NERC Centre for Doctoral Training in Oil & Gas (2017 start)

Project Title: Submarine Landslides and Mass Transport Deposits from Geohazards to Georesources: An integrated field-numerical approach.

Host institution: University of Aberdeen

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Project description: Submarine landslides, among many other phenomena of continental margin instability, represent a major hazard for all the infrastructures deployed on the sea floor, with potential effects also on surrounding coastlines through the generation of tsunamis [1-4]. Understanding the formation and evolution of submarine landslides, and associated mass transport deposits (MTDs), has long been an open issue that attracted a large community of geoscientists worldwide. The recent interest of the energy industry to expand petroleum E&P towards deep-water targets and an increasing availability of surface and sub-surface 3-D data highlighted submarine landslides as a fundamental process in continental margin growth. Mass transport deposits not only constitute large volumes of sediment in deep water settings, but in some basins they may represent more than half of the sedimentary succession, thus exerting a paramount control on reservoirs and seal location, facies distribution, and migration pathways.

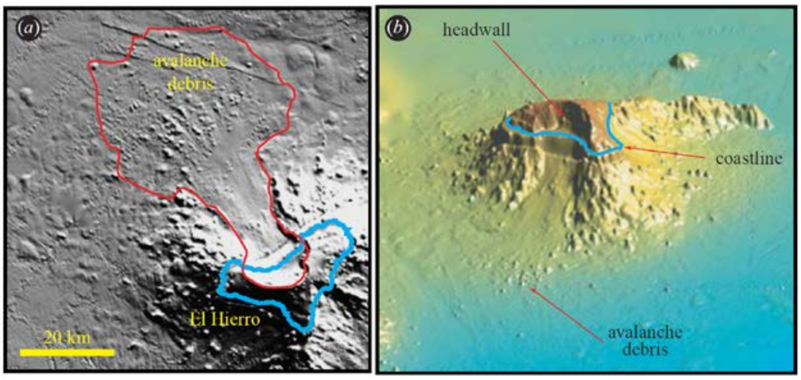

Figure 1. Two views of a submarine landslide on the island of El Hierro [6].

The emplacement of an MTD is a quasi-instantaneous phenomenon that generates a sudden change in the physiography of the basin, in the stress field and in the future evolution of deep-water depositional systems (canyons, turbidity channels, contourites). The increase in shear stress associated with the downslope movement, not only promotes a reorganization of the physical properties of the sediment involved, but may have a profound effect on the underlying stratigraphy that could be completely disrupted and incorporated into the MTD.

Through an integrated mass-balance approach, derived by combining direct geophysical observation with numerical simulation, the student will: 1- quantify the internal architecture and petro-physical properties of mass transport deposits, 2- develop physical and mathematical models for submarine landslides and associated MTDs in different environmental contexts, 3- establish the potential impact of submarine landslides on offshore infrastructures, by assessing also the presence of hazardous zones that might be affected by future mass movements. Moreover, by combining geophysical data with outcrop evidence this project will provide new insights on the nature of the substrate/MTD transition, improving the prediction of the character of this transition at a sub-seismic resolution in this challenging environment.

Data: Conventional and hi-res 3D seismic data, sub-bottom profiles, multibeam bathymetry and sidescan sonar from the Atlantis area of the Gulf of Mexico, modern data from the Tyrrhenian Sea collected by the Institute of Marine Sciences (ISMAR-CNR, Italy), integrated with published data (e.g. from DSDP Leg 155) and data from outcrop studies (Sobiesiak, PhD Aberdeen, 2016).

Approach: In this project, the phenomena of mass transport deposition as a result of landslides are studied numerically based on the rheology of granular materials [4, 5]. The study is conducted in 5 steps: 1) The necessary geometry and geophysical properties of a given geological setting is determined either using available data or conducting further measurements, 2) a computational model is developed to represent the actual setting, 3) various loading and triggering mechanisms are defined and simulations are performed using a commercial software, 4) debris flow and transported mass are assessed and practically useful quantities are computed, 5) uncertainties are evaluated, hazardous zones are specified, and recommendations are given.

CDT Research theme(s): This project primarily relates to "Exploitation of Challenging Environments" (70%) and to "Extending the life of mature basins" (30%).

Major scientific outcomes: Enhances our understanding of underlying mechanisms in mass transport deposition, enables us to produce various submarine landslide scenarios, and allows assessment of hazardous zones.

Research context: The student will join the strong and dynamic scientific community of the Basin Fill Group of the University of Aberdeen that integrates a large number of PhDs and geoscientists with expertise in several fields of geology, petroleum geology and numerical simulation.

Student profile: A First-class honours or Second-class honours, upper division (2:1) degree in Geophysics, Physics, or Engineering. Experience in numerical simulations especially with COMSOL© Multiphysics [8] will be an advantage. Experience with GIS and/or offshore data analysis would be highly beneficial.

Research costs: Costs should not exceed £ 5k per annum, and includes high-performance workstation (£ 3k), attendance of international conferences (£ 4k), field work (£ 6k).

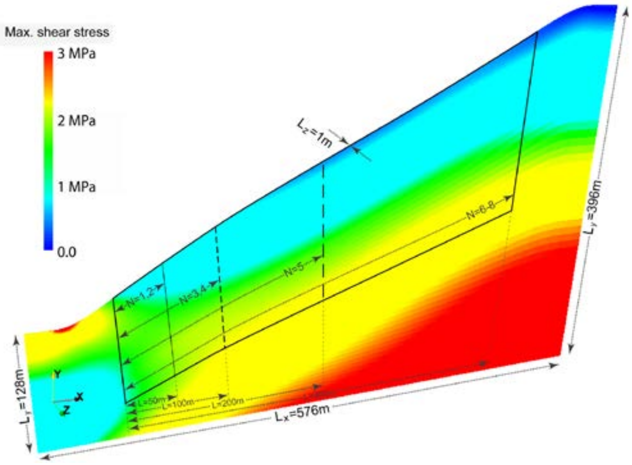

Figure 2. Simulated shear stress along the landslide rupture. Modified from [7].

Career routes: Future career path may include Oil and Gas industry, specialist research in Service Company, post-doctoral research in Academia.

References

[1] De Blasio, F.V. 2011. Introduction to the physics of landslides. Lecture notes on the dynamics of mass wasting. Springer.

[2] Hampton, M.A., Lee, H.J., Locat, J. 1996. Submarine landslides. Review of Geophysics. 34(1), 33-59.

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[5] Savage, S.B., Hutter, K. 1989. The motion of a finite mass of granular material down a rough incline. Journal of Fluid Mechanics. 199, 177-215.

[6] Masson, D.G., Harbitz, C.B., Wynn, R.B., Pedersen, G., Lovholt, F. 2006. Submarine landslides: processes, triggers and hazard prediction, Philosophical Transactions of the Royal Society A, 364, 2009-2039.

[7] Stark, C., Choi, E. 2011. Landslide rupture and length-depth scaling. CSDMS Annual meeting 2011.

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