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Delineation of Multi-level Reservoir in Active Mud Diapir Complex Using Advanced Seismic Imaging and Elastic Inversion: A Case Study in Northwest Sabah Basin, Malaysia

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Abstract

The North Sabah Basin has a unique and complex mud diapir tectonic setting. The tectonic regimes formed irregular confined mini-basin morphology in the deep-water environment that controls facies including reservoir deposition. This complex morphology then results in an uncertainty in reservoir delineation which cannot be reduced by common qualitative seismic attribute only such as seismic RMS amplitude attribute. The seismic elastic inversion (EI) method was introduced to overcome the challenge. Data quality check was carried out as the primary procedure before running the EI. These include well velocity and density variations, 3D seismic data quality, seismic multi-angle spectral analysis, and seismic interpretation. Well cross-plot analysis was run to understand the relationship between elastic parameters with geology parameters such as facies in well point, perform EI on seismic data to produce various cubes i.e., impedance, Vp/Vs, and facies cubes. The result of EI such as facies cube is used to identify the geometry of the reservoir along the area and its relationship with the kinematics of the mud diapir. Combining of impedance and Vp/Vs cross-plot analysis of various well data exhibits good discrimination of lithological variations including hydrocarbon and non-hydrocarbon reservoirs on well basis. Wet sand shows relatively high impedance with low Vp/Vs, gas sand shows relatively low impedance with low Vp/Vs and shale facies shows moderate impedance with relatively high Vp/Vs. Moreover, EI results support an understanding of reservoir fairway geometry in confined-unconfined basins. This includes prediction of hydrocarbon or non-hydrocarbon reservoirs in other undrilled locations inside the seismic 3D area. Compared to the result of RMS amplitude attribute result at several reservoir intervals, the EI facies maps are more appropriate to be utilized for reservoir delineation especially in impedance anomaly areas that are confirmed by alignment to the new well data. Reservoir delineation from EI result leads to a better understanding of the dynamic of mud diapir movement on NE Sabah which mainly controls the reservoir fairway.

Keywords: mud diapir, elastic inversion, confined-unconfined basin, reservoir delineation