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3D-2C OBC Multi-azimuth Seismic Data Processing and Its Applications for a Carbonate Field Offshore Abu Dhabi, UAE

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SUMMARY

A 3D-2C OBC multi-azimuth seismic data processing was conducted in a test area in a carbonate field offshore Abu Dhabi, United Arab Emirates with the main objectives: to demonstrate improvement of imaging; and to detect any HTI response.

Three processing flows were designed to generate (i) conventional, (ii) full-azimuth and (iii) multi-azimuth cubes.

The output cubes were evaluated qualitatively and quantitatively: (1) overall imaging analysis; (2) fault imaging analysis; and (3) HTI analysis.

The results demonstrated improvement of imaging compared to traditional processing and detection of a certain HTI response. These encouraging results will be the incentive to apply multi-azimuth seismic data processing in carbonate fields offshore Abu Dhabi, United Arab Emirates.
Multi-azimuth seismic data processing is considered one of the leading-edge technologies in the industry today. Each azimuth cube represents a sub-surface image focused in the particular azimuth sector, which would illuminate existing faults parallel to the azimuth direction. In addition, Horizontal Transverse Isotropy (HTI, otherwise known as azimuthal anisotropy) response among multi-azimuth cubes would indicate the presence of fracture swarms, their density and orientation.

A 3D-2C OBC multi-azimuth seismic data processing was conducted in a test area in a carbonate field offshore Abu Dhabi, United Arab Emirates with the main objectives: to demonstrate improvement of imaging; and to detect any HTI response. The field has an anticline structure with faults located mainly on the crest and fractures formed during folding and/or faulting. The acquired seismic data exceed 140 fold with wide offset and azimuth distributions. These conditions are suitable for testing and evaluating multi-azimuth seismic data processing.

Three processing flows were designed to generate (i) conventional, (ii) full-azimuth and (iii) multi-azimuth cubes. The conventional cube was generated by a traditional flow through pre-stack time migration (PreSTM) to represent an image focused from all azimuths. The multi-azimuth cubes were generated by data-splitting into four azimuth sectors followed by PreSTM imaging in each azimuth sector separately to represent images focused respectively in each azimuth sector. In addition, multi-azimuth velocity cubes were produced from spatially continuous velocity analysis in each azimuth sector. Moreover, the full-azimuth cube was generated by merging the four azimuth sectors followed by stack, representing an image without blending the azimuth effects. Unless particular reasons necessitated change, the same processing parameters were applied to all cubes to minimize any differences due to processing effects.

The output cubes were evaluated qualitatively and quantitatively. (1) Imaging overall was evaluated between the conventional and the full-azimuth cubes. The full-azimuth cube shows similar resolution but higher S/N than the conventional cube. (2) Fault imaging was evaluated on the four multi-azimuth cubes. The results show that detailed lineaments are revealed on each azimuth cube, which indicates that each azimuth cube contributes to illuminate existing faults parallel to the azimuth direction. (3) HTI response was detected among the four multi-azimuth velocity cubes. To avoid any overburden effects and processing artifacts, azimuthal variations in the interval velocity at the target level were inverted to elliptical parameters to represent principal HTI intensity and direction. These attributes should indicate fracture density and orientation having a higher velocity in the fracture direction than in the orthogonal direction. The results show higher HTI intensity around faults and approximately perpendicular HTI direction to the main faults alignment, which is reasonably consistent with the results of appraisal wells. In addition, higher HTI intensity area is reasonably correlated with higher porosity area, which is likely in accordance with the regional geological interpretation.
In conclusion, this multi-azimuth test-processing demonstrated improvement of imaging compared to traditional processing and detection of HTI response. In addition, it should be noted that seismic response is highly sensitive to the presence of faults and fractures in the field. These encouraging results will be the incentive to apply multi-azimuth seismic data processing in carbonate fields offshore Abu Dhabi, United Arab Emirates.

Figure: HTI analysis results at the target level: (left) HTI intensity, and (right) HTI direction. Dashed pink lines are faults. HTI direction angle is in degree clockwise from North.