Geohazard Surveying Comes of Age

Risks to hydrocarbon exploration and production as a result of geohazards on and below the seafloor can be reduced through the application of modern methods of high resolution surveying.

Jane Whaley, Associate Editor

The search for geohazards on the seafloor and shallow seabed has long been the Cinderella of the seismic industry. As Chris Mott, Commercial and Business Manager of Fugro Survey in Aberdeen, says, "In the past, geohazards were relatively simple to spot and therefore easy to take into account, but this changed with the move into deep and ultra-deep water."

"With recent advances in surveying and other areas of geoscience there has been a step change in the approach to high resolution surveying, and a realisation that it is important to undertake quantified risk assessment of geohazards to oil and gas developments wherever in the world they occur."

Geohazards are costly

Geohazards vary from natural seabed features like pock marks, mud volcanoes, and unexpected ravines, to unforeseen changes in lithologies, the presence of meta-stable sediments and pockets of shallow gas.

Photo: Jane Whaley

Chris Mott and Luis MacArthur, both geophysicists, examine the integrated records from a North Sea pipeline survey. Geohazard surveying is crucial both pre-lay, to determine seabed characteristics which effect the pipelaying techniques, such as anchor holding properties, and also post-lay to ensure the optimum route has been used.

Man-made seafloor hazards, such as wrecks, construction debris, pipelines and cables also constitute potential dangers to drilling activities.

Early in the history of the offshore oil industry a number of accidents happened as a direct result of poor knowledge of seabed conditions. These included disastrous blow-outs, when the drill bit met a shallow high-pressure gas pocket, or pipelines broken when barges were unable to remain stable due to poor anchor holding conditions. As a result, pre-drilling and pre-lay site surveys became mandatory in many parts of the world. Although such dangers pose significant potential risks to offshore drilling, construction and pipeline operations, the search for seafloor and shallow seabed hazards has traditionally been considered an extra expense and has been an underfunded discipline.

Historically, however, geohazards have cost the hydrocarbon industry hundreds of millions of dollars through replacement costs, contractual claims and loss of production. Potential losses due to damage to wells, seabed facilities and pipelines are compounded in the deepwater environment by higher capital investment, increasing the total project risk. As the search for hydrocarbons moves into ever deeper waters, it has become more and more important to shed light on the unknown physical processes, soil conditions and environments to be found at depth.

AUV helps decision making

Key to improved detection of geohazards has been the development of the AUV, or Autonomous Underwater Vehicle. "The machine is programmed to follow a defined route, independent of the mother ship," Chris explains. "It gathers a variety of data, using multibeam echosounders to determine bathymetry, sidescan sonar to look at seafloor features and shallow sub-bottom profilers for seabed geology. The equipment is installed on the AUV, and more than 100 line kilometres of high quality data can be recorded in a day, at water depths of over 2,800m."

"The altimeter, navigation system and obstacle avoidance sonar installed in the vehicle mean that it can stay away from seafloor obstructions while remaining a fixed distance from the seabed and travelling at a steady pace," Chris continues. "In addition, the absence of a towing cable reduces noise and disturbance to the records. An onboard acoustic modem sends a subset of the data to the mother ship for quality control and, if necessary, the equipment can be re-programmed remotely."

"The huge improvements to the quality of the data brought about by this technique means that we are able to recognise deepwater geohazards and do a quantified field assessment of risks, placing them in the context of field development and feasibility studies. It is possible to provide engineering quality data for input into field design, and we can also quantify hazards so engineers can assess threat more accurately, thereby optimising capital expenditure."

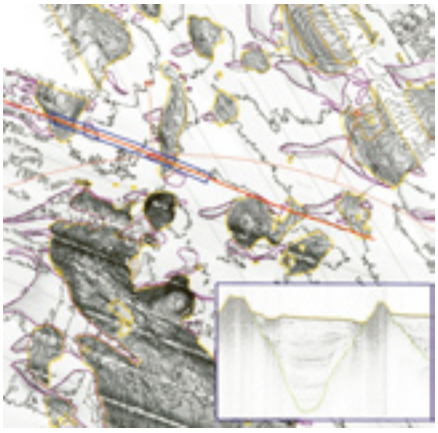
Integrated data in GIS format

AUV surveys are the exception, rather than the norm in the geohazard survey world. Much of the work of Fugro Survey concentrates on more conventional surveys, using instruments towed astern or mounted on the hull of survey vessels, but there is still an emphasis on the acquisition of engineering quality data to abstract real risk assessments based on the geohazards.

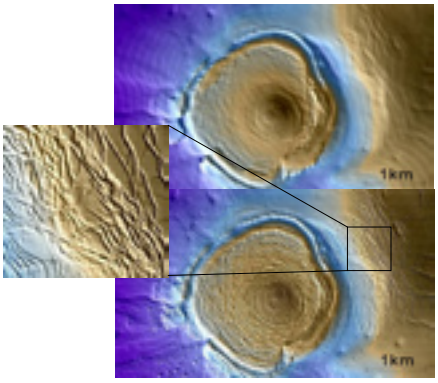
Luis McArthur, a Geoscientist and Project Manager with Fugro Survey, explains the processes involved in more detail. "The onboard geophysicist interprets the data immediately, so if there are any uncertainties or anomalies the route can be altered or resurveyed immediately. The different types of data are acquired simultaneously, digitally referenced together and tied into the navigation. Recent increases in memory size and the processing speeds have been crucial to the improved quality of geohazard surveying, as we can now process and interpret terabytes of data in almost real time."

"We use geotechnical techniques to

The autonomous underwater vehicle is hauled back on board the Geo Prospector in Norway, having undertaken detailed seabed survey trials at water depths of several hundred metres.



Interpreted image from bathymetric and side scan sonar data, showing seabed features and highlighting potential hazards. The inset illustrates an example of shallow profiler data from the same area.



The AUV operates at a fixed distance from the seabed, determined by an onboard altimeter, allowing the collection of high quality data, as can be seen by this comparison between conventional (upper) and AUV collected (lower) bathymetric data.

ground truth the geophysical data, and may include video footage of the seafloor using cameras deployed on an ROV (Remote Operated Vehicle). In this way we offer our clients a complete, integrated package of information. Our deliverable output incorporates all this data, showing the seabed geology, topography and other features, with shallow profiles illustrating underlying geology, all correlated with core and grab sample results. The final delivery is in a GIS format, allowing for the creation of 3D views. If the area is revisited at a later date we can ensure good consistency between surveys – very important, for example, in the case of pipeline investigations."

Risk and cost reduction

"This risk quantified information can be incorporated into engineering feasibility studies and inform design criteria, which is proving very cost effective for oil companies," Luis continues. The cost of a geohazards survey is approximately 1% of the capital expenditure of the project. If through undertaking a pipeline survey, for instance, we can shave one kilometre off a proposed route, something like $1,000,000 could be saved on the total cost of the pipelaying operation."

Recognising that geohazards, especially in deepwater, can significantly increase project risk, leading oil companies now routinely assemble an expert Geohazard Assessment Team to advise on seabed development, as has been done, for example by BP for the Raven Field development in the offshore Nile Delta (see GeoExPro Magazine Vol 5; no.1 "The Raven Field: Planning for Success"). These experts, covering the key disciplines of geomorphology, geology, geophysics and geotechnics, evaluate the possible geohazards to be expected at a development site early in the project, and make relevant recommendations for risk reduction.

"High resolution surveys are coming of age in these days of deepwater developments," says Chris. "The data has been shown to be of real value to the client and is no longer viewed as an additional and unproductive cost."