AMPLIFIED GEOCHEMICAL IMAGING LLC

Ultrasensitive hydrocarbon logging

Downhole Geochemical Logging: an Eagle Ford Case Study

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 hydro-carbons 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.

The study took place in the Eagle Ford field in the Maverick Basin of Dimmit County, Texas near the Rio Grande River border. Samples were collected by the mud logger at the shaker table at 30 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, along with mud blanks, were then sent to Amplified Geochemical Imaging's (AGI's) laboratory in Newark, DE for analysis by gas chroma-tography/mass spectroscopy (GC/MS). Analyses typically take only two weeks.

The data were then subjected to Hierarchical Cluster Analysis (HCA) to evaluate the number of differing hydrocarbon families. The cluster analysis indicated four primary hydrocarbon families. The background samples were primarily associated with the Olmos Fm., a gas and oil family was associated with the San Miguel Fm., the third oil family was primarily found in the Austin Chalk Fm. and the Anacacho Fm., while the fourth hydrocarbon (i.e. oil) family was associated with the Eagle Ford, Buda, and Del Rio formations. The cluster analysis implied that the Olmos Fm. was essentially uncharged, and that the San Miguel, Austin Chalk/Anacacho, and Eagle Ford, Buda, and Del Rio formations had distinct charges.

Figure 1 is a plot of the light hydrocarbons (i.e. C_2 – C_6) on the left and the heavier hydrocarbons (C_{10} – C_{18}) on the right plotted verses depth. Note that the Olmos Fm. shows essentially no hydrocarbon presence in the gas range and liquid range depth plots, as well as, the Total Ion Chromatogram (TIC) on the right.

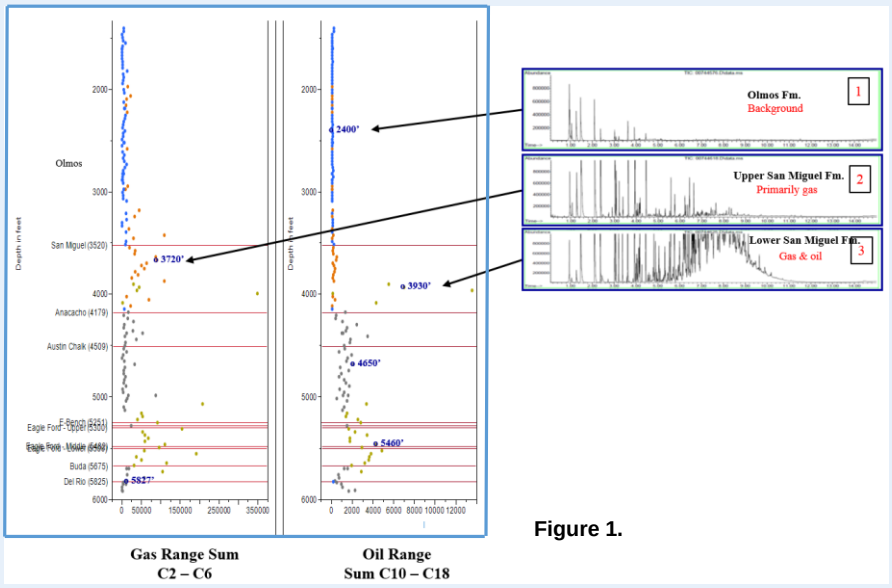

Figure 1.

Seals, Source & By-passed Pay

DGL intensity reflects porosity

The data shows the upper San Miguel Fm. as being gas prone and the lower portion being gas and oil prone. Figure 1 also shows, by the orange dots from the HCA data, similar gas in the San Miguel Fm. and the Olmos Fm. **This implies there is no seal between the two formations.** However, the majority of the San Miguel-type gas seems to stop around 3100 ft. implying a possible seal there.

Figure 2 displays a plot of the ratio of benzene over hexane versus depth. This ratio 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. Thus, in a water saturated zone, benzene preferentially dissolves in the water while hexane does not, resulting in a dramatic increase in the benzene/hexane ratio in zones with high water saturation. This can be seen by the strong green peaks in Figure 2 in the deltaic sandy shales of the Olmos Fm. Note the strong increase in the ratio between 2400 ft. and 3100 ft., once again implying seals at those two depths. The resistivity log also registered significant change between 2400 ft. - 3100 ft. This Sw proxy can be particularly helpful in fields, like the Woodford Shale, with high water saturation issues.

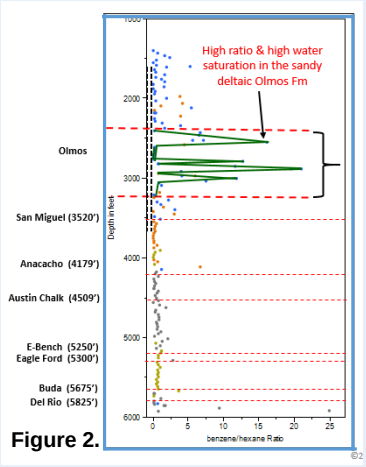

Figure 2.

Figure 3 shows the depth profile with related TICs for the Olmos, San Miguel, Austin Chalk, Eagle Ford, and Del Rio formations. **Even a cursory review of the TICs shows distinct differences between the profiles for the various formations, a level of detail not available from well logs or other technologies.** For example, the liquid depth profile and the associated TICs show the lower San Miguel has the highest intensity of liquid hydrocarbons, even more than the Eagle Ford. This **by-passed pay** would be missed as most companies drill straight to the Eagle Ford Fm. for completions.

Additionally, remember the HCA data indicated that the hydrocarbons in the Austin Chalk and the Anacacho formations were essentially the same, but different from the San

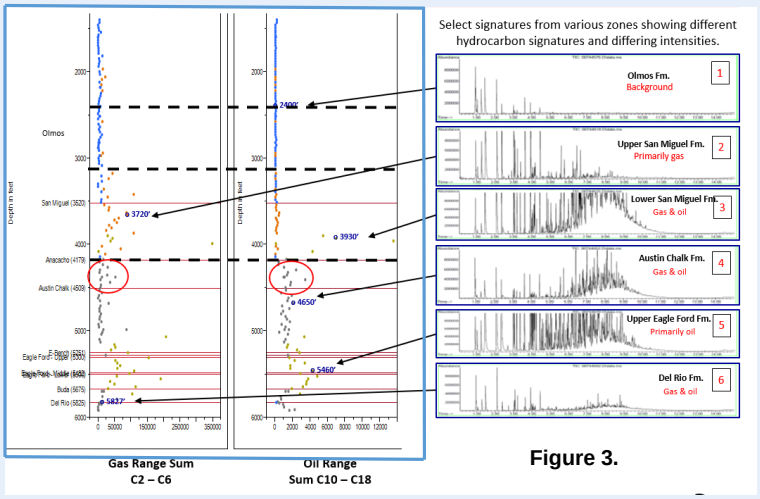

Figure 3.

Miguel Fm. This implies a seal must be present between the two. The hydrocarbon profile showed hydrocarbons amassing at the seal at the top of the Anacacho Fm. (noted by the red circles). The hydrocarbon profile and the TIC also indicated a reduced hydrocarbon intensity or richness in the Austin Chalk and Anacacho Fms.

While there is not sufficient room in this document to discuss all the findings for this case study, an examination of the hydrocarbons in the Eagle Ford Fm. showed that the lower Eagle Ford was most likely charging the upper and middle Eagle Ford, the Buda and Del Rio formations and there appeared to be no seals between any of these various formations. Additionally, DGL intensity matched density log measurements for predicting porosity.

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

- The Olmos Fm. was void of appreciable hydrocarbons,
- The benzene/hexane ratio could be used as a Sw proxy,
- The Olmos Fm. contained a zone of higher water saturation and possibly two seals.
- Three different sources existed in this well (i.e. the San Miguel, the Austin Chalk, and the lower Eagle Ford),
- The hydrocarbons in the upper and lower San Miguel were from the same source,
- The lower San Miguel was most likely a by-passed pay,
- There were also seals at the top of the Anacacho and upper Eagle Ford formations.

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