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Multi-Azimuth, Coil Shooting And Dual Sensor Streamer Acquisition: Step Change Seismic Imaging Results In Deep Water Indonesia

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Abstract

While wide-azimuth seismic surveys represent a routine in land environments, in marine environments things go differently. Conventional offshore 3D acquisition is still being performed mainly using narrow azimuth streamer configurations, even in structurally complex areas. Attempts at breaking this paradigm have been recently made by the industry with good results, through the acquisition of some unconventional “Multi Azimuth” (MAZ), “Wide Azimuth” (WAZ), “Rich Azimuth” (RAZ) and Coil Shooting marine surveys. Here we are presenting planning, acquisition and processing results of the advanced marine surveys, a Multi-Azimuth and a Coil shooting (Full azimuth), recently acquired by Eni e&p in Indonesia. We are also presenting a 2D test and successive 3D acquisition of a broad bandwidth (dual sensor) seismic in West Timor area, aimed at exploiting sub thrust geology. At the end we demonstrate that advanced acquisition techniques effectively provide improved geophysical images and more geological insight for exploration compared to traditional techniques.

Introduction

Towed Streamer Marine seismic acquisition generates a dataset with a limited azimuth range, of the order of 10^{o}. In areas of complex geology, this limited azimuth collection, can result in very poor illumination of the reservoir by the seismic wave-field, due to bending and scattering of the ray-paths in the over-burden. Over the last five years, efforts to mitigate this poor illumination effect, with marine towed streamer surveys, have focused on acquisition solutions to generate seismic datasets with better azimuth distribution. The efforts included multi-direction and multi-vessels geometries to acquire surveys rich in azimuth. These techniques have proven to provide significant value in complex imaging environments; however they are constrained by the cost and availability of the multi-pass, multi-vessel operations.

Aster and Tulip structures are located in the Bukat Block (Tarakan Basin), offshore Kalimantan (Indonesia). The water depth is varying and ranges from 350 to 1800 meters. Several unfavourable geological conditions cause a very poor seismic response in the whole area. The presence of methane hydrates represents the main problem; this is indicated by the BSR reflection covering the whole structure. The hydrates layer generates in this area a very reflective sea bottom that causes the presence of up to seven multiple bounces. The presence of shallow free gas is suggested by an abrupt frequency-amplitude dimming below the BSR. The well drilled on the structure indicates a very small Q factor. Moreover the rough geomorphology of the water bottom, characterized by canyons and irregularities causes a non homogeneous behaviour of the illumination in the subsurface and a complex 3D raypath for surface and internal multiples. Complex deep geology, including steeply dipping thrusts, represents a third critical factor, posing severe structural illumination doubts as well. Last but not least challenge is the low reflectivity of the target sequence, often falling below the noise level. Due to the mentioned factors, the vintage seismic in the area is of very poor quality. In order to get a better image of the subsurface for the appraisal campaign, it was decided to design a new seismic survey which would adequately address the geophysical problems described above. The survey design was carried out by the geophysical planning group in Company’s headquarters. Firstly Aster and then Tulip depth model were ray-traced, using several possible survey configurations. These included single azimuth, multi-azimuth and, on Tulip, also a circular shooting (Coil) configuration [French, 1984; Durrani, 1987]. The latter configuration was investigated together with the Acquisition Contractor, who had tested the “Coil Shooting” technique in recent years. Multi- vessel WAZ techniques were not considered as near offset information is vital to address near surface irregularities. Eventually, a multi azimuth acquisition on Aster and a Coil Shooting on Tulip were judged to be the most suitable solutions for addressing their respective