CROWN GEOCHEMISTRY

Pathplot

This page introduces the initial snapshot of hydrocarbon character within lateral sections or vertical zones. Gamma is included for familiarity and lithology correlation. For laterals the well path is also shown as a dark blue line.

- **Lts vNorm** = C1, C2 and He
- **Mids** = C4 and C5
- Bottom two normed curve sets are scaled min to max with the maximum deflection on the bottom (only on this Pathplot presentation).
- For the normalization process a heavy hydrocarbon (typically C7), is used to normalize data set. Whatever multiplier that is required to push C7 in a straight line is also applied to C1, C4, Lts, and Mids. This can help minimize rig artifacts.
- In Laterals the hydrocarbon character is lighter early and becomes hydrocarbon wetter with increasing depth/time due to retention of wet hydrocarbons in the mud system.
- Both sets of normed curves may mimic each other, but when they don't, it is instructive.

Multiplot

This worksheet has initial and instructive comparisons of curves

- **C1 Std** > **C2 Std** may be related to maturity, or have poro/perm indications when differences occur between C1 and C2.
- **Arom 51** includes fragments from all larger than C4 hydrocarbons and is typically used as a proxy for "pourable" hydrocarbons.
- **H2/He** and **H2/C1** ratios are inorganic vs. organic comparisons. These generally correlate, but deviations can indicate compartmentalization in laterals, and a different lithology package in verticals. In either ratio, look for irregularities, which may indicate frac/faulting, poro/perm variability, and compartmental or bedding changes.
- **CO2++** and **C1** are here as additional inorganic vs. organic comparison; CO2++ can be geologic, mud additive, and/or atmospheric.
- **C1/C4** and **C4/C7** can be used for general dry gas vs. condensate and condensate vs. oil characterization and relative poro/perm variability in tight rock.
- **C1/(Ar/36)** is a QC track used to indicate sampling quality. It should track fairly closely with **Arom51**. Deviations can indicate more sample than atmosphere (hydrocarbon shows) or low sample volume.
- **Sol 5** is a ratio comparison of Benzene (cyclic C6) to normal Hexane (straight chain C6). Increases in this ratio may be indicative of higher water saturation. Benzene is 80X more soluble than hexane, but once the fluids come to surface it ionizes and is detected by the mass spectrometer.
- **Gamma** is included to help with locating lithology package.

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Standardized Data Plots

The data is standardized to compare components with differing scales in order to observe any meaningful variability between them.

The top set of curves includes **C1**, **C4**, **C6**, **Benzene**, and **ROP** (STD2 Chart included with daily report). These are statistically standardized with "μ" representing the mean or average of that data set. All are overlain for comparison to ROP, since that is the main driver of introducing gases into the mud. As drilling speeds increase or decrease, gas curves will generally correlate unless there are geologic highs and lows. This is a good data presentation for finding "sweet spots" (gas values outperform ROP), or possible depletion zones (gas values underperform ROP). Benzene and C6 usually run together, but where benzene outperforms C6, it can be indicative of variable or increased water saturation.

The lower set of curves includes **C1/FPH**, **Benzene/nC6**, **C1/CO2**, C1/C4, and **He/H2** (STD1 Chart included with daily report). **Std C1/Std FPH** can be simplified to units of gas per foot. In laterals we draw a line that best fits a heel to toe "ramp". This is used to highlight above or below trend C1 volume vs. ROP. **Std Benz/Std nC6** is used as a water variability indicator. **Std C1/Std CO2** is instructive for compositional variation, or fingerprinting. **Std C1/Std C4** used for lighter vs. wetter hydrocarbon character. **Std He/Std H2** is instructive for compartmentalization.

Frac Geochemistry Profile

This chart uses a proprietary Crown formula using helium and other components. It is roughly scaled to emulate fracs/ft as an FMI image log might do. Helium is a noble gas with geologic origin, is very small, and moves through tiny spaces due to size. Helium is mainly a product of the radioactive decay of heavy elements in the basement. It is widely accepted and used to indicate fractures, conduits, etc.

Reverse Indicator Plots (Commonly referred to as "DNA" plots)

The data is imported into software which allows the analyst to run hundreds of cross plot ratios, and find zones of "likeness" and even outliers. Only instructive ratios are used in final report. The indicators are color coded for visual guides. Orange or Light Pink indicates lighter hydrocarbon ratios. Lime Green indicates heavy hydrocarbon ratios. Blue is reserved for potential relative Sw indicators. Helium or fracture related indicators are Red or Hot Pink. Above trend hydrocarbon volume is Dark Brown. These are the main colors you'll see in the panel, but others might be included depending on the data set.

Ratio analysis in vertical applications include: hydrocarbon abundance markers for gas or liquid pay zones, fluid contacts (Benz/nC6, C1/C4, C4/C6, etc.), bulk porosity (various helium ratios), stacked pay potential (perf placement), and endorsement for lateral placement.

Ratio analysis in lateral applications include: evidence for compartmentalization (chemistry boundaries, gases not equilibrated along lateral), compositional variations, "sweet spots", variability in relative Sw indicators, and secondary poro/perm features.

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HC Strips

Helium, C1 through C10, Benzene, Toluene, and H2S are generally on this presentation. The data values are scaled min to max for visualization of relative abundance in zone. Methane depletion can be endorsed if C1 is absent but above liquid hydrocarbons are present. For methane depletion, also use the standardized presentation with ROP, C1, C4, C6 and Benzene (on top Std chart look to see if the gas values are underperforming the ROP).

BTU

This log is included to show some additional ratio comparisons and a rough BTU estimate throughout the length of the data. The first column includes C1 and C4 and is scaled to show deviation between the two components. Hydrocarbon wetter zones are green with C4 values higher than C1 values. Alternately, hydrocarbon lighter zones are red and have C1 values higher than C4 values. This same scaling is applied in the second column to show C1 vs ROP. This is just another visual representation of gas per foot, much like the two standardized charts. Red indicates C1 higher than ROP. Black indicates C1 below ROP. BTU values are calculated per foot and distributed along a color scale to indicate a predicted production BTU estimate. The BTU Value Spectrum is included to the left as a guide (1200 and below BTU is red – 1650 and higher BTU is purple). The fourth column displays a duplicate copy of the Frac Chemistry curve.

Crown Curves

This text file includes all the curves from the log and charts in the power point if you would like to import our curves into other programs. Alternately this can be sent as an excel file.