Rock physics model to link elastic characterization to thermal maturity and rock properties of organic-rich carbonate mud rock

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Abstract

Objectives/Scope: Evaluation of organic matter maturity is required to assess the resources available in unconventional play. However, prediction of thermal maturity from elastic properties has not been fully understood. Contemporary techniques are limited to borehole samples availability. Therefore, a theoretical rock physics model was developed to understand the influence of mineralogy, porosity, pore-pressure, fluid saturation and fracturing on the elastic rock properties. An attempt is made to link elastic properties to thermal maturity proxies gained from geochemical analyses.

Methods, Procedures, Process: Extending the results from well log scale to seismic scale by using pre-stack seismic inversion and multi-attribute analysis is applicable. As our rock physics feasibility studies with model-based inversion technique illustrates the assessment of organic richness and maturity from pre-stack seismic based on compressional and shear velocities This study presents empirical equations using elastic properties from seismic and well log data that allow us to estimate rock maturity and to distinguish between different fluid phases using the elastic properties from seismic and well log data.

Results, Observations, Conclusions: The rock physics model shows clearly how elastic response with various mineral composition (Calcite and Kerogen), intra-kerogen porosity and the pore-fluid within the source rock that can be influenced during the maturation possessing. Organic-rich carbonate mud rocks are characterized by low density, low porosity and low compressional and shear velocities. Cross-plotting of elastic properties from well logs against source rock analyses (T-max, TOC and HI, from core samples) exhibits a quantitative correlation that allows prediction of fluid types (e.g., black oil, volatile oil, and rich and lean condensate). Changes in the compressional to shear wave velocity ratio (vp/vs) are attributed to differences in maturation-induced bulk and shear softening, therefore employed here as a seismic indicator of thermal maturation. The final step of this study is to predict organic content and maturity from seismic-derived P and S- impedances and VP/VS ratio. We observe that low acoustic impedance corresponds to high organic fraction while high VP/VS ratio corresponds to relatively higher maturity depend on the fluid type.

Novel/Additive Information: This methodology has been applied to different geographic areas and the produced hydrocarbon phase map agreed between the seismically-derived lateral property distributions, core measurements and observations from produced fluids originating from the organic-rich carbonate mud rock.