Reprocessing the East Coast Canada Stonehouse Survey with 3D SRME and Hybrid Layer Tomography PreSDM*

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Abstract

During the original processing of the Stonehouse 3D project through a PreSTM sequence, the biggest challenges were the handling of statics and multiples generated by a very rugose waterbottom. EnCana considered reprocessing the 3D to take advantage of the latest developments in processing technology by using 3D SRME and hybrid layer tomography PreSDM velocity model building to enhance the imaging of the zone of interest below the Base Tertiary.

Introduction

A 2000 km^2 seismic survey was acquired by EnCana offshore Nova Scotia in 2003. CGG (Calgary) processed the volume through PreSTM, finalizing the result at the beginning of 2004. The data had severe problems associated with a hard and rugose waterbottom (Figure 1) that generated strong, "diffracted" multiples (whose apparent moveout could be faster than those of the primaries), and large time distortions even "busts", on primary events. For the multiple issues, CGG used at that time a 2D Surface Related Multiple Elimination (SRME) algorithm. 2D SRME, now an industry-wide standard, was first introduced by Delft University in 1992. The method is a "data-driven" program that uses a form of surface-consistent auto-convolution to predict multiples automatically. This works well as long as the multiples are never from out of the plane, i.e. 2D not 3D, and when the shots and receivers are densely sampled. Within these limitations, the 2D algorithm worked well on this survey in tandem with de-aliased Radon demultiple. Standard frequency-wavenumber-dependent de-noising techniques were then utilized to further suppress the remnant multiples. To lessen the impact of the raypath distortions, modeling was done to produce surface-consistent statics; these were fairly successful in improving the imaging and continuity of the final time result.

The rugose waterbottom and complex sub-seabed stratigraphy in this area of the East Coast severely distort the time image and it was clear from an early stage that the 3D PreSTM would not adequately solve this problem and that PreSDM would be required. In addition, both the 3D and aliasing problems of the free-surface multiple could now be addressed with CGG's newer technology.

3D SRME

Typically, 3D SRME requires a vast amount of pre-stack interpolation and extrapolation, filling every surface location with a shot and receiver that becomes a real data sampling nightmare; the aliasing issues alone make this quite problematic. In 2005, Antoni Pica came up with a completely new way of directly modeling surface-related multiples, utilizing wavefield extrapolation. Last year, David Le Meur presented this new algorithm at the CSEG convention that demonstrated how a migrated section starts the process, and acts as the reflectivity model for the survey. Each shot acts as an aerial source and is propagated down through the model, and then extrapolated back to the surface, thereby generating all orders of multiples in one pass. The resultant model is then subtracted from the same shots, after an adaptation for phase and amplitude errors. Since each shot is essentially processed independently, the algorithm is extremely efficient, making survey size and acquisition problems fairly irrelevant. The results of 2D and 3D SRME are compared in Figure 2 where the benefit of applying 3D SRME to attenuate severe 3D rugose WB multiple contamination is apparent.

Consequently EnCana contracted CGG to reprocess the survey, ultimately through PreSDM. It was expected that primaries would be correctly imaged without the application of aggressive denoising techniques, thereby preserving a broader bandwidth and relative amplitudes for more faithful rock property extraction.

3D PreSDM

To meet EnCana's deadline commitments, Velocity Model (VM) building was started while the data was being processed through the 3D SRME flow. When the new data was available, it was used in the subsequent iterations of the VM building stages.

In the 2003 processing after 2D SRME and prior to PreSTM, several processing techniques were used in the offset domain to "clean" the data of residual multiple interference. These along with a low frequency emphasis de-signature, suppressed the recorded high frequency bandwidth of the data below the first waterbottom multiple. These processes were not used during PreSDM reprocessing and as a result, the data has a more balanced, broad-bandwidth character.

Due to the rugose waterbottom and existence of large, lateral velocity contrasts just below the waterbottom several iterations were required to get a good VM in the Tertiary layer. Once the VM was optimized for this layer, a hybrid approach was used to freeze the VM above the Base Tertiary and then allow the tomographic update to invert for the velocities below. This technique was also used to update subsequent deeper layers below the Base Cretaceous.

After each iteration gathers, stacks and velocity fields were QC'd to meet stringent image improvement criteria. Furthermore the stacks were converted back to time to be compared with previous PreSTM processing (Figure 3 and Figure 4).

Conclusions

A significant improvement in image quality and resolution was achieved through the application of new 3D SRME methods and other de-multiple strategies. The data's broad bandwidth and relative amplitude was preserved through a 3D hybrid layer tomography PreSDM flow. The resulting gathers and stacked structural image are now fully optimized for further AVO/LMR inversion and quantitative interpretation methods to be shown.

Acknowledgements

References Cited

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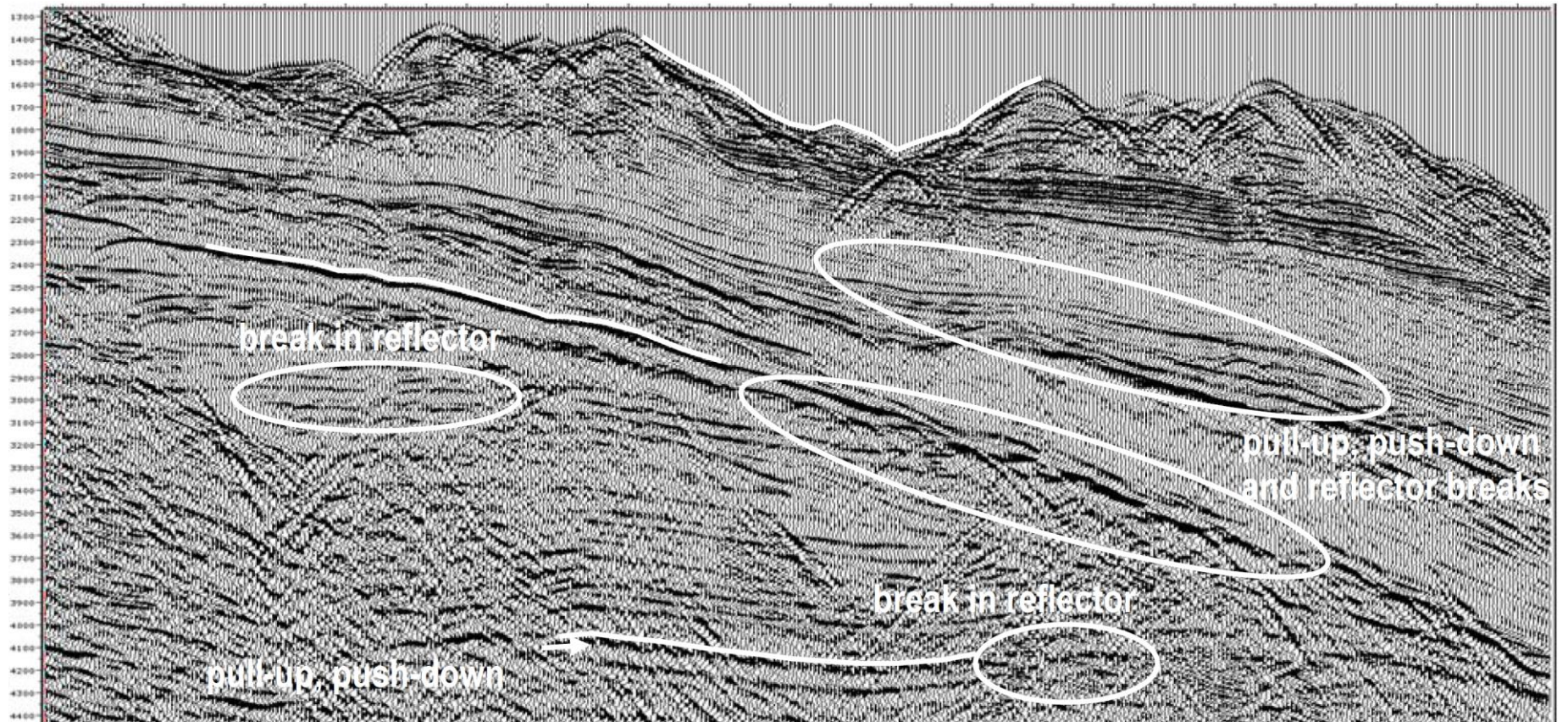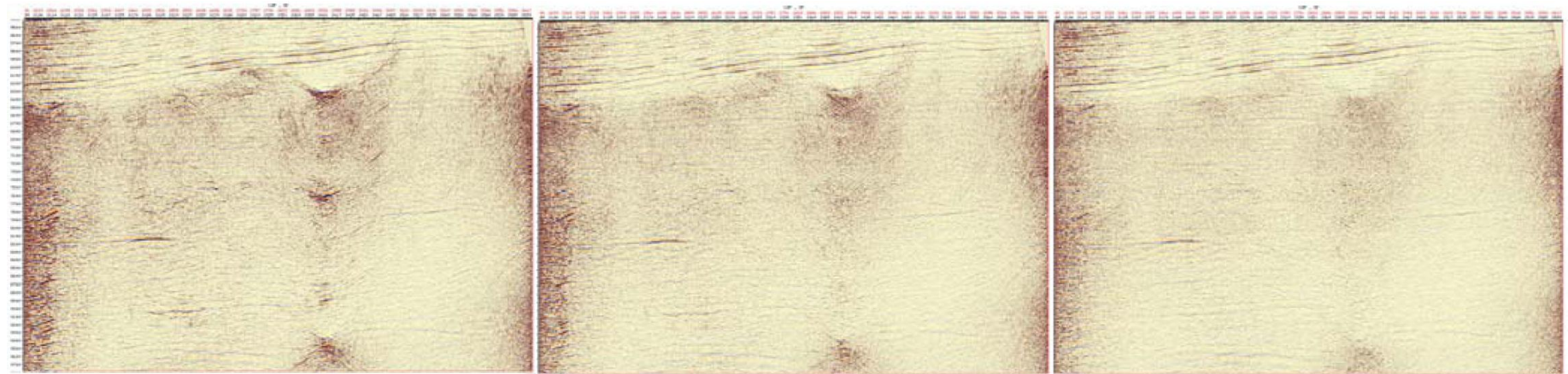
Figure 1. Original seismic inline illustrating the rugosity of the sea floor and its impact on the time image that cannot be solved by 3D PreSTM but requires 3D PreSDM.
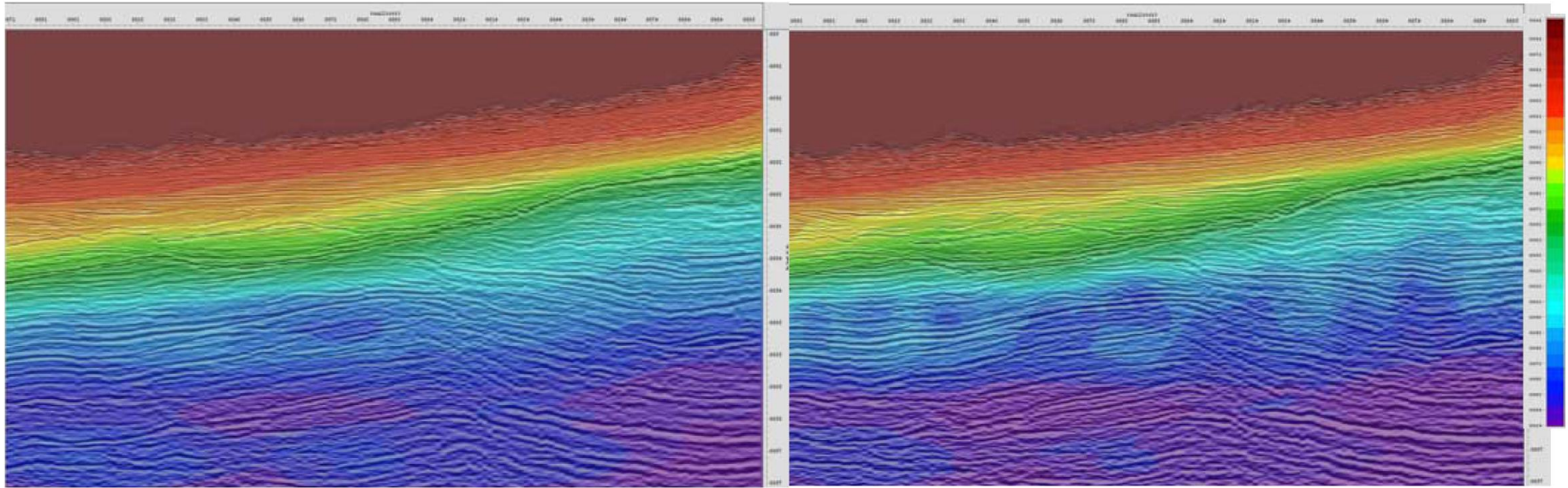
Input Stack **2D SRME** **3D SRME**

Figure 2. Input stack and 2D vs. 3D SRME comparisons showing progressive reduction of multiple contamination.

2nd iteration PreSDM velocity model   3rd iteration PreSDM velocity model

Figure 3. Comparison between 2nd and 3rd iteration interval velocity fields from PreSDM model building, overlaid on stacked inline showing increase in spatial variability and improved structural conformance.

0s

2.0s

4.0s

6.0s   (a)   (b)
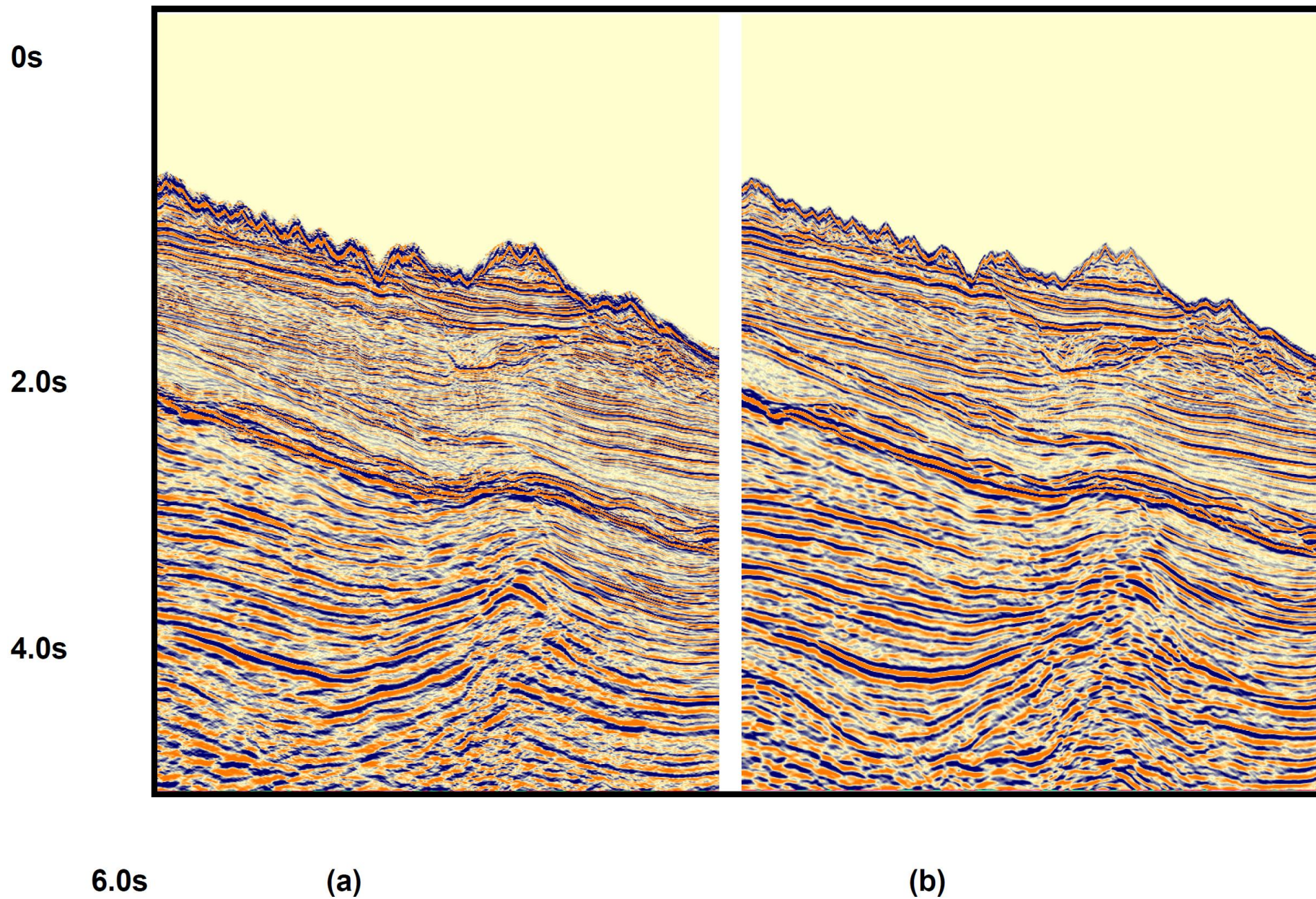
Figure 4. An inline Stack. (a) PreSTM, and (b) PreSDM converted to time.