Evaluation of a Laminated Tight Sand Formation by Integrating Logs, Core Data and Digital Rock Analysis

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ABSTRACT

The Granite Wash formation is a stacked liquids-rich tight sand play in the Anadarko Basin covering 2.5 million acres from the Texas Panhandle into Western Oklahoma, USA. A four inch diameter core of 290 feet was obtained from a well in the Texas Panhandle and a comprehensive suite of petrophysical properties were measured at various scales to characterize multiple formations. The main purpose of the project was to improve well log calibration by integrating continuous high resolution core data and statistically sound plug sampling. This process can greatly reduce petrophysical uncertainty and help optimize lateral wellbore target selection. The analyses included high resolution dual-energy X-ray CT (DE-CT) imaging, spectral gamma logging (SGR), plug sample selection, digital rock analysis (DRA), and traditional core analysis lab data. Digital rock data from plugs was upscaled to the whole core. Continuous vertical curves were computed for mineralogy, total organic content (TOC), brittleness index (BI), total porosity (PhiT), effective porosity (PhiE), porosity associated with organic matter (PAOM), and permeability. The results from DRA were compared to other lab measurements including XRD, LECO TOC, and porosity. Multiple rock types were identified from SGR, bulk density (RHOB), and photoelectric factor (PEF) computed from the DE-CT scans. Plug samples were taken from 84 depths that were representative of key rock types. Samples were analyzed for XRD, LECO TOC and DRA. For each DRA sample, XRF analysis and micro-CT X-ray imaging were used to select locations for SEM imaging. Ion-milled SEM data and 3D FIB-SEM data was used to compute effective PhiE, solid organic matter (OM), PAOM, and permeability. There is high vertical variability in alternating thin layers of carbonates and mudstones, each with distinctive rock properties. DE-CT imaging was used to identify and quantify thin beds that were below well log resolution. SEM image data allowed for direct measurement of PAOM which is often a critical factor in unconventional reservoir quality. DRA enabled the upscaling of high resolution pore scale data to the DE-CT data, providing calibration to well logs and improving petrophysical interpretation. Integrating DE-CT results with SEM analysis, and combining traditional laboratory measurements, we obtained a robust petrophysical model from core at very early stages of evaluation, as well as identifying intervals with the highest reservoir potential.