On the Role of Excess Pore Pressure in Offshore Geohazards

Vanneste, Maarten [1]; Forsberg, Carl Fredrik [1]; Kvalstad, Tore J. [1]; Madshus, Christian [2]; Solheim, Anders [3]; Strout, James Michael [4] (1) Offshore Geotechnics, NGI & ICG, Oslo, Norway. (2) Computational Geomechanics, NGI & ICG, Oslo, Norway. (3) Natural Hazards, NGI & ICG, Oslo, Norway. (4) Monitoring and Geophysics, NGI & ICG, Oslo, Norway.

As the offshore industry gradually moves towards deepwater, offshore geohazards become a growing concern for field development, sub-sea installation and transport. In particular, understanding stability within the escarpments of the Storegga landslide off Norway for safe development of the Ormen Lange reservoir set the scene for an unprecedented multi-disciplinary approach, by integration of geology, stratigraphy, geophysics and geomechanics, complemented with advanced geotechnical laboratory program and numerical modeling of landslide dynamics and consequences (tsunamis). Since then, the integrated approach for offshore geohazards assessment is applied to numerous geological-tectonic settings. Examples are Nile and Krishna-Godavari deltas, Gulf of Mexico, North Sea Fan, Hinlopen-Yermak landslide complex, or dedicated studies to small coastal landslides (Finneidfjord, Norway).

Many geohazards have one parameter in common: excess pore pressure. However, pore pressure is not easy to measure or quantify in deepwater settings. Therefore, pore pressure/basin modeling and new technologies are needed to derive reliable estimates of pore pressure and its migration/dissipation. Swath bathymetry and high-resolution 2D/3D seismic data combined with chronology are essential to understand sediment dynamics and stratigraphy, which constrain input parameters for basin modeling and pore pressure generation. However, P-wave data tell us little about geomechanical properties, particularly when saturated and at low confining stresses. Shear waves have higher potential to quantify geomechanical properties and pore pressure. NGI identified shear waves as an important target for offshore applications, both in terms of hardware (seabed-coupled shear wave vibrators and densely populated ocean bottom cables) as well as developing analysis and interpretation tools, in particular for fluid and lithology discrimination and shallow water flows or gas accumulations. Also surface waves emitted by seabed-coupled sources allow for high-resolution shear wave velocity mapping in the uppermost soils, an approach rarely adopted for offshore investigations.

Long-term monitoring and sub-sea instrumentation is necessary, as it provides crucial information on pore pressures, permeability, fluid flow, gas composition. In summary, a multi-disciplinary approach is key to understand marine geohazards and excess pore pressure processes in particular, and is important to design mitigating measures.