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AUV Ultrahigh-Resolution 3D Seismic Technique for Detailed Subsurface Investigations

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Abstract

The efficiency and navigation accuracy at which subbottom profiler data (2-8 kiloHertz) can be acquired with deepwater Autonomous Underwater Vehicles (AUVs) allow for the acquisition and creation of a high-resolution (4-meter bins) seismic cube. The seismic cube allows the interpreter the advantages of 3D seismic interpretation techniques. Researchers, geohazard specialists and civil engineers could benefit in some instances from the creation of an Ultra High-Resolution (UHR) 3D seismic data cube. This paper describes the benefits of using an AUV platform to acquire UHR 3D seismic data. The survey methods, seismic processing and results of a UHR 3D seismic survey over a newly forming pockmark on the upper continental slope of Nigeria are explained.

Introduction

C & C Technologies (C&C) teamed with its Nigerian partner, Multinational Geosurveys Limited, to provide Total Upstream Nigeria a deepwater AUV geohazard survey offshore Nigeria (**Figure 1**). The AUV survey fieldwork was performed on the Nigerian mid-continental slope in September-October 2004 using the *C-Surveyor I*™ AUV. There are numerous large and small diameter pockmarks found within the survey area. The formation of these deepwater pockmarks is not fully understood and a proposal was made during course of the data acquisition to conduct a UHR 3D seismic survey at the location of young or newly developing pockmark. This seismic survey project is used as a case study in this paper to describe the AUV UHR 3D seismic technique.

AUV UHR Seismic Survey Methods

Survey AUVs have been commercially available from C&C since early 2001[1,2]. The oil and gas industry is the largest user of this technology. There are several aspects of AUV technology that allow for the navigation of closely spaced 2D seismic lines required to generate a 3D seismic cube. Inertial navigation accuracy and survey efficiency combine to make the acquisition of closely spaced grids over small survey areas feasible.

Navigation Accuracy

Inertial navigation technology is used for deepwater AUV positioning[3]. Inertial systems very accurately measure the accelerations and decelerations of a vehicle to determine the positions for the AUV. The inertial system is aided by a shipboard acoustic positioning system and acoustic Doppler profilers mounted on the AUV provide speed-over-ground measurements. The final AUV positions are post-processed to a horizontal accuracy of +-5 meters in water depths of up to 3,000 meters. The accuracy is a function of water depth and becomes more precise when operating in shallower water depths.

The accuracy of the positioning system is one of the limiting factors in determining the grid spacing for a AUV UHR 3D seismic survey design. Although the positioning accuracy for inertial systems used in deepwater is superb, using a line spacing interval less than the positional accuracy for a UHR 3D seismic survey could result in significant degradation of the final seismic data quality. The trace positions used in the cube generation and processing require the georeferencing to be as accurate as possible to ensure the trace accurately reflects the true acoustic response within the assigned area of the seabed.

Survey Speed and Efficiency

There is little survey time wasted with AUVs. Mission plans are efficiently designed to minimize line turn time and the AUV survey speed is nearly constant at just under 4 knots. The propeller, stern planes and rudder planes found in the AUV stern section provide the maneuverability. The AUV maintains the same survey speed when making a line turn as it does when running a survey line. Maintaining a constant survey speed results in an even dispersal of the acquired seismic or other geophysical data in the alongtrack direction.

The propeller, rudder and stern planes are the moving parts responsible for maintaining the AUV attitude and altitude above the seabed. The minimum diameter circle the AUV can navigate is 30 meters. This tight turning radius allows trackline turns to be made in minutes with very short lead in distances required (**Figure 2**).