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Reading Between the Lines II: A NEBC Shale Gas Quantitative Interpretation Case Study Incorporating Multi-component Data

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Summary

This presentation will describe an unconventional case study in the context of an integrated interpretation workflow, incorporating converted-wave shear (PS) data. The objective of the case study was to enhance and improve the prediction of facies and geomechanical properties of a shale reservoir interval by incorporating the pre- and post-stack PS data. The conditioning, analysis and blending of the PS data into the more conventional workflow (which was presented at Geoconvention 2014) will be described to illustrate the successful integration of geological information and seismic attributes. The results of this expanded workflow will be compared to those achieved using the P-wave component only, with additional insight provided by a 3D VSP.

Introduction

The Horn River shales contain about 70% of Canada's total estimated shale gas resource and the largest accumulation of gas in North America (Figure 1). Nexen Energy ULC holds multiple leases in the area but this case study focusses on a specific project where a multi-component 3D survey was acquired in 2012. The resource objectives in this area are the organic shales of the Devonian Muskwa Formation and the Otter Park and Evie members of the Horn River Formation. Nexen has been proactive in acquiring the 3D early in the development process, so thorough analysis can focus the drilling program and reduce risk.

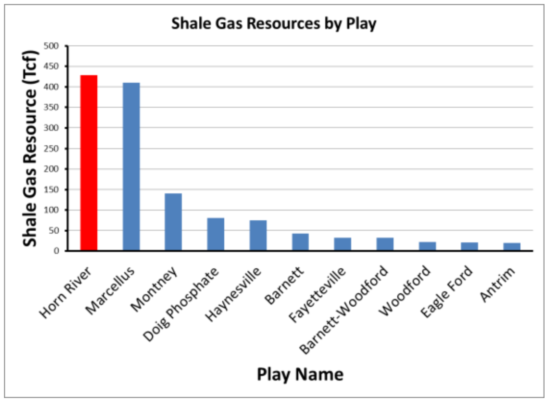

Figure 1: Relative shale gas resource size by play (after EIA, 2011).

PS data are not commonly used by interpreters, mainly due to additional uncertainty in subsurface positioning (both laterally and vertically), complications in processing related to accurate estimation of velocities and statics, anisotropic effects that are much more pronounced than in P-wave data, and most of all, the severe attenuation of high frequencies in the near surface, resulting in considerably lower resolution than the P-wave data (Stewart, 2009). For these reasons, PS data on their own have been mostly ignored as an interpretive tool, although the workflow employed in this case study has shown promising results elsewhere (Weston Bellman, 2014). The purpose of this project was to determine if any additional benefit to the quantitative analysis of P-wave data was realized by blending the PS information with the PP.

Quantitative analysis of the P-wave data in this study was completed in 2013, resulting in comprehensive predictions of facies and properties such as Young's Modulus, Poisson's Ratio and relative Brittleness Index (Rickman et al., 2008). The results were summarized in an abstract (Weston Bellman and Leslie-Panek, 2014) and presented at Geoconvention 2014. Since then, a 3D VSP and the converted-wave component of the 3D seismic have been analyzed and incorporated into the predictions. This presentation will focus on the workflow implemented to achieve this integration.

Method

Quantitative Interpretation (QI) is the process of relating seismic amplitude measurements directly to rock and fluid properties, and using these derived relationships to convert seismic data to geological predictions. Simple to say, but the execution is complex, sensitive to subjective parameter choices, dependent upon assumptions and inclined to interpretation biases. For these reasons, we affectionately refer to the process as QQI or qualitative quantitative interpretation. The workflow employed in this project was constrained where possible by 'known' quantities, and subjectivity was restrained by parameter scanning and quantitative measures of assessment (where possible; this is difficult in practice when there are few wells with uncertain data).

The main elements in our multi-component workflow comprise the following general categories:

- Well data QC, elastic property computation and crossplotting
- Seismic data QC, conditioning, and seismic attribute and elastic property derivation
- Callibration to 3D VSP, depth conversion and registration between PP and PS data volumes

- Combined mathematical multi-attribute analysis in depth for specific properties
- Interactive conversion of elastic properties into facies and rock property classes using QI-Pro

The depth-registered stacked P-wave data compared to the PS-data are shown in Figure 5 illustrating the similarities and differences in character, frequency content and amplitude variation. Both pre- and post-stack data of each type were analyzed and incorporated in the attribute and elastic property predictions.

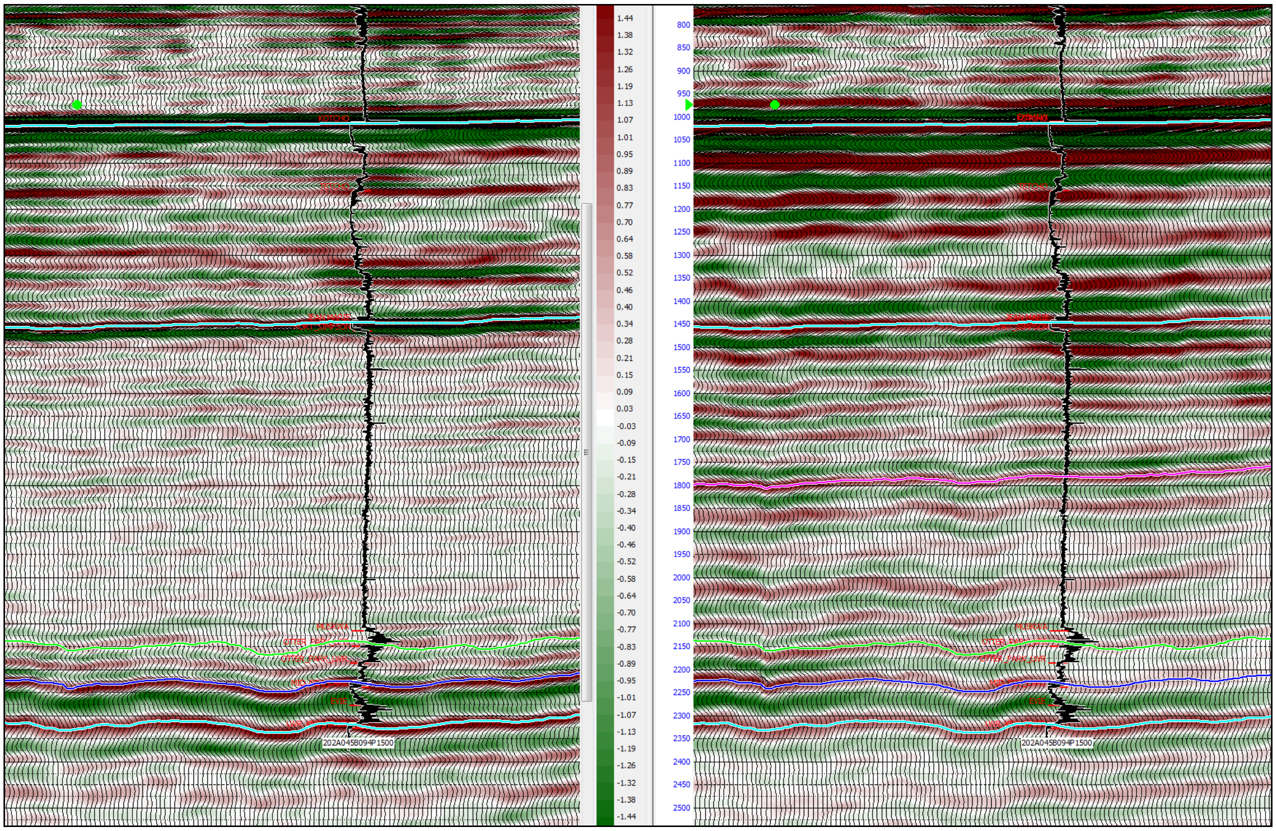

Figure 2: Original PP PSTM (left) and PS PSTM (right). Both volumes have been depth-converted and are shown with a gamma-ray log displayed at a key well location.

Figure 5 shows the final classified volumes (with and without using the PS data and attributes) after all data have been integrated and all steps in the process completed and optimized. In this version, geological intervals have been identified and the Muskwa and Upper Otter Park have been selected for further sub-division by relative Brittleness Index.

Conclusions

The objective of this project was to assess the benefits of incorporating the PS data into the QI workflow. Additional detail is apparent in the PS-derived attributes in some of the layers of interest, which contributes to greater resolution of rock property predictions. However, the differences in QI results between the two methods can only be definitively assessed with additional accurate log data (including measured dipole logs) from future drilling.

This project has shown that with attention to detail in well analysis, and accurate seismic attribute derivation, calibration and classification, PS data can be merged with PP data to provide improved results in a QI workflow in spite of the apparent shortcomings of converted shear data.

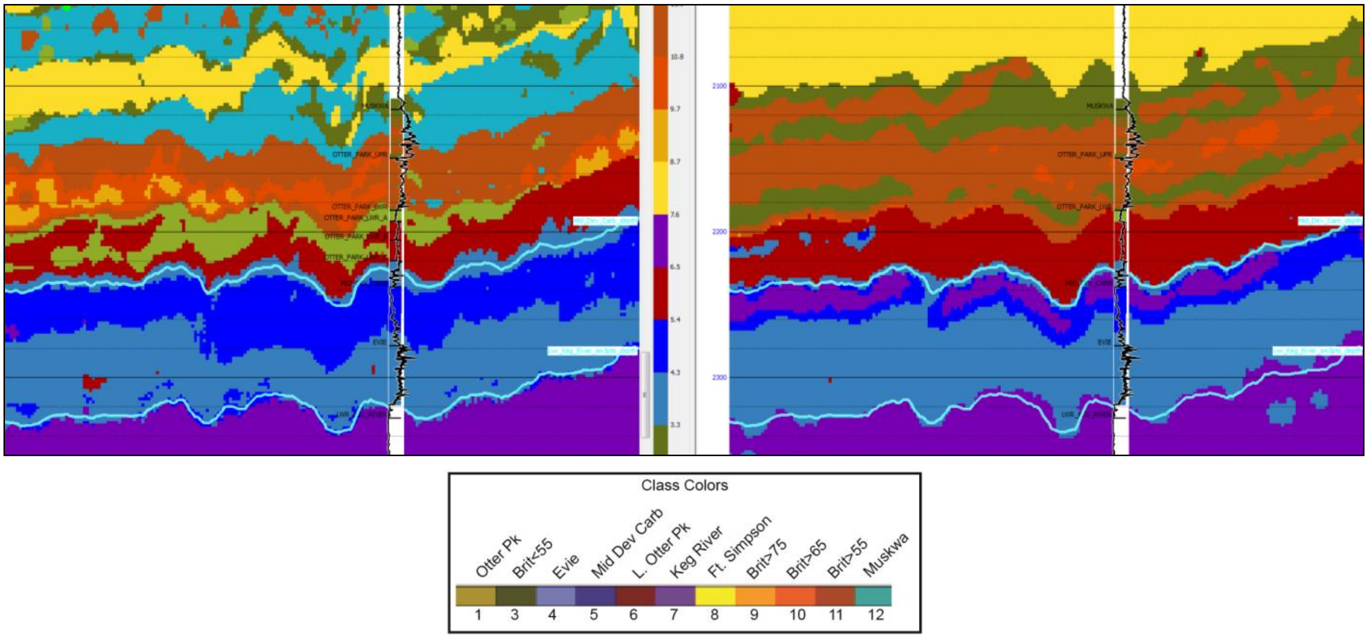

Figure 3: Final classified volume using PS attributes (left); and without using PS attributes (right). Both profiles are shown with a gamma-ray curve and a colour track representing formation and relative brittleness index displayed at a key well location.

Acknowledgements

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