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Seismic Geomechanical Properties for Fracture Characterization of a Carbonate Reservoir, Saudi Arabia

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ABSTRACT

Fractures, interpreted from image-log data, which are essentially sparse in nature, cannot represent the complex fracture network in a reservoir; therefore, other drivers to detect fractures away from wellbores can help in the prediction and population of discrete fractures. Geometrical seismic attributes, such as curvature, coherence and dip, can be generated to map discontinuities. Discontinuity attributes from seismic data are intrinsically noisy and need to be constrained. One-dimensional geomechanical earth models (MEMs) can constrain the seismic discontinuity attributes. A geomechanical model built with static measurements of Young's modulus (E), Poisson's ratio (PR) and brittleness from core-plugs, and coupled with the dynamic calculation of these elastic moduli from well-logs, can be propagated spatially and temporally to generate mechanical layers. These mechanical layers are characterized by stiffness parameters that constrain fracture intensity. The Vp/Vs ratio obtained from pre-stack seismic inversion can be used to compute the seismic elastic moduli (E and PR). Once validated with well data, seismic moduli can infer stiffness and fracture intensity. Seismic discontinuities are then correlated and validated with fracture intensity and stiffness. In this study, fault-trend attributes are computed by blending structure-oriented semblance, dip and tensor attributes from the post-stack seismic data. A fault-trend attribute represents a seismic discontinuity pattern discernable from seismic data. A horizon slice along the reservoir from this attribute volume was created. The geomechanical property logs were calculated from the acoustic logs. Our aim is to identify areas with high E and low PR; in other words, brittle areas of the formation that are susceptible to be cracked under stress. Two data slices – maximum E and minimum PR – are both created along a small interval of the reservoir horizon. Another slice is also created by dividing the E slice with the square of the PR slice (E-PR). Since PR is a fraction, squaring it reduces its magnitude. Therefore, dividing the E slice by the square of PR, a new slice will be obtained to highlight the brittle zones. The structural contours of the reservoir and the fault-trend slice are superimposed on the E-PR slice to visualize the brittle zones from the structural perspective and highlight the relation of brittle zones with the seismic discontinuities.