Volatiles Analysis Service

Optimize and Understand Gas Plays with Advanced Geochemical Cuttings Analysis

Volatiles Analysis Service (VAS) from Baker Hughes, supplied by Advanced Hydrocarbon Stratigraphy, a Baker Hughes strategic partner, is an advanced geochemical analysis that provides detailed information on the composition of entrained volatile chemistries from geological materials (PDC cuttings, rock bit cuttings, side wall core, core, etc.) be they legacy (several years/decades old) or hermetically sealed at the well site. The volatiles monitored are extensive and provide unique insights into the geochemistry of the subsurface system in addition to providing a mechanical strength index and species by species permeability indices.

VAS assists the exploration/development of gas plays by:

1. Assessing EUR, resource concentration, and resource quality/composition
2. Evaluating the effect of structural features on a well
3. Understanding the petroleum system

VAS is a low risk nonintrusive method for efficiently and affordably logging laterals and challenging conditions such as high temperature and/or high-pressure (HT/HP) wells.

VAS has been used in N.A. gas plays including the Barnett, Piceance, Utica, Marcellus, Arkoma, and HT Haynesville, and internationally in Nigeria, Kuwait, and HT/HP North Sea.

Volatiles measured by VAS include:

- C1-C4 Gases
- C5-C10 Paraffins
- C6-C10 Naphthenes
- C6-C8 Aromatics
- Helium
- Carbon Dioxide
- Hydrogen Sulfide
- Carbon Disulfide
- Carbonyl Sulfide
- Formic Acid
- Acetic Acid
- Water
- Methyl Ethyl Ketone
- Argon
- Molecular Oxygen
- Molecular Nitrogen
- Ethene
- 2-Trans-Butene
- Additional species, isotopes, and/or isomers may be possible upon request

EUR and Resource Concentration/Composition

Using sealed at well site samples a representative resource concentration/composition is measured allowing EUR predictions to be made. VAS can be used to select landing locations and understand how resource composition/concentration changes across a lateral, see **Case 1**.

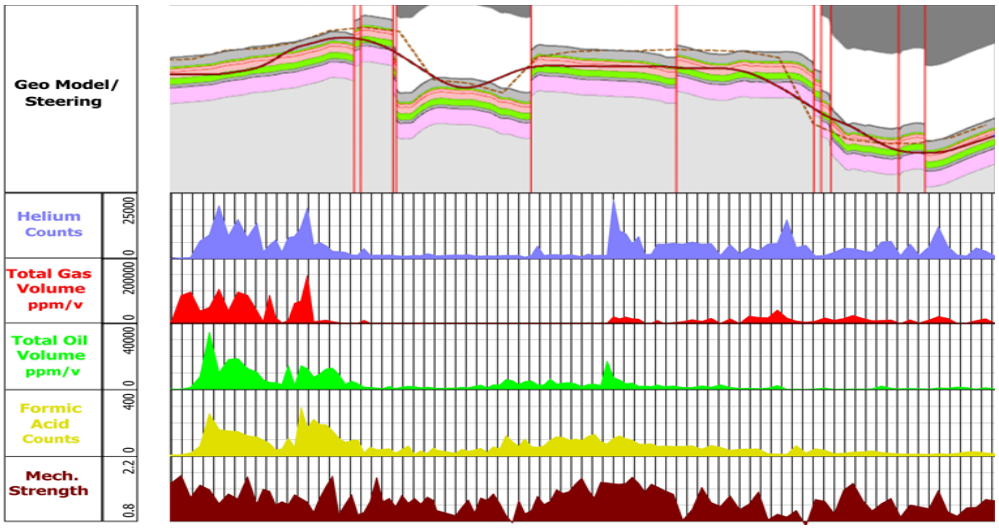
Effects of Structure on Resource

Features like faults and/or fracture networks can have significant impacts on the resource concentration and/or completions of laterals. Faults in gas plays frequently serve as conduits allowing gases out of formation and/or in for diagenetic liquids; faults can participate in resource loss or reservoir destruction, see **Case 1**. Fracture swarms can also be identified by VAS. VAS data provide unparalleled insights into how the features that the lateral encounters can affect resource contribution and performance.

Petroleum System Evaluation

There are many situations where a detailed assessment of the petroleum system may be necessary for the economics of a gas play. Beyond better understanding the play itself, economic hazards such as unwanted CO_2 communicated in from a different formations or biogenic overpressures can be identified and a strategy to address the hazard can be created, see **Case 2**.

Contact your Baker Hughes representative to learn more about how Volatiles Analysis Service can supplement your gas play characterization or visit www.bakerhughes.com



Case 1: Samples sealed at well site were used to evaluate a 2-mile Woodford lateral in the Arkoma. Faults control the resource concentration acting as communication pathways. Gas and helium are depleted hundreds of feet proximal to some faults. Large quantities of liquid HCs and diagenetic compounds (acids) are present; their distributions influenced by the faults too. Reduced mechanical strength occurs at faults. VAS data demonstrate the challenges faced by laterals in structured plays.

Case 2: A shallow overpressure above a gas play assessed with legacy samples; intermediate casing was economically prohibitive. VAS identifies overpressure at the same depth as the mud log (red highlight). Overpressure caused by the severe biodegradation of an unknown oil column; extreme degradation with major depletion of paraffins (API <20) and high organic acid (biodegradation product) content. Organic acids preferentially partition into the water leg (orange track) but are minimally present suggesting immediate breakdown; at this depth one volume of acids decomposes to 400 volumes of CO_2, CO, and CH_4. Degradation appears aerobic; if meteoric water source is identified wells could be deviated away from overpressure making intermediate casing unneeded.