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Seismic Porosity Prediction in the Montney: A Quantitative Interpretation Case Study

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Summary

A quantitative interpretation (QI) study, which was undertaken in the Kakwa area of northwestern Alberta, will be described in this presentation. The objective of the study was to determine the effectiveness and accuracy of porosity prediction in the Triassic Montney Formation using seismic attributes. Paramount Resources reprocessed legacy 3D seismic data over a project area that included several vertical wells with dipole sonic logs for rock physics analysis and calibration of the seismic data.

The Montney is a challenging reservoir from many perspectives. Slight variations in reservoir quality can significantly affect productivity and mean the difference between success and failure. Imaging that subtlety using seismic data, with its own inherent uncertainty and resolution limits, forces detailed and thorough inspection of all aspects of the data and process. Indeed, for this particular unconventional project, unconventional thinking was required.

Introduction

The Lower Triassic Montney Formation is a complex siliciclastic, and locally carbonate, reservoir system that is dominated by relatively well-sorted dolomitic siltstones (with limited argillaceous content) and very fine-grained sandstones. The clastic component, most likely of aeolian origin, has been extensively reworked in the marine environment (Montney Regional Hydrodynamics Study, 2009).

In the area of this study, the Montney is predominantly siltstone deposited in a lower shoreface environment. It is broadly segregated into upper and lower sequences, each including several higher order cycles (Figure 1). In the local area, the prospective cycles include the D1, D2, and D3 of the Upper Montney.

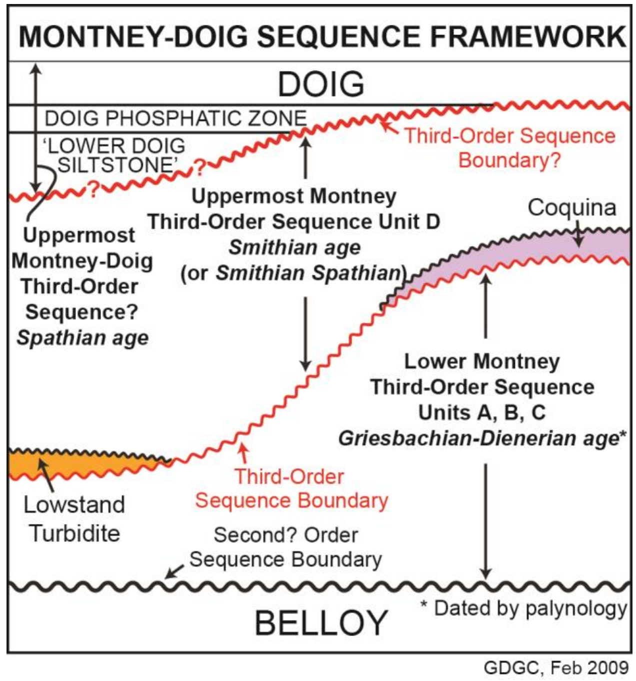

Figure 1: Montney-Doig sequence framework defining major divisions and nomenclature (after GDGC, 2009).

Method

Figure 2 is a log display showing original and computed logs over the Montney Formation. The higher porosity, lower density zone in the D1 interval is the primary target. The computed logs shown represent a selection of elastic properties that can be seismically derived, and are therefore key to relating seismic attributes to geological properties. For example, the crossplot shown in Figure 3 is the computed Young's modulus vs. Poisson's ratio with the points coloured by porosity. The trend suggests that these elastic properties may be calibrated to predict porosity. Subsequent relationships derived from the crossplot analysis of elastic properties (referred to as deterministic rock physics templates or DRPTs) provide a method of transforming the elastic properties to rock properties.

The 3D seismic data available in this project were analyzed using AVO, Inversion and multi-attribute processes to derive the relevant elastic properties. Incorporating these elastic properties and other attributes (including at least one unusual one) with the well data analysis provides the basis for a complete lithological and property classification of the seismic volume.

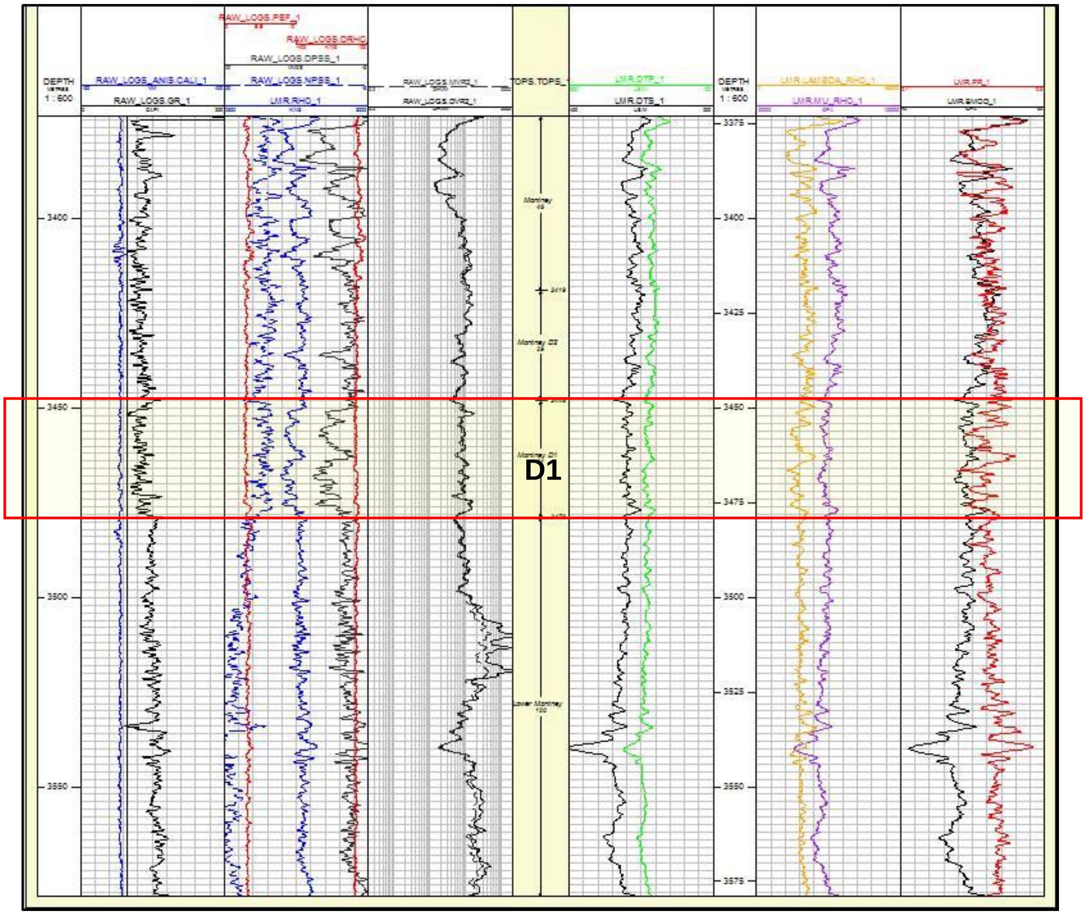

Figure 2: Log display showing original curves to the left of the tops track and computed curves to the right. Computed curves are P-wave and S-wave slowness, Lambda*rho, Mu*rho, Poisson's Ratio and Young's Modulus.

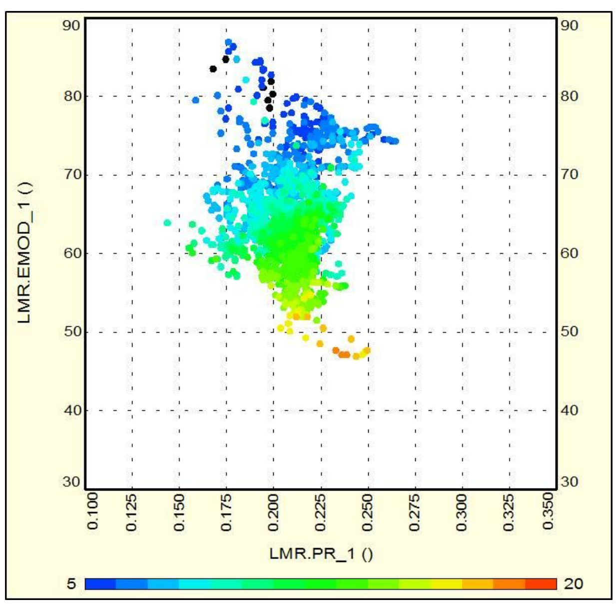

Figure 3: Crossplot of Young's Modulus vs. Poisson's Ratio within the Montney interval with points coloured by porosity.

The final classified volume represents a systematic interpretation of appropriate attributes for optimum property prediction. Figure 4 shows a series of crossplots of relevant computed attributes from logs, overlain by their seismically-derived equivalents. The polygons and cutoffs shown represent categories of geological units or rock properties that have been identified and translated back to the seismic volume shown in Figure 5. The predicted phi*h ranges coincide with the D1 target zone in all wells, and the maximum predicted phi*h value at the well location is shown in Figure 6, graphed against the actual phi*h in the D1 for all wells in the survey.

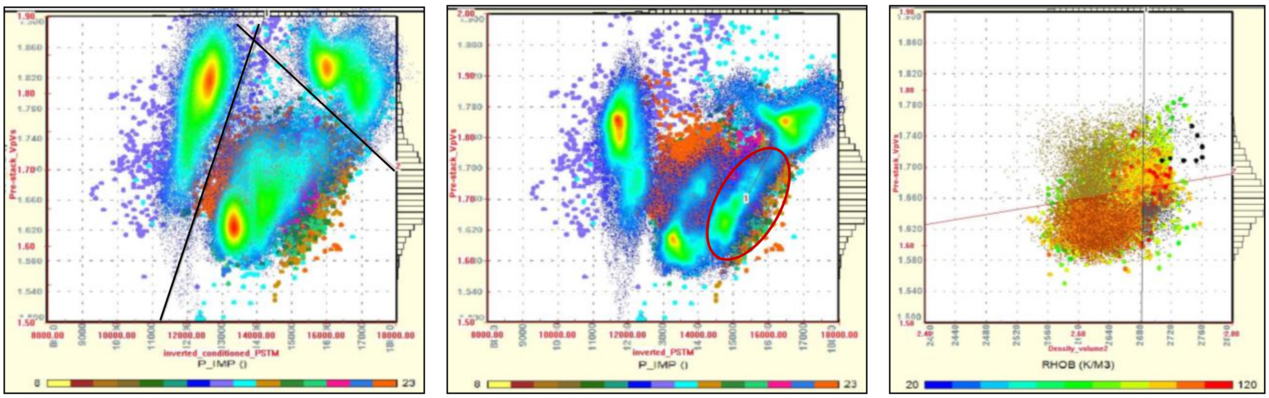

Figure 4: Crossplots representing DRPTs overlain by equivalent seismic attributes. The seismic points are coloured by cluster density (left and centre) or assigned class colour (right). Cutoff lines and polygons are interpreter-defined regions segregating geological units or properties.

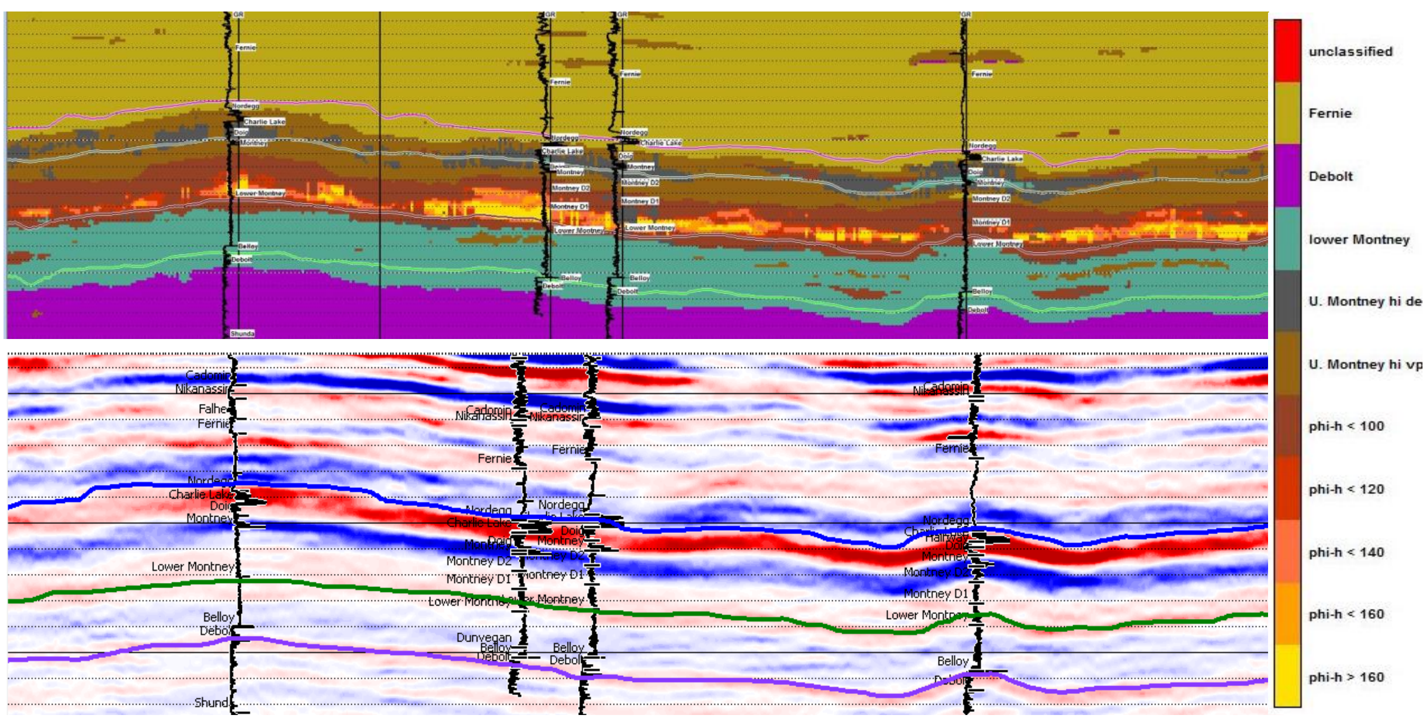

Figure 5: Classified seismic volume profile tying several wells in the 3D (top), compared with the conventional seismic profile through the same wells. Gamma-ray logs are displayed at the wells and the class colours are defined by the legend. The predicted phi*h ranges coincide with the D1 interval in all wells.

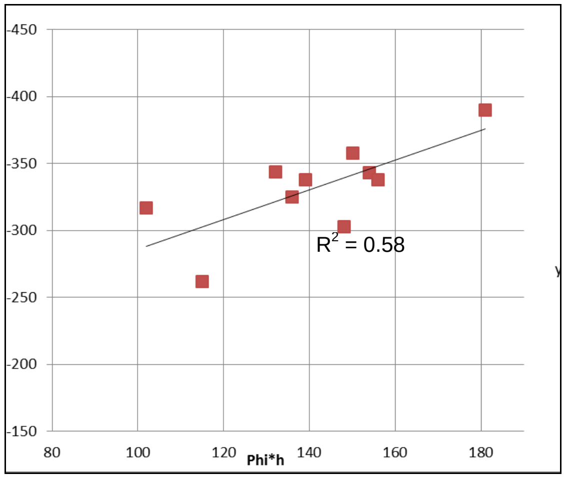

Figure 6: Phi*h attribute (Y) vs. actual D1 phi*h computed from logs.

Conclusions

In spite of subtle and challenging property characteristics within the Montney, this project has shown that with careful calibration of well data and optimum attribute classification, important features within the reservoir unit can be predicted and mapped.

Acknowledgements

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References

Montney Regional Hydrodynamic Study, 2009, Canadian Discovery, Ltd.