geoconvention
Virtual Event
September 13 - 15 2021

AVO Compliant Processing - Common Pitfalls

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Summary

In any project, there are many considerations when performing amplitude preserving (AVO Compliant) processing. This "Back to the Basics" talk will focus on some of the pitfalls commonly encountered during AVO Compliant processing and how to effectively QC the data to avoid these pitfalls and ensure proper preservation of amplitudes.

Theory

Any AVO compliant processing workflow must preserve the amplitude variation across offset associated with differences in lithology and fluid content. Thus any step in the processing workflow must not be applied in a trace to trace manner. In conventional, or non-AVO processing, where preserving any AVO response is not the primary goal, trace to trace processes are used often and can be very effective. Trace to trace mean scaling, AGC and trace to trace spectral whitening are some of the common processes applied in a conventional workflow. A trace to trace process, such as an AGC or trace to trace mean scaling, only operates on the single trace they are being applied to. Any variation in amplitude across offset will therefore not be preserved, as the goal of these trace to trace processes is to make all amplitudes within a window the same. Figure 1 (left) shows a synthetic CDP gather with several constant amplitude horizons, and three horizons at 1000, 1500, and 2000ms with noticeable AVO effects. Figure 1 (middle) shows the same synthetic gather but with a 200ms AGC applied. Notice how the AVO response has not been preserved, as the AGC has made the amplitudes at near and far offset very similar. Figure 1 (right) is the same gather with trace to trace mean scaling applied. Again, the amplitude variation across offset has not be preserved. Although effective in attenuating noise and scaling the data appropriately, trace to trace processes must not be used in any part of an AVO compliant processing flow.

Great care must be taken to remove as much noise as possible during any AVO compliant processing flow. A balance must be struck between removing as much noise as possible, while at the same time not removing any signal. The presence of too much noise will distort the AVO response, while the removal of too much signal in order to attenuate the noise will also distort the AVO response. Near offset and near angle data are particularly important for the determination of any AVO effect. Unfortunately, it is common for near offsets to be highly contaminated with noise. Great care must be taken to remove all the noise at near offsets, while still preserving all the signal which will contribute to the AVO effect. This is particuarly important at low frequencies, as it is the low frequencies that anchor the AVO inversion. Figure 2 (top) shows a shot gather, sorted by offset, of a 3D survey. Notice the noise at near offset that contaminates the record. Figure 2 (middle) shows the same shot gather after a pass of AVO compliant noise attenuation, while Figure 2 (bottom) is the difference between the two. At first glance, this noise attenuation looks to be successful in removing the noise while still preserving the underlying signal. However, if we filter the data and only look at the low frequencies between 0 and 30 Hz, we see that the noise attenuation has actually attenuated much of the near offset signal. Figure 3 (top) and 3 (middle) are the same as Figures 2 (top) and 2 (middle), this time with a 30Hz high cut filter. Notice how the near offsets do not have good continuity of the underlying low frequency signal. If a different noise attenuation is preformed which takes more care in preserving the near offset signal, the continuity of the signal can be seen back to the nearest offset. Figure 3 (bottom) shows this noise attenuation which has preserved the near offset signal.

Conclusions

AVO compliant processing is always a balancing act between removing as much noise as possible, while at the same time preserving the true amplitude of the signal. Two common areas where pitfalls can be encountered are in the appropriate scaling of the data, and in the removal of the noise. Any trace to trace processes must not be used during an AVO compliant processing flow, as they can alter the AVO response. Noise attenuation, particularly at near offsets and low frequencies, can be challenging. By QCing the data in such a way to isolate the near offsets and low frequencies, an AVO compliant processing flow can ensure that the noise is effectively removed while preserving the amplitude of the underlying signal.

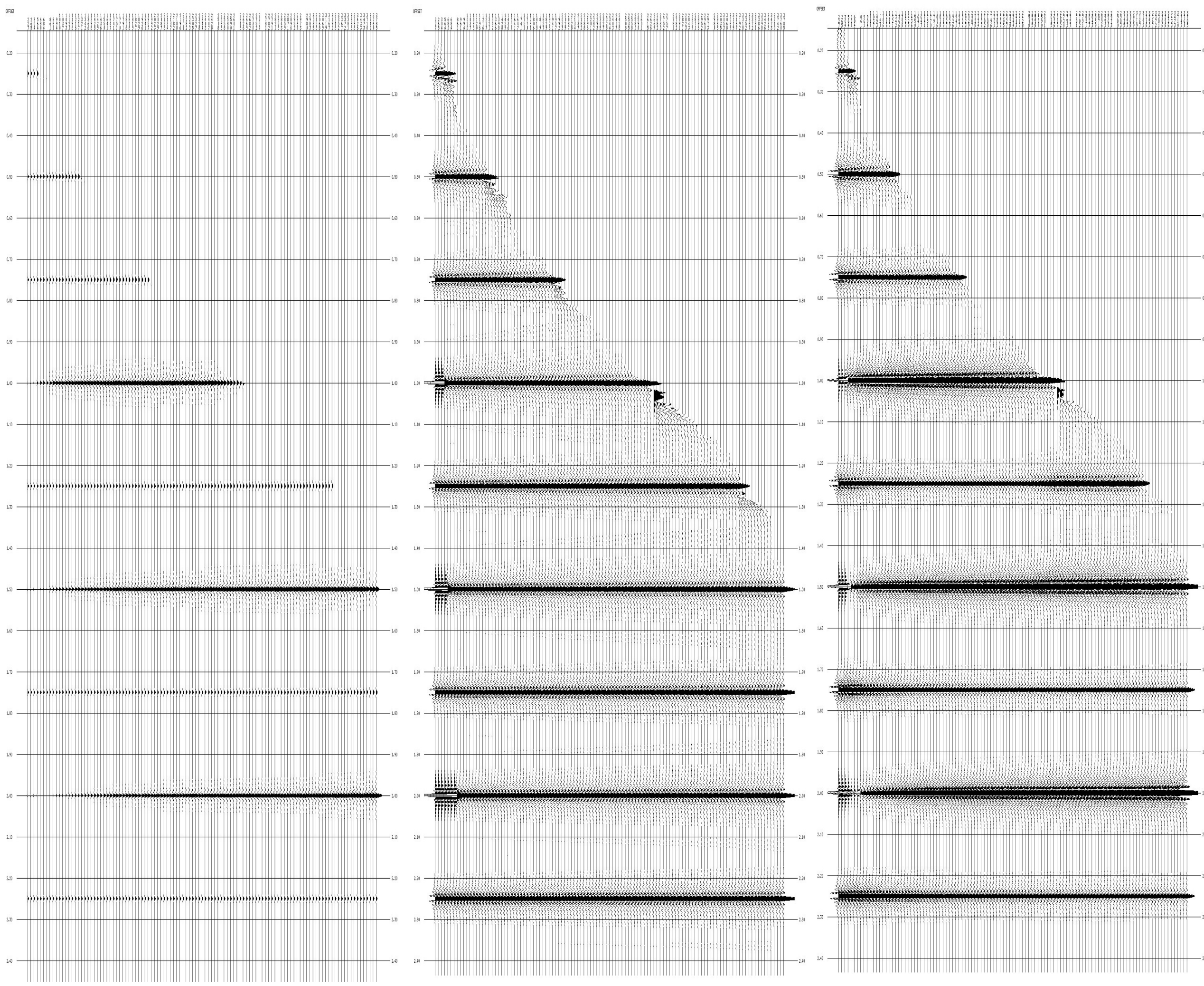

Figure 1: Synthetic gather without scaling (left), after AGC (middle), and after mean scaling (right).

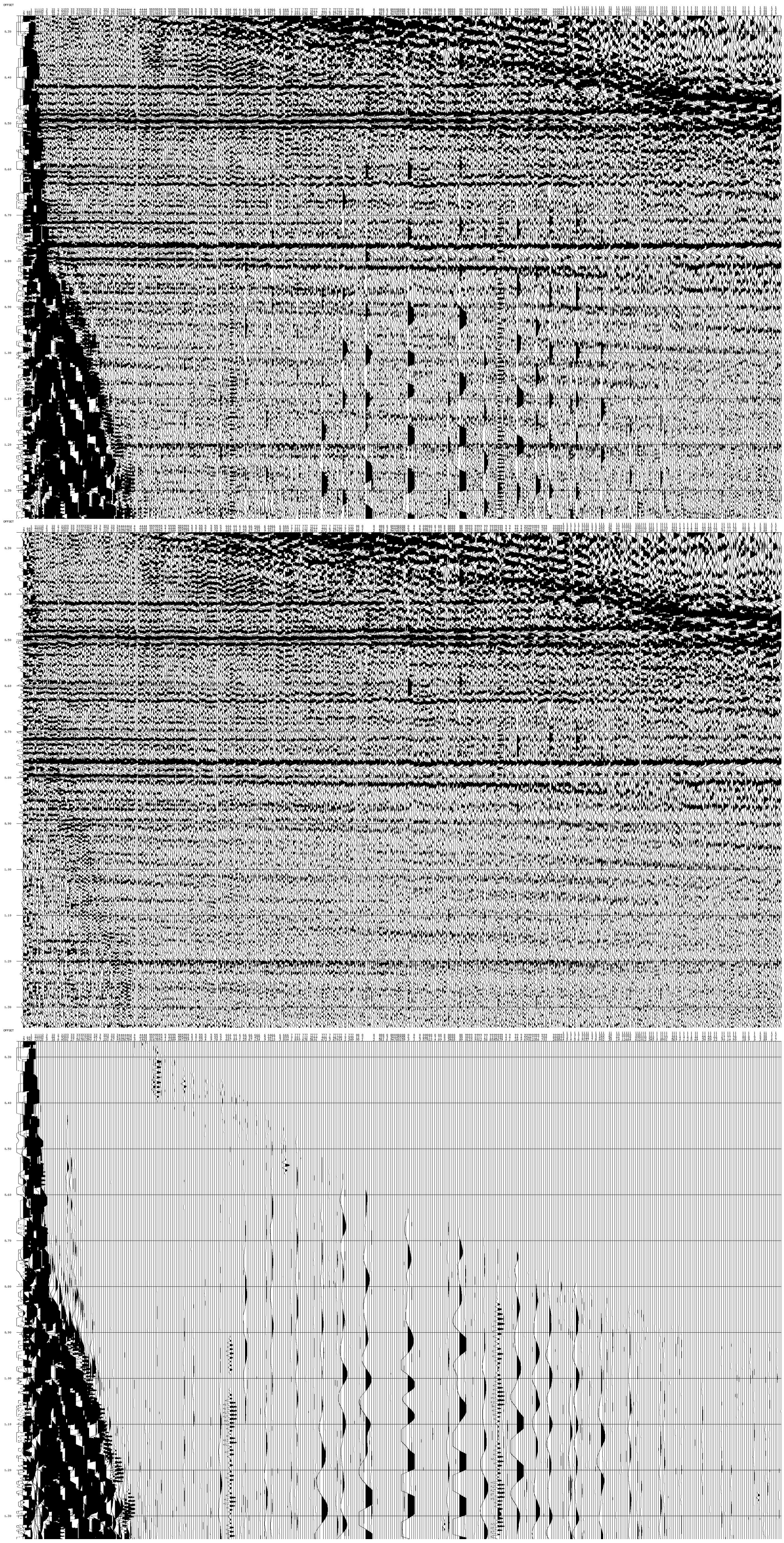

Figure 2: A shot gather on input, after non optimal AVO compliant noise attenuation, and the difference. At first glance this noise attenuation appears to preserve the underlying signal.

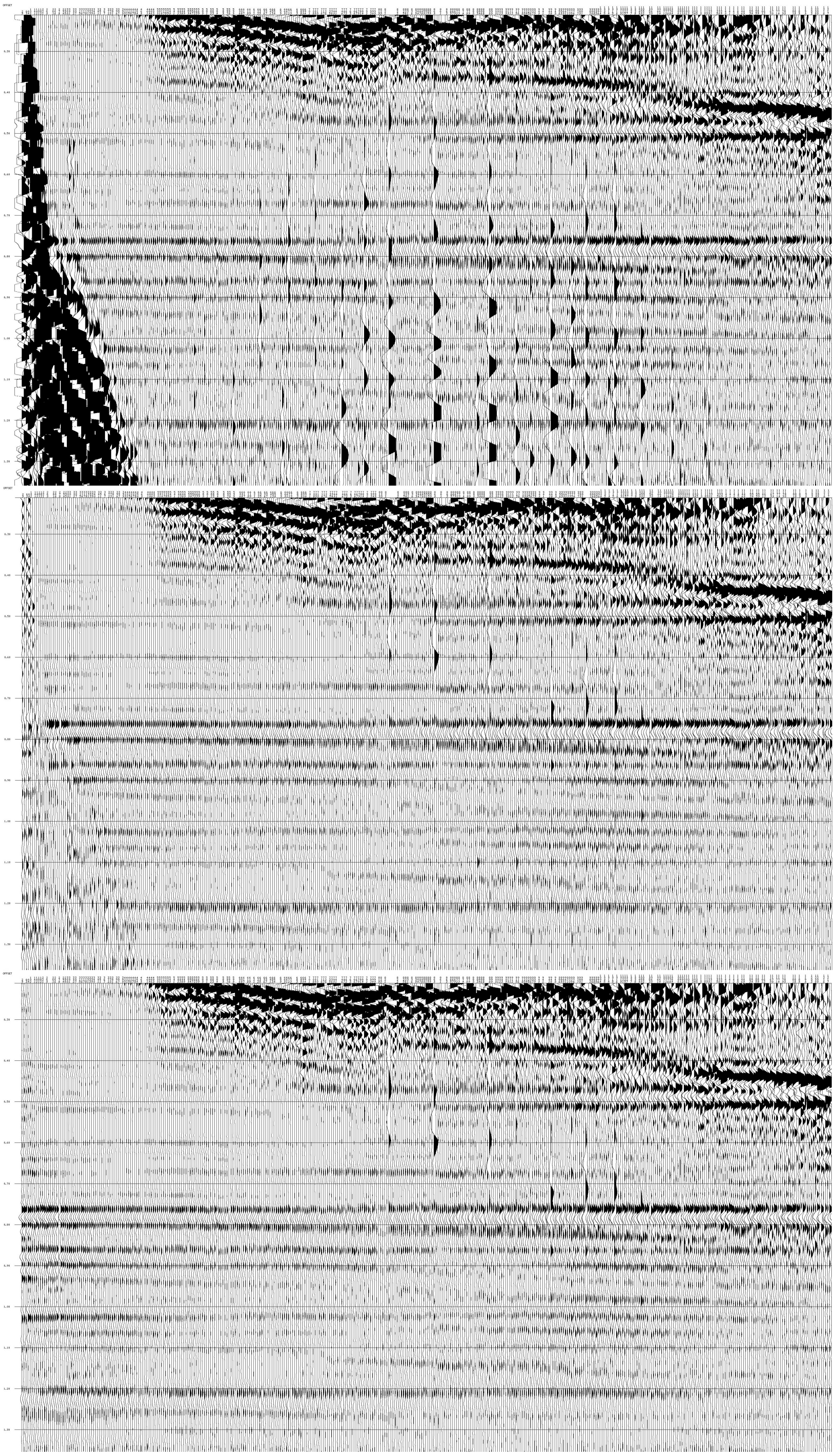

Figure 3: A filtered shot gather on input, after non optimal AVO compliant noise attenuation, and after optimal AVO compliant noise attenuation. Note that the non optimal AVO compliant noise attenuation resulted in signal distortion at near offset that was not visible in difference displays, while the optimal AVO compliant noise attenuation better preserves the near offset signal.