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Azimuthal Anisotropy Resolved By Tilted Orthorhombic Tomography

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Summary

This paper explains a qualitative and quantitative approach to identify and resolve P wave TTI and HTI variations in the depth migration velocity model building process. The combination of these effects can be represented by an orthorhombic model with three mutually orthogonal planes of mirror symmetry; the P-waves in each symmetry plane can be described kinematically as an independent TI model (Song and Alkhalifah, 2013).

Orthorhombic velocity model building and imaging tools are required to address both HTI and TTI simultaneously in subsurface. The orthorhombic anisotropy has been correctly identified and resolved, which has subsequently resulted in a high resolution velocity model (figure 8).

A combination of the accurate velocity model building and advancement in the pre-processing techniques has shown significant uplift in the image quality on the earlier processing. The re processed PreSDM has provided improved coherency, recovered improved bandwidth, enhanced character, and better fault plane definition.

Introduction

We would like to share with you a seismic re-processing case study for offshore Cameroon. In this study we discuss both qualitative and quantitative approaches used to identify and resolve P wave velocity HTI (Thompson, 1988) and TTI in the depth migration velocity model building process.

The combination of these effects can be represented by an orthorhombic model with three mutually orthogonal planes of mirror symmetry; the P-waves in each symmetry plane can be described kinematically as an independent TTI model (Song and Alkhalifah, 2013).

Etinde MLHP-7 is a geologically complex area offshore Cameroon, Northwest of, and adjacent to the Cameroon Volcanic Line (CVL) in water depths ranging from 30 to 87 metres. The southern portion of the survey area is obscured by a gas chimney. Well penetrations in the area have discovered hydrocarbons of various types, in stratigraphy ranging from thin beds to massive sands. In addition to the stratigraphic complexity of the block, the dominant structural form is of thin skinned slope collapse, with later relaxation giving rise to both low angle extensional and compressional faulting.

Hydrocarbon discoveries in the block have focussed on the Miocene Upper and Middle Isongo reservoirs were present on the structural highs. Well IM-5RZ, drilled in 2013, opened up a new stratigraphic play in the block within the Intra-Isongo.

Method and Theory

In 2006 a towed streamer marine survey was acquired which covered the block, azimuth 112^{0}. Two further towed streamer surveys were acquired in 2010 (azimuths 52^{0} and 172^{0}). These were designed to undershoot the gas cloud obscuring the IF-1 oil discovery. Initial processing of the two surveys using a Multi-AZimuth (MAZ) PreSTM work flow resulted in very limited uplift over the single azimuth 2006 image. An OBC survey was also acquired over the IF-1 discovery with the aim of using shear waves to image through the gas cloud, however strong shear wave splitting complicated the processing and imaging of the radial and transverses components.

In 2016 the MAZ data were reprocessed to take advantage of advances in de-ghosting, de-multiple and depth imaging with the aim of obtaining a seismic image suitable for further field appraisal and development. With the presence of azimuthal anisotropy proved by the OBC shear wave splitting it was clear that a focus on resolving the azimuthal kinematics was central to event alignment between surveys and therefore realising any improvements in the signal.

Azimuthal anisotropy was confirmed by the kinematics and dynamics. Robust QC's were developed to identify, quantify and subsequently resolve azimuthal anisotropy using tilted orthorhombic tomography. The characteristics of HTI (ellipcity and directions) were estimated using Quasi's acoustic approximation for the othorhombic medium.

In the presence of azimuthal anisotropy we were anticipating that amplitudes would be stronger along the fast direction (Alkhalifah and Tsvankin, 1995), and indeed this is what was observed (figure 1). These dynamic changes are systematic and in this respect are less likely to be due to variation in illumination or coherent noise, (Jenner 2008).

Conclusions

The objective of the proposed PSDM reprocessing was to provide a seismic dataset suitable for further field appraisal and development. Key processing challenges included extreme structural, stratigraphic and lithologic variability, in addition to the gas blanking effects at IF-1r and Manyu-1. The utilisation of multi-azimuth data and processing significantly improved target imaging and resolution in this area.

Using modern reprocessed de-ghosted data, the tilted orthorhombic tomography has resolved both the HTI and TTI along the all three azimuths which have contributed to the imaging enhancements, resulting in better coherency, continuity and structural definition around the IF-1 well.

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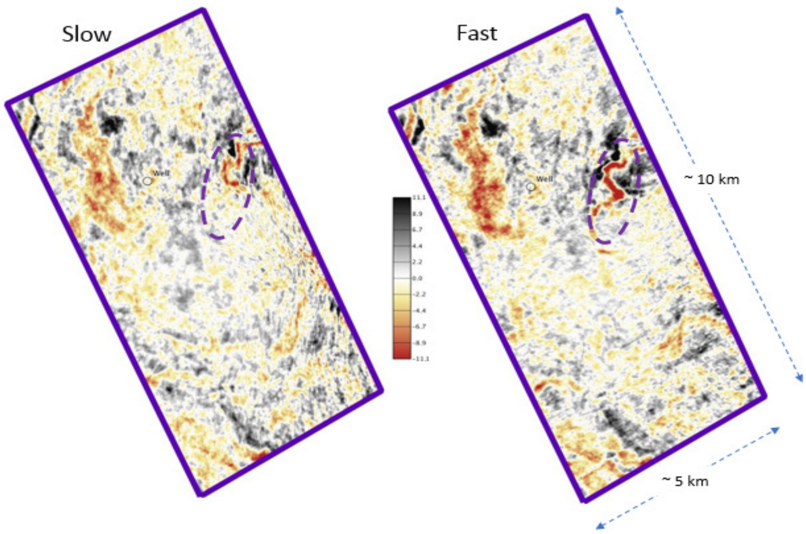

Figure 1 *Fast and slow velocity seismic images.*

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