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Geoscience Interpretation and Visualization of a Multicomponent 3D Seismic Survey in Extreme Southern Alberta

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Summary

The understanding of a Lower Cretaceous clastic reservoir and the underlying Mississippian carbonate subcrop play was greatly enhanced by the rock properties and attributes derived from a multicomponent (3C3D) seismic survey. Integrating numerous vertical (PP) 3D seismic images led to a preliminary assessment of the property. However it was the 3D images of the converted wave (PS) data and the derived density (from the joint inversion of the PP and the PS-wave seismic data), which provided insight into potential reservoir permeability barriers and post depositional tectonics events. The resultant interpretation led to a better understanding of the reservoir facies and provided a new play concept that was not imaged on the PP-wave data.

Project Story

The Red Coulee 3C3D survey was originally shot in 2006 to help reduce the risk in developing the Lower Cretaceous and Mississippian reservoirs in T1 R17W4. The converted PS-wave data was eventually processed in 2009 along with a reprocessing of the P-wave data and has been described as "one of the best 3C3D surveys recorded to date" (P. Cary, personal communication, 2009).

Although the majority of the reservoir characteristics are syn-depositional, the entire stratigraphic column has been impacted and modified throughout geological time by uplift and erosion caused by the rising of the Sweetgrass Arch to the South in Montana. The company had several producing pools on the property, and needed a tool to help identify the structural and stratigraphic elements of the Lower Cretaceous clastics as well as the structural closures of the karsted Mississippian carbonates.

The initial interpretation stage involved the "standard" suite of 3D images/seismic attributes of P-wave data including: "Peaks and Troughs", Instantaneous Frequency, Instantaneous Phase, Coherency/ Semblance analysis and Time Slicing.

The processing and merging of the 3C3D data with well log information (sonic, density, gamma ray and dipole sonic) led to an enhanced understanding of the reservoir limits and potential permeability barriers.

The 3C3D reservoir characterization involved: 1) edge detector attributes, such as semblance and spectral decomposition; 2) deterministic joint-inversion attributes, such as P-wave and PS-wave impedances and Density, 3) neural network analysis and stochastic inversion attributes. The comparisons between the P-wave and PS-wave data also aided the company in understanding existing production histories and will help define future field development.

Comparative analysis between 3C3D seismic attributes led to the interpretation of a new play concept, which was not imaged on the P-wave data (Figure 1). Other geological features such as reservoir facies, channel tracks, fault separations, and karst features (Figure 2) were also supported or confirmed by the comparative analysis, existing production history, and subsequent drilling results.

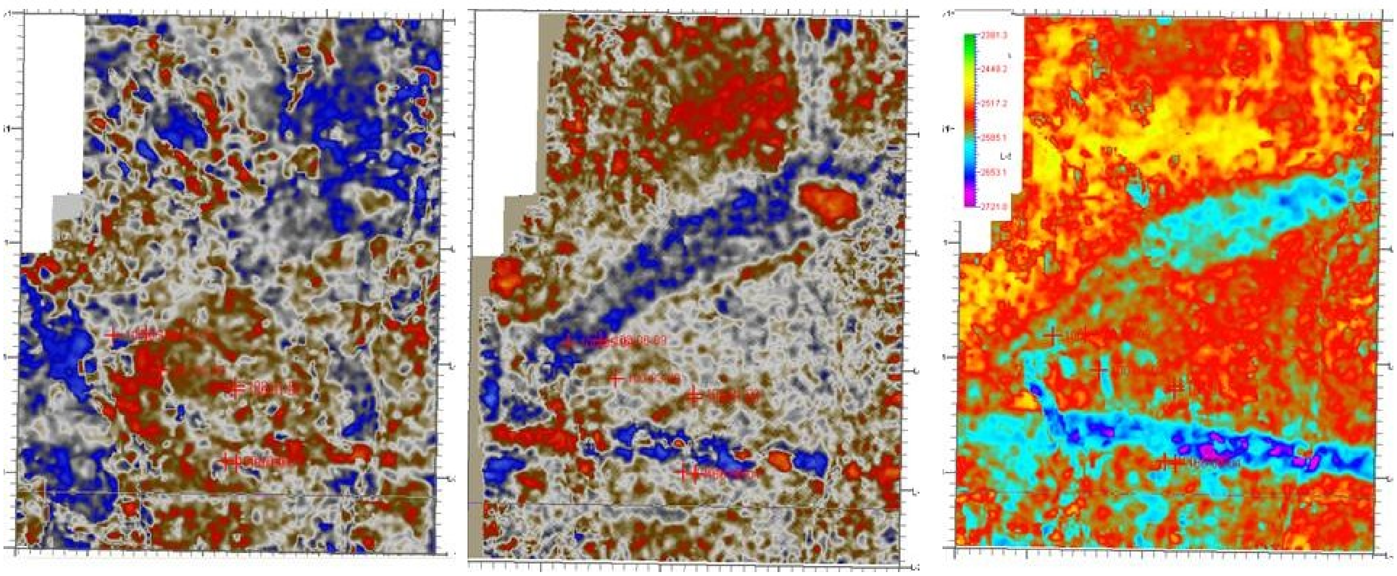

Figure 1: Red Coulee 3C3D horizon slices (left to right): PP PSTM stack, PS PSTM stack (in PP time), Density (from a joint inversion of PP and PS seismic data).

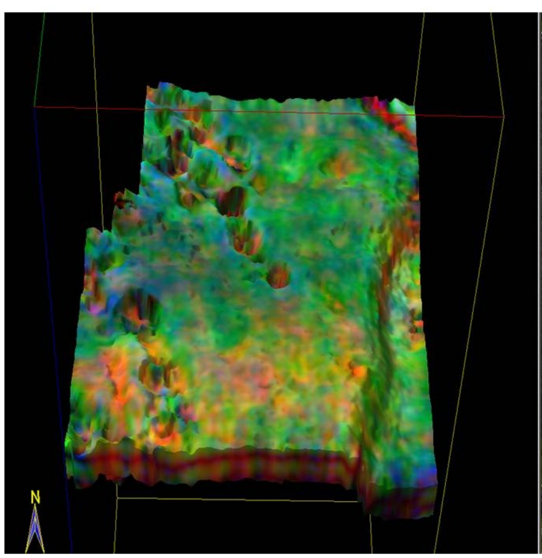

Figure 2: Devonian karst structure as imaged by spectral decomposition: red: 8Hz, green: 26 Hz, blue: 48 Hz.

Conclusions

Acquiring and combining P-wave and PS-wave multicomponent 3D data resulted in a qualitative and quantitative set of 3D images. The resulting interpretations will assist in identifying new opportunities, and reducing risk for developing the existing pools in both the clastic and carbonate reservoirs.

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