

An In-Depth Analysis of the Four Spatial Dimensions in Seismic Survey Geometries

Mostafa Naghizadeh and Andrea Crook
OptiSeis Solutions Ltd.

Summary

Acquisition of 3D seismic surveys on a 2D surface results in 5-dimensional data, consisting of four spatial dimensions and one temporal dimension. The distribution of seismic traces in the 4D spatial domain can vary across different geometries, with significant implications for seismic data reconstruction algorithms. In this paper, we will investigate the seismic spatial dimensions for various orientations and arrangements.

Methodology

Figures 1a-1c show the Orthogonal, MegaBin, and EcoSeis™ zigzag geometries with equal trace density, respectively. The MegaBin and EcoSeis™ geometries feature interleaved sources and

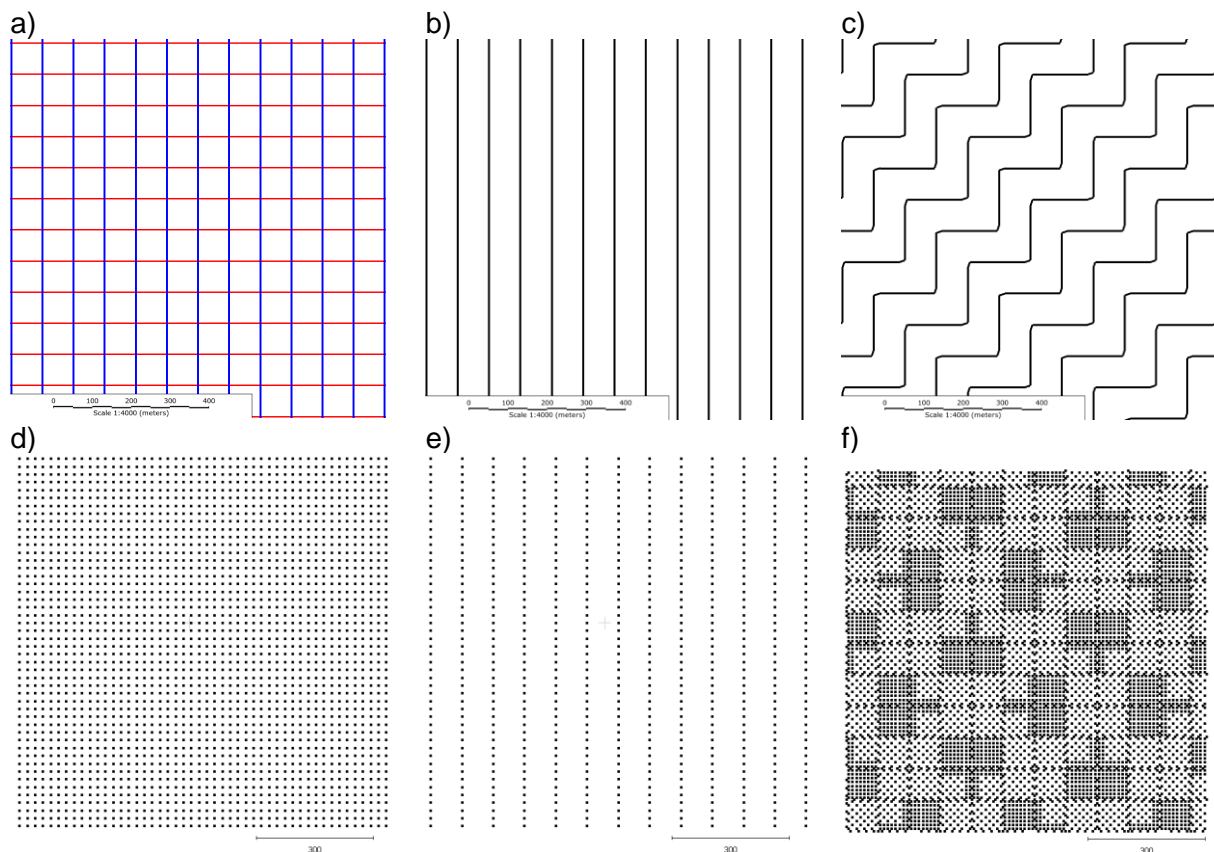


Figure 1: Survey lines representing a) Orthogonal b), MegaBin and c) EcoSeis™ geometries with equal trace density. d)-f) show the offset-x vs offset-y distribution of traces inside 16x16 bins from geometries a) to c), respectively.

receivers along the lines (black lines), while the orthogonal geometry has sources along the E-W direction (red lines) and receivers along the N-S direction (blue lines). Figures 1d-1f depict the offset-x vs offset-y distribution of traces for 16x16 bins from the geometries shown in Figures 1a-1c, respectively. The MegaBin and EcoSeis™ surveys provide an abundance of very near-offset traces compared to the Orthogonal survey. The MegaBin survey results in coarse and regular spatial sampling in the offset-vector domain (Figure 1e). In contrast, the EcoSeis™ survey (Naghizadeh et. Al., 2023) leads to finer, irregular spatial sampling in the offset-vector domain (Figure 1f), which is beneficial for effective Sparse Fourier reconstruction (Naghizadeh and Sacchi, 2010) of the seismic data.

We will investigate the 4D spatial distribution of traces from 3D real seismic data and highlight the advantages and shortcoming of different seismic geometries.

Conclusions

We provide a thorough investigation into all 4 spatial dimensions of different 3D Seismic survey geometries. We show survey design attribute analyses and real data interpretations that emphasize the importance of proper 4D spatial sampling.

Acknowledgements

The authors would like to acknowledge OptiSeis Solutions for supporting this study.

References

- Naghizadeh, M., M. Sacchi., 2010, "On sampling functions and Fourier reconstruction methods," GEOPHYSICS 75: WB137-WB151.
- Naghizadeh, M. et. al., 2023. EcoSeis™: A Novel Acquisition Method for Optimizing Seismic Resolution While Minimizing Environmental Footprint. SEG The Leading Edge, 42 Issue 1, 61-68.