AMPLIFIED GEOCHEMICAL IMAGING LLC

Horizontal & Vertical Hydrocarbon Mapping

Creating a 3-D Hydrocarbon Profile in Shale Plays

Shale plays are an extremely difficult arena in which to explore because they are all different. While general lessons can be translated from play to play there are important differences which control exploration and development decisions. This means that effective development of shale plays requires extensive evaluation and coordination of various data sources such as geology, geophysics, geomechanics, petrophysics, and engineering. (Durham, 2012)

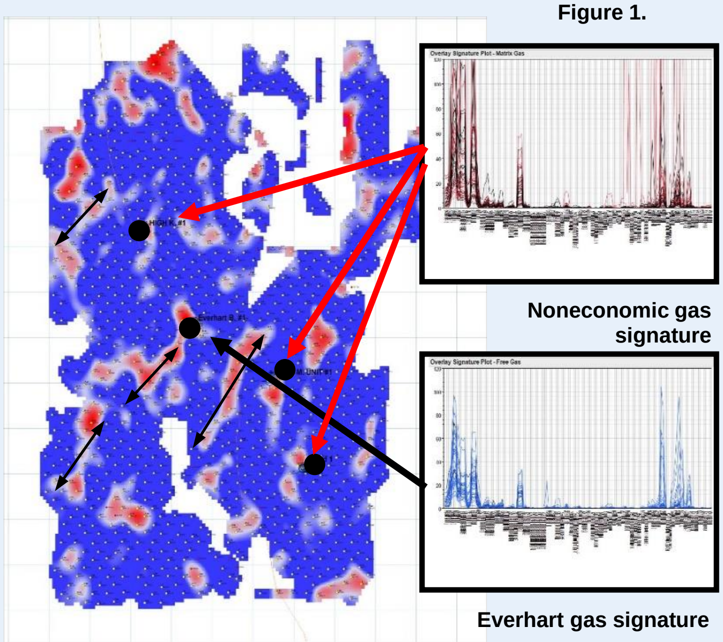
However, while these conventional disciplines provide a wealth of important data, one important data set is often lacking – hydrocarbon data. Additionally, given the current price of oil and gas, it is critical that companies identify sweet spots to optimize production and reduce production costs. To accomplish this, new technologies and new paradigms must be used. One such technology is ultrasensitive hydrocarbon mapping.

AGI's **Amplified Geochemical Imaging** is an ultrasensitive direct hydrocarbon detection surface survey technology that provides a **horizontal assessment** of a play resulting in the ability to not only detect where hydrocarbons are in a field, but also determine phase and areas of better porosity, pressure, and net pay thickness.

AGI's **Downhole Geochemical Logging** (DGL) technology provides **a vertical assessment** of the hydrocarbons in a well. Downhole Geochemical Logging analyzes cutting samples to directly characterize the composition of hydrocarbons vertically through prospective sections. 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 traditional ranges of C_1-C_5 of most gas analyses. The result is a detailed characterization of petroleum phase contained in the stratigraphic intervals as well as addressing compartmentalization and water saturation down the well.

In this **Utica case study** three wells were drilled prior to the Everhart #1 well and each well was noneconomic. The Everhart #1 well, which targeted the Trenton formation, was a highly successful gas well with an IP of approximately 10 MCF/day which then leveled-off at ~3 MCF/day. This begged the question, why was this well so productive, and more importantly, where do you drill the next well? So, Amplified Geochemical Imaging was utilized to generate a hydrocarbon anomaly map across the field to identify sweet spots with better hydrocarbon richness. The results of the survey are shown in **Figure1**.

Figure 1.



The red anomalies indicate areas with an 85%-95% probability of finding gas that matches the composition of the Everhart #1 gas. The blue areas represent areas with very low probability of containing Everhart gas. Note the Everhart #1 well falls within a red anomaly while all three noneconomic wells fall in the blue areas of low probability. It should be noted that the blue does NOT mean there is no gas detected in the area, but rather there is no economic Everhart-type gas in those areas.

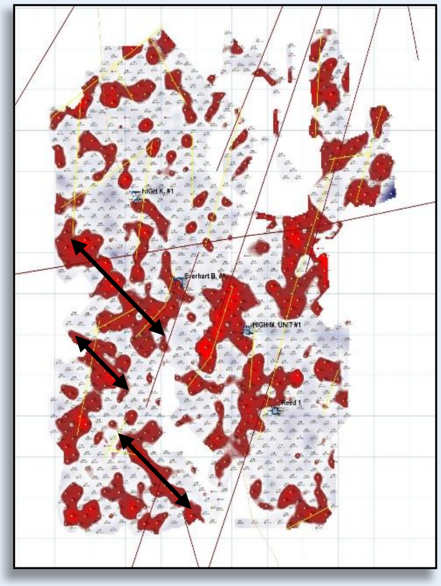


Figure 2.

The SW to NE trending of the red anomalies aligned with surface lineaments in the area. It was believed that the Everhart-type accumulations were actually naturally occurring fractures, from glacial rebound, that had been charged with gas from the deeper Trenton formation. It was also believed that the ubiquitous noneconomic gas, in the blue areas, was present from a shallower formation.

Identify Phase & Areas of Hydrocarbon Richness

According to the AGI survey map, the red anomaly encompassing the Everhart #1 well was approximately 1.25 miles long. A subsequent pressure test on the well indicated a fracture in place that was estimated to be 1 – 2 miles in length, thus ground-truthing the hydrocarbon survey.

The hydrocarbon survey also identified a liquid hydrocarbon phase in the field (**Figure 2**). While the gas anomalies essentially ran SW to NE, the liquid anomalies ran SE to NW, implying that the gas hydrocarbons and the liquid hydrocarbons **were at different depths in different formations**.

Subsequent to the Utica surface hydrocarbon survey, the Butler Creek 1 well was drilled with the intent to penetrate the economic Trenton formation at ~2,500 ft. Downhole Geochemical Logging (DGL) cutting samples were collected every 100 ft. The DGL results are shown in **Figure 3**. The light hydrocarbon data (C_2 – C_5) were plotted versus depth on the left while the heavier hydrocarbons, C_{12} and the sum of the hydrocarbons greater than C_5, were plotted on the right. The green shaded box in each hydrocarbon signature highlights the subtle differences between each signature

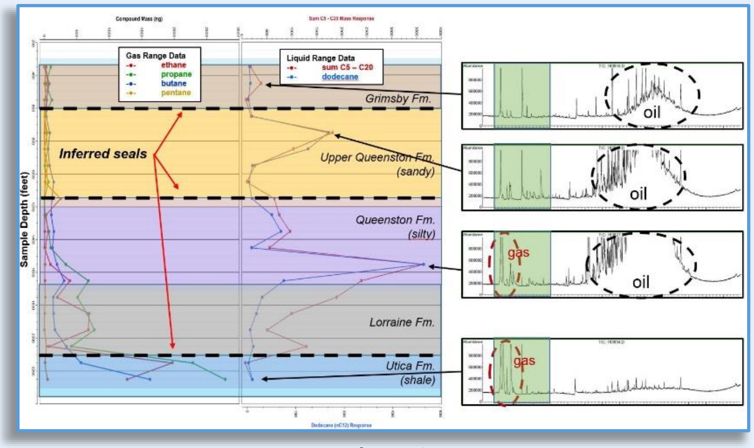


Figure 3.

The data indicated a small by-passed oil pay in the Grimsby Fm. The Upper Queenston Fm. showed a strong oil kick with a different fingerprint than the other formations, **indicating a seal** between the Grimsby and Upper Queenston and another seal between the Upper and Lower Queenston. The Lower Queenston had a gas and oil signature which pervaded the Lorraine Fm., indicating no seal between the two. At the top of the Utica Fm. the gas sharply increased while the oil intensity dropped to baseline indicating a hydrocarbon change and a third potential seal.

Summary:

- The surface survey demonstrated why there were economic and noneconomic gas areas in the field **and mapped them for future prospectivity**,
- The surface survey also identified a previously unknown oil leg in the field,
- The combined DGL and surface data inferred the Utica Fm. to be the source of the noneconomic gas and the Trenton Fm. to be the source of the economic gas,
- The DGL data confirmed the presence of liquid rich formations; ground-truthing the surface survey results,
- The DGL data inferred three seals in the well and implied no seal between the Lower Queenston and the Lorraine.

The second case study took place in the **Marcellus shale play** in northern Pennsylvania. The objective of the surface survey was to define the thermal maturity transition line (i.e. the Line of Death) between dry gas in the north and no gas in the south. Calibration modules were placed around two gas wells, NW-1 and NE-1 in the north and two dry wells, SW-1 an SE-1 in the south.

The results are seen in **Figure 4**. The red area represents areas with a 85%-95% probability of finding dry gas. The yellow indicates a ~50% probability while the blue represents a <25% probability. The results confirmed a general Line of Death in the field and correctly predicted the two producing wells in the north. **It also showed that the company had not yet drilled in the most prolific part of the field,** as defined by the dark red anomalies.

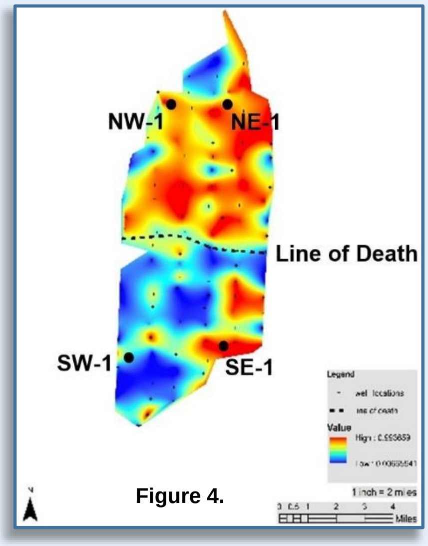


Figure 4.

The dry well SW-1 was also correctly predicted, but the dry well, SE-1, was predicted as a producer, not dry. However, it was later determined that SE-1 had, in fact, produced gas, but had been plugged and abandoned due to mechanical problems, thus, ground-truthing the surface survey results.

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