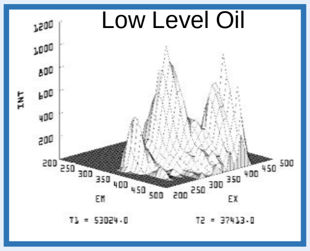
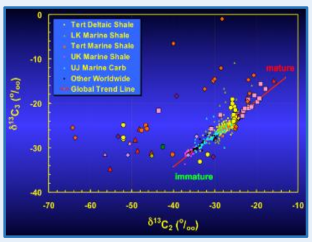
Derisking Offshore Exploration Using Ultrasensitive Hydrocarbon Mapping

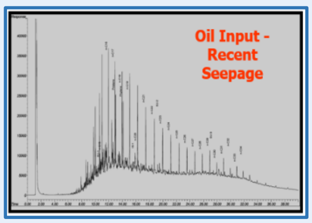
Offshore exploration is a costly endeavor which utilizes seismic data to evaluate subsurface structures. However, seismic imaging does not address the critical question of hydrocarbon presence, especially in environments such as the Gulf of Mexico, Brazil, and the Red Sea with thick salt and anhydrite sequences. New technologies need to be implemented to derisk exploration efforts and reduce the number of noneconomic and dry wells.

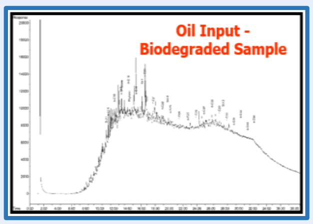
Traditional methods are useful in that they:

- Provide screening techniques (i.e. Total Scanning Fluorescence) to detect liquid hydrocarbons
- Use Gas Chromatography (GC) analysis for C_{15}+ compounds to provide insight into oil quality and make-up.
- Use biomarker analysis, with added expense, to evaluate biodegradation, depositional environment, age, thermal maturity, and oxic/anoxic conditions.
- Provide screening techniques (i.e. Head-space analysis) to detect C_1 - C_5 compounds for the presence of gas hydrocarbons.
- Use isotope analysis, at additional expense, to differentiate between biogenic and thermogenic gas.









Images courtesy of TDI Brooks

Thus, conventional geochemical methods provide good screening techniques and biomarker data can provide effective insight into correlations with known regional petroleum systems.

However, one important limitation of traditional geochemical methods is they only work over macroseeps.

What happens when there are no macroseeps?

Ultrasensitive hydrocarbon mapping technology, by Amplified Geochemical Imaging (AGI), has advantages that strongly complement and enhance traditional data. Traditional methods only measure C_1 – C_5 and C_{15}+ which miss the heart of the hydrocarbon fingerprint. As indicated by the red box in **Figure 1**, AGI measures from C_2 – C_{20}.

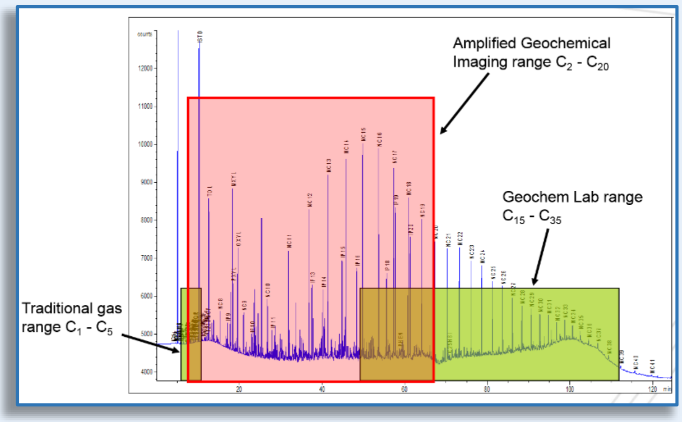


Figure 1.

With ~ 85 compounds, Hierarchical Cluster Analysis (HCA) can be used to compare various hydrocarbon signatures. Thus, subtle differences can be elucidated from similar hydrocarbon signatures to distinguish if multiple petroleum systems may be present, which cannot be accomplished by traditional or conventional methods.

The AGI passive sampler contains a specially engineered oleophilic (i.e. oil loving) adsorbent encased in a microporous polytetrafluoroethylene (ePTFE) membrane. These membrane pores are small enough to prevent soil particles and water from entering, but are large enough to allow hydrocarbon molecules to pass through.

The result is an ultrasensitive technology that is approximately **1,000 times more sensitive than traditional methods**. Sensitivity becomes critically important when assessing the presence of a potential petroleum system, particularly when macroseeps are not present.

Reduce Exploration Costs by 58%

Virtually Eliminate Dry Wells

AGI reports in the part per billion (ppb) range, three orders of magnitude lower than traditional methods. The result is the detection of hydrocarbons in baseline samples, microseep samples and macroseep samples.

In this case study the survey took place on the shelf of the Gulf of Mexico (GOM) in a water depth of <150 ft. The target reservoir section was Tertiary in age at a depth of ~8,500 – 9,000 ft and 20 ft cores were taken with an average spacing of ~1/2 mile. Previously 6 dry wells and 2 producing wells had been drilled. So, the objectives of the **MICROSEEP** geochemical survey were to a.) delineate existing field boundaries in the central structure, b.) confirm prospectivity of untested structures along fault trends, c.) determine if adjacent fields and structures were charged, and d.) determine the hydrocarbon phase of any charged structures.

As seen in **Figure 2**, the dark purple areas represent an 85%-95% probability of finding gas condensate similar to the producing wells. The probability map shows gas condensate in the central structure right up to the proposed gas/water contact line as indicated by the dashed line. The gray area indicates areas of very low gas condensate probability and correctly predicted the dry wells. Additionally, the data shows charged structures to the east and west of the main structure. The two producing wells, indicated with white centers, were drilled post survey and corroborated the AGI results.

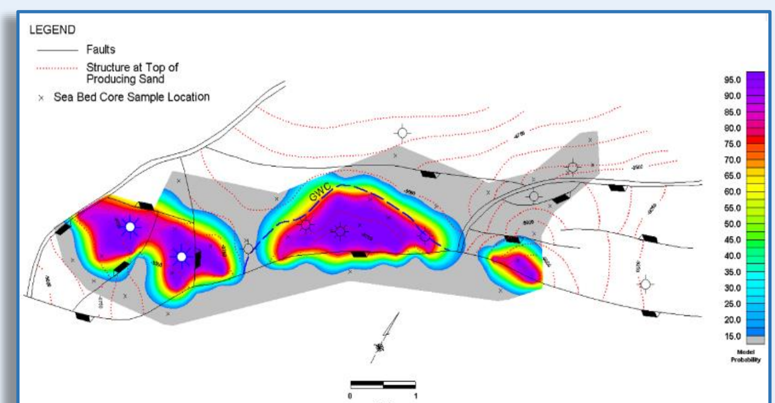


Figure 2.

The second case study took place in a **frontier** offshore area of Colombia/Peru. The data of the 115 cores indicated one macroseep sample and 114 microseep samples. The HCA data indicated **two possible petroleum systems**, one condensate phase and the other oil phase.

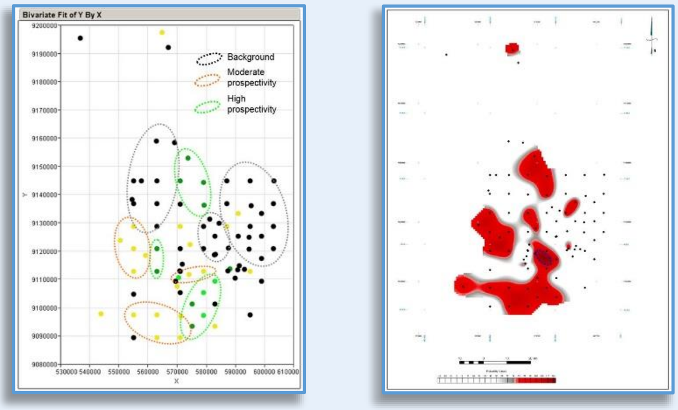


Figure 3.

Figure 3 shows a prospectivity map on the left. The green dots within the green lines are the areas of highest prospectivity. The red areas in the probability map on the right indicate areas with a 85%-95% probability of finding oil. The blue circle inside the red area indicates the macroseep.

This predictive ability is not possible with traditional methods. AGI compliments conventional data and **provides a more detailed picture of petroleum system hydrocarbons**.

As published in AAPG Memoir 66 by Santa Fe Minerals, AGI surveys were combined with 3D seismic over a seven year period in North, Central, and South America, both onshore and offshore. As seen in **Figure 4,** AGI data correctly predicted 131 of the 141 post-survey wells. So 96% of the dry wells and 92% of the producing wells were correctly predicted.

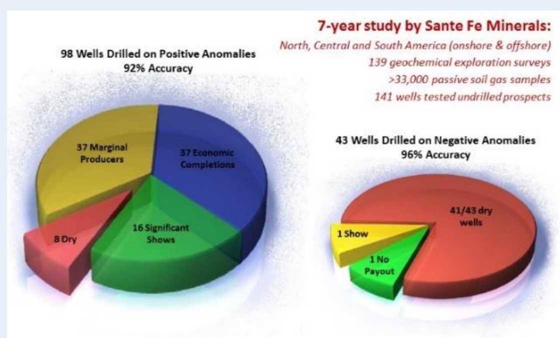


Figure 4.

By the end of the seven year period, Sante Fe Minerals was able to **reduce their explorations costs 58% by virtually eliminating dry wells** when they combined their 3D seismic with AGI data.

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