Submarine landslides off NW-Africa: How dangerous are they?

Sebastian Krastel, Dynamics of the Ocean Floor - Marine Geodynamics

The passive NW-African continental margin is characterized by several very large but infrequent landslides. Most of these landslides occurred during periods of low or rising sea level. Hence, the probability of future large-scale slope failures during the current sea level high stand is generally considered to be low. This interpretation is challenged by new observations during a recent research cruise to the Sahara Slide.

Submarine landslides are the dominant process for sediment transport from the continental shelf to the deep ocean. Sand-rich gravity flow deposits form many of the World's largest oil and gas reservoirs, while mud-rich deposits may sequester globally significant volumes of organic carbon. Landslides and sediment gravity flows are also a significant geohazard to seafloor infrastructure. In some cases, submarine landslides have generated tsunamis that have caused widespread damage to coastal communities.
The passive continental margin off Northwest Africa is characterized by low sediment supply by rivers, even during glacial times, but high primary productivity caused by oceanic upwelling results in relatively high sedimentation rates. The margin shows several large-scale but infrequent landslides and numerous canyon/channel systems (Fig. 1, Krastel et al., 2011). The four major slides (excluding landslides around the Canary Islands) are Dakar Slide, Mauritania Slide, Cap Blanc Slide, and Sahara Slide from south to north. These slides show run-out distances up to 900 km and volumes of up to 600 km^3; they belong to the largest submarine landslides on continental margins worldwide.

It is important to assess the geohazard potential related to submarine mass wasting off Northwest Africa, especially as the area offshore Mauritania is a current focus for hydrocarbon exploration and production. Age data are available for most of the major slide events suggesting that all major slides occurred during periods of low or rising sea level. The uppermost slide unit of the Mauritania Slide, e.g., is dated at 10.5-10.9 ka (Henrich et al., 2008) at the end of Late Glacial sea-level rise. Direct linkage between sea level and slide occurrence is not well understood, but indirect effects include spatial variations in primary productivity and hence the maximum sedimentation rate (Georgiopoulou et al., 2010). As a consequence, the probability of future large-scale slope failures during the current high stand is generally considered to be low. This view is challenged by new observations made during Poseidon-Cruise P395 in spring 2010. Detailed maps of the upper headwall of the Sahara Slide (Fig. 2) reveal a complex morphology typical for a retrogressive slab-type failure, with multiple headwall incisions and several glide planes. Some areas are characterized by elongated blocks, which have not moved far, while other areas are characterized by quickly disintegrating sediment masses. Seismic data show older mass transport deposits and giant downslope striking mound-like features, which are aligned with the sidewalls. We suggest that migrating fluids along and on top of the mound-like features control the location of the failure.

The well-studied distal deposits of the Sahara Slide yield an age of 60 ka

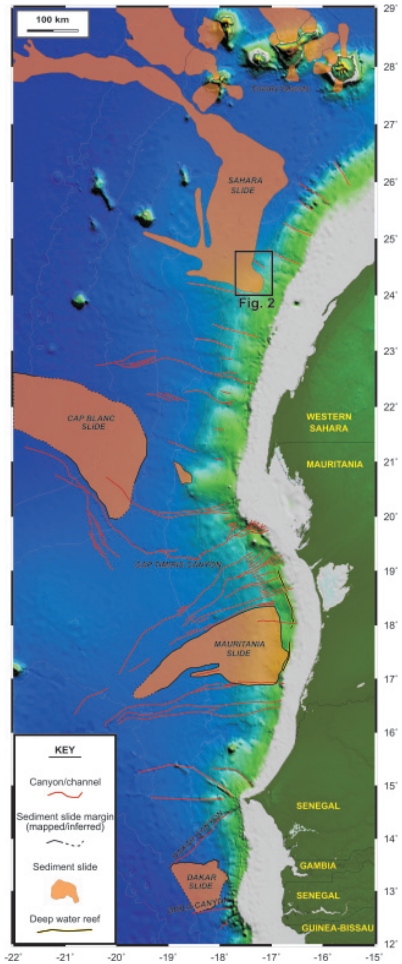

Figure 1: Map showing the distribution of seafloor features on the Northwest African continental margin.

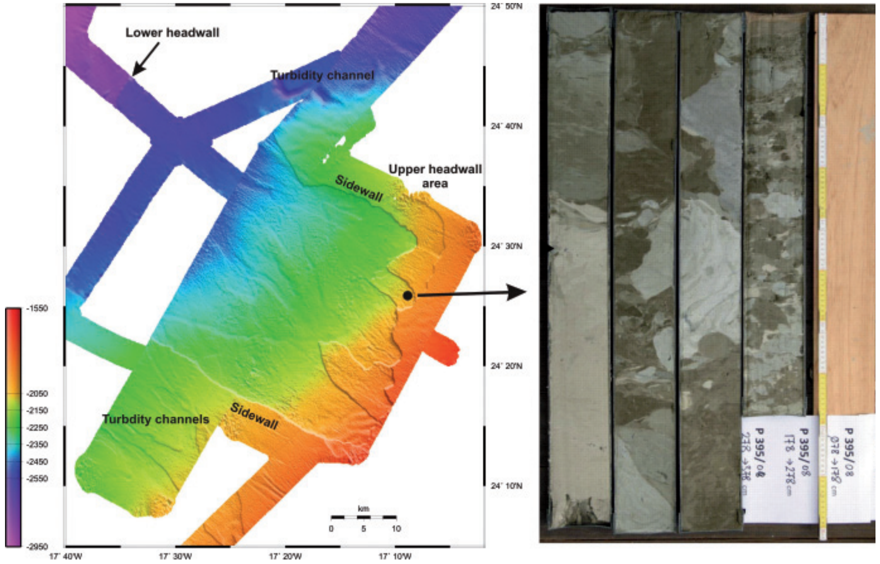

Figure 2: Left: Bathymetric map of the Sahara Slide headwall showing a complex morphology typical for a retrogressive slab-type failure. Right: Core taken immediately beneath the headwall showing a typical debrite. A hemipelagic drape of less than 5 cm indicates a late Holocene age of the debrite.

for the main slide event, which is a period of global sea level rise (Georgiopoulou et al, 2010). Several cores taken immediately beneath the headwall of the Sahara Slide, however, show pronounced slide deposits with a thin (< 5 cm) Holocene drape (Fig. 2). Using average sedimentation rates of 2 – 4 cm/ka in this area, we infer an age of 1 - 2 ka for the deposition of the mass transport deposits (Krastel et al., 2011). This event is most likely the largest submarine failure in historic times. Therefore, it questions a stable NW-African continental margin during the current sea level high stand. We are currently investigating whether this young age represents a major re-activation of an existing headwall or a major failure of undisturbed slope sediments.

The young age and large size of the Sahara slide immediately brings up the question of the tsunami potential of submarine landslides off NW-Africa. The principal tsunamigenic potential of submarine landslide is a matter of ongoing debate. Volume and initial acceleration are the most important parameters but other factors (e.g., flow dynamics, water depth, velocity, length, thickness) might be important as well. Especially initial acceleration and flow dynamics are very difficult to reconstruct based on geological and geophysical measurements alone. At least one slide off NW-Africa (Mauritania Slide) shows indications for a landslide-triggered tsunami. A turbidite containing shelf sands, deposited immediately above the slide deposits, might indicate mobilization of shelf sands by a tsunami.

Due to this uncertainty for landslide-generated tsunamis, one focus of our future work will be a more realistic assessment of the tsunami potential of submarine landslides. We started to employ an integrated model that combines the simulation of landslides and related tsunamis, and compare model results to measured slide geometries. If a specific model run produces a terminal slide geometry that is similar to the observed slide geometry, we assume that we selected realistic parameters for the slide, which then in turn allows assessing the height of the associated tsunami. In addition, the young age of the Sahara Slide calls for a re-assessment of the risk potential of NW-African and other passive margin.

References

Georgiopoulou, A., Masson, D.G., Wynn, R.B., Krastel, S., 2010: The Sahara Slide: Initiation and processes from headwall to deposit of a giant submarine slide. *Geochemistry, Geophysics, Geosystems*, **11**, Q07014, DOI:10.1029/2010GC003066.

Henrich, R., Hanebuth, T.T.J., Krastel, S., Neubert, N., Wynn, R.B., 2008: Architecture and sediment dynamics of the Mauritania Slide Complex. *Mar. Petrol. Geol.*, **25**, 17-33, DOI:10.1016/j.marpetgeo.2007.05.008.

Krastel, S., Wynn, R.B., Hanebuth, T.J.J., Henrich, R., Holz, C., Meggers, H., Kuhlmann, H., Georgiopoulou, A., Schulz, H.D., 2006: Mapping of seabed morphology and shallow sediment structure of the Mauritania continental margin, Northwest Africa: some implications for geohazard potential. *Norw. J. Geol.*, **86**, 163-176.

Krastel, S., Wynn, R.B., Georgiopoulou, A., Geersen, J., Henrich, R., Meyer, M., Schwenk, T, 2011: Large scale mass wasting at the NW-African Continental Margin: some general implications for mass wasting at passive continental margins. 'Submarine mass movements and their consequences'. *Advances in Natural and Technological Hazards Research*, Springer, in press.