# Enhancing Seismic Data with Surface Geochemistry

Exploration is a costly endeavor that entails multi-million dollar expenditures to acquire synthetic aperture radar data, 2-D seismic data, as well as 3-D seismic data to evaluate subsurface structures. While these technologies lend an understanding to the geologic structure of subsurface systems, they do not address the critical question of the presence of a petroleum system. Surface geochemical data can work to enhance the understanding of seismic data when the two are used in conjunction, as in this Berkine Basin case study in Algeria, see **Figure 1**.

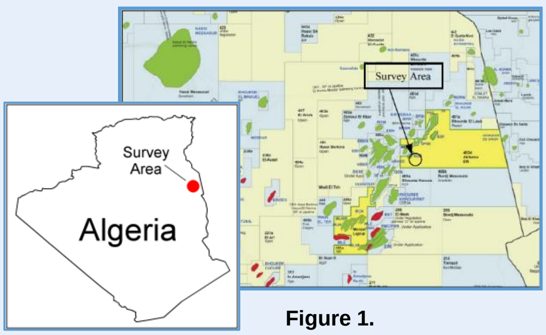


Figure 1.

Burlington Resources Algeria LLC, Petro SA and SONATRACH were partnered in Block 402d. While 2D seismic had been performed over the block, Burlington wanted to investigate the hydrocarbon bearing potential of Prospect "E", identified in the western portion of the block. The purpose of the survey was to integrate Amplified Geochemical Imaging (AGI) survey data with other exploration information (e.g. seismic time-depth maps, petroleum system data, geological and petrophysical interpretations) to reduce the exploration risk.

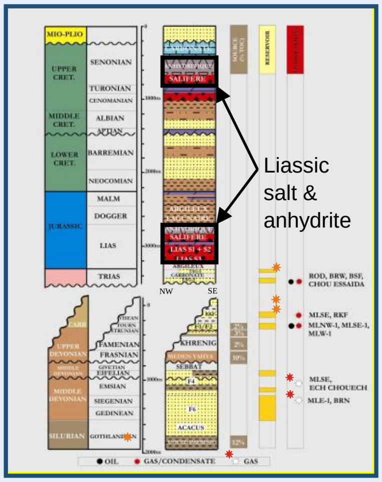


Figure 2.

The target formation was a Triassic TAG-I sandstone, see **Figure 2**. The source was believed to be Devonian Frasnian shale (oil) and Silurian Tannezuft shale (gas). The top seal was a thick sequence of Liassic salts and evaporates. Thus, the question also arose would microseepage penetrate the evaporitic sequences. The trapping mechanism was primarily structural.

Prospect "E", as seen in **Figure 3**, was identified on 2D seismic data as a fault and dip-closed structure downthrown to the main fault system with the up-dip culmination in Block 402d. Predrill mapping indicated that the prospect could be in communication with the RDB field to the west. Thus, Burlington wanted to determine whether or not Prospect "E" contained hydrocarbons similar to the RDB-1 well before committing to drilling the prospect.

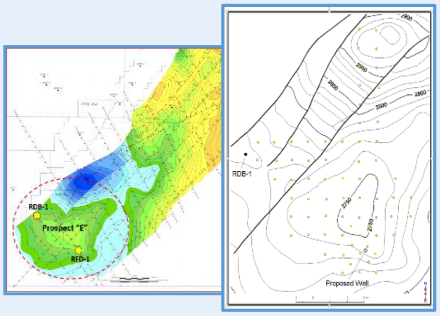


Figure 3.

However, one inherent problem with the 2D seismic data was the very flat structure, see **Figure 4**. Consequently, the seismic data was very sensitive to depth conversion, particularly in the north east where there could be a structural spill point if the structure was higher than mapped.

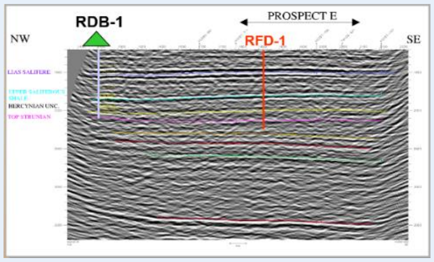


Figure 4.

**Figure 5** shows the changing position of the crest of the structure, as indicated by the black arrows, for the different depth conversion methods. Location of the structural high relative to the well positioning was important when determining the volumes of hydrocarbons discovered and the economic viability of the discovery.

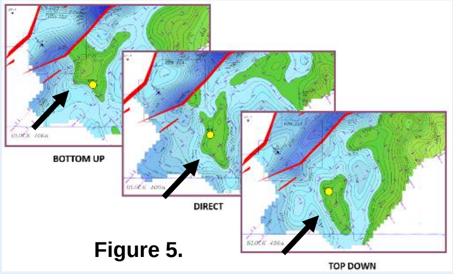


Figure 5.

# Merging Geoscience Data Sets

The RDB-1 well was interpreted to be on the western flank of the structure, some 10m down-dip from the culmination. Thus, Burlington chose an AGI geochemical survey to help determine whether the Prospect “E” structure contained hydrocarbons similar to the RDB field and potentially extend the original field discovery. Seventy-two samples were placed in a grid pattern, see **Figure 6**, with 1 km spacing. The red dots on the survey map represent the location of the passive sorbers at the surface. Sample spacing scaled down to 0.5 km near the RFD-1 well to gain higher resolution for contouring. Additionally 15 sorbers were placed around the RDB-1 and the RFD-1 wells to isolate the individual hydrocarbon signatures for comparison purposes. Seventy-five additional samples were also placed around 5 calibration wells in the 65 $km^2$ acreage. It is important to note that the AGI technology provided a unique patented ultra-sensitive mechanism for the capture of hydrocarbons. The technology has advantages over traditional methods in that:

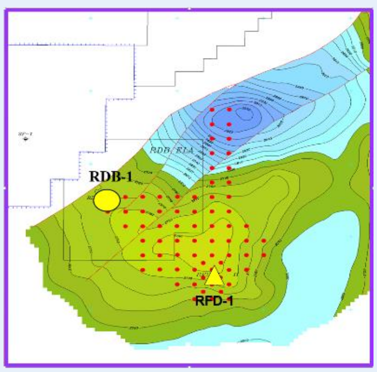


Figure 6.

- it is 1,000 time more sensitive and can help prevent dry wells with a 90% accuracy, thus reducing exploration costs,
- it has an extended carbon range from $C_2$ – $C_{20}$, enabling detailed characterization of gases, condensates, and oils,
- it encompasses ~85 compounds which provides the ability to distinguish and identify multiple petroleum phases and systems.

Traditional methods measure only $C_1$ – $C_5$, which miss the important $C_6$ – $C_{15}$ range (the heart of the hydrocarbon fingerprint). While traditional analyses ratio specific compounds to guess at the hydrocarbon phase, Amplified Geochemical Imaging can clearly differentiate between gas, condensate, or oil signatures, as seen in **Figure 7**. This is particularly important in liquid plays where companies are trying to differentiate between multiple liquid signatures.

**Figure 8** shows the hydrocarbon probability map. The red anomalies indicate areas with an 85%-95% probability of finding oil similar to the RFD-1 well. The blue areas indicate areas with only a 25% probability.

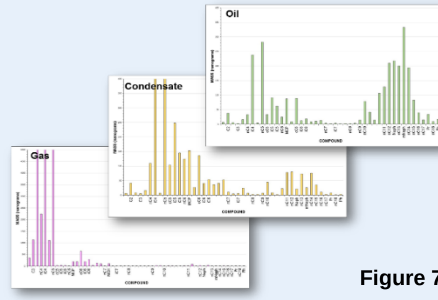


Figure 7.

1.) Notice the contours of the crest structures indicated by the black arrows. Note the correlation between the structural high in the Bottom-Up depth conversion method and the AGI anomaly map. This indicates the Bottom-Up method was most likely the best predictive seismic model.

2.) Results indicated similar hydrocarbon composition at the RFD-1 and RDB-1 wells (i.e. same source), but there was not a continuous anomaly across the fault indicating RDB-1 was not in communication with the field as originally suspected.

3.) A second geochemical feature located in the NE part of the survey did not match any known structural trap in the Triassic. This feature was determined to most likely be associated with a stratigraphic trap in the deeper Carboniferous formation.

4.) It should be noted that liquid hydrocarbons were able to migrate through the evaporitic salt sequences to be measured and contoured for the project.

5.) The RFD-1 well was drilled on the down-dip edge of the anomaly as opposed to the geochemically predicted high. The result was 3 m of noneconomic pay. Thus, the survey correctly predicted the TAG-I structure and crest.

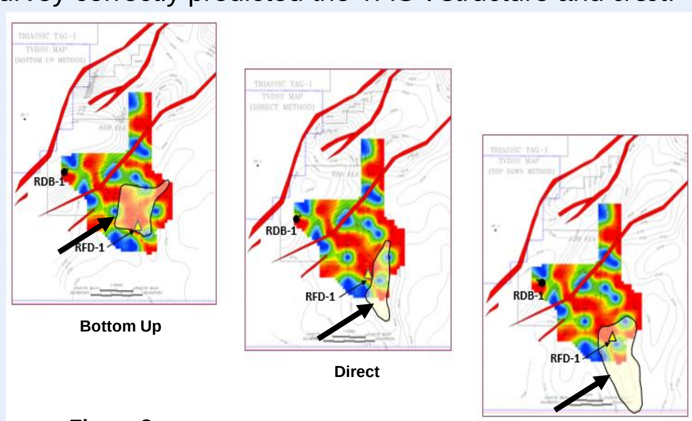


Figure 8.

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