Please fill in the name of the event you are preparing this manuscript for.	International Petroleum Technology Conference 2021
Please fill in your 5-digit IPTC manuscript number.	21IPTC-P-3588-IPTC IPTC-21795-Abstract
Please fill in your manuscript title.	Step Change in Reservoir Imaging through Massive Gas Cloud Using Rich Azimuth Ocean Bottom Nodes, Time Lag Full Waveform Inversion and Q Reverse Time Migration

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Abstract

Objective

The deep-water part of the North West Borneo Basin, characterized by major compressional folds related to regional thrusting, is an area of active hydrocarbon exploration in Malaysia. Seismic imaging in this area has been challenging due to presence of gas clouds and a regional stress field expressed through azimuthal anisotropy in seismic data. Using a recently acquired rich azimuth OBN data, tilted-orthorhombic (T-ORT) velocity modeling, Full Waveform Inversion (T-Ort-FWI), joint velocity and Q estimation using Q-FWI and T-Ort-Q-RTM are expected to come together to resolve the imaging challenges in this area.

Method

As azimuthal velocity variations were observed during data QC, the rich azimuth OBN data was separated into six azimuthal sectors for tomographic update. The six sectors resulted in six updated velocity models, which were able to reduce the curvatures on migrated gathers within their corresponding azimuths. However, due to the azimuthal variation of the velocity field, the same seismic event was imaged at different depths in different azimuths. To accommodate these azimuthal velocity variations, an initial T-ORT model was built from the six velocity models. Using this T-ORT model as the initial model, T-Ort-FWI was run from 2Hz to 12Hz using all recorded diving waves with maximum offset of 14km.

Results

The initial T-ORT model was able to simultaneously i) ensure that same event from different azimuths are imaged at similar zero-offset depths and ii) improve overall gather flatness for all six azimuths (Figure 1a and 1b). Figure 1c and 1d further compares TTI and T-ORT stack images where better stacking response is observed on the dipping events using ORT model. Starting with the initial T-ORT model, T-Ort-FWI was run up to 12Hz. The resulting velocity and image is a step change from the vintage towed streamer data (Figure 3a and 3b). Figure 2a and 2b illustrates the advantage of using Q-RTM where the gas-oil contact and anticlinal structure are better imaged due to its ability to handle complex wavefields.

The T-Ort-FWI velocity model was validated by analyzing the pre-stack depth migrated (PSDM) seismic data. Figure 3c and 3d shows cross-sections of the PSDM stack before and after the velocity model was updated. T-Ort-FWI velocity helps correct the gas velocity, resulting in better reservoir image below.

Conclusion

Despite of high hydrocarbon potential in NW Borneo Basin, identifying reservoir distribution and continuity remain a challenge in this area. With rich azimuth OBN data, we have demonstrated that orthorhombic modeling and FWI can be used to resolve azimuthal anisotropy and slow gas cloud velocity. These eventually led to an improved reservoir image beneath gas cloud that can provide new ideas about the internal geometry of the crestal structure.

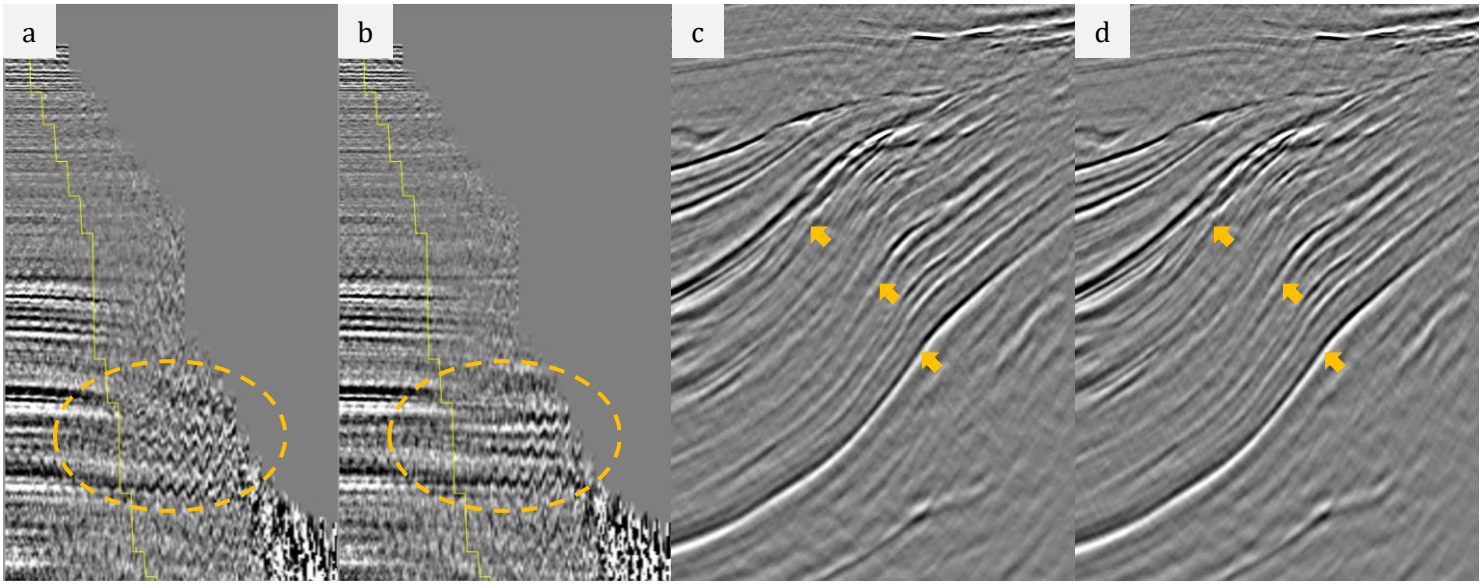

Figure 1: (a) Azimuthal moveout, seen as jitters on common-offset-common-azimuth gather using TTI model, (b) Jitter effect is resolved, to some extent by using an orthorhombic model, (c) Stack from TTI model, (d) Stack from orthorhombic model

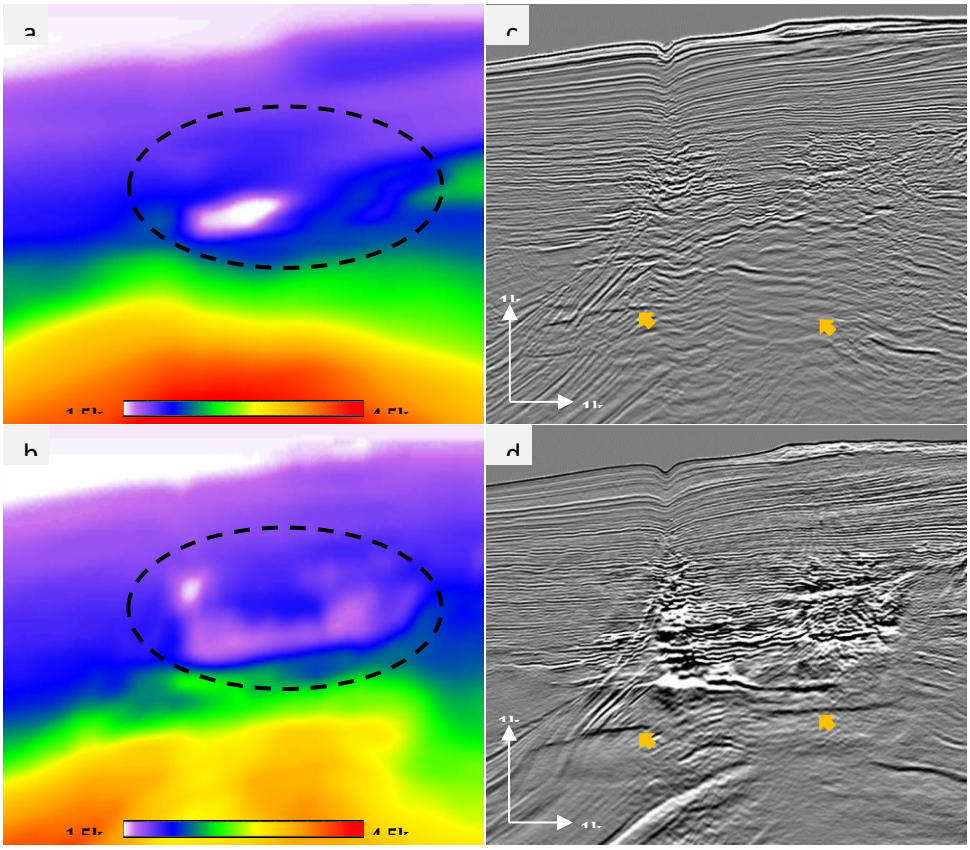

Figure 3: (a) Legacy velocity model with streamer FWI, (b) Current velocity model with OBN FWI, (c) Q-RTM Stack using legacy model, (d) Q-RTM Stack using current model

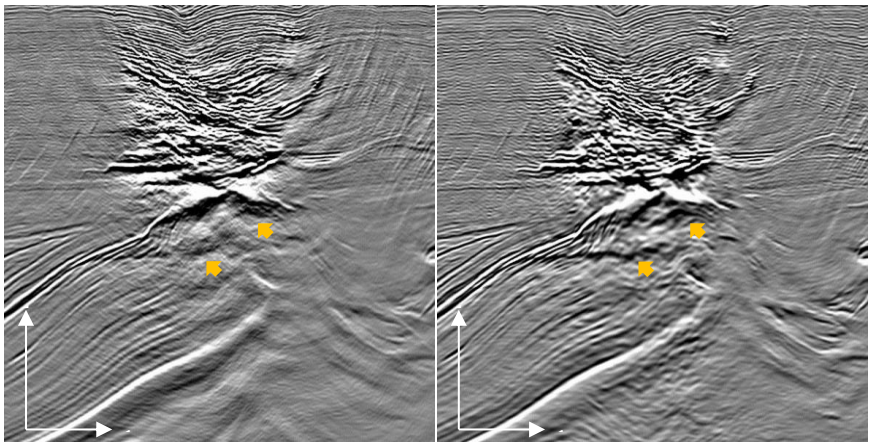

Figure 2: (a) Q-Kirchhoff-PSDM Stack b) Q-RTM Stack