On the advantages of slant seismic acquisition geometries

Mostafa Naghizadeh[1], Andrea Crook[1], Rob McGrory[2]
[1]OptiSeis Solutions Ltd.
[2]Crescent Point Energy Corp

Summary

Orthogonal seismic acquisition geometries are considered the conventional acquisition layout for seismic reflection surveys. Slant seismic geometries are generated from orthogonal geometries by slanting the angle between source-lines and receiver-lines away from 90 degrees. This modification results in better distribution of offsets and azimuth and reduces the minimum near-offset in data which provides a more suitable data set for AVO inversion and Quantitative Interpretations.

Theory

A slant seismic acquisition geometry can be generated from an orthogonal geometry by slanting source-lines with respect to receiver-lines with various aspect ratios. They were originally designed to obtain the improved offset distribution achieved with brick geometries, but without some of the disadvantages associated with noncontinuous source lines (Cordsen et. al., 2000). Slant geometries are created by slanting the source line according to a specific ratio of inline and crossline offsets from orthogonal. The most common aspect ratios for slants are 1:1 (45 degrees) and 1:2 (~26.6 degrees). Figure 1a shows an orthogonal geometry with 60 m source and receiver station interval, 300 m source-line, and 180 m receiver-line intervals. Figures 1b and 1c show the slant geometries with 26.6 and 45 degrees, respectively. The slant geometries have similar number of source stations but with a reduced source-line line interval as measured perpendicular to source lines and increased source station interval as measured along the source line. This results in the same overall fold/trace density, but with a better bin-to-bin distribution, which can reduce acquisition footprint. This improvement is most obvious when examining the near offset distribution. In Figures 1d-1f, the minimum near-offset plots for the three geometries shown with corresponding near offset distributions shown in Figures 1a-1c. Both slant geometries lead to a closer source-line interval, and resulting in improved near offset values that are distributed more uniformly across the bins. The orthogonal geometry displays a regular pattern of high near-offset values in the middle of box extending in N-S direction (Figure 1d). However, for both slant geometries, the distribution of high near-offset values diverts from a single orientation and becomes evenly distributed. Figures 2a-2c show the rose diagram plots for the selected bins (black polygons in Figures 1d-1f) with offset range of 0-400 m for orthogonal, slant 26.6-degree, and slant 45-degree geometries, respectively. The rose diagram plots also show that slant geometries contain more abundant and diverse distribution of offsets and azimuths. Therefore, slant geometry will be more suitable geometry for 5D interpolation methods that utilize sparse Fourier recovery algorithms (Naghizadeh and Sacchi, 2010).

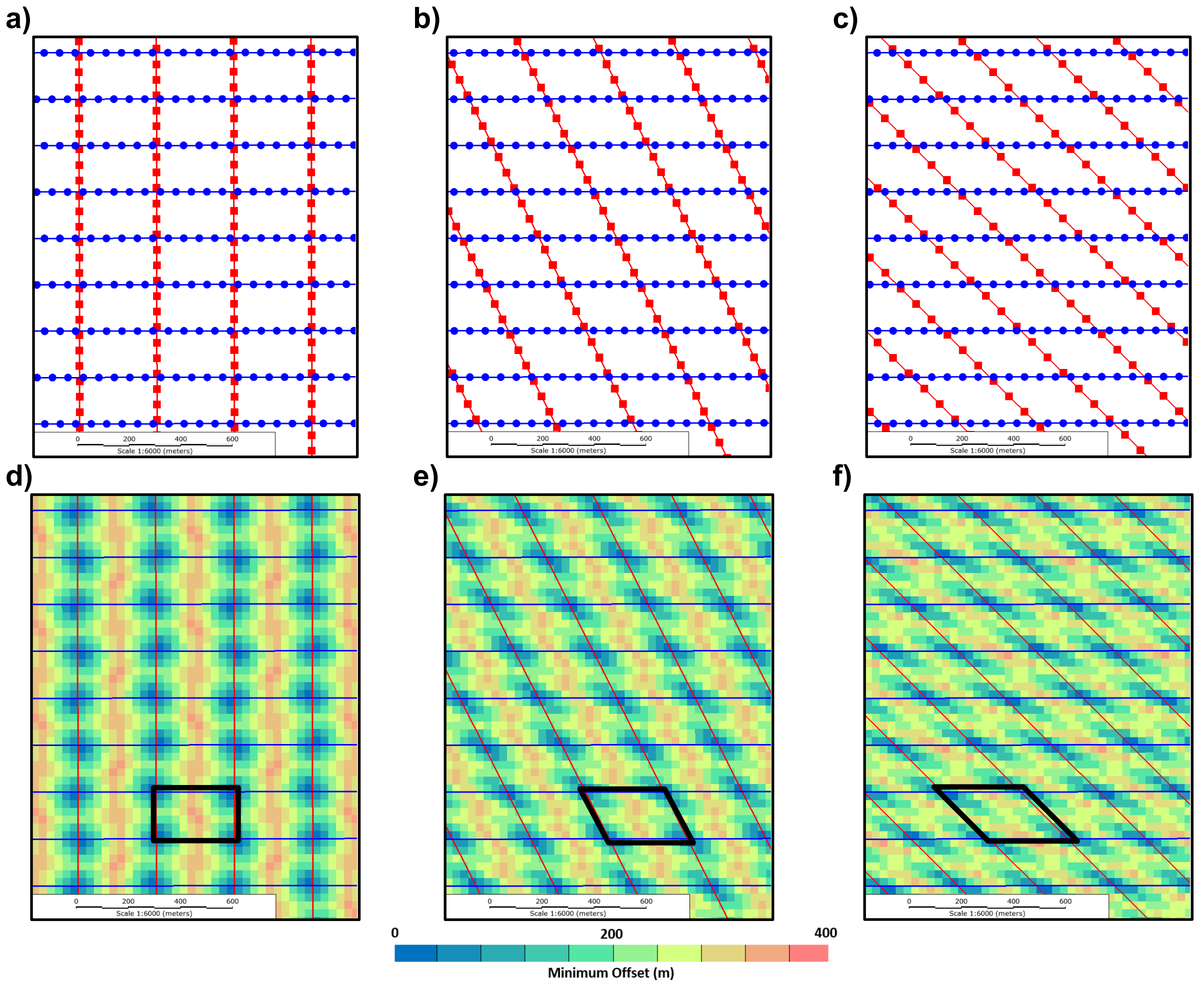

Figure 1: a) Orthogonal, b) Slant 26.6-degree, and c) Slant 45-degree geometries. d)-f) depict the minimum near-offset plots for a-c, respectively.

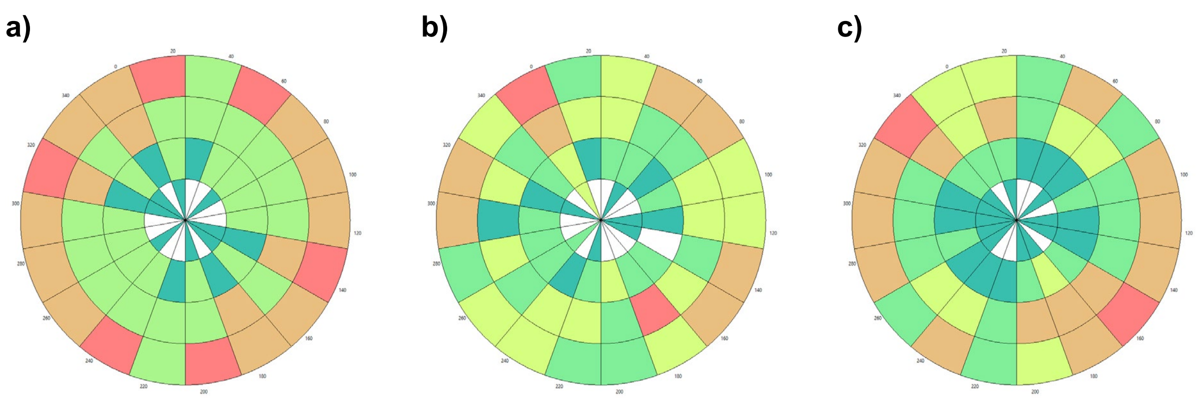

Figure 2: Rose diagram plot for select bins (black polygons in Figures 1d-1f) with offset range of 0-400 m for a) orthogonal, b) slant 26.6-degree, and c) slant 45-degree geometries.

Real Data Example

Figures 3a and 3b show Common-Offset Common-Azimuth (COCA) super-gathers from an orthogonal survey before and after 5D interpolation, respectively. Figures 3c and 3d also depict COCA super-gathers before and after 5D interpolation, but these are from a survey in the same area and utilizing the same geometry as the orthogonal, but with slanted lines. The slant geometry shows better 5D interpolation results in comparison to the orthogonal survey for both the near and far offset data. This can clearly be seen on the shallow near angles, where better sampling of the very near traces has led to improved 5D interpolation results. Preserving near and far offsets in the slant geometry also resulted in a better AVO inversion and interpretations which will be highlighted in the full presentation.

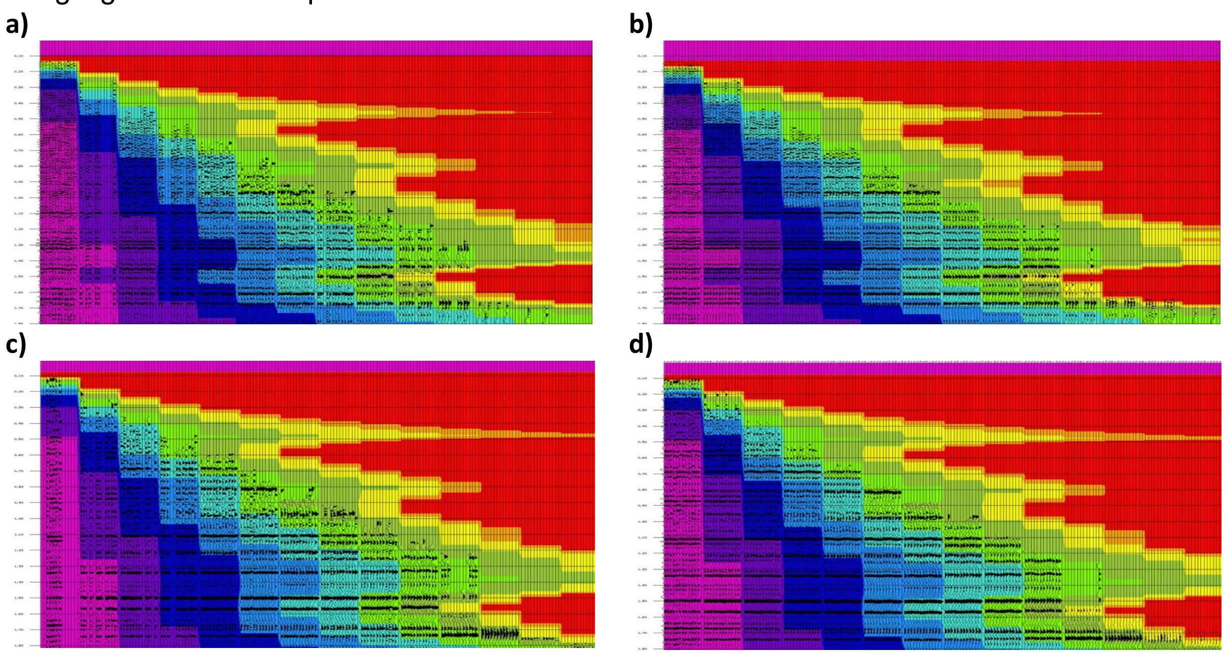

Figure 3: a) and b) are Common-Offset Common-Azimuth (COCA) super-gathers from an orthogonal survey with narrow harvest patch before and after 5D interpolation, respectively. c) and d) are COCA super-gathers from a slant survey with extended harvest patch before and after 5D interpolation, respectively. Colors represent angle ranges from 0 to 100 (red).

Conclusions

We discuss the advantages of using slant geometries for seismic data acquisition. We show survey design attribute analyses and real data 5D interpolation results from slant geometries and how it can lead to better AVO inversion and interpretations.

Acknowledgements

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References

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