BIG'95 (1). In this area the base-of-slope down to the Valencia Channel shows a rougher aspect. The mosaics made from multibeam bathymetry show a series of low backscatter patches surrounded by a series of high backscatter stripes describing the shape of a horse tail. This pattern is believed to correspond to a debris flow with rafted blocks surrounded by the pathways of coarser sediment material (1).

At the head of the debris flow a sinuous scarp up to 200 m high is present. Upslope such scar minor scars also develop, while immediately downslope the ghost of a former channel is present strikingly parallel to the main headwall scar. In seismic reflection profiles the headwall scar appears closely linked to a subjacent structure, which is believed to correspond to a volcanic dome (2).

The geotechnical parameters analysed in the cores collected from the debris flow and nearby areas allow to distinguish an upper post-landslide unit, which shows a similar pattern through all the cores. This upper part shows high water contents (up to 80% of the total weight) and corresponding low densities, as expected from a recently deposited sediment. The post-landslide unit has much lower shear strengths (around 5 kPa) than that of the sediments below (3).

The landslide sediments, i.e. those involved into the debris flow, have lesser amounts of water, and thus their density is also slightly higher. Water content is also slightly lower (by about 10%) than that of the sediments that have not been affected by the passage of the debris flow (cores CLKS02 and CLKS03). On the other hand, at the same consolidation stress, shear strength appears to be higher for the sediments involved into the debris flow than for those pre-dating the BIG'95. However, the remoulded shear strength is similar (around 5 kPa) for both the BIG'95 and pre-BIG'95 sediments probably reflecting that increased pore water pressures at the source area were involved in the genesis of the landslide. Destructuration of the sediment into the debris flow and consolidation after deposition have been able to dissipate such pressures.

The most striking difference arises when comparing the two cores obtained from the area not affected by the landslide, CLKS02 and CLKS03, which, on the other hand, are probably the most interesting cores since their physical properties most probably match those of the sediments affected by the landslide before it took place. These two cores show quite distinct shear strength profiles, with CLKS03, collected on the open slope showing an increasing trend with depth and CLKS02, on the flank of the levee showing almost no increase with depth (3). This reflects a change in sedimentation rates according to the environmental setting, the ones on the levee, being probably much higher than those on the open slope, also probably reflecting that those of the levee are underconsolidated.

Since the Ebro margin is largely aseismic, earthquakes may have only played a secondary role in triggering the landslide. Thus, failure most probably occurred in a retrogressive fashion due to oversteepening of the slope associated to the presence of a volcanic dome , with failure initially occurring downslope, in the low shear strength channel-levee deposits. Due to the age of the landslide a climatic influence on triggering can not be discarded.

References

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