From Elastic to Geomechanical Properties. Onshore Field Case Study, Saudi Arabia

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ABSTRACT

Geomechanical properties such as Young's modulus and Poisson's ratio can be directly related to rock and fluid properties such as reservoir properties, stress/fractures and brittleness which can be vital for field development and sweet spot detection. Amplitude Versus Offset (AVO) seismic inversion can estimate the elastic properties like the Acoustic Impedance (AI), the P-wave to S-wave velocity ratio (VP/VS) and the density. The next step would consist of directly calculating Young's modulus and Poisson's ratio from their respective theoretical rock properties relationships We demonstrate the application of this approach with an onshore field from Saudi Arabia. The pre-stack seismic data, well log data and borehole seismic data was integrated in the seismic inversion workflow to produce AI, VP/VS and density volumes. As an initial step, a set of deterministic angle-dependent wavelets are estimated at both single and multi-wells. The next step aims at compensating for the lack of low frequencies in the seismic data. Models for AI, VP/VS and density are generated based on a horizon-guided interpolation and extrapolation of well log data. The models are only used up to 10 Hz to fill in the missing low end of the seismic spectrum. Afterword, the seismic angle stacks, the angle-dependent wavelets and the three low frequency models are input to the AVO inversion algorithm to be simultaneously inverted into the desired elastic properties. The accuracy of the inversion results is assessed with the help of well log data. As expected, the quality of the inverted density is confirmed to be substandard. The last step of the workflow concerns the estimation of Young's modulus. As a straightforward step, we employ the Young's modulus formula. Since the density term is explicit in the Young's modulus formula, we consequently did not obtain satisfactory results. As an alternative, we determine the relationship between the AI and the Young's modulus logs with a least-squares regression line having a correlation coefficient of 99%. The resulting regression line is used to estimate Young's modulus from the inverted AI. In conclusion, the estimated Young's modulus volume will be eventually integrated in future reservoir characterization studies.