Should one honor or ignore polarity during gather flattening?

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Summary

Trim statics applications of the previous era which aligned peaks to peaks have been all but forgotten and replaced with more modern gather flattening methods. While polarity blind methods preserve class2 AVO, polarity sensitive methods provide more powerful alignment of gathers reminiscent of the powerful trim statics of the past.

Introduction

Prior to the advent of surface consistent statics methods in early 1980's, trim statics programs were used as a method to increase stack quality. With the reliability of emerging commercial surface-consistent statics methods, trim statics fell out of favour in the geophysical industry.

The need for gather flattening in conjunction with imaging and AVO became apparent around the year 2000 (Hinkley, 2004). We presented a few papers on the subject illustrating one such method that preserves class2 AVO (Gulunay et al, 2007a, 2007b, and, 2008). This method made the alignment process polarity blind in order to achieve that property. Such a process could align troughs to peaks if need be.

The need to apply such a process to Multi Azimuth (MAZ) gathers (processes in which three or more Narrow Azimuth (NAZ) surveys were merged on the same common midpoint gather) also became apparent along with the need for stronger alignments (i.e. the alignment of peaks-to-peaks and troughs-to-troughs). This paper describes the illustration of such a process on three different surveys. We call this method polarity sensitive flattening.

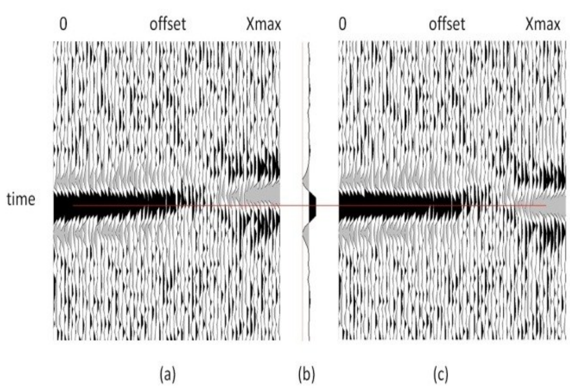

Figure 1a) Synthetic gather with Class 2 AVO anomaly b) Near offset stack c) After polarity blind gather flattening

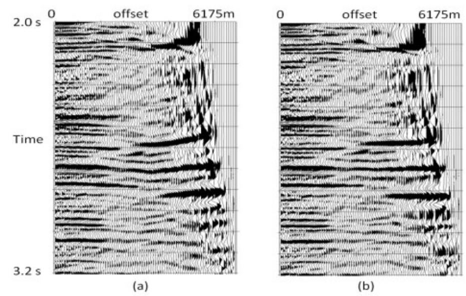

Figure 2a) Image gather with large RMO **b)** Gather after 5-trace polarity blind alignment

Polarity Blind versus Polarity Sensitive Gather Flattening

A gather flattening method that preserves class 2 AVO was illustrated in Gulunay et al (2007a) showing a synthetic gather (Figure 1a) in which one event with amplitude variation, polarity reversal, and residual moveout is present among some added random noise. This method, with the use of absolute values in cross correlation, was able to push down the far offsets, properly preserving class 2 AVO (Figure 1c), despite the use of a pilot trace to derive the statics (Figure 1b) that resembles only the inner offsets. This polarity blind gather alignment method was later illustrated by Gulunay et al (2007b, 2008) on real data in which both 2-trace event tracking and 5-trace tracking algorithms were used in lieu of correlating traces to a pilot stack. The algorithm consisted of t-x domain moveout mapping followed by moveout editing and moveout application using 3-point quadratic interpolators. The moveout map was obtained by tracking event wavelets from offset to offset at each time sample. This process was used successfully in the following years with some modifications. Figure 2 presents a typical run on a gather. The quality of gather flattening on such gathers is excellent.

MAZ data example and Polarity Sensitive Gather Flattening

Then came the time when we applied such a method to MAZ surveys recorded in the Mediterranean Sea, where three or more NAZ surveys were combined in super gathers to be stacked. Such super gathers contain large jumps from azimuth to azimuth in need of correction before being stacked as short (spatial) period statics. In this case the polarity blind gather flattening method left a lot to be

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desired from the alignment process, as the magnitude of statics from trace to trace was quite large and troughs were sometimes misaligned with peaks. We then tried a polarity sensitive flattening method using signed cross-correlations which align peak to peak and trough to trough with better results. This form of our method is similar to standard trim statics, except that we derive statics by event tracking (or by statics calculation with respect to a reference stack) at every time sample, create and edit a moveout map from them, and then apply statics at every time sample using this moveout map. In the standard trim statics methods statics are calculated only for a small number of time gates. As one can see from the example given in Figure 3, for a narrow azimuth gather this moveout mapping approach results in better alignment of events.

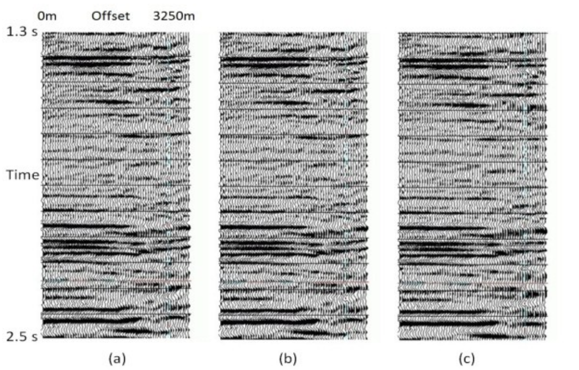

Figure 3a) input gather **b)** Standard trim statics **c)** Trim statics at every time sample using moveout mapping

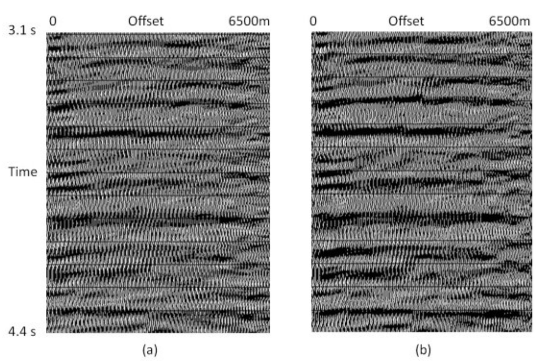

Figure 4a) A MAZ gather made of 3 NAZ surveys **b)** Same gather after polarity sensitive alignment

We show, in Figure 4a, a MAZ gather which exhibits the standard jitter that is created by merging three azimuths in the same offset sorted gather. Figure 4b shows the same gather after polarity sensitive short period alignment. This was achieved by using signed cross correlations, using a 5-trace running space window (Gulunay 2007b) to track event times to create the moveout map, subtracting the spatially smoothed version of the moveout map to keep only short spatial period components and then applying them. We see that at many locations alignment of different azimuths is achieved.

The stacks of the gathers before and after such polarity sensitive flattening of MAZ gathers are shown in Figures 5a and 5b respectively. Increase in stack amplitude due to better alignment of azimuths is evident from the comparison of these two stacks.

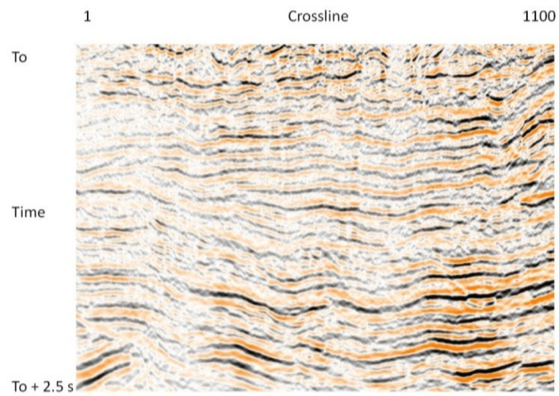

Figure 5a Stack of MAZ gathers before polarity sensitive alignment of different azimuths (3 azimuths are used)

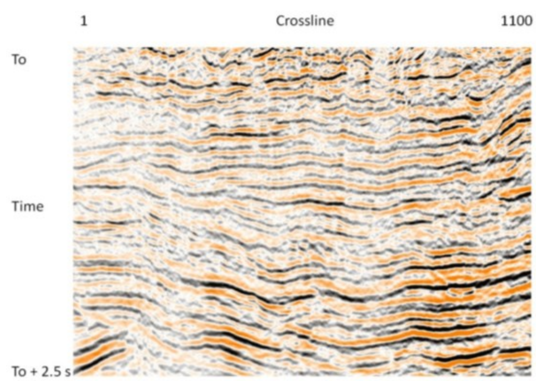

Figure 5b Stack of MAZ gathers after polarity sensitive alignment of different azimuths (3 azimuths are used)

Controlled Beam Migration Example

Migrated gathers generally need moveout alignment despite the efforts made in improving velocity models. In Figure 6a we show three gathers from a common offset vector (COV) domain Controlled Beam Migration (CBM). Note the jitter on these gathers. Figure 6b shows the same gathers after polarity sensitive alignment. Observe that most of the jittering is corrected. Stacks before and after polarity

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sensitive alignment are shown in Figures 7a and 7b respectively. These show increase in stack amplitudes at many locations as well as better fault definition.

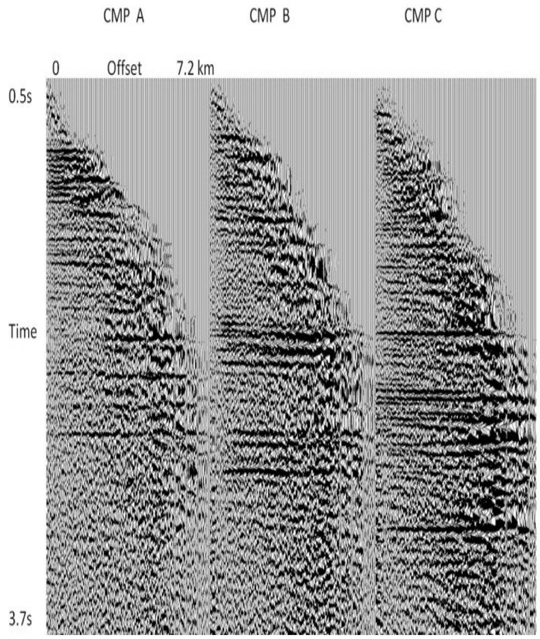

Figure 6a Three image-gathers from COV domain CBM

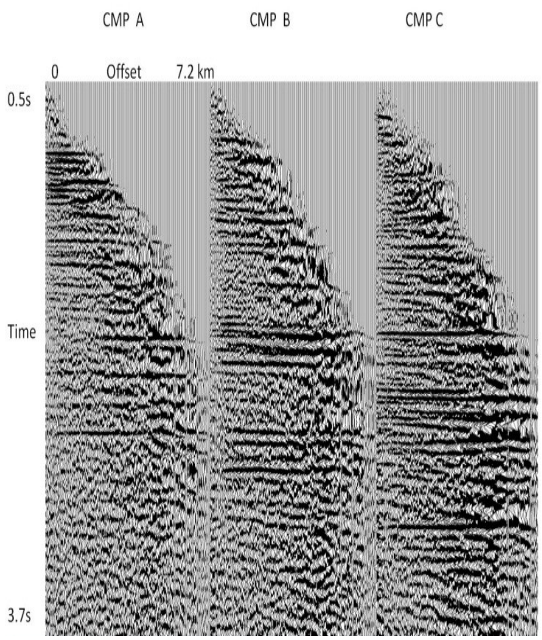

Figure 6b Gathers after polarity sensitive alignment

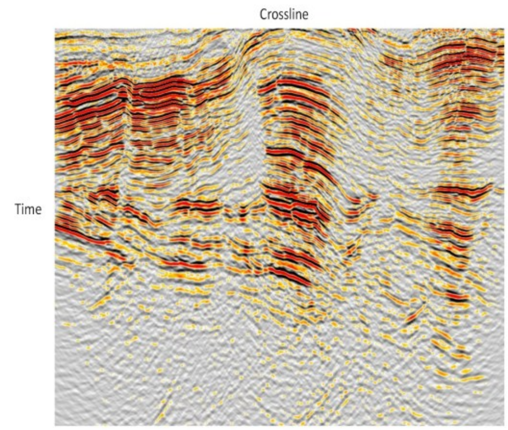

Figure 7a Stack of image gathers from COV domain CBM

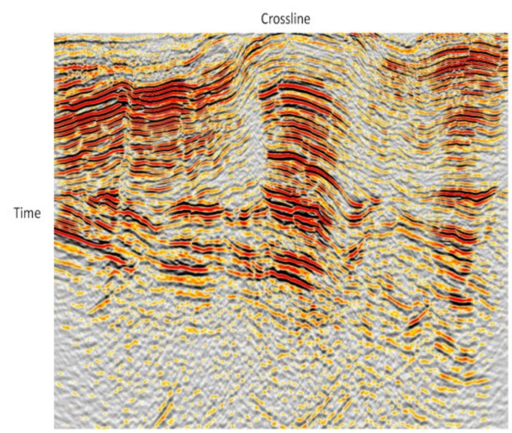

Figure 7b Stack after polarity sensitive alignment

Land data set example

Here, in Figure 8a, we show some naturally noisy land gathers. The gathers have jitter causing degradation of the stack quality. Figure 8b shows the same gathers after polarity sensitive gather alignment. Here we used the same short period alignment method that was described above for the CBM gather example. Stacks of the gathers before and after polarity sensitive gather alignment are shown in

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Figures 9a and 9b respectively. Increase in stack quality especially in deeper horizons is evident.

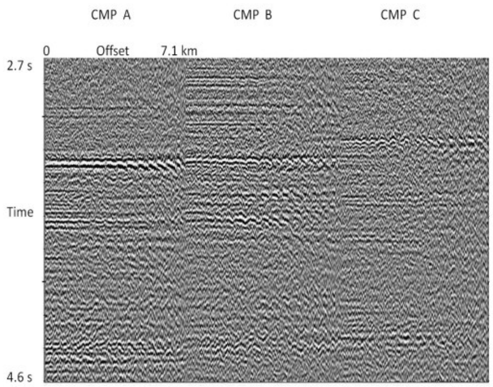

Figure 8a Three image-gathers from land PSTM

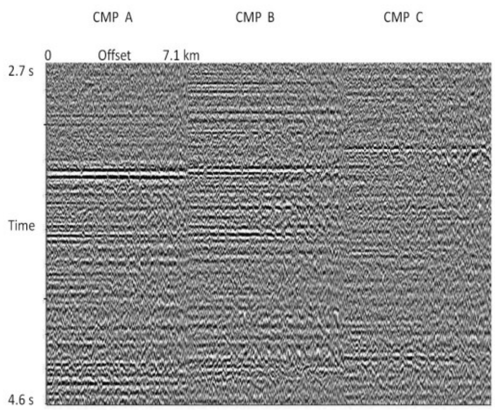

Figure 8b Same gathers after polarity sensitive alignment

Conclusions

Gather flattening recently became a necessity for better stacking of image gathers as well as for successful AVO analysis. As AVO analysis requires an AVO friendly gather flattening method, our earlier developments on gather flattening used a polarity blind method, where the absolute value of the cross-correlation function was used, so that class 2 AVO effects could be preserved. The alignment needs of MAZ gathers, as well as noisy land data, led us to investigate and develop the polarity sensitive gather flattening presented in this paper. We find the use of polarity sensitive alignment in gather flattening to be a powerful method of increasing the quality of stacks. So whether or not one should honor or ignore polarity during gather flattening depends on whether one has good signal and a clear AVO signature and whether or not one wants to preserve that signature.

Acknowledgements

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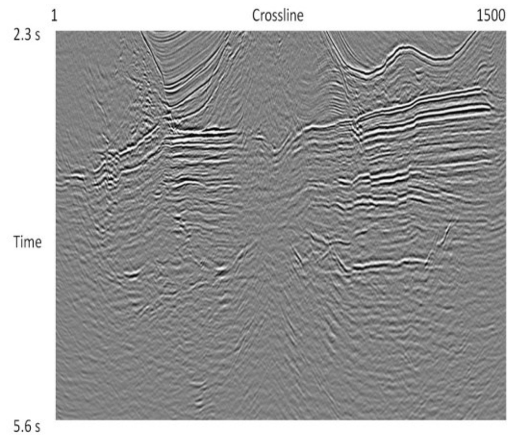

Figure 9a Stack of image gathers from land PSTM

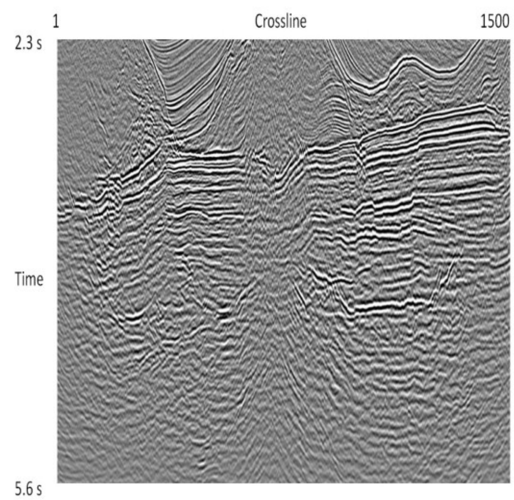

Figure 9b Stack after polarity sensitive alignment

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EDITED REFERENCES

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REFERENCES

Gulunay, N., F. Gamar, H. Hoeber, M. Dyce, C. MacKenzie, D. Whitcombe, 2007a, Robust gather flattening: 77th Annual International Meeting, SEG, Expanded Abstracts, 229–233.

Gulunay, N., M. Magesan, and, H. Roende, 2007b, Gather flattening: The Leading Edge, **26**, 1538–1543.

Gulunay, N., M. Magesan, and, H. Roende, 2008, Gather flattening based on event tracking for each time sample: 70th Conference and Exhibition, EAGE, Extended Abstracts, P066.

Hinkley, D., G. W. Bear, and C. Dawson, 2004, Prestack gather flattening for AVO: 74th Annual International Meeting, SEG, Expanded Abstracts, 271–273.