Differentiating Gas From Light Hydrocarbon Phases Utilizing An Integration Of Elastic And Inelastic Seismic Attributes

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Abstract
Objectives/Scope: In field development where the field has a large commercial gas cap, focusing on oil production is significant at early stages. Delineating the gas cap spatially using seismic data will be a crucial step for successful field development. The objective is to study the elastic and inelastic properties of the gas/light oil saturated reservoirs to understand their seismic response for optimum interpretation.

Methods, Procedures, Process: First, we applied a post stack rock physics analysis to understand the effect of porosity on acoustic impedance (AI). Then, the pre-stack analysis was used to understand the effect of lithology and clay content of the elastic response. After that, Gassmann Fluid Substitution was performed by substituting gas and light oil. Later, we examined the inelastic properties looking at the frequency domain, where we modeled the reservoir for the gas/brine reservoirs assuming that oil will have the same attenuation response as the brine. Finally, both elastic and inelastic responses were analyzed to separate the gas from light oil fluid scenarios.

Results, Observations, Conclusions: First, a porosity transform equation was determined to approximate the porosity in the sandstone matrix of the reservoir using the AI with a good correlation. From the rock physics analysis, we concluded that from the AI/VpVs cross plot there is a good separation of lithology and fluid content. The sand has lower VpVs and AI values compared to the clay. Similarly, the fluid movement of the rock generally gives lower VpVs and AI. However, the light oil and gas scenarios can hardly be separated, and they had a quite large overlap in VpVs and AI values. In mono-frequency analysis, we started by forward modeling using ray tracing to test how frequency plays with fluid type in the reservoir. Assuming that the Q factor for gas is 20 and water is 100, we noticed a fair attenuation difference between gas and brine going from low frequency to high frequency. The attenuation, where we have thick reservoir, was 70% in gas case, compared to 55% in the brine case. As a result, elastically, the hydrocarbon saturated reservoir intervals can be separated using elastic inversion, but to separate the gas cap we can only rely on the attenuation analysis as the elastic attributes are similar for both hydrocarbon phases.

Novel/Additive Information: This study demonstrates best practices for using rock physics and seismic forward modeling to distinguish hydrocarbon phases that behave identically, and it shows that the integration of elastic and inelastic seismic behavior is essential to resolving such a complex problem.