

Rock Physics Templates for well seismic quantitative interpretation in thin sands reservoirs

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Rock Physics Templates (RPTs) are very useful tools for well seismic quantitative interpretation since they capture multiple rock properties variations for a given set of geophysical attributes. RPTs can be used in combination with seismic derived elastic attributes to estimate lithology, porosity and fluid in the prospective non drilled areas.

Standard RPTs can be built using theoretical rock physics models that properly describe the elastic and petrophysical properties of the reservoir and encasing rocks at log scale. However, depending on seismic data resolution and reservoir thickness, elastic trend responses may not fall in agreement with the log scale data. In this work we propose a methodology for generating RPTs upscaled to the seismic frequency using well data from a thin oil sandstone reservoir in the Gulf of Mexico. This work can be divided in three main phases (a) Rock Physics Diagnostics (RPD), (b) defining a log scale RPT, and (c) upscaling the final RPT.

The aim of the Rock Physics Diagnostics (RPD) is to identify and describe useful relations between elastic rock properties (density, P and S-wave velocity) and petrophysical properties (porosity, lithology, fluid content, etc) in the target zone, as well as understanding possible trends in the encasing sediments. RPD will also allow to identify the rock physics models that will be used to predict a sandstone reservoir and shale responses in the standard RPT. For this study, the Poisson's ratio vs. P-Impedance attributes provide a clear discrimination of oil sand from overlaying shale facies at log scale. Final rock physics model combination has been calibrated at the reservoir conditions, and superimposed to the data assuming theoretical rock compositions, porosity and fluid content (see figure 1). At this point, the rock physics template has been calibrated at log scale, but it does not take into account how the discrimination space may change as a function of reservoir thickness and the dominant frequency of the seismic data

Assuming several 3-layer models composed by a blocky sand interbedded with two thick shales, the log scale RPT can be upscaled to the dominant seismic frequency via Backus average (Backus, 1962). Shale properties are assumed to be constant and the sand properties are allowed to vary per model with a specific clay volume, porosity and water saturation. Figure 2 shows a comparison between log scale and upscaled RPTs. Upscaled RPT was generated assuming a 30 m thick sand and a dominant seismic frequency of around 20Hz. There is a very good fit between the RPT lines and the upscaled elastic curves.

Standard RPTs can have some limitations in the seismic derived elastic attributes domain due to log resolution. This extended methodology allows to generate an upscaled RPT from the well log data and rock physics diagnostics, which would help to understand the thickness and seismic resolution effect on the elastic rock properties.

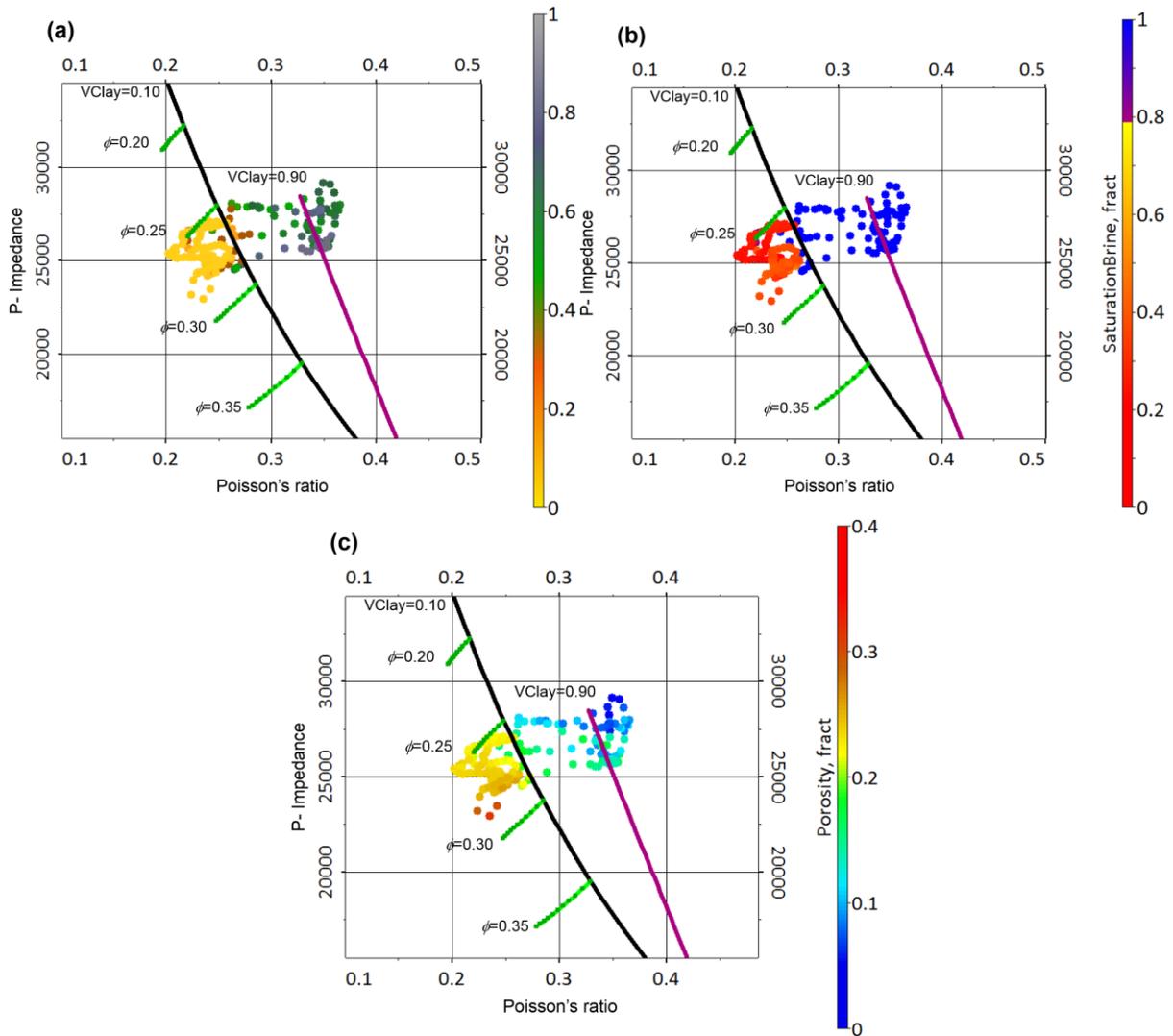


Figure 1. Poisson's ratio vs. P-Impedance crossplots at log scale overlaid by RPTs. Samples are color coded by clay volume (a), water saturation (b) and total porosity (c). Model lines correspond to shale with 90% clay (purple) and 100% brine saturated sandstone with 10% clay (black) using the Soft and Stiff sand model respectively. Green lines correspond to the different oil bearing sandstones (10% Clay) for each porosity case: 20%, 25%, 30% and 35%.

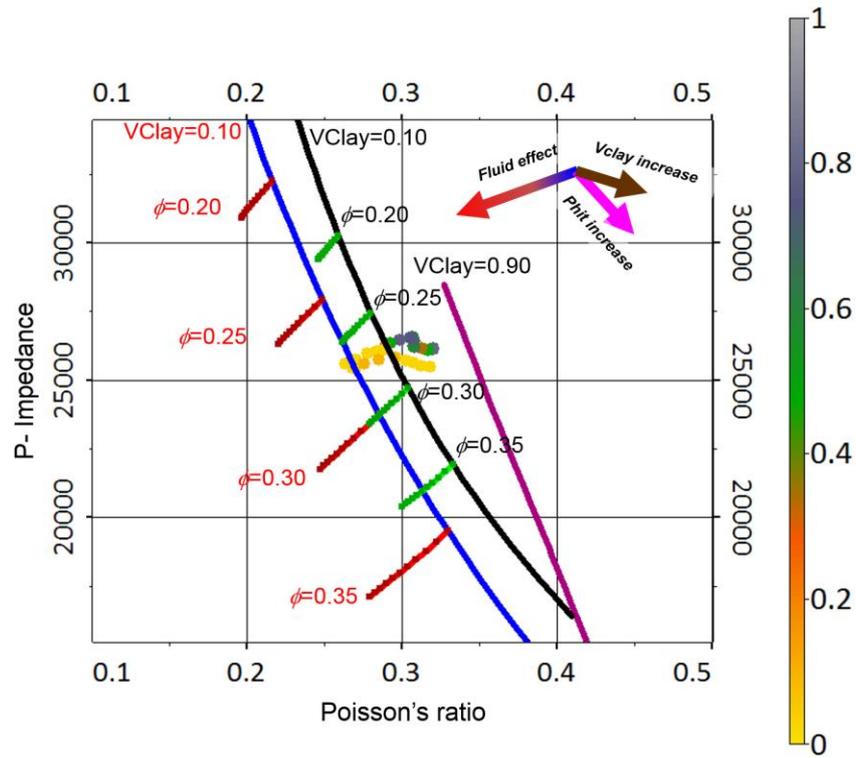


Figure 2. Comparison between log scale and upscaled RPTs. Well log data was upscaled to 20 Hz. Red lines correspond to the log scale RPT lines. The purple line corresponds to a shale with 90% clay, while the blue and black lines correspond to a 100% brine saturated sandstone at log scale and upscaled domains, respectively. Green and red lines correspond to the different oil bearing sandstones for each porosity case in the log scale and upscaled domains.