AMPLIFIED GEOCHEMICAL IMAGING LLC

Technical Note

Downhole Geochemical Logging in the Permian Basin

Amplified Geochemical Imaging LLC's Downhole Geochemical Logging (DGL) provides ***an ultra-sensitive assessment of the hydrocarbons in a well****.*

DGL analyzes downhole cutting samples to directly characterize the composition of hydrocarbons vertically and laterally through prospective sections and ***is 1,000 times more sensitive than traditional methods****.*

This methodology has the unique ability to look at a broad compound range from C_2 ***to*** C_{20}*, which is significantly more expansive than the limited mud logging range of* C_1-C_5 *or the* C_1-C_9 *of other techniques.*

The result is a detailed characterization of petroleum phase, the ability to infer seals and compartmentalization, infer multiple hydrocarbon sources and detect water saturation.

DGL provides the most detailed and granular hydrocarbon data available on the market today.

While this study took place in the Permian Basin, the technology has been used in conventional and unconventional drilling, both onshore and offshore. For this project samples were collected by the mud logger at the shaker table at 100 ft intervals. Sampling intervals can vary from every 10 ft to every 100 ft depending on the project objectives. The samples did not require cleaning or drying. The samples and mud blanks, were then sent to Amplified Geochemical Imaging's (AGI's) lab for analysis by gas chromatography/mass spectroscopy. Analyses typically take two weeks.

The data were then subjected to Hierarchical Cluster Analysis (HCA) to identify the number of hydrocarbon families. The cluster analysis indicated four primary hydrocarbon families: a background hydrocarbon signature, a gas & condensate signature, a gas & oil signature, and a gas, condensate, & oil signature. The samples were then color coded and plotted versus depth, **Figure 1.**

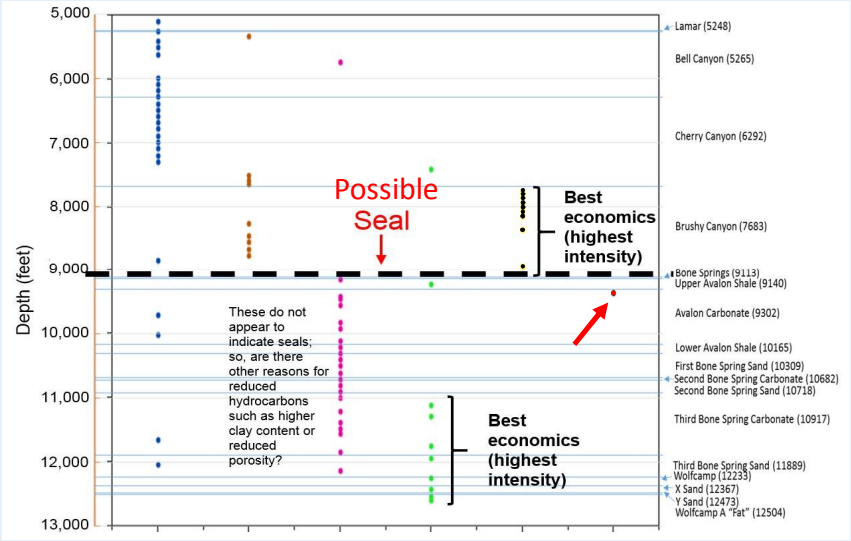

Figure 1.

The blue dots, found in the Lamar, Bell Canyon, and the majority of the Cherry Canyon formations, were background hydrocarbons with very low hydrocarbon richness and were, thus, noneconomic. The brown and black samples in the lower Cherry Canyon and in the Brushy Canyon were gas & condensate hydrocarbons. The brown samples were lower intensity indicating areas of lower economics while the highest gas & condensate samples, indicated by black, were found entirely in the Brushy Canyon formation.

There was a sample at the top of the Avalon Carbonate, indicated by the red arrow, that was unique. **This Sweet Spot was gas, condensate, & oil and had the highest intensity of any sample.**

Seals, Source & By-passed Pay

DGL intensity reflects porosity

Below the Brushy Canyon the hydrocarbon signature changed from a gas & condensate signature to a gas & oil signature. **This infers a possible seal at the top of the Bone Springs formation**.

Figure 2 displays the plot of various hydrocarbon ranges and components (e.g. gas, light oil, oil, aromatics, etc.) versus depth for the upper section of the well. Again, the blue dots represent samples with background concentrations of hydrocarbons. Note the hydrocarbon intensity for gas, light oil, and Cyclics gradually begins to increase at ~7,100ô peaks at ~8,200ô and then drops significantly. **The ability of DGL to monitor cyclics provided a unique ability to differentiate these Permian hydrocarbons**. The sharp decrease in hydrocarbon richness could be due to a reduction in porosity or an increase in clay content. The data indicates that the most hydrocarbon rich and most economic section of the upper portion of the well is ~7,800ô- ~8,200ô

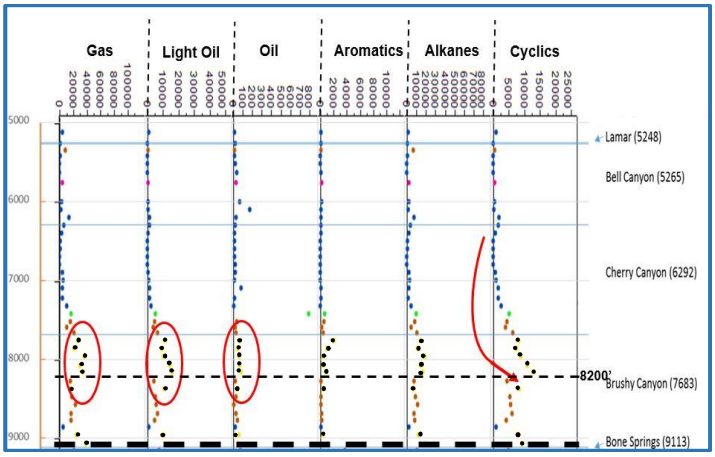

Figure 2.

The lower portion of the well, below the Bone Springs, was dominated by a different hydrocarbon profile of gas & oil. Note, the Wolfcamp A, Y Sand, X Sand, and the Third Bone Spring Carbonate formations, **Figure 3**, have the highest condensate and gas range hydrocarbons in the well. With the exception of the single point at ~9,350ô the Wolfcamp A, the Y Sand, and X Sand are most likely, the most productive sections of the well. The Wolfcamp at 12,233ô has the highest oil range concentrations in the well.

Note there is a gradual decrease in the gas and condensate range intensities as you move up the well from the Wolf-

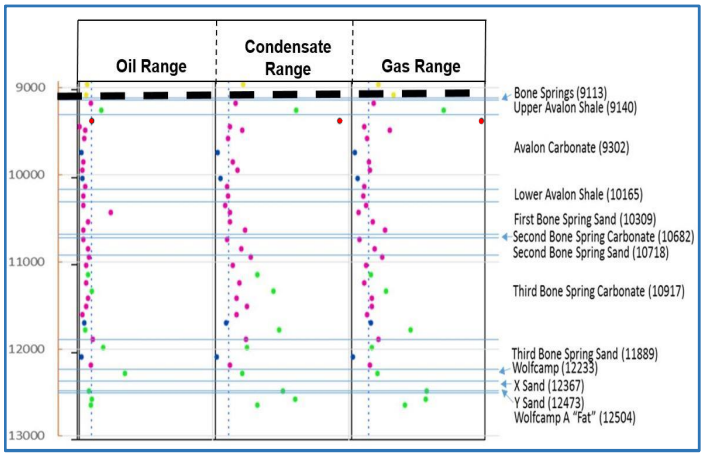

Figure 3.

camp A. Thus, it may be possible the Wolfcamp A may be sourcing the sections above, which would infer there are no seals below the Bone Springs.

This ratio of hexane over benzene serves as a proxy for water saturation (Sw). This is based on the fact that benzene (C_6) is highly water soluble while hexane (nC_6) is not. While not shown here, the Sw proxy plot showed significantly higher water saturation in the blue dot samples between 5,000ôï 7,200ô Thus, the reason for the low hydrocarbon intensities may have been due to increased water saturation in the pore spaces.

Summary: the AGI Downhole Geochemical Logging data for this Permian well was able to show:

- There were **essentially two hydrocarbon charges** in the well ï gas & condensate in the upper section and gas & oil in the lower section,
- The Lamar, Bell Canyon, and the majority of the Cherry Canyon contained only noneconomic hydrocarbons and greater water saturation,
- There appeared to be a seal at the top of the Bone Springs Fm.,
- **The Sweet Spot for the well appeared to be a narrow window at the top of the Avalon Carbonate Fm. - ~9,350'**,
- There appeared to be no seals below the Bone Springs Fm.,
- The Wolfcamp A, Y Sand, and X Sand appear to be the most hydrocarbon rich and productive in the well.

Amplified Geochemical Imaging, LLC
210 Executive Drive, Suite 1, Newark, DE 19702, USA
Phone: +1.302.266.2428, Fax: +1.302.266.2429
E-mail: info@agisurveys.net **www.agisurveys.net**

Copyright © 2015 Amplified Geochemical Imaging LLC

Sales Offices
Houston, TX, USA: Phone: +1.281.782.8914
Germany: Phone: +49.89.638.7927.12
AIPC, AUS/NZ/PNG: Phone: +61.417.659.144
PT Geoservices, Jakarta: Phone: +62.21.830.5555