Prestack Seismic Data Analysis with 3D Visualization – A Case Study

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Summary

The dataset generated in prestack seismic processing consists of a variety of attributes and CMP gathers. It poses challenges in the quick evaluation for reservoir characterization and often prevents the full exploitation of valuable information contained in prestack seismic data. We present a case study to demonstrate how to improve interpretation on a 3D survey by using traditional approaches and new techniques in 3D visualization.

Introduction

The interpretation of 3D prestack seismic data involves poststack and prestack seismic attribute volumes, CMP (or CIP) gathers, and well log data. The size of the datasets is commonly large. In order to conduct prestack data interpretation efficiently for an optimized solution in reservoir characterization, one not only needs to have knowledge on how to analyze prestack seismic data, but also needs new technologies for visualization. In this study, we use a 3D dataset to demonstrate how to efficiently conduct the interpretation on prestack seismic data with advanced 3D visualization tools.

The study area is located in Southern Alberta with a multi-channel system in the target formation. Figure 1 shows the base map with the horizon across the base of the target zone.

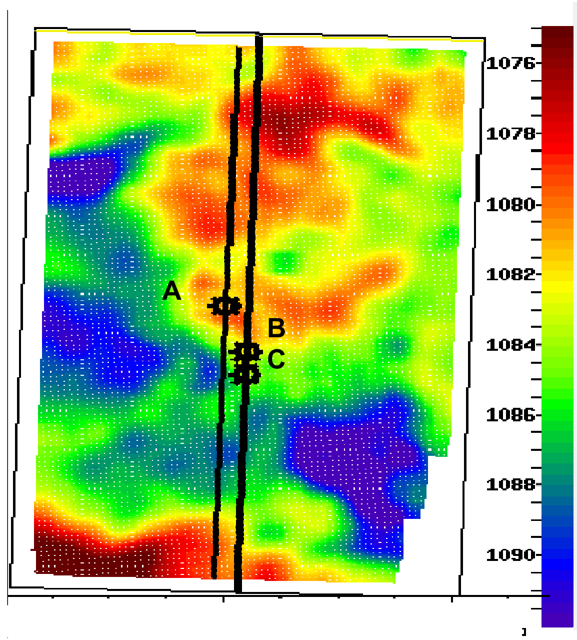

Figure 1. Base map

The well logs from three wells are shown in Figure 2. The target zone is the Ellerslie sand that has lower velocity and density in comparison to the encasing shale. The velocity of the sand is between 3600 m/s to 4000 m/s. In well A, the encasing shale has similar rock properties. In well B, only part of the Ellerslie formation was drilled. And in well C, the shale above has similar velocity as the sand, and a high velocity layer exists at the base of the Ellerslie formation.

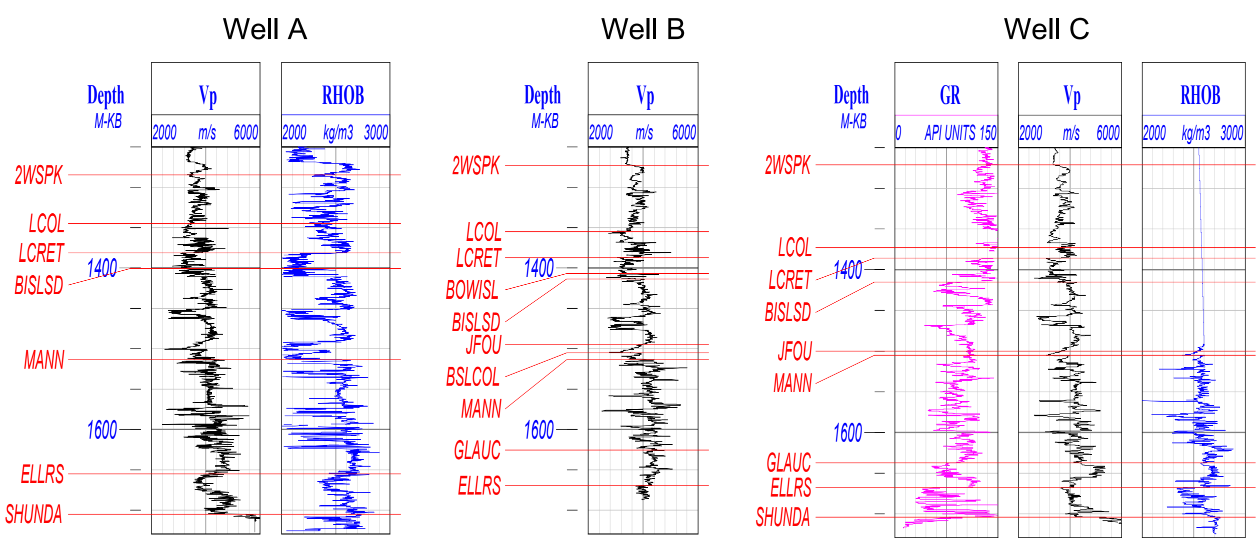

Figure 2. The well logs of the studies wells.

Prestack time migration was conducted in this study. AVO processing was then pergormed and various attributes were generated (Table 1). Figure 3 shows the well ties to the PSTM sections. In general, the well ties are good.

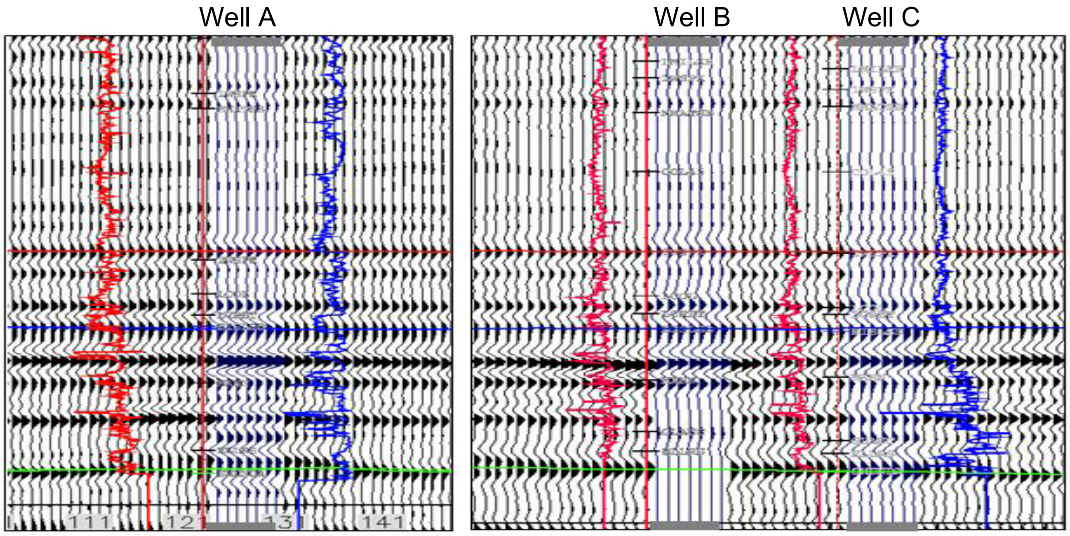

Figure 3. Well ties to inline sections across the three well locations.

Table 1. Seismic attributes generated from prestack seismic processing.

Gather	Prestack attributes	Poststack attributes	Well logs & synthetics
CMP gathers	P-reflectivity S-reflectivity Fluid stack NIP Gradients P-impedance S-impedance Vp/Vs ratio Poisson's ratio $\lambda\rho$ $\mu\rho$ λ/μ ratio	Coherence cube Spectral decomposition volumes	Well logs Rock physics data Petrophysical data Synthetics

Figure 4 shows the 3D displays of the channel system from the PSTM volume. The amplitude in blue is the trough corresponding to the top of the channel system. We see that there is little differentiation in amplitude between the three locations and even the thickness and the reservoir quality are significantly different.

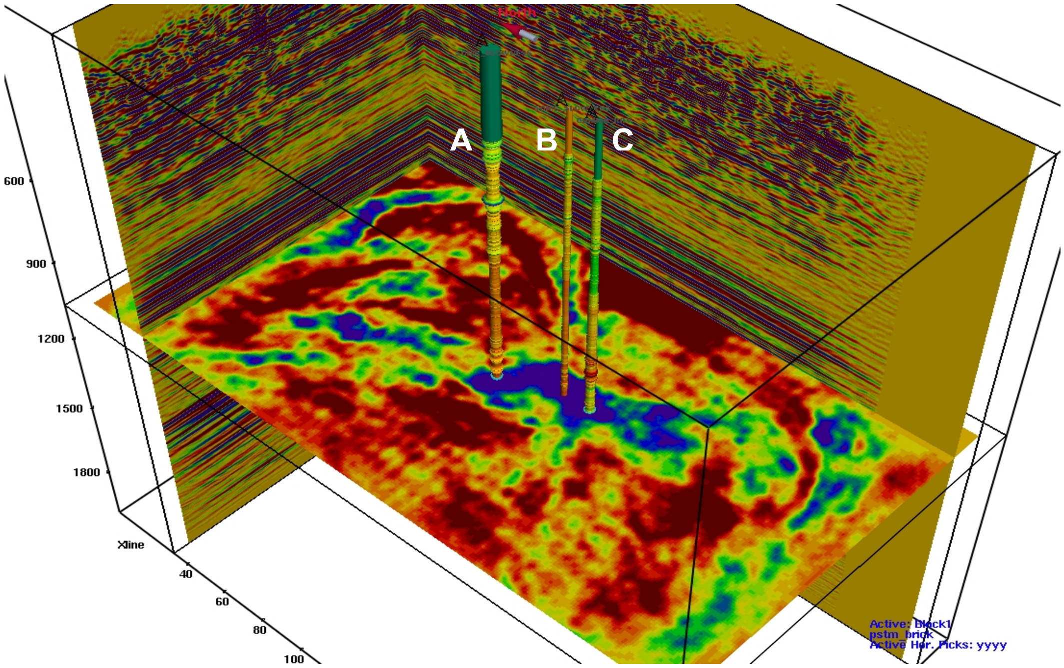

Figure 4. PSTM display with a flattened horizon across the channel system.

To explore the possibilities of whether the reservoir quality can be distinguished we examined P- and S-impedances, Lambda*rho, Mu*rho as well as Vp/Vs ratio. Figure 5 shows inline and crossline sections corresponding to the location of well A. It can be seen that the channel is well defined by the P-impedance. 3D displays show that well B has relatively higher values in P- and especially in S-impedance (Figure 6). They also show that well A has the lowest Vp/Vs ratio.

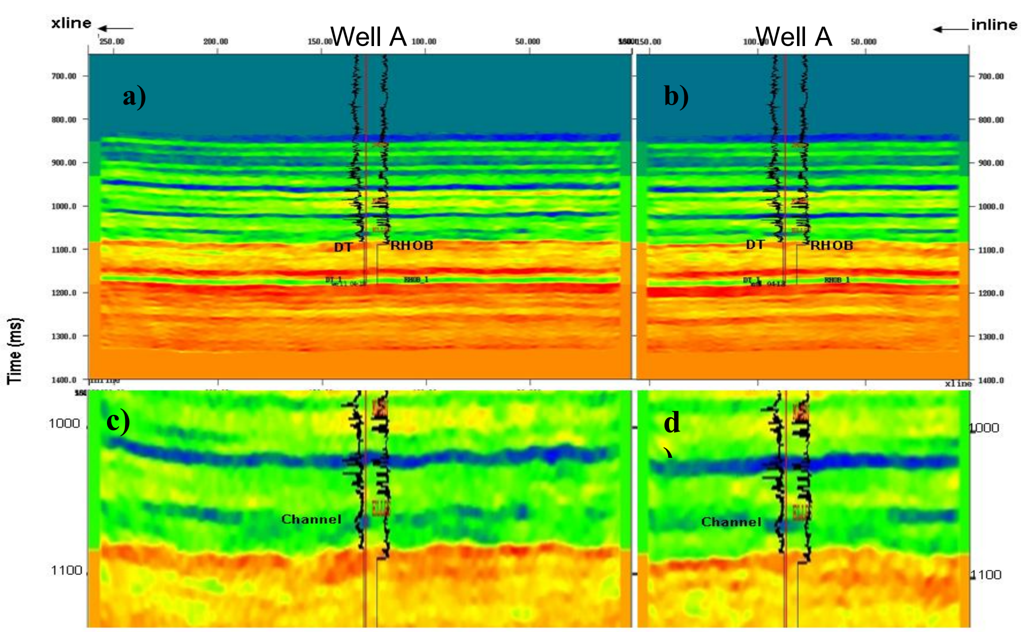

Figure 5. Well ties to inverted P-impedance at the location of well A: a) inline section, b) crossline section, c) and d) zoomed inline and crossline sections at the target zone.

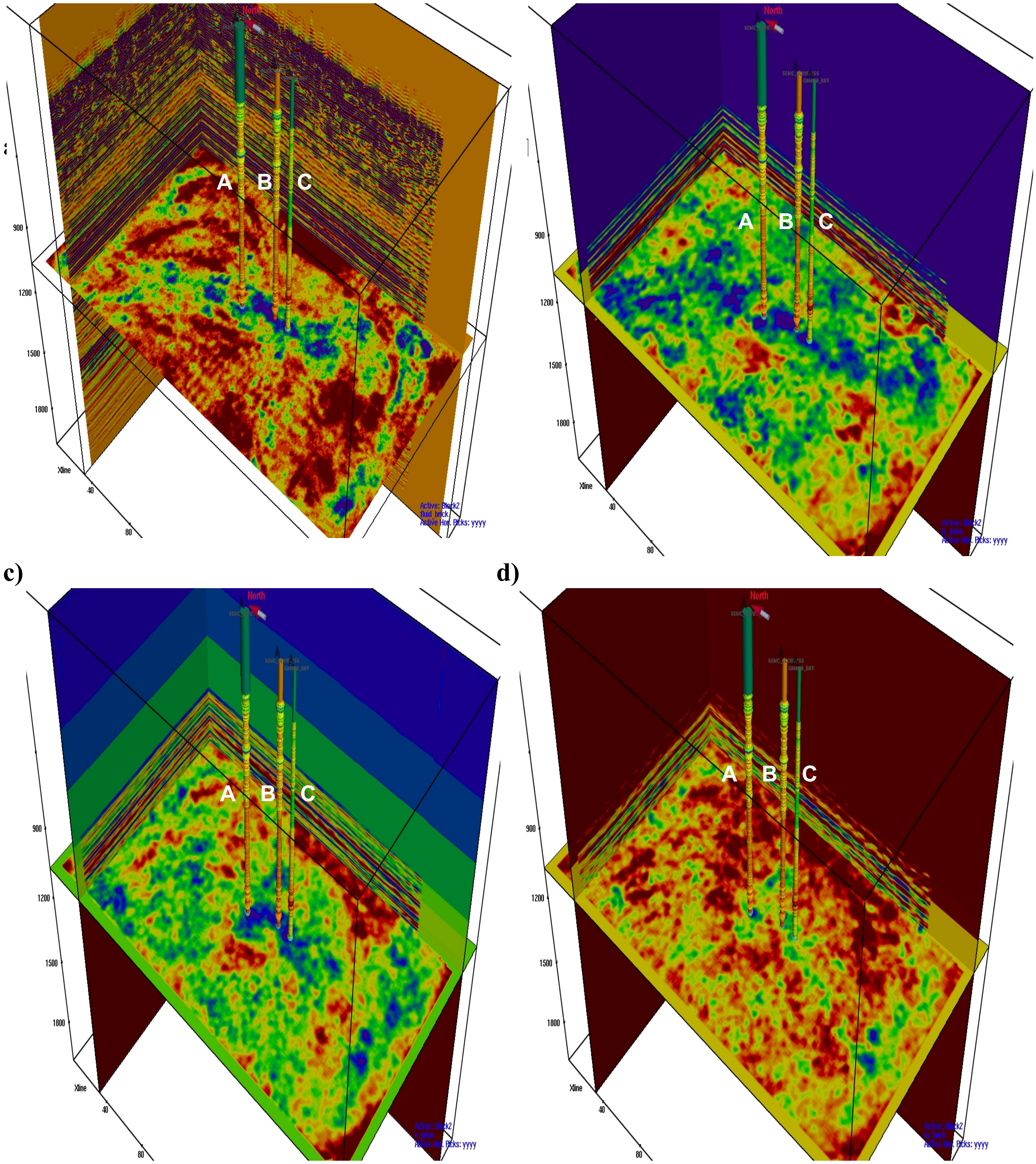

Figure 6. a) P-impedance, b) S-impedance, c) Lambda*rho, and d) Vp/Vs ratio.

3D Visualization of Attributes with Gathers

We present a method to analyze CMP gathers using a pseudo 3D formed by CMP gathers in which 'crossline' is the offset. The pseudo 3D can be displayed with poststack or prestack attributes. One of the advantages of this method is that the amplitude versus offset at a given event can be viewed with a horizon that has constant time in the 'crossline' direction. Figure 7 shows the base map with the original 3D and two pseudo 3Ds corresponding to the inlines and crosslines of the well A. Figure 8 gives an example of 3D visualization of a pseudo 3D. The characters of amplitude versus offset along the line can be identified.

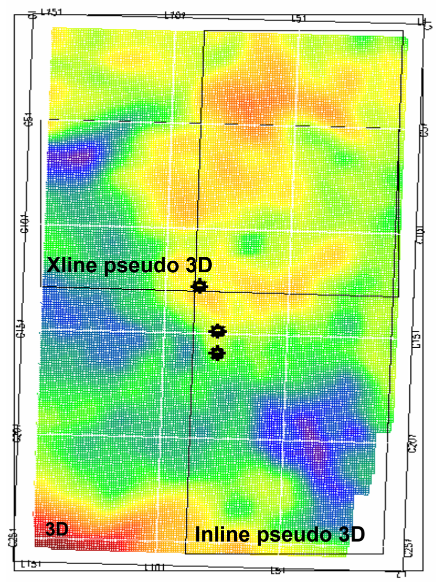

Figure 7. Base map of original 3D with pseudo 3Ds.

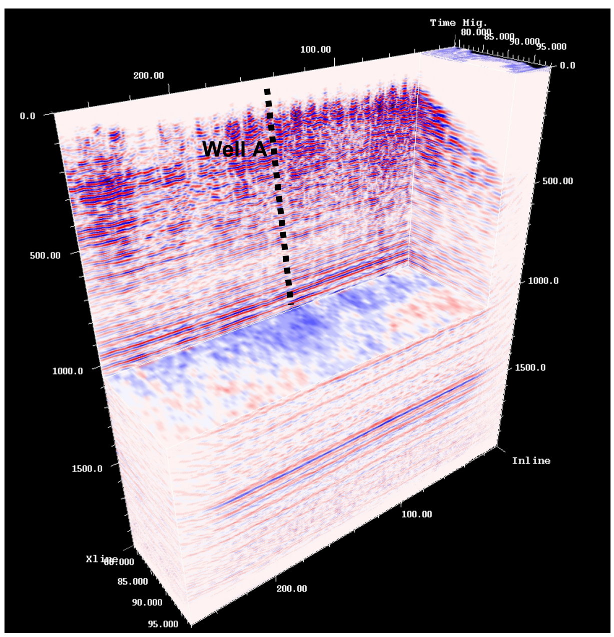

Figure 8. 3D visualization of a pseudo 3D.

Conclusions

A 3D case study has been presented to demonstrate the use of traditional approaches with 3D visualization. A new 3D visualization technique has been proposed to view and analyze seismic attributes and CMP gathers simultaneously. This technique uses the pseudo-3Ds formed by CMP gathers using offset as crossline.

Acknowledgments

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