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Geological Processes and Rock Physics Signatures of Upper Jurassic Organic-rich Shales, Norwegian Shelf

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SUMMARY

In this study we investigate the rock physics properties of Draupne/Spekk Fm organic rich shales offshore Norway. We attempt to understand the complex geologic processes of organic rich shales, and how these processes control the rock physics properties and seismic signatures of these rocks.

With burial depth, there are many competing effects that impact the rock physics parameters of organic rich shales. The compaction itself will reduce porosities and stiffen the rock frame. The kerogen will gradually transform to hydrocarbons with increasing maturity. Using rock physics models we try to understand the effects of reducing TOC or kerogen volume, gas/oil expulsion, cracking and overpressure.

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Comparisons between well log data from the Norwegian shelf and published laboratory measurements by Vernik (1995), show very good match (Figure 1). The well log data seem to indicate non-linear behavior in Vs-Vp domain, which seem to reflect competing effects of clay volume, TOC volume, maturity and compaction. Gas expulsion may also affect the data, but we expect the gas to be located patchy in disconnected pores, hence we shouldn't expect too large fluid effects (c.f. Carcione et al., 2010). This may not be the case if lenses of silt are interbedded within the shaly rock.

Finally, we establish rock physics templates for organic rich shales, where geological trends are indicated in a crossplot of acoustic impedance versus Vp/Vs. We test different rock physics models to better understand the effect of various geological processes, including DEM, Backus, and Hashin-Shtrikman. The Backus model allows us to investigate anisotropic properties, how these are affected by the geologic processes, and how these can significantly alter AVO signatures in these rocks.

References

Carcione, J., Helle, H. and Avseth, P. [2010] Source-rock seismic-velocity models: Gassmann versus Backus. *Geophysics*, **76**, N37-N45.

Vernik, L. [1995] *Petrophysics of the Kimmeridge shale, North Sea*. Stanford Rock Physics Laboratory.

Figure 1 Well log data from the Norwegian shelf, showing the properties of Draupne and Spekk Fm. Superimposed are laboratory measurements (Vernik, 1995) of the Draupne Fm, where colour is kerogen volume. The linear trends are the Greenberg-Castagna Mudrock line (blue), the Sandstone line (cyan), and the Dry rock line (red).

Figure 2 Rock physics template showing different geologic trends in the Draupne/Spekk Fm, and well log data from various wells. Superimposed a DEM model with aspect ratio of 0.1, for water (green) and gas (orange) saturation.