XII BOLIVARIAN SYMPOSIUM
PETROLEUM EXPLORATION IN THE SUBANDEAN BASINS
BOGOTÁ 2016 26/28 September

Hiding in Plain Sight: Improving seismic resolution through diffraction imaging technique

Dan Negut, I. Carter Edie, and Todd D. Keedwell*
Divestco Inc

Summary

Large impedance contrasts within the stratigraphic column provide both benefits and challenges during seismic processing and interpretation. We discuss the main issues faced by the seismic interpreters and processors when mapping is attempted in the presence of strong and obscuring coal reflection events. We also examine how diffraction imaging provides improved vertical and lateral resolution for the evaluation of underlying prospects when the technique is compared to traditional reflective seismic imaging methods. We conclude with case studies from the Mannville Group and Spirit River Formation.

Introduction

With seismic imaging there are positive and negative elements associated with large impedance subsurface interfaces. High amplitude seismic horizons, such as those generated from thick or interbedded coal seams, can provide for the processor excellent markers for stacking and migration velocity analysis. For the interpreter, the strong reflectors provide robust anchor ties to synthetic seismograms. The downside is that the large relative amplitude characteristic of coal reflectors creates a masking effect on both the temporal and lateral resolution of the depositional and tectonic features within the inercalated or underlying strata. The seismic response of discontinuous geobodies such as paleo-valleys, channels, and fault cuts becomes overwhelmed and obscured by powerful coal reflectors. Moreover, interbed multiples can be generated and the coals can act as high frequency filters, lowering the recoverable temporal limits of the seismic wavelets below (Perz, 2001). Thin-bed tuning effects from tightly spaced coal packages can be a major concern when determining depositional timing. These coal-generated challenges for seismic processors and interpreters are prominent throughout the Western Canada Sedimentary Basin.

Theory and/or Method

The Mannville Group has been a traditional target for hydrocarbon exploration in central and southern Alberta, where the unit is producing large amounts of oil and gas from several conventional reservoir sub-units. The unit also provides a prime example for negative, interfering coal effects on seismic data.

The Upper Mannville sub-unit contains a succession of nonmarine interbedded sandstones, shales, and coal layers. In the south, oil and gas is trapped in numerous fluvial and valley filled systems (Hayes, 1994). Within the Early Cretaceous alluvial plains or deltaic environments of southern Alberta, several coal beds were formed (Smith, 1994).These Mannville coal layers provide excellent markers on seismic sections while concurrently obscuring the sub-resolved reflective wavelets generated by incised fluvial channels, located in between or under coal beds. An innovative technique is required for recovering the poorly imaged details of the concealed paleo-drainage system, which has dimensions and depths often beyond seismic resolution.

The Pre-stack Time Migration Diffraction Imaging (PSTMDI) provides the three-dimensional super resolution improvement required for such complex stratigraphic setting (Sturzu, 2014; Edie, 2014; Veenhof, 2014). Diffraction Imaging is the process of reflective seismic energy suppression in order to enhance the diffractive wavefield that is generated from subsurface geometrical discontinuities such as fault scarps, cracked interfaces, stratigraphic pinch-outs, channel edges, etc. With PSTMDI super resolution, more precise detail recovery beyond the customary seismic wavelength resolution is achieved and, as demonstrated by our examples, the mappability and interpretation of sub-coal channel systems is vastly improved.

Examples

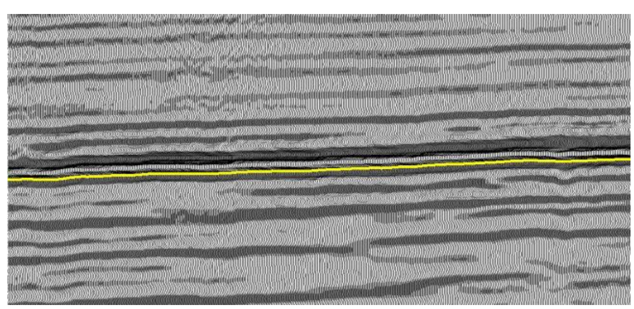

Figure 1. Pre-Stack Time Migration seismic inline section showing a Mannville coal seismic reflector (yellow marker)

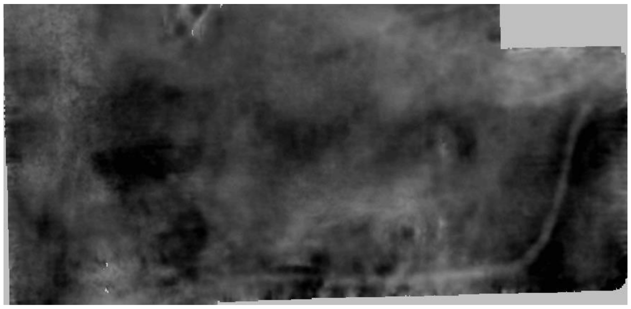

Figure 2. Pre-Stack Time Migration amplitude horizon slice (yellow event from Figure 1.)

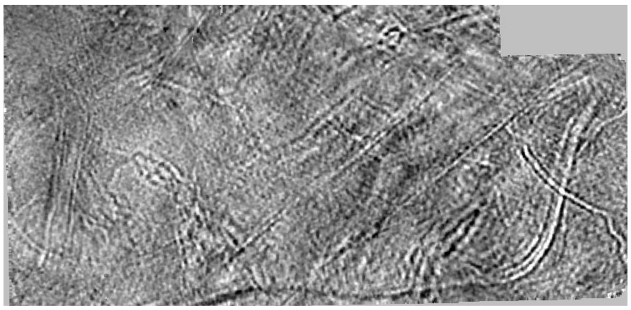

Figure 3. Pre-Stack Time Migration Diffraction Imaging (PSTMDI) horizon slice (corresponding to Figure 2.)

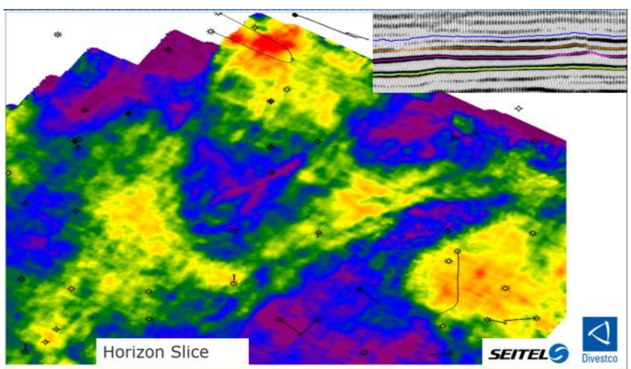

Figure 4. Horizon Slice of a Coal Masked Channel (yellow marker)

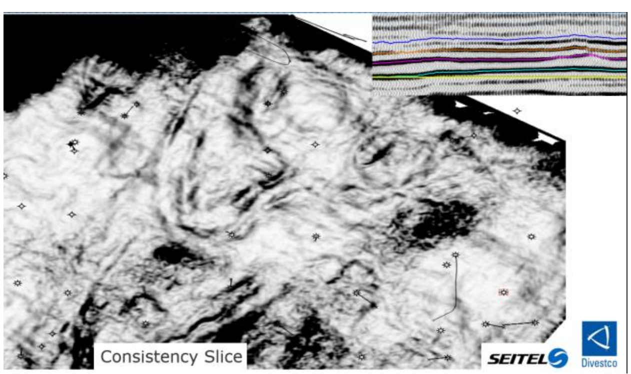

Figure 4. Consistency Slice (yellow marker) of a Coal Masked Channel (Same channel as Figure 4)

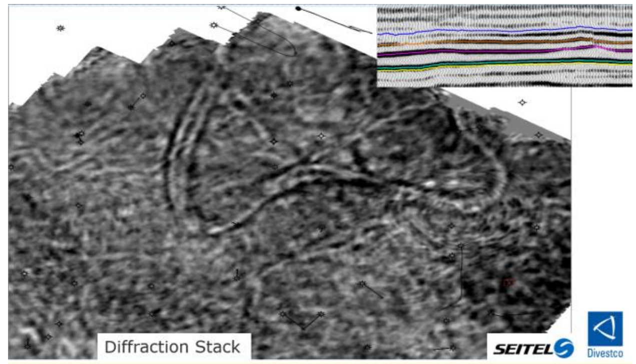

Figure 5. Diffraction Image (DI) Time Slice (yellow marker) of Coal Masked Channel (Same channel as Figure 4)

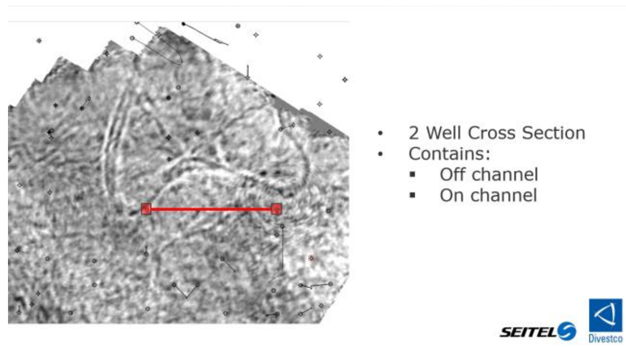

Figure 6. Di with 2 Well Cross Section of Channel shown in Figure 5. Well on left is in the channel and well on right is out of the channel

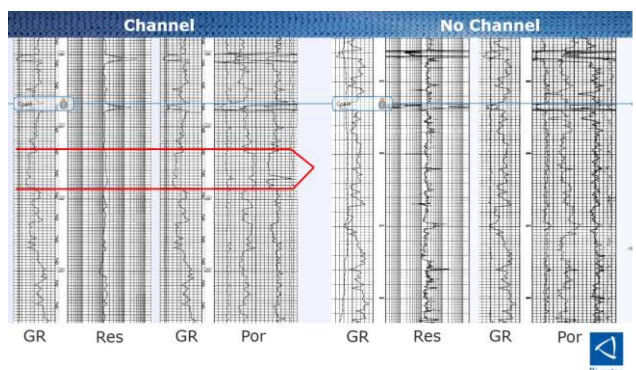

Figure 7. Well Logs of Channel (highlighted in red) and no channel sands.

Conclusions

Imaging subsurface discontinuities associated with paleo-valley systems and fault scars in the presence of coal intervals is a persistent challenge for the seismic processor and interpreter looking for subtle stratigraphic traps. The use of Pre-stack Time Migration Diffraction Imaging provides an elegant solution for improving resolution and visualisation of elusive traps within high reflectivity stratigraphy when compared against conventional reflective seismic imaging.

Acknowledgements

We thank Divestco and Seitel for letting us use the data for illustrations and Dr. Michael Enachescu for review.

References

Edie, I.C., Negut, D., Diffraction Imaging Case Study – Slipping Through the Cracks: CSEG GeoConvention 2014

Hayes, B.J.R., Christopher, J.E, Rosenthal, L., Los, G., and McKercher, B., 1994, Cretaceous Mannville Group of the western Canada Sedimentary Basin: in Geological Atlas of the Western Canada Sedimentary Basin, Canadian Society of Petroleum Geologists and Alberta Research Council, http://www.ags.gov.ab.ca/publications/wcsb_atlas/a_ch19/ch_19.html , January 21, 2015

Perz, M., 2001, Coals and Their Confounding Effects: CSEG Recorder, December 2001, 34-53

Rosenthal, L., 1988, Wave Dominated Shorelines and Incised Channel Trends: Lower Cretaceous Glauconite Formation, West-Central Alberta: Canadian Society of Petroleum Geologists, Memoir 15, 207-220

Smith, G.G., Cameron, A.R., and Bustin R.M., 1994, Coal Resources of the Western Canada Sedimentary Basin: in Geological Atlas of the Western Canada Sedimentary Basin, Canadian Society of Petroleum Geologists and Alberta Research Council, http://www.ags.gov.ab.ca/publications/wcsb_atlas/a_ch33/ch_33.html, January 21, 2015

Sturzu, I., Popovici, A.M., Pelissier, M.A, Wolak, J.M., and Moser, T.J., 2014, Diffraction imaging of the Eagle Ford shale:First Break, Vol. 32, No. 11, 49-59

Veenhof, R., Moser, T.J., Sturzu, I., Dowell, D., Popovici, A.M., and Nieuwland, F., 2014, Diffraction Imaging in the North Sea, Case Study Over the Dutch Q16 Fields: 76th EAGE Conference and Exhibition 2014