Interactive Rock Physics in the Gulf of Mexico using rockAVO

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Hydrocarbon exploration and exploitation activity in the GOM has been ongoing for over 100 years; recently there has been renewed interest both within and outside US waters. Locations such as Walker Ridge, Mississippi, Green, Alaminos, and Keathley canyons have continued to provide good prospectivity, with field discoveries such as St. Malo, Tucker, Silver Tip, and Great White. As wells become available, they can be incorporated into a regional rock physics atlas for reservoir characterization studies and rock property calibration of zones of interest. If no other information is available, the modeling of probable reservoir quality within zones of interest is possible. Rock physics is fundamental to this in exploration, appraisal and production cases, by allowing us to understand rock properties and possible geophysical scenarios due to changes in the elastic and also electrical domains. In the GOM, RSI has worked on more than 540 wells (figure 1) using a rock physics driven approach as a way to link geophysical responses and rock and fluid properties of reservoir rocks and their encasing sediments.

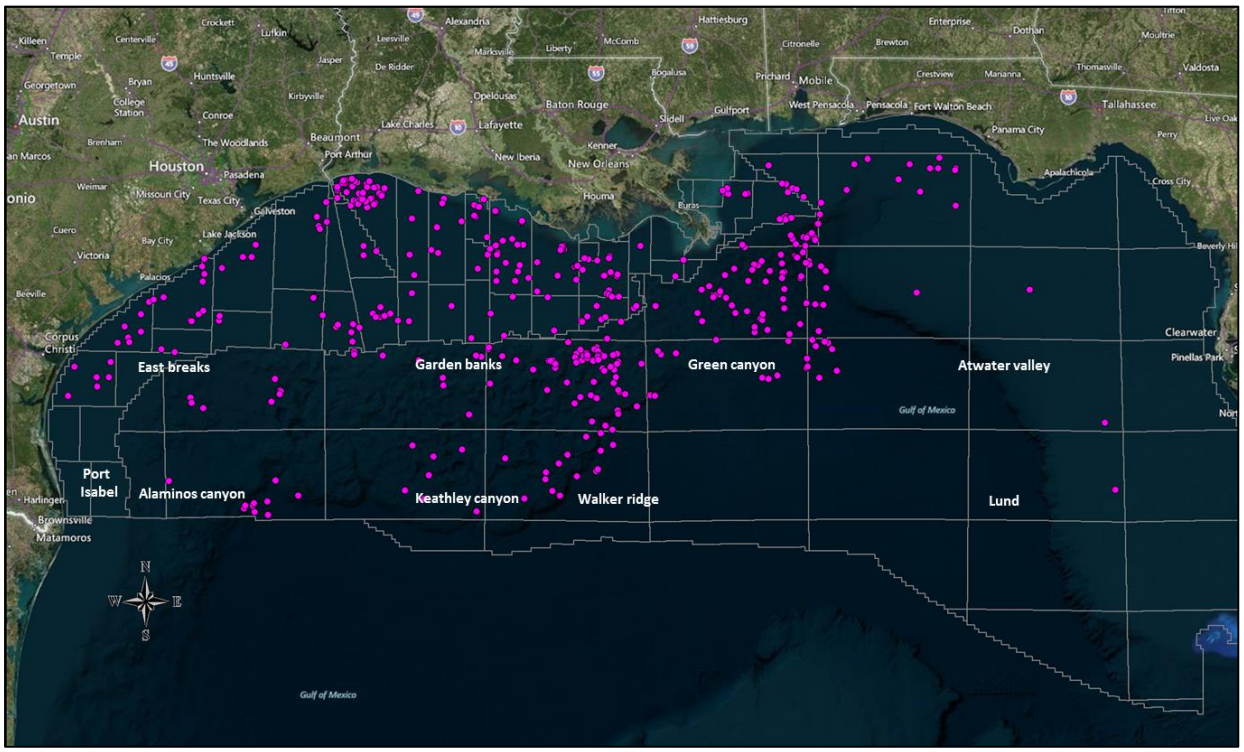

Figure 1. *Map of the Gulf Mexico showing RSI's well database.*

RSI has started to deliver multi-well rock physics atlases as dynamic studies which include rockAVO, a data viewer allowing real time modeling and visualization by interpreters and geophysicists alike. Current studies allow the fluid properties in reservoir zones to be perturbed, and display the seismic signature for each case desired. Fluid substitution can provide a good understating of AVO changes as a function of fluid phase change for a given rock. In some cases, matrix modeling is also included so that

the seismic response of the reservoir as porosity and mineralogy change can be also observed instantaneously. The overall objective of this approach is to encapsulate the underlying rock physics modeling methodology so interpreters and geophysicists who do not have specialized rock physics expertise can interact with the data without violating physical bounds defined during the rock physics diagnostics and modeling phase. The workflow is shown in figure 2.

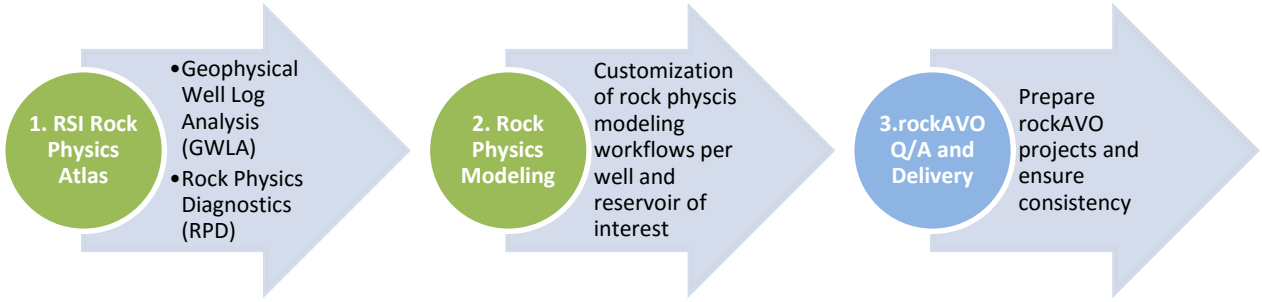

Figure 2. *Generalized workflow of the Interactive rock physics modeling in rockAVO.*

1) Step 1: all well data is processed through RSI's Geophysical Well Log Analysis (GWLA) and Rock Physics Diagnostics (RPD) in order to condition all logs in a consistent matter. In this step, a rock model or combination of models are identified for reservoir quality rocks. This model will be used as a proxy for perturbational purposes.
2) Step 2: Based on the rock model derived in step 1, the reservoir is perturbed for variations in fluid, porosity and clay content as the main changing variables. Since the goal of this modeling is to understand theoretical responses of reservoir changes, synthetic seismic modeling is also incorporated into the workflow so that geoscientists can understand the effect of changing these properties on pre-stack seismic and (if required) electromagnetic response.
   Finally, results are delivered within the rockAVO browser, which allows users to see changes in seismic response with variations in rock and fluid properties in real time without changing the core of the methodology.

Figure 3 shows the fluid modeling results at the main oil sand in the Great White well (AC857-1). The AVO signature in fields such as this tends to vary from class III to II as a function of sand facies change. Litho-classes in the area ranged from blocky oil sands to silty and shaly sands with residual oil saturations. Simultaneous changes to this particular example included API gravity, dissolved gas, water salinity and seismic geometry. The display can also include a rock physics template (RPT) to better understand reservoir property signatures with the principal objective of minimizing uncertainty and risk.

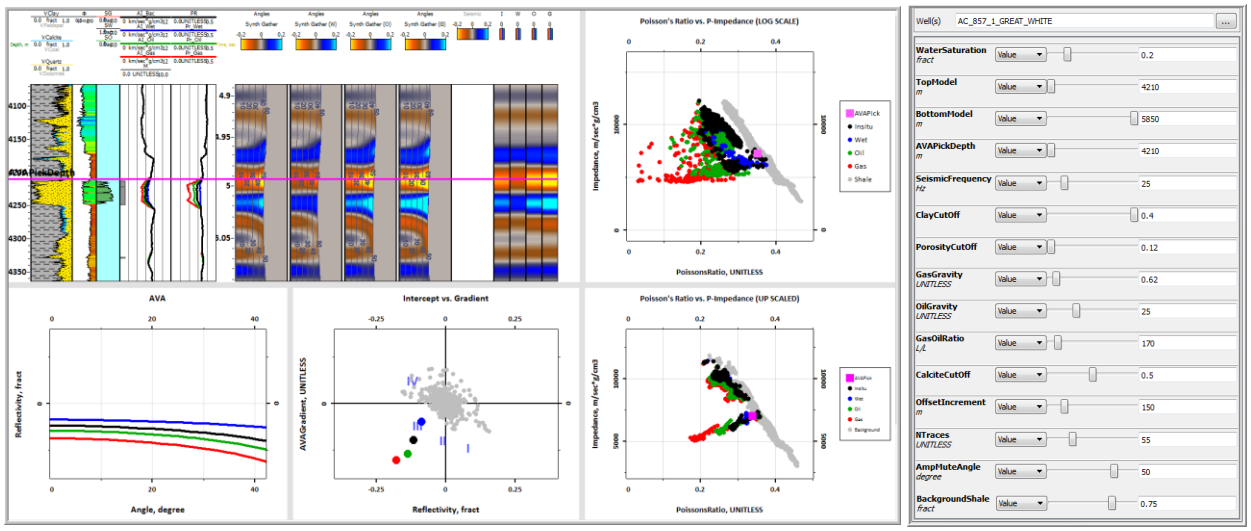

Figure 3. *Dynamic deliverable in rockAVO for the AC857-1 well in Alaminos Canyon. Upscaled Elastic attributes (P-Impedance and Poisson's ratio) are displayed after fluid substitution cases (80% gas in red, 80% oil in green, and 100% brine in blue). From left to right, ray traced synthetic gathers and stacks are shown for in situ, brine, oil and gas cases. Left bottom plots show the reflectivity response at the depth indicated by the magenta line. P-Impedance and Poisson's ratio plots show the log scale (upper right) and upscaled (lower right) response within the zone of interest and sand response (magenta square). Modeling window shows the controls user can interactively change while using rockAVO.*