Improving the Image: 5D Interpolation and COV Gathering of a MegaBin™ Survey

Darren P. Schmidt*, David Gray, Xinxiang Li, Daniel Trad, and Jon Downton
CGGVeritas, Calgary, Canada
darren.schmidt@cggveritas.com

Summary

Using new processing technologies, it has become possible to improve the images and usefulness of MegaBin™ 3D seismic surveys shot in areas of limited structure such as the Western Canadian Sedimentary Basin (WCSB). Two technologies are examined here: 5D interpolation and pre-stack time migration (PreSTM) of Common Offset Vectors (COV's). MegaBin surveys are designed to be interpolated. The new 5D interpolation method allows the interpolation of these surveys pre-stack, preserving azimuthal and offset amplitude variations. Thus it is a natural extension to the MegaBin processing workflow. This technology is tested on a well-shot 3D seismic survey from the WCSB, where the data can be decimated to produce a MegaBin geometry. These decimated data are then interpolated and compared to the original data, both post-stack and pre-stack. COV's are natural tools that allow the maintenance of azimuth and offset information through migration. They are used on wide-azimuth surveys, such as a MegaBin, in order to retain the azimuth and offset information for later azimuthal analysis, such as seismic fracture detection. The migration of COV's is tested on this dataset to make certain that this technology, especially when combined with 5D interpolation, produces images that are comparable to those generated by conventional PreSTM.

Introduction

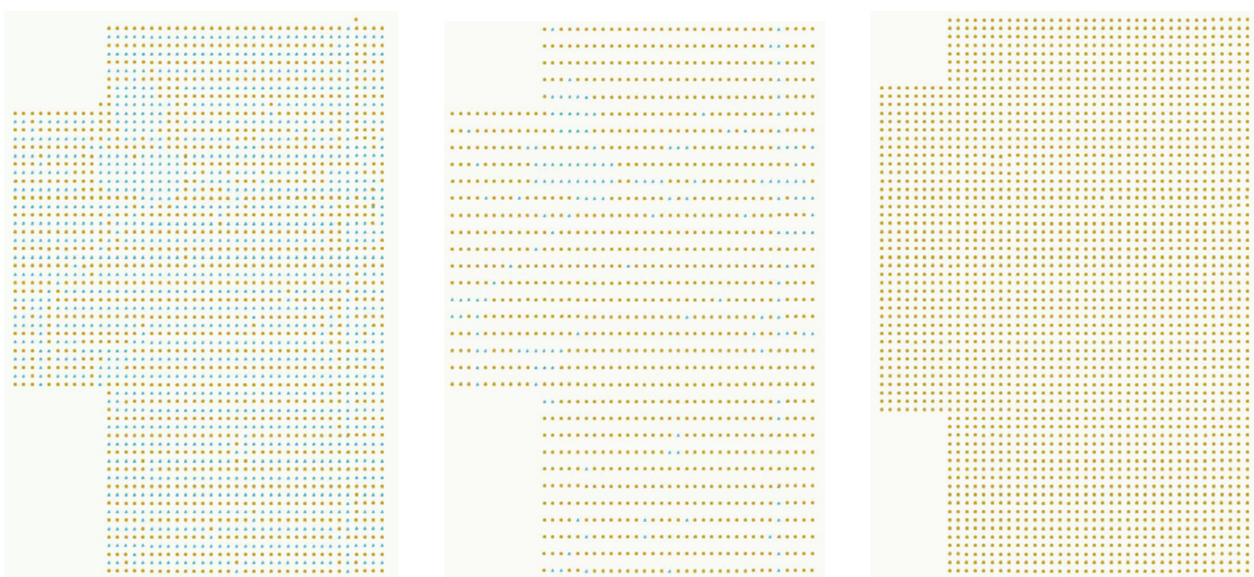
New processing technologies are available that may improve the image of surveys shot using the MegaBin technique. The specific technologies examined here are 5D interpolation (Trad et al, 2005) and the migration of COV's (Cary, 1999). MegaBin surveys were designed from their inception to include the use of interpolation in their processing (Goodway and Ragan, 1996). Trad et al's 5D interpolation is a new pre-stack interpolation method that is able to capture offset and azimuth variations in the data. It seems natural to apply this technique to MegaBin surveys, which have good offset and azimuth distributions. There is a well-shot 3D seismic survey shot in the mid-1990's in the Western Canadian Sedimentary Basin used to test the MegaBin concept (Goodway and Ragan, 1996). Hunt et al (2008) showed that Trad et al's 5D interpolation produced better AVO results nearby. Trad et al's method is tested by decimating this survey so that it is equivalent to a MegaBin acquisition, processing it and the original survey independently, then interpolating the decimated survey and comparing the interpolated data to the original data to see how well the interpolation recreates the traces removed by decimation. Moreover, the idea of pre-stack migration (PreSTM) using COV's is tested with these data, the idea being that the gathers output from PreSTM should also be suitable for azimuthal analysis. Here, the purpose is to ensure that the PreSTM stack image produced through migration of COV's of the interpolated data is at least as good as that produced by conventional PreSTM of the original data.

Method

A well-sampled 3D survey shot in the WCSB is reprocessed using COV binning and 5D interpolation. Three datasets are compared: 1) the original data acquired; 2) a decimated dataset where every 2nd receiver line was removed, thereby producing a MegaBin geometry; and 3) 5D interpolation of this MegaBin decimated dataset. The shot and receiver maps of the aforementioned configurations are shown in Figure 1. All datasets are processed with focus on a preserved amplitude flow. The processing parameters are identical for each dataset. Weathering statics, velocities and mutes are also the same. PreSTM migrations were performed using a Kirchhoff algorithm, with the data sorted into either offset class gathers (standard processing) or sorted into COV gathers. In addition, prior to PreSTM the decimated data was interpolated using the 5D algorithm to simulate a survey which, after interpolation, could be compared to the original data to test the effectiveness of the 5D interpolation. This allows for comparison of the interpolated traces with the original data traces both post-stack and especially pre-stack where the efficacy of the 5D interpolation can be properly assessed by comparing the interpolated to the original traces. Offset class and COV PreSTM were done on this dataset as well.

Example

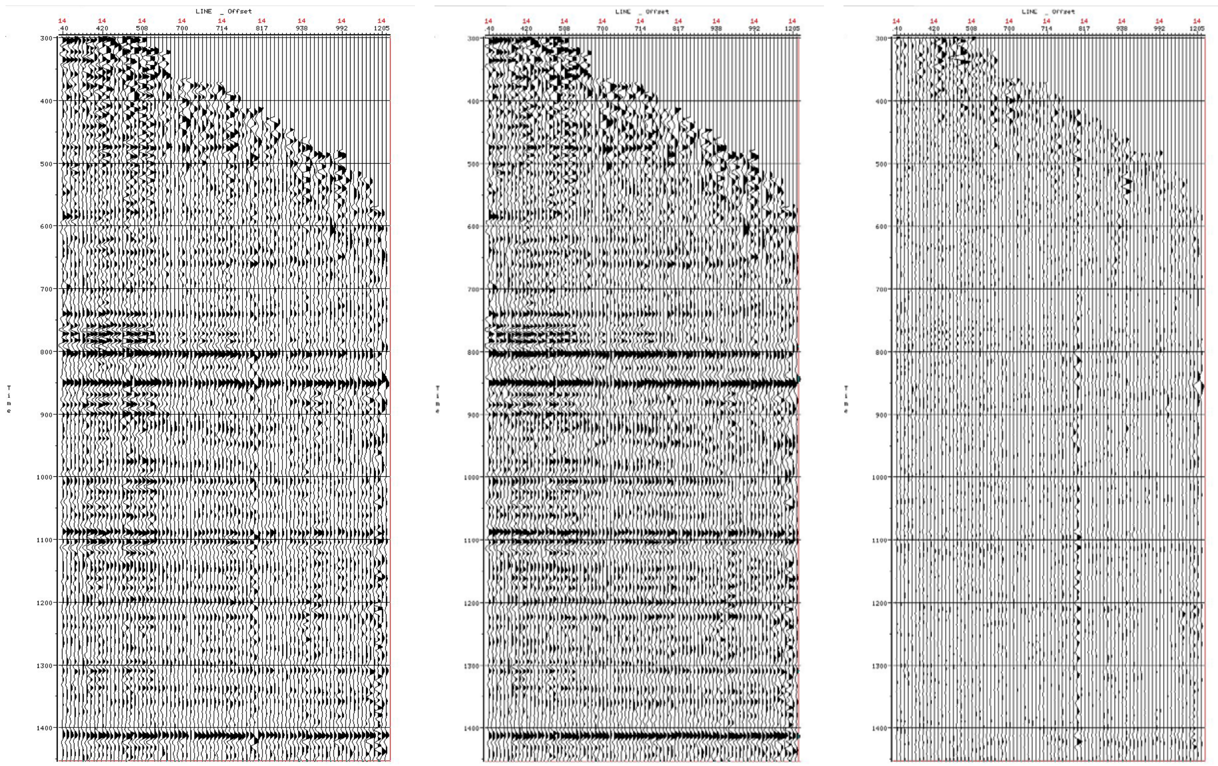
This example is a 3D shot in Western Canada in the mid-1990's. Shot and receiver line spacing of the original survey is 140 m and 70 m respectively. Shot point spacing is 70 m and receiver spacing is 70 m. This 3D is decimated to simulate a MegaBin™ survey. The receiver line spacing of the decimated survey is doubled to 140 m, while the shot line spacing remains the same. The shot point and receiver spacing remains the same at 70 m each. The decimated data is then pre-stack interpolated using 5D interpolation to simulate a survey with 70 m shot line and receiver line spacing and 70 m shot point and receiver point spacing. These three surveys are compared in Figure 1.



(a) **(b)** **(c)**

Figure 1: Shot (yellow) and receiver (blue) locations for a) original survey b) decimated and c) 5D interpolated.

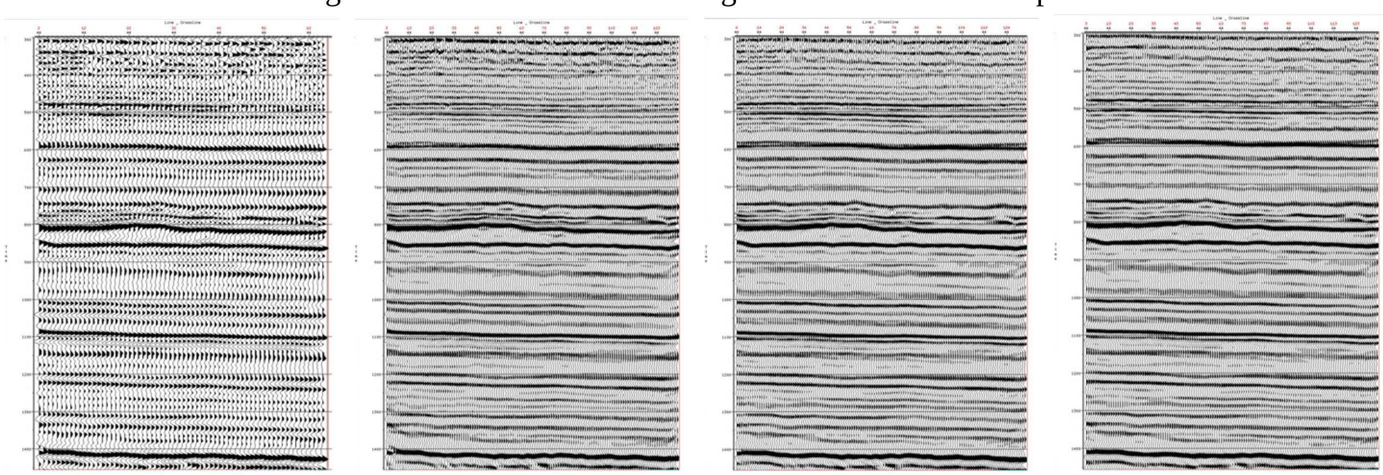
Figure 2 shows the difference in a pre-stack CMP gather before migration between the original data and the gather created at the same location through the interpolation of the decimated MegaBin data. Comparing pre-stack data is the toughest test of an interpolation algorithm. There is very little coherent difference



(a) (b) (c)

Figure 2: Gather prior to PreSTM. a) Original data, b) 5D interpolation of decimated data and c) difference

between these two datasets with the observed differences likely due to independent processing of these two surveys, and the interpolated data may even be considered preferable because a bad trace has been eliminated due to its being so different from surrounding traces used for its interpolation.

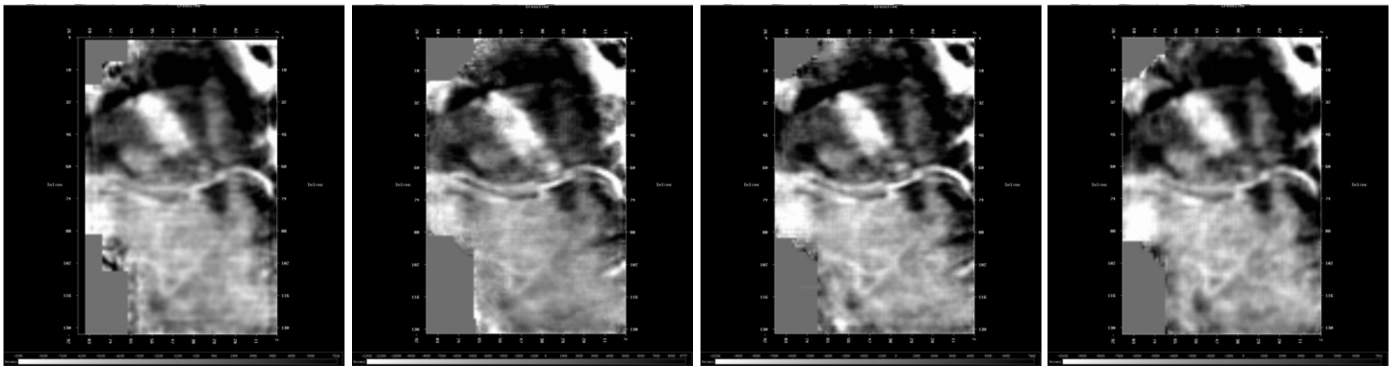


(a) (b) (c) (d)

Figure 4: A crossline after PreSTM. a) Decimated data, b) original data, c) COV PreSTM on original and d) COV PreSTM on 5D interpolated.

The PreSTM stacks shown in Figure 4 demonstrate that the interpolated data produces images comparable to those of the original data. Interpolation improves the image in the shallow sections because it reduces the footprint through decreasing shot line spacing. Furthermore, COV migration (Figure 4c) produces images that are as good as conventional PreSTM migration (Figure 4b). The COV PreSTM migration also provides the opportunity to measure azimuthal AVO attributes post-migration because the azimuthal information is not lost in a COV migration (e.g. Calvert et al, 2008). All of these migrated stacks show a much clearer image of the subsurface than does the conventional processing of the data decimated to a MegaBin acquisition, shown in Figure 4a.

Timeslices displaying a shallow channel as a lighter colored line meandering E-W are shown in Figure 5. The channel is very clear in the PreSTM of the original data (Figure 5b), in the COV PreSTM (Figure 5c) and in the COV PreSTM of the interpolated data (Figure 5d). The channel is less clear when produced by conventional processing, which included migration of the post-stack interpolated data, shown in Figure 5a.



(a) **(b)** **(c)** **(d)**

Figure 4: Time slices. a) Post-stack migration on decimated data after post-stack interpolation, b) PreSTM of original data, c) COV PreSTM on original data , d) COV PreSTM of 5D interpolated data.

Conclusions

It is clear from this example that 5D interpolation of MegaBin surveys in the Western Canadian Sedimentary Basin improves the ability to image subsurface structures, producing gathers that are almost indistinguishable from those shot in a much more intense survey. It should be noted that interpolation can only work with the data that is there; it will not compensate for a survey that is not properly shot to image the target horizon. It can be used to enhance the image of those surveys that are properly shot and extend viable amplitude analysis somewhat shallower in the seismic section. Furthermore, COV migrations of these data produce images analogous to those produced by conventional PreSTM, while allowing for post-migration analysis of azimuthal variations. We recommend that when reprocessing existing MegaBin surveys, they be 5D interpolated. We also recommend using COV migration to image the data if there is a possibility of doing AVO and/or azimuthal analysis, e.g. for fracture detection, on these data.

Acknowledgements

We thank EnCana and Bill Goodway for permission to show these data, Todd Mojesky for his assistance in designing the workflows used here and Jean-Michel Ducher for the inspiration to do this work.

References

Calvert, A., Jenner, E., Jefferson, R., Bloor, R., Adams, N., Ramkhelawan, R, and St. Clair, C., 2008, Wide azimuth imaging and azimuthal velocity analysis using offset vector tile prestack migration, First Break, 26, 9, 103-107. http://www.firstbreak.org/files/FBSept08_07.pdf

Cary, P.W., 1999, Common-offset-vector gathers: An alternative to cross-spreads for wide-azimuth 3-D surveys, 69th Annual Internat. Mtg., Soc. Expl. Geophys Expanded Abstracts, 1496 – 1499

Goodway W. Ragan B. and Li G., 1996 “Mega-Bin Land 3D Seismic: Toward a cost effective "symmetric patch geometry" via regular spatial sampling in acquisition design & cooperative processing, for significantly improved S/N & resolution” CSEG National Convention Expanded Abstracts.

Hunt, L., Reynolds, S., Hadley, S., Downton, J. and Durrani, B., 2008, Are key technological changes of the last three years enough to warrant reprocessing? Interpolation and AVO Inversion for the Nisku at Brazeau, CSEG, Expanded Abstracts.

Trad, D., Deere, J., and Cheadle, S., 2005, Understanding land data interpolation: 75th Annual Internat. Mtg., Soc. Expl, Geophys., Expanded Abstracts, 2158-2161.