Rock Physics and The Seismic Response

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The main problem in seismic interpretation has always been how to transform our seismic measurements into an accurate model of the earth's subsurface. This is an inverse problem, which has proven to be very difficult. An alternate approach is start with the forward problem. That is, we need to look at how the rocks and fluids at the reservoir level affect the seismic response. The important key here is to have an understanding of the fundamental rock physics. Although many theories have been developed to explain the relationship between the rocks, fluids, and the seismic response, the most robust approach has proven to be the theory of Biot and Gassmann. I will therefore start with an in-depth look at Biot-Gassmann theory, and show how their work is related to more recent developments such as lambda-mu-rho (Goodway, 1997) and pore space modulus (Hedlin, 2000).

I will then go on to look at how Biot-Gassmann theory can help us understand the results of some of the inverse methods that are currently being used to derive fundamental reservoir properties. These methods include post stack inversion, AVO attribute analysis, and the combination of post stack inversion with AVO attributes. By using these methods to derive seismic volumes such as Rp, Rs, lambda-rho and mu-rho, and interpreting crossplots of multiple attributes, we are able to potentially identify both the lithology and fluid content of our reservoir. I will also look at the limitations of each of these methods.

Finally, I will look at some of the newer statistical methods that allow us to integrate inversion and AVO attributes with well log measurements to increase the resolution of our final predicted earth response. These methods include both geostatistics and multiattribute transforms using neural networks (Hampson et al, 2001).

In keeping with the spirit of the session, I will use the Socratic method to encourage audience participation.

References

Goodway, B., Chen, T. and Downton, J., 1997, Improved AVO fluid detection and lithology discrimination using Lame petrophysical parameters: Annual Meeting Abstracts, Society Of Exploration Geophysicists, 183-186.

Hampson, D., Schuelke, J.S., and Quirein, J.A., 2001, Use of multi-attribute transforms to predict log properties from seismic data: Geophysics, 66, 220-231.

Hedlin, K., 2000, Pore space modulus and extraction using AVO: Annual Meeting Abstracts, Society Of Exploration Geophysicists, 170-173.