AVO Rock Physics Templates: Beyond AVO Classes

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Introduction

AVO classes is a simple and qualitative, yet often used, method for understanding the seismic amplitude responses of a target (Castagna and Swan, 1997). The various classes, which are associated with different polarity combinations for the intercept and gradient, can be used in reservoir characterization. Rock physics templates (RPT) is a more sophisticated method for doing reservoir characterization, and can be used to make more quantitative predictions of porosity, lithology and fluid saturation from acoustic impedance and Vp/Vs-ratio (Ødegaard and Avseth, 2004). Jensen et al. (2016) combined the concepts of RPT with AVO cross-plot analysis to create a so-called AVO RPT. It was used as a basis for scaling relative AVO into absolutes attributes, which were used as input data to the inversion method referred to as inverse rock physics modelling. But, just as regular RPT can be used in reservoir characterization, so can also AVO RPT; at least it can provide some more insight compared to only using the AVO classification scheme. We demonstrate this on a data set from the Norwegian Sea, as well as comparing the AVO RPTs for some common rock types.

Methods

As sediments are deposited and buried, rocks are formed. There exists numerous different rock types reflecting the burial history they have undergone. For example, friable sandstones which are very loose and unconsolidated, have not yet reached a depth where geochemical compaction sets in. While, when such depths have been reached, we find more cemented and consolidated rocks. Other rocks might have undergone periods of uplifts; typically causing fractures in the rock. Just as there exists a wide range of rock types, we also have a wide range of rock physics models which relate the constituent properties, their volume fraction, texture and composition to the effective elastic properties of the rock (Avseth et al., 2010). The rock physics template takes advantage of these relations to provide a tool for estimating reservoir properties such as porosity, volume fraction of clay (lithology) and fluid saturation from the effective properties. The concept of the RPT method, is to superimpose the data onto modelled effective properties in a cross-plot. This is typically done in the acoustic impedance versus Vp/Vs-ratio domain.

If we combine the concepts of RPT with AVO-cross plot analysis, we get AVO RPT; i.e. RPT done in the intercept versus gradient domain. Because AVO is an interface response depending on the properties of the layers above and below the interface, the modelled template must be extended to reflect the effective properties of not only one, but two mediums related to each sample. This can be handled by making assumptions about which interface one would like to investigate. For example, when studying the amplitude response at the interface between the cap-rock and the reservoir, appropriate cap-rock

properties are assigned to the layer above and a calibrated reservoir rock physics model to the layer below the interface. The intercept and gradient are then calculated using the relations

$$R = \frac{Z_2 - Z_1}{Z_2 + Z_1} \quad \text{and} \quad G = R_p - 2R_s \tag{1}$$

Results

Figure 1 shows an AVO RPT on a dataset from the Norwegian sea using a patchy cement model for the calibrated reservoir rock physics model; i.e. the layer below the interface. The highlighted black samples are from the Garn formation, which from an intersecting well we know is formed up of gas saturated sandstone with 30-35 % porosity.

Comparing this template with templates of other rock types depicts for example differences in sensitivity to fluid saturation, porosity and lithology.

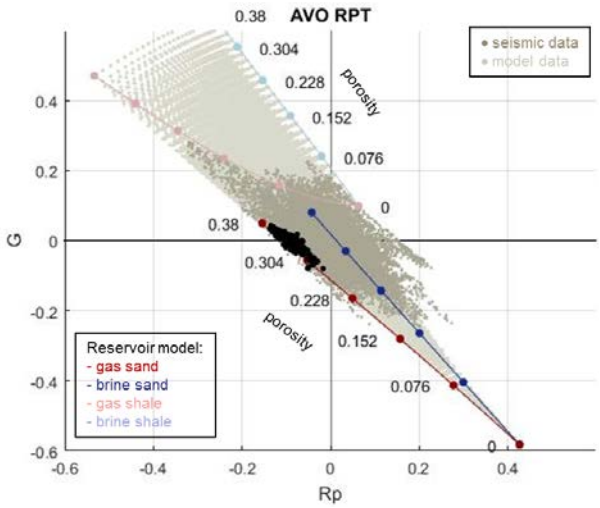

Figure 1: AVO RPT on a data set from the Norwegian Sea using a patchy cement model.

Discussion and conclusions

AVO classes is a very accessible, but also very simple, method for analysing seismic amplitude responses. AVO RPT provides more insight; incorporating rock physics models which can link the amplitude responses to quantitative estimates of the reservoir properties. It avoids a full seismic inversion, which is required when using a regular RPT. But is of course not free of assumptions; e.g. about the characteristics of the two interfacing layers. Comparing AVO RPTs for various rock types can also for example give insight into the fluid sensitivity of various rock types.

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References

Avseth, P.A, Mukerjo, T., Mavko, G., and Dvorkin, J. (2010) Rock-physics diagnostics of depositional texture, diagenetic alterations, and reservoir heterogeneity in high-porosity siliciclastic sediments and rocks – A review of selected models and suggested work flows. Geophysics, 75(5); 75A31-75A47.

Castagna, J.P, and Swan, H.W. (1997) Principles of AVO crossplotting. The Leading Edge, 16(4); 337-344.

Jensen, E.H., Johansen, T.A., Avseth, P., and Bredesen, K. (2016) Quantitative interpretation using inverse rock-physics modeling on AVO data. The Leading Edge, 35(8); 677-683.

Ødegaard, E., and Avseth, P. (2004) Well log and seismic data analysis using rock physics templates. First Break 22, 37-43.