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Impact of Seismic Anisotropy on Predicted Reservoir Properties

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ABSTRACT

Anisotropic prestack depth migration (PSDM) reduces inherent distortions of isotropic PSDM particularly in the presence of complex geology, and rapid vertical and lateral velocity changes. This results in improved imaging of faults and deeper horizons, and allows the depth section to be tied correctly to well data (using check shots, VSPs and well tops). We developed an appropriate methodology (anisotropic PSDM workflow), where borehole information and seismic information are integrated to provide better results for predicting the reservoir properties. Approximately 400 km^2 of wide azimuth land seismic data located in Saudi Arabia were imaged. The target layer is a shale formation. We observed large anisotropy (~50%) in the target shale in both the isotropic prestack-migrated seismic and the corresponding checkshot-calibrated velocity models. We restricted ourselves to vertical transverse isotropy (VTI), the simplest and most common form of anisotropy observed in shale. Significant imaging improvements were achieved by processing the data with the anisotropic depth imaging workflow, using anisotropic parameters derived from a walkaway VSP. The anisotropic velocity models produced a seismic depth image that calibrated to the well with less than 1% depth error.

Three datasets (PSDM-isotropic, PSDM-anisotropic and PSDM-anisotropic with no far offset mute) were analyzed using prestack seismic inversion. Angle stack ranges of 0 to 60^0 at 5^0 angle increments were input to the AVA simultaneous inversion algorithm. The AVA workflow simultaneously inverts for P-impedance and Vp/Vs. There was no difference in inverted P-wave impedance between isotropic and anisotropic cases since acoustic impedance is solely dependent on near angle stacks. For the inverted Vp/Vs volume, an improved seismic inversion-to-well calibration was obtained using the PSDM-anisotropic cases rather than the isotropic case. Across the target reservoir, the inverted Vp/Vs volume from PSDM-anisotropic without mute provides smoother results compared to the mute case due to the inclusion of more angles. These results clearly exemplify the benefits of incorporating Thomsen's anisotropic parameters into the data preparation for AVA inversion. The benefit is particularly apparent for the seismic inversion for Vp/Vs since this reservoir property depends upon large incidence angles (greater than 20 degrees) and, is significantly influenced by the VTI effect of shale.