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Complete Cased Hole Unconventional Formation Evaluation in Niobrara Shale Wells in One Run

Combining new Pulsar multifunction spectroscopy service and ThruBit Dipole acoustic service delivers high-confidence determination of RQ and CQ

CHALLENGE

Efficiently obtain high-quality through-casing measurements in lateral wells for defining reservoir quality (RQ) and completion quality (CQ) in unconventional reservoirs.

SOLUTION

Conduct a single logging run per well using the TuffTrac* cased hole services tractor to acquire key petrophysical and geomechanical formation properties data with a slimhole sourceless toolstring pairing Pulsar* multifunction spectroscopy service and ThruBit Dipole* through-the-bit acoustic service.

RESULTS

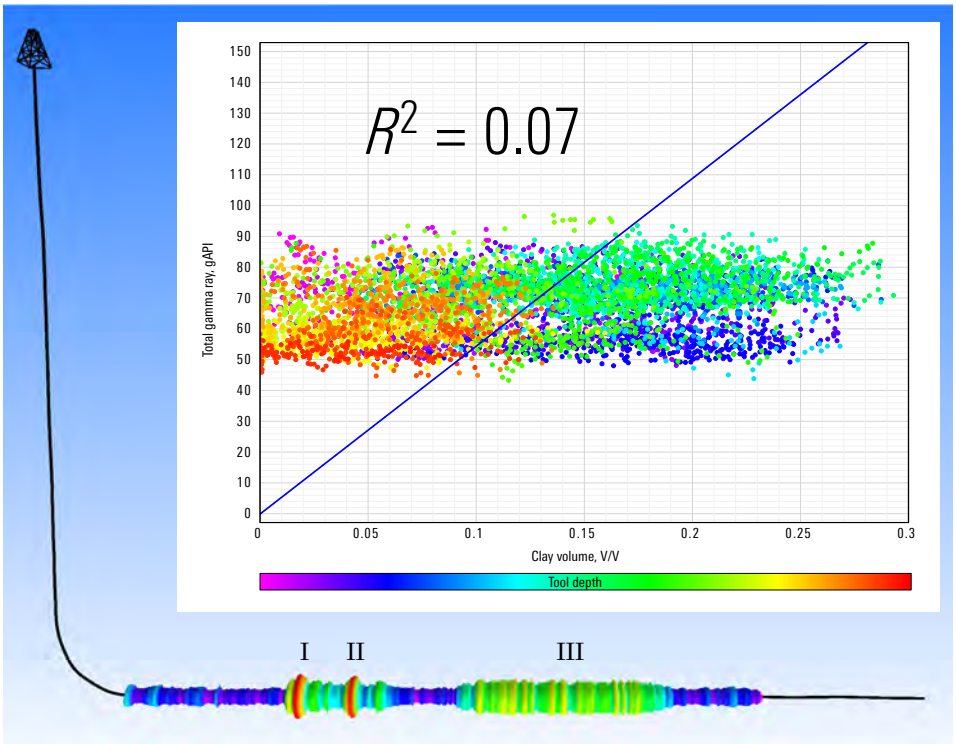
Identified marl beds and related faults within the clay volume—which were not possible to distinguish with total gamma ray–based MWD measurements—by using the combined data to build a comprehensive petrophysical model and calculate RQ and CQ refined by mechanical properties for guiding completion.

Challenging logging conditions in cased lateral wells

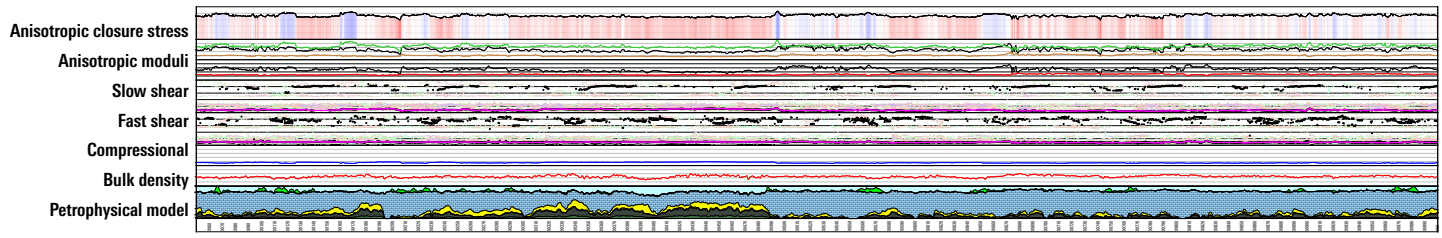
Through-casing measurements, necessary for formation evaluation and as an input to hydraulic fracture stimulation design, have been historically difficult to obtain, particularly with sufficient quality and in lateral sections. An operator in the Niobrara Shale was facing this challenge of acquiring high-quality data to properly evaluate RQ and CQ in two lateral wells.

Cased hole measurements with the precision and range of openhole logging

Introduced to fill the measurement gap for cased holes, innovative Pulsar multifunction spectroscopy service obtains a standard formation evaluation suite with a single slim-diameter tool for conducting a complete petrophysical volumetric interpretation. By employing state-of-the-art cerium-doped lanthanum bromide ($LaBr_3$:Ce) gamma ray detectors proven by Litho Scanner* high-definition spectroscopy service, Pulsar service similarly obtains highly accurate elemental concentrations for a robust determination of mineralogy—including total organic carbon (TOC)—in addition to traditional sigma, porosity, and carbon/oxygen ratio measurements. Pulsar service also provides the new fast neutron cross-section (FNXS) measurement that differentiates gas-filled porosity from liquid-filled zones and tight formations.



The clay volume, obtained from the petrophysical model built with Pulsar service measurements, exhibits abrupt changes along the well path where transected by marl as the result of faulting. Because some of the faults are at the subseismic level, they had not been previously identified. The marl in the toe half of Well A (III) was also not previously identified because there was no correlation between the clay volume and MWD total gamma ray measurement. Identifying the presence of marl is important for anticipating production challenges because marl often contains ash beds that can pinch off production.



The petrophysical interpretation of Pulsar service measurements in Well B provides mineralogy, bulk density, and fluid analysis. The compressional and fast and slow shear slownesses are obtained from ThruBit Dipole service's sonic measurements. The slownesses are paired with the bulk density to compute the horizontal and vertical Young's modulus and Poisson's ratio. The anisotropic moduli are then used as inputs to the hydraulic fracture stimulation design.

ThruBit Dipole through-the-bit acoustic service is also well suited for cased hole logging in shale reservoirs. Both monopole and cross-dipole waveforms and Stoneley waves are acquired for processing with a 3D anisotropy algorithm to obtain anisotropic moduli referenced to the borehole axes. These are used to classify the formation as isotropic or anisotropic and determine whether the anisotropy is intrinsic or caused by drilling-induced stress. Bulk density derived from Pulsar service's volumetric interpretation refines the acoustic processing for mechanical properties, providing critical information for guiding well completion, designing fracturing stages, understanding wellbore stability aspects, and planning trajectories for future wells.

Single-run formation evaluation and geomechanical modeling

The Pulsar service measurements were spectrally processed with the Quanti.Elan* multicomponent inversion solver to build a petrophysical model of formation properties including mineralogy, porosity, and saturation. The model also provided the bulk density required for accurate processing of the formation elastic properties. In addition to supporting high confidence in the assessment of RQ and CQ, the model revealed subseismic faulting that was not identified by the MWD interpretation, which was based on total gamma ray measurements.

Dipole sonic from ThruBit Dipole service was paired with the bulk density to define the elastic properties Young's modulus and Poisson's ratio. These values were key to solving the anisotropic closure stress profile for evaluating potential completion challenges along the lateral.

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