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Petrophysical Joint Inversion – Rising to the Reservoir Characterization Challenge

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ABSTRACT

Reservoir characterization objectives are to understand the reservoir rocks and fluids through accurate measurements to help asset teams develop optimal production decisions. Within this framework, we introduce a new Petrophysical Joint Inversion (PJI) of seismic and Controlled Source ElectroMagnetic (CSEM) data to rise to the reservoir characterization challenge. PJI exploits the complementary information contained in seismic, CSEM and well log data to drastically improve the reservoir's description. The advent of CSEM, measuring resistivity, brings the possibility of integrating multi-physics within the characterization workflow and has the potential to significantly improve the accuracy with which reservoir properties in general, and saturation in particular, can be determined. The PJI technology introduced here follows a two-stage workflow: the first stage deals with the accurate calibration of a robust rock physics model at well locations. The objective is to match the PJI-numerically derived porosity and water saturation estimates with the ones empirically calibrated from the petrophysical interpretation constituting the benchmark. In the second stage, a common domain of sensitivity to the reservoir interval of interest and changes in properties within it is established, then both seismic and CSEM data are inverted for physical attributes (Acoustic Impedances (AI) in the case of seismic and anisotropic resistivity in the case of CSEM). These physical attributes are then simultaneously inverted for rock and fluid properties using the well logs calibrated rock physics model to couple electric and elastic domains. To reduce scale uncertainty (seismic and CSEM sampling the earth at different scales) and reconcile the resistive anomalies at reservoir scale, a 3D CSEM 'localized' model-based inversion is applied, capable of quantitatively reconstruct improved-resolution resistivities contained within the seismically derived vertical and lateral reservoir boundaries. Through a case study, based on a deep water sandstone reservoir, located in the Sergipe Alagoas Basin, offshore Brazil, we demonstrate the power of PJI in the retrieval of reservoir parameters and to augment the certainty with which reservoir lithology and fluid properties are constrained compared to a cascaded workflow. PJI inverted petrophysical properties show good correlation with the assumed rock model parameters and good agreement with the well estimates.