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The Analysis of Sands Grain Size Classes in the Elastic Domain

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ABSTRACT

Advanced petrophysical manipulation of microresistivity borehole image (BHI) data with core data, using image-based petrophysical (IBP) modeling methods can provide details of the lithological fabric and estimates of grain sizes. This study considers integration of IBP grain size classes with seismically derived parameters, e.g., the P- to-S velocity ratios (Vp/Vs), P-wave acoustic impedances, in an Ordovician aged glacial-fluvial tight gas sandstone from northwestern Saudi Arabia.

Integrated results from core, borehole image, and conventional open hole log data from 42 wells are used to demonstrate the potential of this methodology for improving the calibration and consistency of core to seismic scale physical modelling. The workflow involves five main steps:
1) Standard petrophysical interpretation of well logs and MultiMin analysis.
2) IBP (neural network and grain-size modeling).
3) Environmental correction and normalization of acoustic and formation density logs.
4) Selection of a Rock Physics Model for fluid substitution to alleviate effects on the logs for seismically derived parameters.
5) Cross-plotting of elastic parameters with embedded grain-size classes to evaluate the grain-size classes separation before propagation into 3D seismic cube.

Neural net and image-based petrophysics were used to model for the water-wet case to identify elastic parameter variations corresponding to tight sandstones grain size classes. Using the IBP grain size classes, four types of rocks (1. medium-grained sands; 2. fine-grained sands; 3. very fine-grained sands; 4. silts and shales) were distinguished. Rock physics analysis shows that within the sandstones the variation in the finer particle content in the sand matrix controls the reservoir quality.

Integration of core data, BHI and open hole logs improved the prediction of grain size classes in the tight sandstones, allowing high vertical resolution (class discrimination) and transference of borehole based grain size classes to the elastic domain for quantitative seismic interpretation. These results reduce subjectivity in the sedimentological model through use of mathematical algorithms and physically measured rock parameters rather than subjective interpretive results. Further development of this approach requires the population and distribution of the grain size classes into a 3D seismic model to generate seismic facies.