Vp/Vs Ratio in Carbonates

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Project Purpose

The compressional to shear wave velocity ratio (Vp/Vs) is an important parameter in seismic amplitude versus offset (AVO) analysis, and has been claimed to provide lithologic information (Wilkens et al., 1984) and pore fluid and pore pressure information (Duffaut and Landro, 2007; Rojas, 2008). Based on the assumption that the pore structure influences the Vp and Vs differently, its ratio has been used to extract various rock properties from the Vp/Vs ratio. There is, however, no established correlation between the pore structure and Vp/Vs ratio. Nonetheless, the ratio of P-wave over S-wave velocity, as the ratio of longitudinal over transverse strain, should relate to the speed of propagation and reflection of stress waves and as such be important in predicting the nature of rocks (Rafavich et al., 1984).

The project will utilize the CSL database petrophysical laboratory measurements to assess how intrinsic factors (mineralogy, pore shape parameters) and extrinsic factors (saturation type, pressure) influence Vp/Vs ratio. The findings will have implications for amplitude versus offset techniques and general prediction of lithology and type from acoustic data.

Scope of Work

Previous years CSL has investigated how intrinsic and extrinsic factors control Vp/Vs ratio in carbonates. This has led to findings in particular around extrinsic parameters such as pressure and saturation type. No intrinsic parameters, such as pore type, however, have been identified. In addition, it was shown that Vp/Vs ratio proved to be non-constant with porosity. This is of significance as many rock physics modeling theories assume that the decrease in Vp with increasing porosity is equal to the decrease in Vs and as a result the Vp/Vs ratio remains constant with porosity.

This project evaluates how intrinsic factors influence Vp/Vs ration in carbonate rocks. Digital image analysis (DIA) parameters will be correlated with measurements of acoustic properties. The relationship between intrinsic parameters and Vp/Vs ratio will be incorporated and tested in Sun's Extended Biot Theory.

Key Deliverables

This project will provide an overview of the factors controlling Vp/Vs ratio in carbonates. Results will be presented at the Annual Review and images and data made available to the Industrial Associates.

Project Description

The project will utilize the following workflow:

1. Mine CSL Petrophysics database for Vp/Vs, density and porosity data at identical effective pressure steps, fluid saturation and availability of DIA parameters from thin sections.

2. Evaluate scatter in acoustic measurements of Vp/Vs ratio as a function of intrinsic and extrinsic parameters.
3. Incorporate obtained relationships between Vp/Vs ratio and parameters within Sun's Extended Biot Theory.

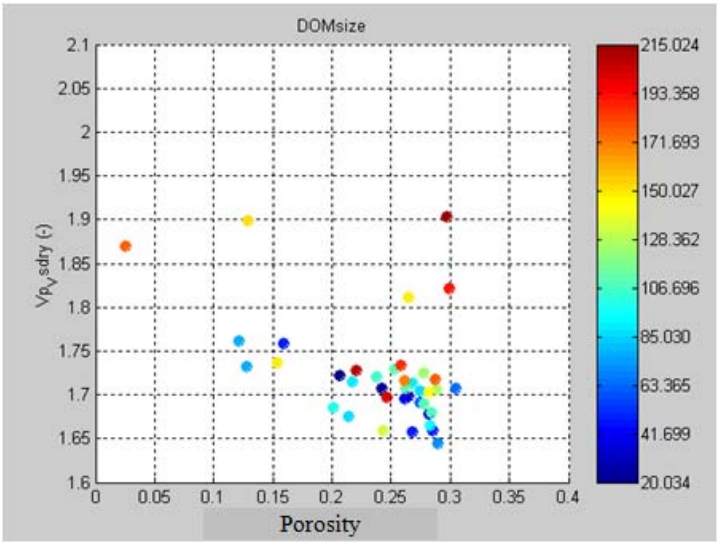

Figure 1: Cross plot of porosity and Vp/Vs ratio for a sample set of dry measurements from a Middle Eastern limestone reservoir. Superimposed is the digital image analysis parameter Dominant Poresize (in microns). No clear relationship is visible between pores structure data and Vp/Vs ratio. Vp/Vs ratio shows a negative correlation with increasing porosity, indicating that Vp/Vs ratio is non-constant with porosity.

Expected Results

It is recognized that the relationship between intrinsic parameters, such as pore structure, and Vp/Vs ratio is difficult to establish. The project aims to further explore the usability of Vp/Vs ratio as a pore structure discriminator in carbonate rocks. Expected results will include an inventory of parameters influencing Vp/Vs ratio and implications of a non-constant Vp/Vs ratio with porosity in rock physics models.

References

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