C04

Passive Margin Play and Prospect Evaluation Using Regional Depth Seismic and Inversion of Seismic Processing Velocities

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SUMMARY

In contrast to time seismic, reliable depth seismic is a good screening tool for petroleum systems analysis. With a constant temperature gradient across the area, the oil and gas windows are parallel to the water depth in a depth seismic section. Inversion of seismic processing velocities can be used to predict lithologies, porosity, pore pressure and uplift / erosion. Our presentation will show how we are using a consistent set of regional depth seismic sections together with Velocity Inversion as tools from the early play screening phase to the beginning of prospect evaluation. This method is especially well adapted to passive margins with deep water and little well control. We will show examples from passive margins in Australia and Norway.

Introduction

In contrast to time seismic, reliable depth seismic is a good screening tool for petroleum systems analysis. With a constant temperature gradient across the area, the oil and gas windows are parallel to the water depth in a depth seismic section. Inversion of seismic processing velocities can be used to predict lithologies, porosity, pore pressure and uplift / erosion. Our presentation will show how we are using a consistent set of regional depth seismic sections together with Velocity Inversion as tools from the early play screening phase to the beginning of prospect evaluation. This method is especially well adapted to passive margins with deep water and little well control. We will show examples from passive margins in Australia and Norway.

Method and/or Theory

Velocity Inversion, is a technique which has a similar scientific basis as basin modeling and pore pressure estimation, in the sense that one defines a physical model for the compaction of sediments, and inverts the data on the basis of that. Based on model assumptions the velocities can be inverted to a lithofacies indicator (Pseudo Lithology), to apparent porosity, apparent pore pressure, and apparent uplift / erosion. The lithofacies indicator can easily differentiate between massive overpressured shales, normally pressured clastics, limestones, and high velocity units such as volcanites and basement. It is also possible to differentiate between normally pressured sand and shale, but these are close in terms of velocity, and the classification will be less precise. This indicator, especially when combined with depth seismic, brings out a lot of geological information from the seismic data, and makes it much easier to quickly get a handle on what kind of rocks might be present in an undrilled section. While the Pseudo Lithology inversion assumes normal pressure everywhere and that all velocity variation depends on compaction and lithology, the inversion to apparent pore pressure and uplift assumes that the lithology is known, and that these can be calculated from the difference, in meters, between the present position of a layer and the depth at which the layer would be in compaction equilibrium.

Examples

In our presentation we will show an example from the Bight Basin, where a potential reservoir section exists below TD in an exploration well. We will also show data from one well known gas play of the Australian North West Shelf, where a Tertiary limestone platform distorts the structural time image in the seismic, so that the structures appear to have no closure. A depth seismic section with a Pseudo Lithology overlay not only shows the true structural picture, but also gives the geological explanation for the distortion. There are also overpressure shales in the Australian North West shelf, and in the Vøring platform offshore Norway. We will show how Velocity Inversion can be used to study this regionally. A regional 3D velocity model has been inverted, and shows how the potentially overpressured shales are distributed regionally. A seismic section which runs into an area with a very obvious uplift effect will be displayed. This kind of uplift calculation is best done from inversion of interval velocities in layers with known lithology. A map example will be shown from the Norwegian Continental Shelf, where there is a significant uplift effect parallel to the coast line.

The lithological identification of units in frontier areas with little or no well control may be challenging. Using well data from well explored basins with many wells it is possible to determine interval velocity versus depth curves which reflect the normal compaction trends for various lithologies (Peikert, 1985). These curves may then be applied to the seismic velocities in frontier areas to correct for normal compaction effects. Variations that remain after these corrections are then mapped and used for prediction of lithology, porosity and formation pressure. In Figure 1 we shown how a lithology transform applied to the velocity model may be used as an apparent lithology overlay on the seismic. Although the spatial resolution of the velocity analysis from seismic data lacks the fine resolution required for lithological identification of individual formations we can, in general, identify units of relatively hard or softer rocks. The combination of this information with geological knowledge will normally give a better picture of the geometrical distribution and alternative interpretations of the probable lithology when interpreting seismic data.

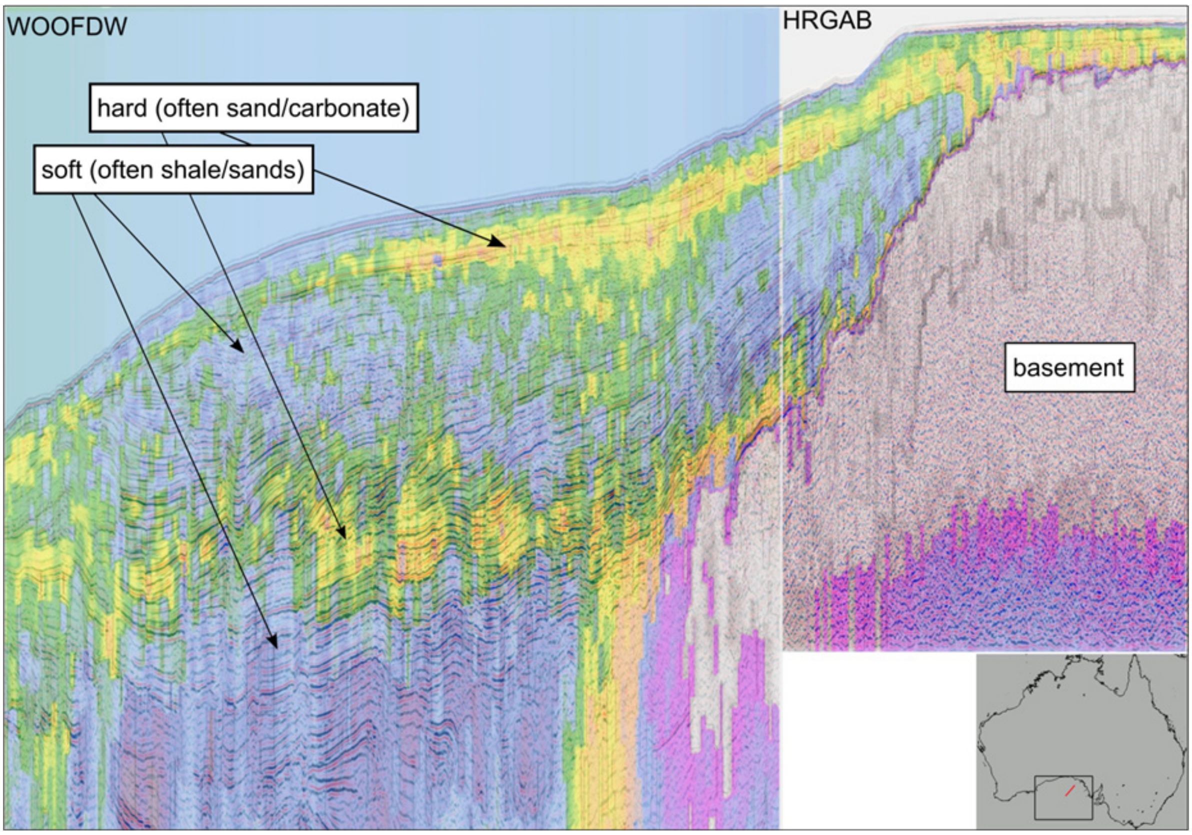

Figure 1 *"Velocity inversion". Depth converted seismic from the Bight Basin Australia with apparent lithology overlay based upon seismic velocity. The staking velocity is good were the seismic is good. "Velocity inversion" is relatively inexpensive but the results are often impressive. The passive margin in the Bight Basin is predicted to have a sandy interval with potential for structural and stratigraphic traps at a depth which should be favorable for oil and gas exploration. Example from the GAB High Resolution (HRGAB) and Flinders Deep Water (WOOFDW) surveys, Australia.*

Conclusions

The methods we will show all have one goal, namely to help the exploration geologists, by bringing out the regional geological information that is carried in the seismic processing velocities. Either indirectly, through the regional depth seismic, or directly, through the Velocity Inversion. They are quick and fairly simple to compute, and should give good answers up to a certain resolution, which is sufficient for play evaluation and in early prospect evaluation phases. They interface nicely with the traditional PSDM, seismic inversion and AVO studies which are often carried out in support of detailed prospect evaluation.

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