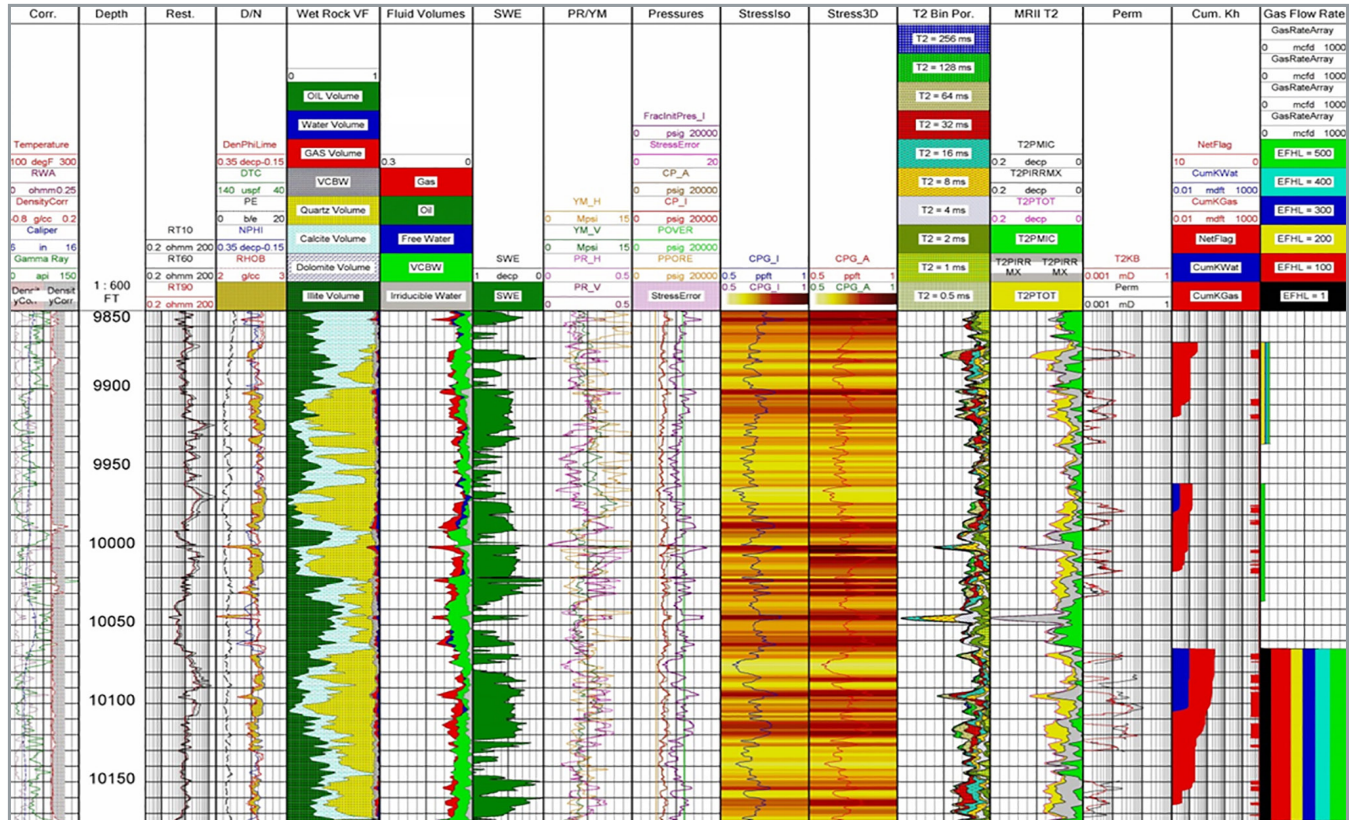# TightRockXpert℠ Service—Advanced Low-Perm Asset Workflow Solution

East Texas TightRockXpert℠ Example—Lower Frac Stage = 1.0 MMCF/D

Unconventional geoscientists analyzing vertical wells containing multiple stacked low-perm gas reservoirs need new tools to help quantify potential productivity before deploying a correct completion methodology. Recently, Halliburton developed TightRockXpert℠ service, a new integrated solution based on an optimized workflow for low perm, partially cemented gas sands. This asset-level analysis combines conventional reservoir volumetrics, a calibrated texture-based permeability, and a calibrated anisotropic stress calculation to predict production using an integrated hydraulic fracture simulator.

In addition to a standard triple combo, the two key logging technologies that are required for this analysis include the Magnetic Resonance Imaging Log (MRIL®) T1-T2 tool and an oriented WaveSonic® tool. Technologies that are used to calibrate the solution offering include GEM™ Mineralogy, Reservoir Description Tool (RDT™) or Sequential Formation Tester (SFT™) formation pressure with drawdown mobility, RDT Microfrac analysis, and finally, a cased-hole Diagnostic Fracture Injection Test (DFIT™) analysis.

The TightRockXpert service consists of the following:

Fluid and Minerals Evaluation (FAME™) Methodology
The heart of the TightGasXpert volumetric analysis is its probabilistic solver. An optimum total porosity is best resolved by logs using geochemically derived minerals whenever barite-weighted mud systems are deployed. GEM Mineralogy is also mandatory if clay typing is required for fluid-compatibility analysis. When the analyst has a good match of all measured log inputs for a "dry" rock model, a "wet" rock model is run utilizing resistivity with either a Simandoux or dual-water saturation model using core measured values of m (cementation) and n (saturation) exponents.

Advanced NMR Saturation Modeling
Since nuclear magnetic resonance (NMR) modeling directly measures clay and capillary-bound water, those portions of the volumetric analysis can easily be constrained. An NMR "spectral" BVI (bound- volume irreducible) relationship is typically used for capillary bound water in cemented low-perm rocks due to

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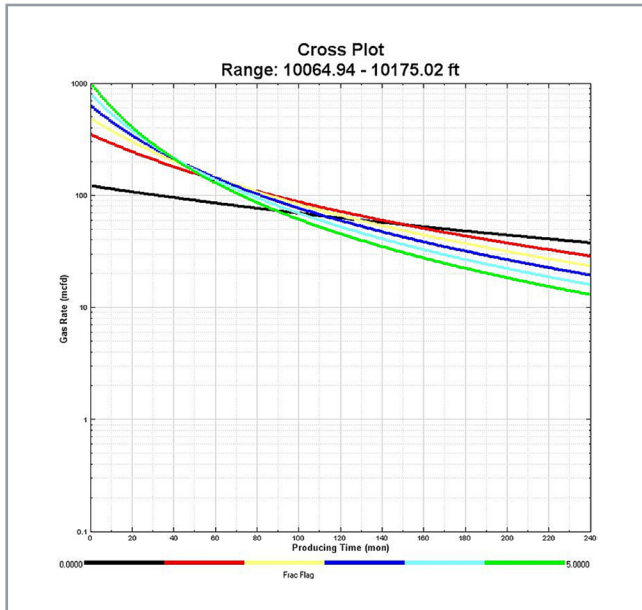
Frac Decline Prediction, 500-ft half length = 1.0 MMCF/D,
1-ft Natural Completion Zero Skin = 125 MCF/D

uni-modal porosity distributions seen on the lower end of the T1 and T2 spectrums. In environments like these, fixed T2 or T1 cutoffs become meaningless for capillary-bound water. A distinct advantage of T1 data is that flush zone T1 bulk gas shows up completely separated to the high end of the T1 spectrum and that allows better estimates of BVI from the lower end of the spectrum, which is water wet. These BVI models have been well established using NMR core data over the past 15 years and represent best practices rigorously matched to well performance.

NMR Hydrocarbon Typing
Using simultaneously acquired NMR T1 and T2 data, new 2D Fluid Characterization processing allows for the quantification of separate volumes of unflushed oil and gas. A simple ratio of the two volumes can often be used to predict condensate yield. While this fluid typing is very robust in fresh mud systems, it can still be used in oil-based systems as OBM filtrate can often be distinguished from native oils, while the characterized gas volumes remain the same.

Anisotropic Mechanical Properties
Laminated clay-rich shales often exhibit large differences between vertical and horizontal elastic properties, both Young's modulus and Poisson's ratio. This anisotropy is quantified in a 3D Stress analysis using fast, slow, and Stoneley shear from an oriented cross-dipole sonic. This yields much better estimates of fracture initiation pressure and closure stress to be used in industry-standard 3D fracture propagation models for optimized completion planning. The absolute static values of calculated fracture initiation pressure and closure stress are calibrated to RDT™ Microfrac analysis or a cased-hole DFIT analysis.

NMR Texture Permeability
TightRockXpert℠ service uses advanced NMR texture-based models to best match core-measured Klinkenberg perm, downhole injection-based DFIT perm, or RDT drawdown fluid mobility. Four different NMR methods can be used in fresh mud systems to precisely describe a capillary pressure curve that is closely linked to actual pore throat distribution. In oil-based mud systems, the free fluid portion of the NMR-measured porosity is filled with oil filtrate, so custom "Coates Model" perm calculations must be employed using separate free fluid (FFI) and capillary bound-water (BVI) porosity components. The "pumping" perm from these models is used in the workflow for all induced fracture leakoff and inflow production predictions.

Pay Analysis
TightRockXpert service allows the asset team up to six different criteria for flagging net pay for cumulative reserves. Besides typical saturation, effective porosity, and clay volume cutoffs, additional cutoffs for closure stress and permeability are employed to segregate stacked pay into logical vertical frac stages. These proposed stages are primarily categorized by interval perm-height (kH) that contacts the maximum amount of porosity-height (phiH).

Productivity Prediction
The final piece of the workflow is to actually predict fracture stimulated production for each frac stage identified in the pay analysis. Rigorous fracture inflow performance is modeled with the specific production type (gas, gas condensate, or oil) that is identified through the rest of the workflow or actual field knowledge of gas-oil ratios. Idealized fracture conductivity is modeled for a specific value of contacted kH, and then separate decline curves are generated for different effective fracture half lengths that could be realized. These projected decline curves are delivered to the client for integration into existing reservoir performance or economic models.

For more information, contact your Halliburton representative.

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