ShaleXpert℠

Advanced Source Rock Reservoir Analysis Solution

Engineers and geoscientists need petrophysical solutions that will define the most optimum techniques to deliver most shale gas and oil to the market. The Halliburton ShaleXpert℠ new integrated analysis solution, based on a calibrated workflow for organic shales, can bring all the pieces together. It allows you to build reservoir models to exploit these resources.

Questions

- Is this a potential shale reservoir?
- What is the gas or oil resource in place?
- Can I frac this zone?
- How do I frac this zone?
- How does my well compare with offsets?
- Where do we perforate or go horizontal?

Challenges

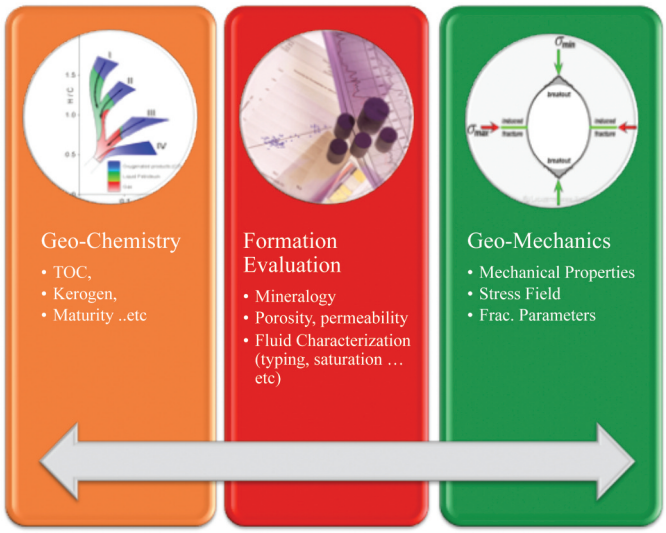
- Define the resource volumetrically – need accurate kerogen volume
  - Effective porosity and bound water
- Define the type of resource
  - Gas, condensate or oil
- Multicomponent porosity system for storage and matrix flow
  - Inter-kerogen, conventional pore, micro/macro fractures
- Complex vertical vs. horizontal mechanical anisotropy conditions
  - Clay layering, vertical fracturing, embedded strength members
- Brittle vs. ductile prediction for surface area drainage and frac performance

Solution

- Develop a completely new integrated solution based on a calibrated workflow for organic shales
- Bring all the requisite pieces of an exploration shale play analysis into a single place
  - This is critical when very few vertical exploration wells are used to define the economics of a resource play before full-scale horizontal development

Features

- Total Organic Content (TOC) estimation and organic maturity
- Fluid and Minerals Evaluation (FAME™)
- Advanced saturation modeling
- Mechanical properties and brittleness
- 3D stress and orientation
- Permeability
- Pay analysis



Petrophysical Model Workflow

What does ShaleXpert℠ Software Address?

TOC and Maturity

Determine an accurate volume of organic kerogen and potential hydrocarbon type based on level of maturity. TOC measured by pyrolysis can be calibrated to logs using industry-accepted correlations. Organic maturity measured from Ro or calculated from Tmax finalizes the TOC calibration and hydrocarbon type.

FAME™ Methodology

The heart of the volumetric analysis is its probabilistic solver. Total porosity in organic shales is resolved by combining log measured relative amounts of geochemically derived minerals with the previously solved TOC. The ShaleXpert℠ software uses a probabilistic error-minimization methodology to determine formation fluid and mineral volumes. Tool-response equations are expressed in terms of fluid and mineral volumes and their corresponding tool-response parameters. The key to the entire analysis is only solving for, and calibrating to those minerals that are actually found by core X-ray diffraction (or alternately X-ray fluorescence).

Advanced Saturation

All organic shales exhibit both "water" and "hydrocarbon" wetting phases as a result of the varied porosity systems present in the rock, so the application of resistivity-independent saturation measurements, such as NMR and dielectric porosity, allow direct measurements of total fluid-filled porosity (NMR) and total water-filled porosity (Dielectric). The "wet" rock volumetric analysis can directly use all the discriminated NMR and dielectric porosity measurements. Clay-bound water can be constrained to what is seen from NMR. Total water can be constrained by a total dielectric porosity. A solved oil or gas volume can be constrained to the difference observed between NMR and dielectric porosities.

Mechanical Properties

Conventional vertical Young's Modulus and Poisson's Ratio are calculated from DTC and DTS dipole sonic data and are calibrated to static rock properties using surface core stress tests and small-volume Diagnostic Fracture Injection Tests (DFIT℠) analysis. ShaleXpert℠ analysis then determines fracture initiation pressure, fracture closure pressure, and closure stress gradient. Using directly measured values of DTC and DTS, calibrated synthetic DTC and DTS curves can be generated from mineralogy and effective porosity data to use on future wells without actual sonic data, but when accurate mechanical properties prediction is needed.

3D Stress

The differences between vertical and horizontal elastic properties is quantified in a 3D stress analysis requiring Fast Shear, Slow Shear and Stoneley shear from an oriented Dipole Sonic log. 3D stress is a better predictor of true fracture geometry when used in 3D frac modeling software.

Permeability

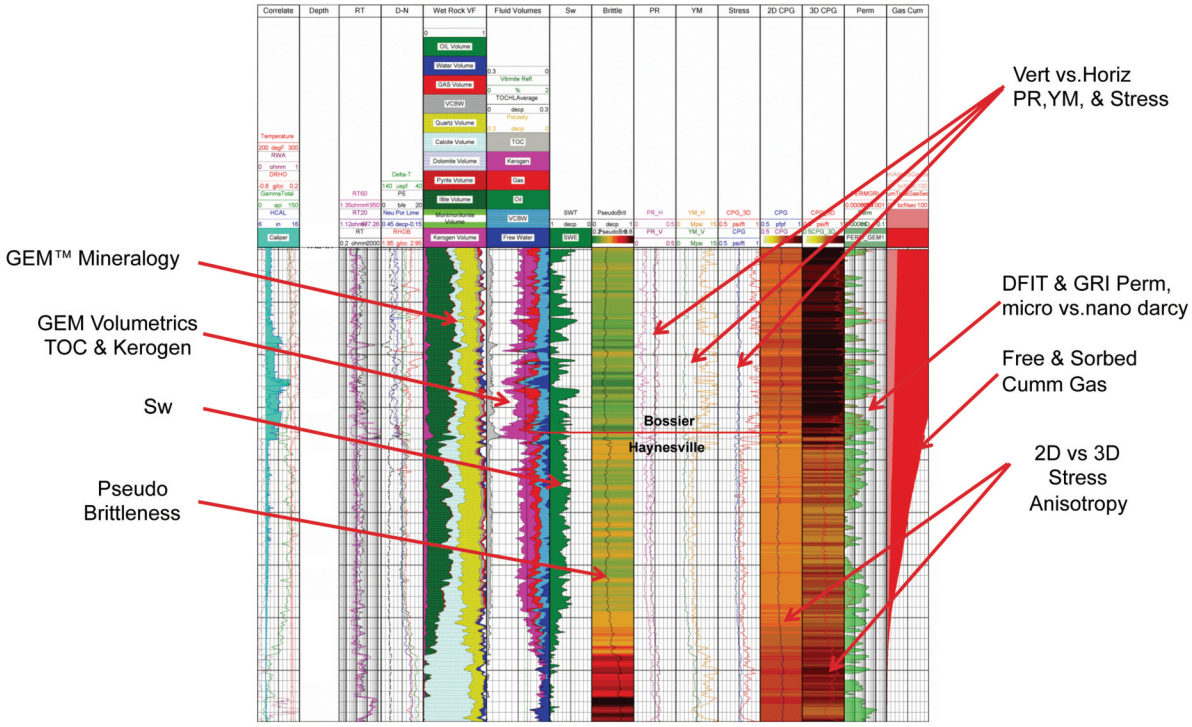
ShaleXpert℠ analysis uses a linear regression technique to match core-measured GRI matrix shale perm. DFIT effective perm analysis can be used to calibrate Timur or Coates model "system" matched perms, or one of two new regression perms with better dynamic range. Frac simulators require an estimate of fluid leak-off using such perm estimates.

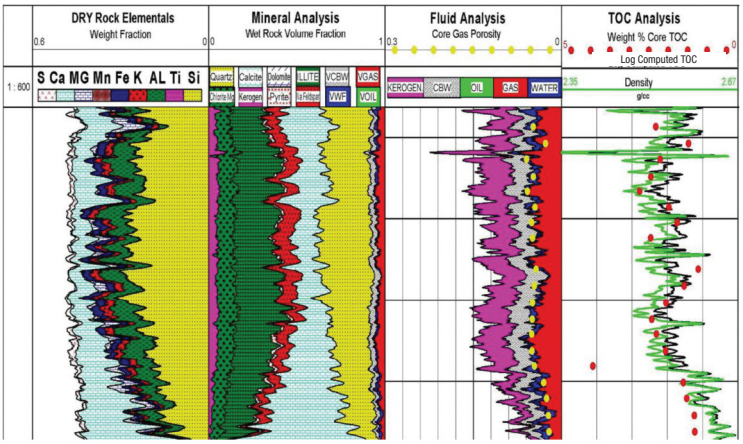
Pay Analysis

ShaleXpert℠ software allows up to six different criteria for flagging and counting net pay. Typical criteria used include effective porosity, effective water saturation, pseudo brittleness, and closure stress. Either gas, oil, or both, can be volumetrically solved, and cumulative reserves are output alongside flagged net pay. If core-canister isotherm data is supplied, free vs. sorbed gas volumes are also calculated.

The Final Product

The final composited ShaleXpert℠ analysis brings together all the different workflow modules in a display that aids in primary sweet-spot identification, identifies in-place reserve estimates, and delivers everything required for an optimized fracture stimulation design. Along the way, it can also generate individual quality-control plots and logs from any of its workflow components, so all processes are transparent to the end user.





Define the Sweet Spot

- Higher index of brittleness and low plasticity = highest fracture complexity and most surface area
- Lowest effective closure stress
- Highest effective porosity (most free gas)
- Least amount of clay layering per unit volume (low VTI anisotropy)
- Most amount of microfractures per unit volume (high HTI anisotropy)
- Highest TOC-FT when thermally mature

For more information about how Halliburton can help improve your profitability, visit www.Halliburton.com or contact your local Halliburton representative.

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