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What is the Current "Best Practice" in Offshore Geohazard Investigations? A State-of-the-Art Review

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Abstract
The pace of exploration and field development on the continental slopes and in ultra-deep waters world wide has increased rapidly since the 1990'ies. The major change compared with the shelf areas is the seabed slope. Activities are concentrated in areas where the sediment thickness is high and accompanied by diapirism and overpressured formations. An increasing number of observations of seabed instabilities, often on slopes with very low inclination, is of concern to the oil industry. The size of the affected areas range from small surficial slumps to enormous retrogressive slide events. The latter may affect field development areas several kilometers upslope as well as downslope of a slide initiation area.

Rapid sediment deposition may generate excess pore fluid pressures, resulting in overpressured formations, and reduced sediment strength. This may lead to increased faulting, diapirism and fluid flow processes with possible impact on local seabed inclination and seabed instability. On the continental slopes, the pore pressure distribution is a key factor in assessment of slide risk. Natural overpressured formations also represent a drilling hazard regarding shallow gas and shallow water flow. Overpressured formations may also be caused by cross flow along well casings from deeper to shallower reservoirs. This may ultimately lead to well collapse, blowouts and cratering with potential for damage to installations and slide initiation.

The understanding of the geological processes that may create hazardous conditions, the geomechanical explanation of observed instabilities, the dating of these events and the evaluation of present and near future conditions are key elements in geohazard investigations. Likewise, human induced changes have to be understood and evaluated with respect to their hazard potential.

Geohazard risk assessment is an integral part of the overall risk assessment in offshore oil and gas projects. This requires a systematic search for geohazards with identification of potential failure events and associated consequences followed by quantitative assessment of the likelihood of occurrence and vulnerability of the events.

Introduction

Geohazard definition
Geohazards in an offshore oil and gas perspective can be defined as local and/or regional site and soil conditions having a potential of developing into failure events causing loss of life or damage to health, environment or field installations. The triggering of the events can be caused by natural geological processes or by human induced changes caused by the field operator or by 3rd party activities.

Large Scale Geological Processes
Large scale, long-term geological processes need to be understood and incorporated in petroleum exploration activities and are often of vital importance for geohazard evaluations. Plate tectonics control on a global basis the development of continental shelves and margins. Long term environmental changes with a period of about 100.000 years caused major glaciations repeatedly during the last 900.000 years. The shift between interglacial seal level high-stand and glacial sea level low-stand periods with more than 100 m change in sea level have had a significant impact on the development of continental shelves and slopes.

Regional Conditions
Regional geological conditions control the sedimentation rate and thickness as well as the type of sediments. The major river deltas of the world and the enormous glacial fans along the Atlantic and Arctic Seas are areas where the average sedimentation rate has been very high during several 100.000 to millions of years.

During sea level rise and fall, wave action has caused resuspension of material and during periods of a few 1000 years enormous masses of predominantly clayey sediments have been resedimented on the continental slopes in the vicinity of the major river deltas (Solheim et. al., (1)).

In higher latitudes glaciers have repeatedly eroded the continental shelf and transported sediments to and over the shelf edge as enormous debris flows, interbedded with interglacial hemipelagic clay layers (Bryn and Andersen (2)). Glacial sediment deposition centres like the North Sea Fan and