Seismic processing with downward continuation to mitigate near-surface/subsurface anomalies

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Summary

During onshore seismic data processing, we observe local anomalies at the surface and at the subsurface affecting time and depth imaging. An example of such local anomalies are overburdens with thin velocity layers (local anomalies) that significantly distort the wave field propagating downward. Some of these local anomalies cannot be resolved by production seismic tomography and seismic. In the case of thin layers with abrupt velocity changes, the velocity and thickness of these thin layers cannot be decoupled by inversion or tomography. The local anomalies negatively impact the final imaging result. We address the surface and near-surface local anomaly effect on processing, by downward continuing the wavefield to the top of the anomaly and applying residual static corrections. The method can be applied sequentially to deeper levels, if such anomalies exist at these levels.

Introduction

In this study we present an approach dealing with overburden thin layers. The detrimental impact of Eocene channels (Padmos et al. 2010), or carbonate Karst collapse (Hardage, 2002), affects the seismic imaging, seismic waveform and fluid/lithology response. Furthermore the local anomalies of overburden are not restricted to land data. A similar problem was highlighted for deep-water top of salt rugosity by Etgen et al. (2014) and by Hu et al. (2015). A traditional processing approach to deal with this problem is to allow only near-angles passing through these layers, leading to the same problems as noted above. If no angle limiting is done, the gathers might give the appearance of apparent anisotropy, which leads to exaggerated anisotropic parameter corrections. See Lau/Yin (2003) and (2017).

Method

We processed a 2-D onshore line acquired on the Eagle Ford trend. This 2-D line has shot spacing of 82.5ft, CMP spacing of 41.25 ft and 480 shots. The elevation range of this 2-D seismic data acquisition is 650-750 ft. The 2-D line was processed in two ways. First, we processed the 2-D line from floating datum, as done in production seismic processing. Separately, we downward continued the shot gathers to a flat elevation of 600 feet, we applied residual statics in the 200-1000 ms area and we continued the processing with the same steps but with different parameters, as we did for processing from floating datum. The production seismic processing started with first arrival picking/tomostatics/refraction residual statics, continued with predictive deconvolution, followed with three passes of stacking velocity picking and reflection residual statics. The final processing steps were the migration velocity picking and the prestack time migration. Separately, we downward continued the shot gathers to a flat elevation of 500 ft, we applied residual statics in the 200-1000 ms two-way traveltime range and we continued the processing with the same steps but with different parameters, as we did for the processing from floating datum. The seismic imaging differences between the two processing results are shown in Figures 1, 2 and 3. Figure 1 shows the stack processed from floating datum on the left and the stack processed from downward continued data on the right. The stack quality is improved on the downward continued processed data set, in particular below 500 ms. In Figure 2, we show a seismic horizon interpretation picked unambiguously on the downward continued processed data set, while it is more difficult to pick and interpret on the data set processed from floating datum. Figure 3 demonstrates the difference in imaging quality deeper than 1000 ms. In particular for the interval 1200-1600 ms, the downward continued processed seismic data set shows a definite imaging quality improvement for both fault imaging as well as stratigraphic imaging. The structural and stratigraphic imaging quality difference is more evident on a subset of the stack as shown in Figure 4. A major factor in the improved imaging quality of the downward continued processed seismic data set is the significant improvement in the stacking velocity analysis as is evident from Figure 5.

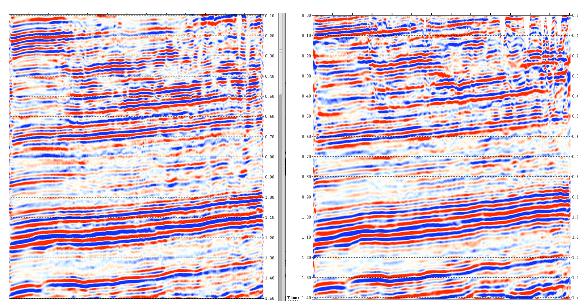

Figure 1: Comparison of stacks from the production processed from floating datum data set (left) and from the downward continued processed data set (right).

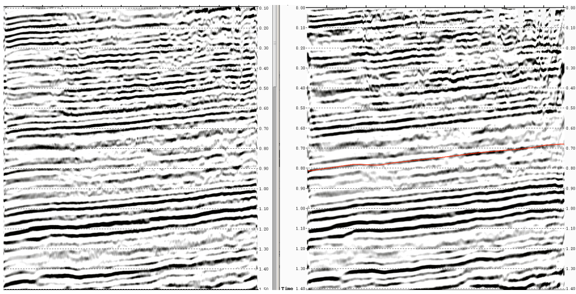

Figure 2: Comparison of horizon picking on the downward continued processed seismic data set (right).

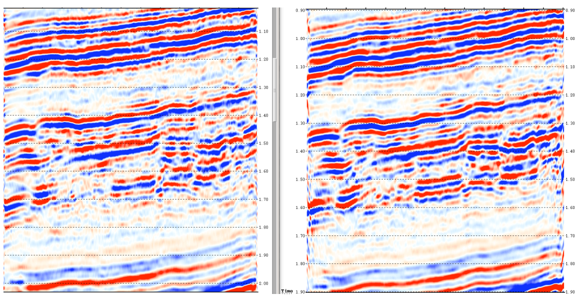

Figure 3: Comparison of structural and stratigraphic imaging for the production processed from floating datum stack (left) as compared to the downward continued processed stack (right).

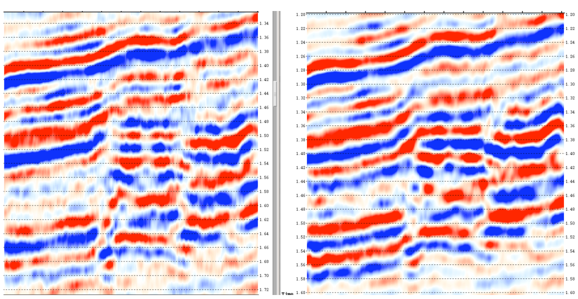

Figure 4: Detailed comparison of the structural and stratigraphic imaging between the production processed from floating datum (left) and the downward continued processed stack (right).

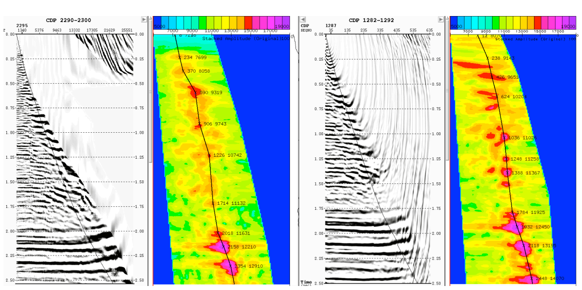

Figure 5: Stacking velocity analysis of the production processed data set (left) and the downward continued processed data set (right).

Conclusion

Overburden creates wavefield distortions due to thin beds that could not be resolved by inversion or tomography. Without mitigating the overburden effect of thin beds, the image could be distorted and gives incorrect structural and stratigraphic interpretation or even cycle skipping. We propose using a combination of downward continuation to top of anomaly and applying residual static. While this is computationally expensive, it does alleviate the imaging error.