TESTING THE EXTENDED BIOT THEORY IN CARBONATES OF THE MALDIVES

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PROJECT OBJECTIVES

- Test the extended Biot Theory on core and logs from IODP Site U1467 by:
  - Calculating the pore shape parameter γ_k from laboratory measurements of porosity and p-wave and shear wave velocity.
  - Assessing the pore structure with digital image analysis and relating it to the theoretical pore shape parameter γ_k.
  - Correlating γ_k to permeability.

PROJECT RATIONALE

The extended Biot theory captures theoretical pore structure variations in a term called γ_k, which uniquely quantifies velocity variations at a given porosity (Fig. 1; Sun, 1994; Weger, 2006). Other theoretical equations of poro-elasticity do not account for pore structure and thus produce large uncertainties when relating porosity to velocity in carbonates. Because the pore shape factor is directly linked to the pore structure, it links sonic velocity to permeability. Laboratory measurements of discrete samples have shown that γ_k indeed relates to the pore structure (Weger, 2006). The next step is to test the extended Biot Theory with core and log data. During IODP Expedition 359 in the Maldives, the necessary data set was acquired for such a test. At Site U1467, a continuous core through highly porous carbonates was recovered and the logs included a DSI sonic log that measures both compressional and shear waves as needed to test the extended Biot theory in core and logs.

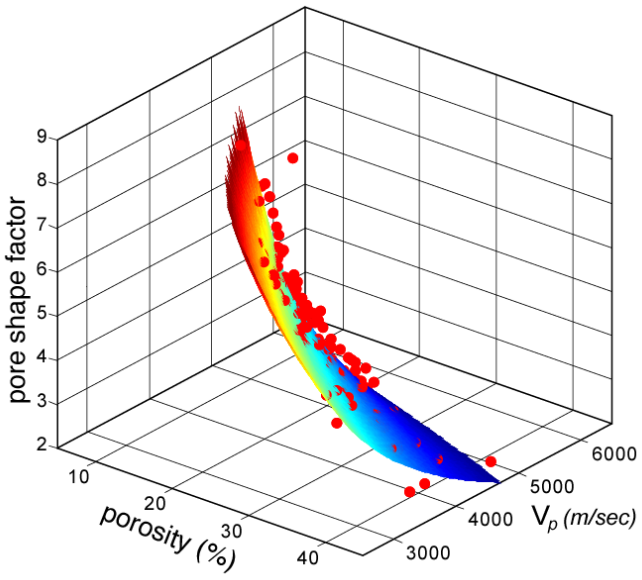

Figure 1. 3-D plot of velocity-porosity and γ_K. Red dots are measured samples. The colored surface is a theoretical surface of γ_K values formed by all possible velocity-porosity combinations for water saturated calcite at a given Vp-Vs ratio.

SCOPE OF WORK

At Site U1467 all the data are in hand to test the extended Biot theory (Fig. 2). The log data (P and S-waves, density and porosity) will be used to calculate the theoretical pore shape parameter γ_k. We will measure the acoustic properties in the laboratory on discrete samples and calculate γ_k. Thin sections from the plug samples will be used to determine the pore structure with digital image analysis (DIA) in a workflow described by Weger et al. (2009). The test will be positive if γ_k correlates to permeability.

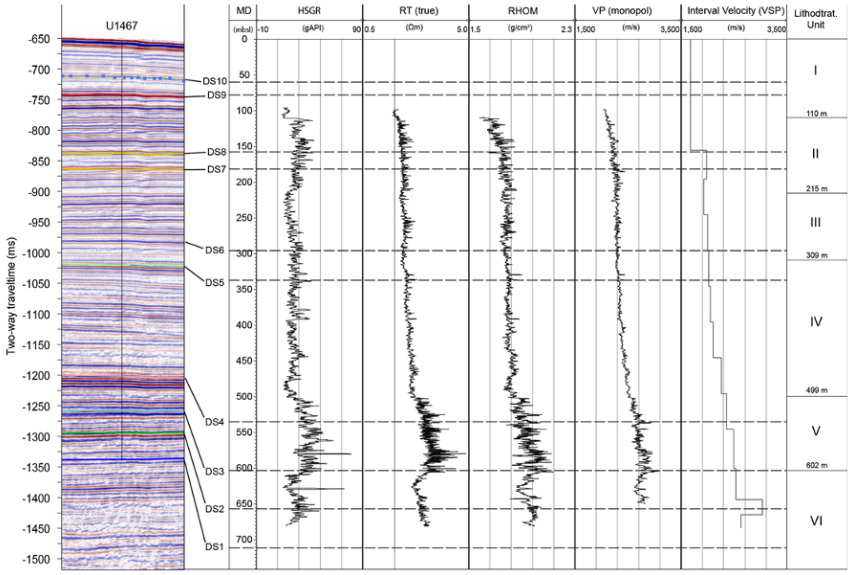

Figure 2. Seismic data of IODP Site U1467 and the corresponding logs allowing the extended Biot theory to be tested in carbonates (from Betzler et al., 2016).

SIGNIFICANCE

The extended Biot theory captures the pore structure using acoustic properties and therefore relates acoustic to hydraulic properties, which can potentially help to estimate permeability from seismic data. Because γ_k is derived from theoretical equations it can be calculated from acoustic data like a seismic attribute.

REFERENCES

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