
Early-arrival waveform inversion: Application to cross-well field data

Xukai Shen*, Tieyuan Zhu, and Jerry M. Harris

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Outline

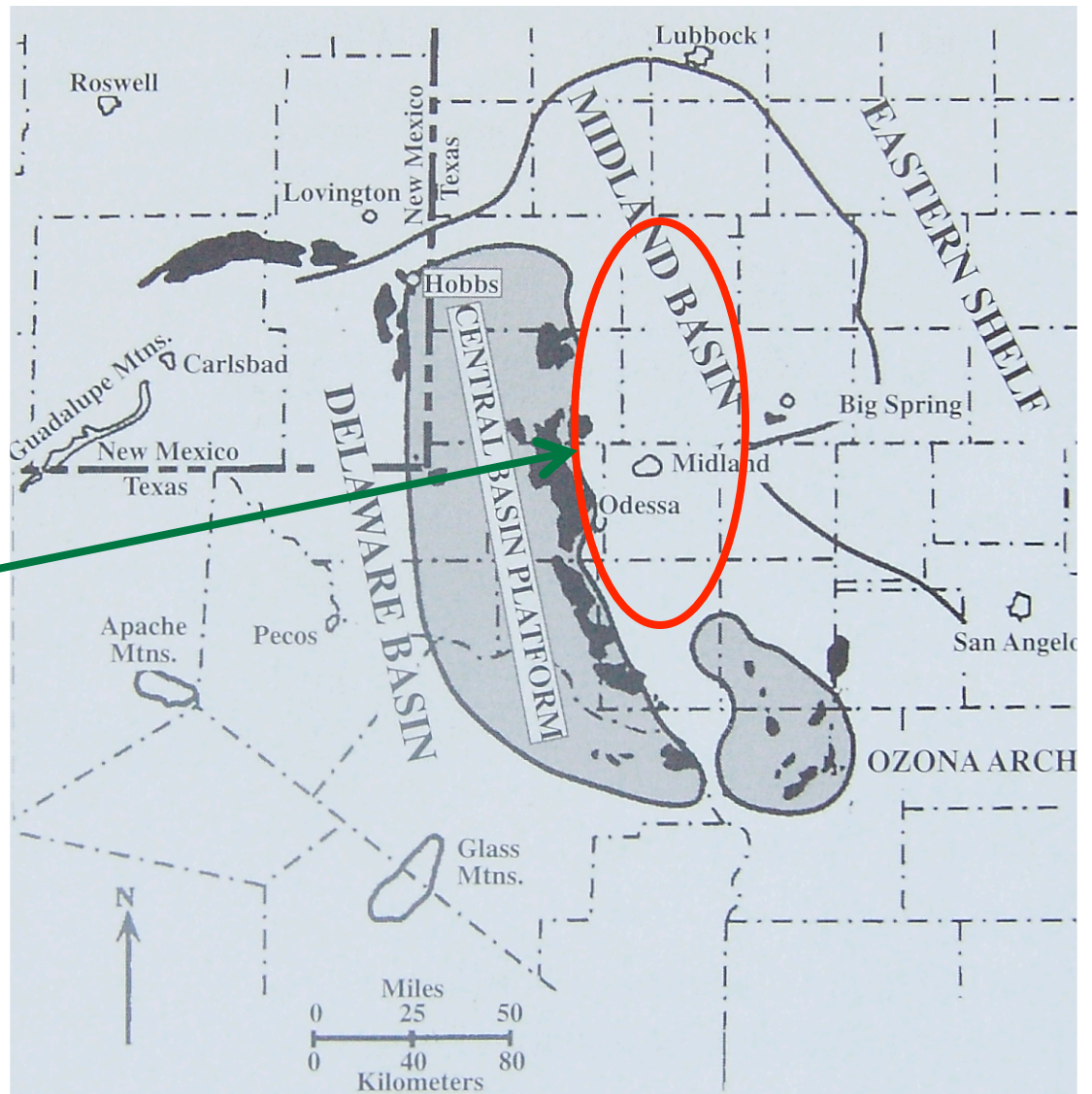
1. Introduction
2. Preprocessing
3. Results and verification
4. Conclusion

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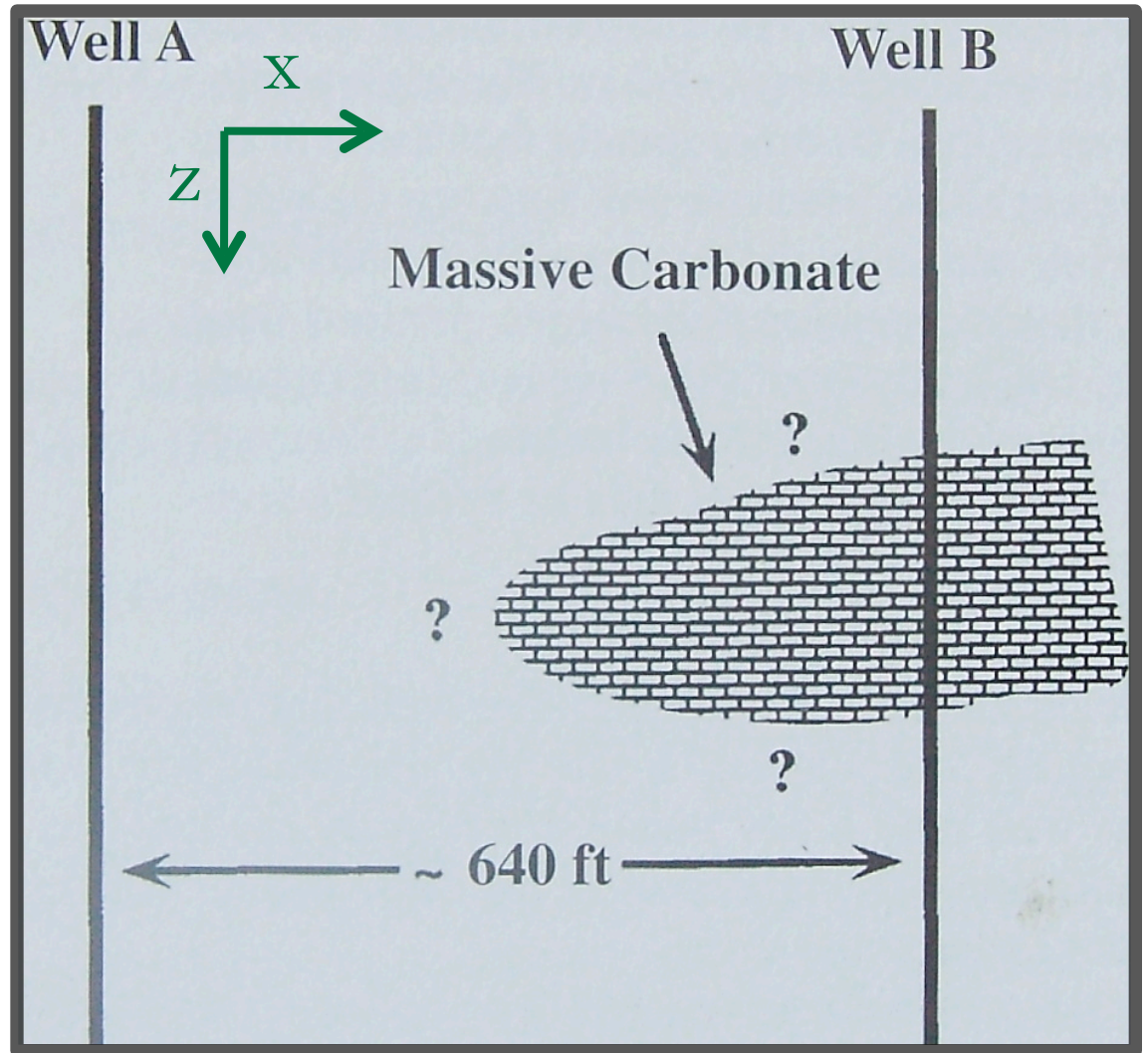
Field Map:

Approximate
well location



(Langan et al., 1997)

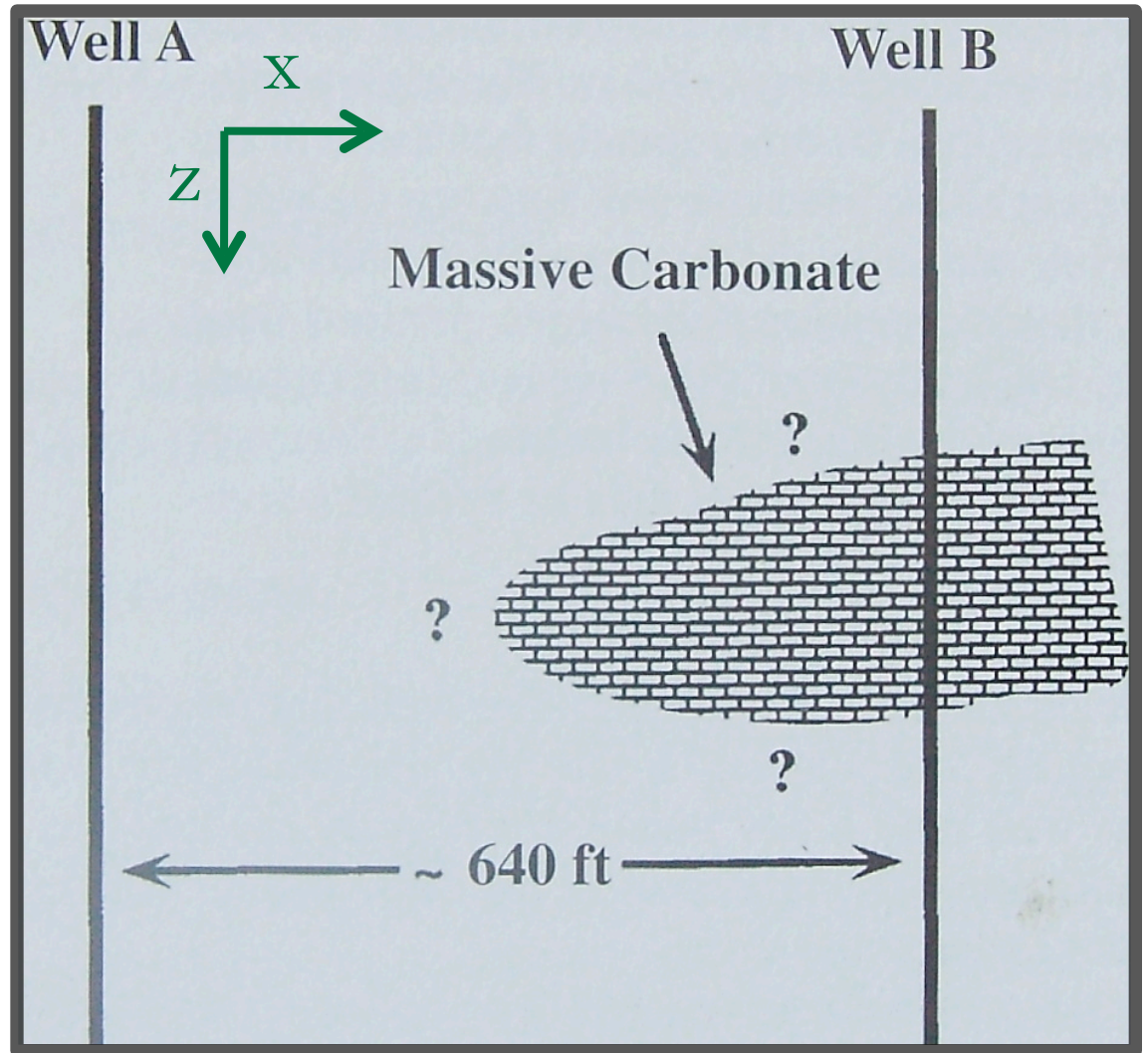
Well diagram:



(Langan et al., 1997)

Well diagram:

Cross-well data:
Determine where
“?”s are



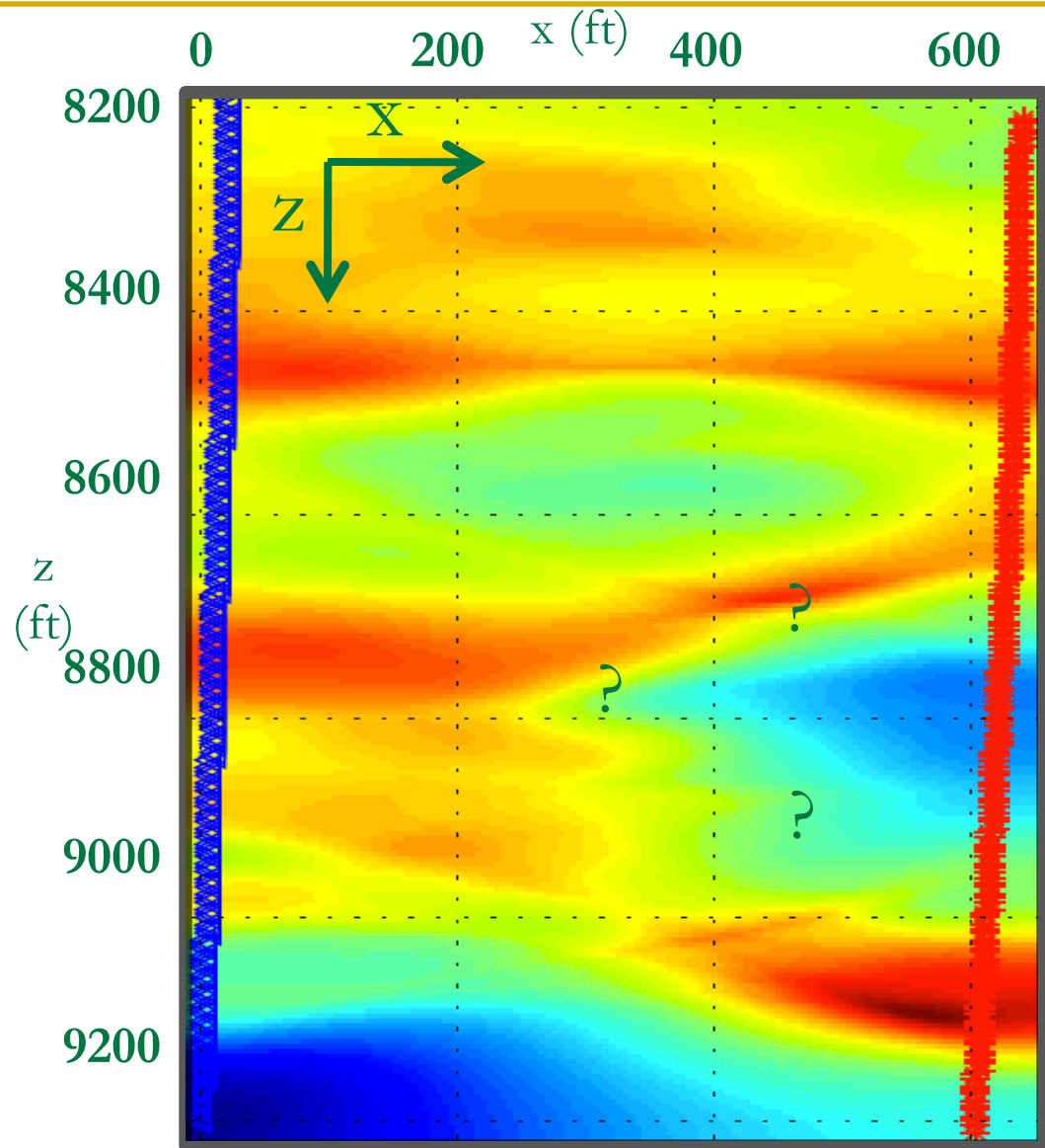
(Langan et al., 1997)

◁ Receiver

* Source

Cross-well data:
Determine where
“?”s are

Not enough resolution
from ray-based method



First-break travelttime tomography result

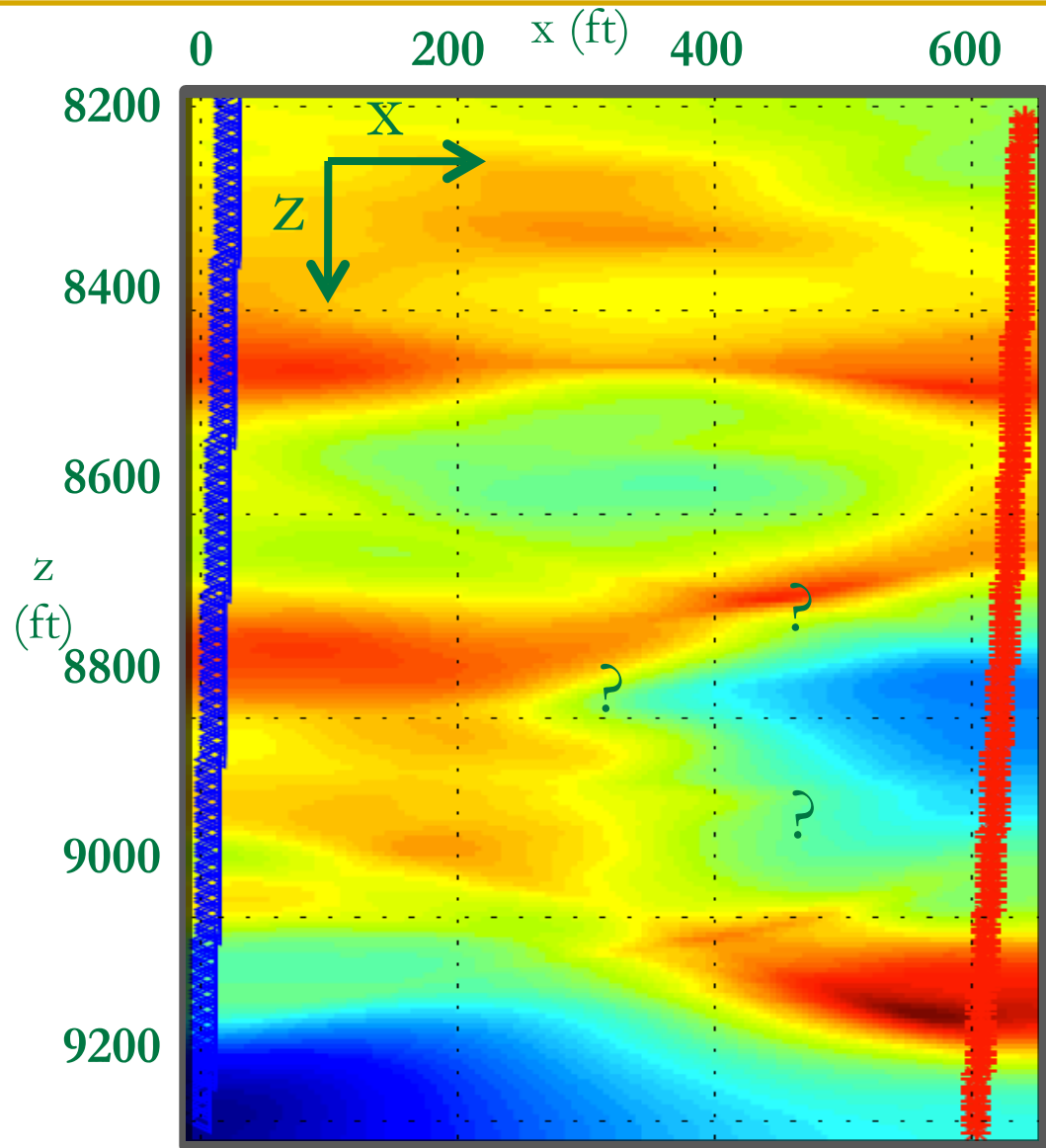
◁ Receiver

* Source

Cross-well data:
Determine where
“?”s are

Not enough resolution
from ray-based method

Use Waveform
inversion to obtain
higher resolution result



First-break travelttime tomography result

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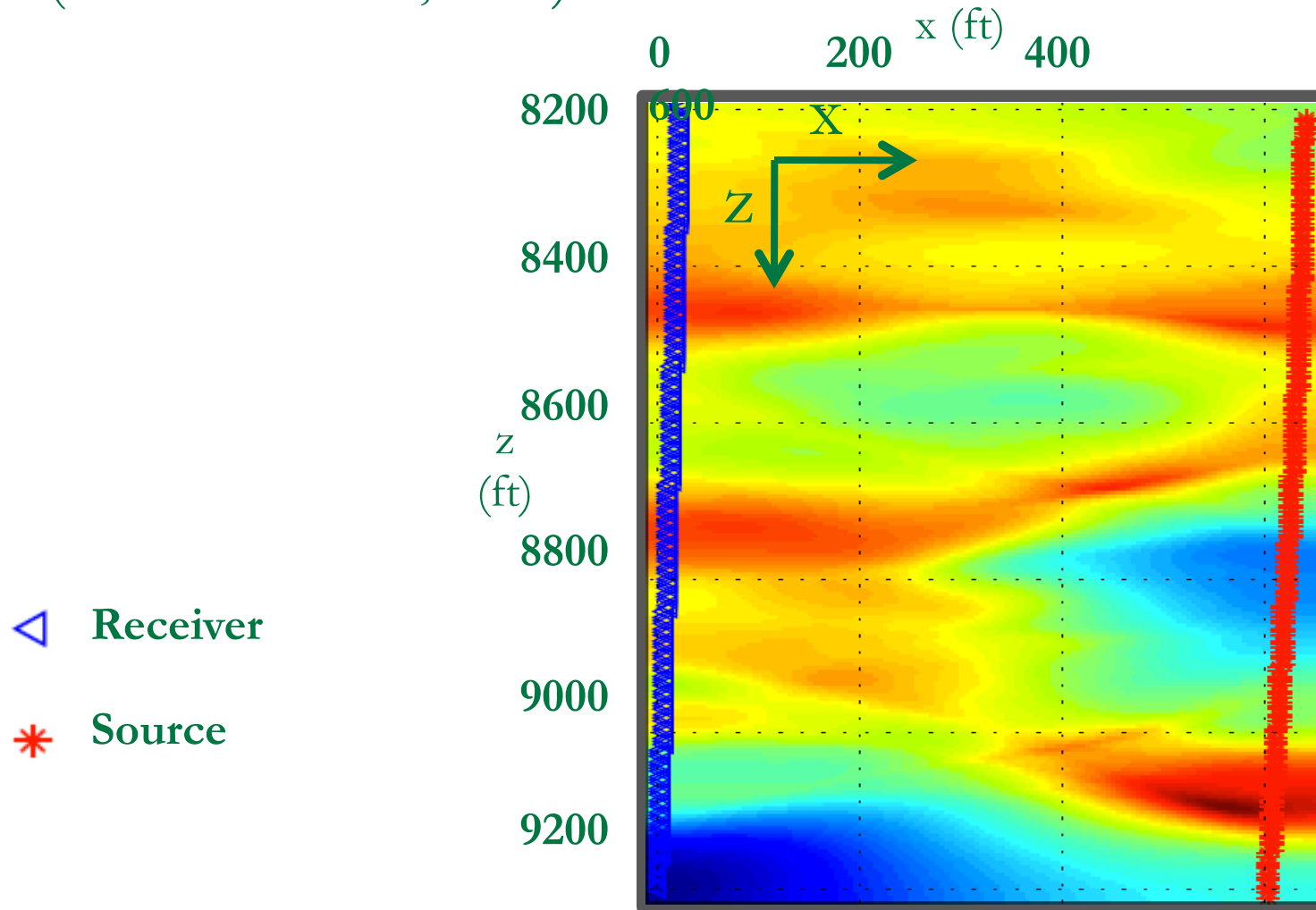
Key elements in Early-arrival waveform inversion

- Starting velocity
- Source wavelets
- Sources and receivers locations
- Data mask

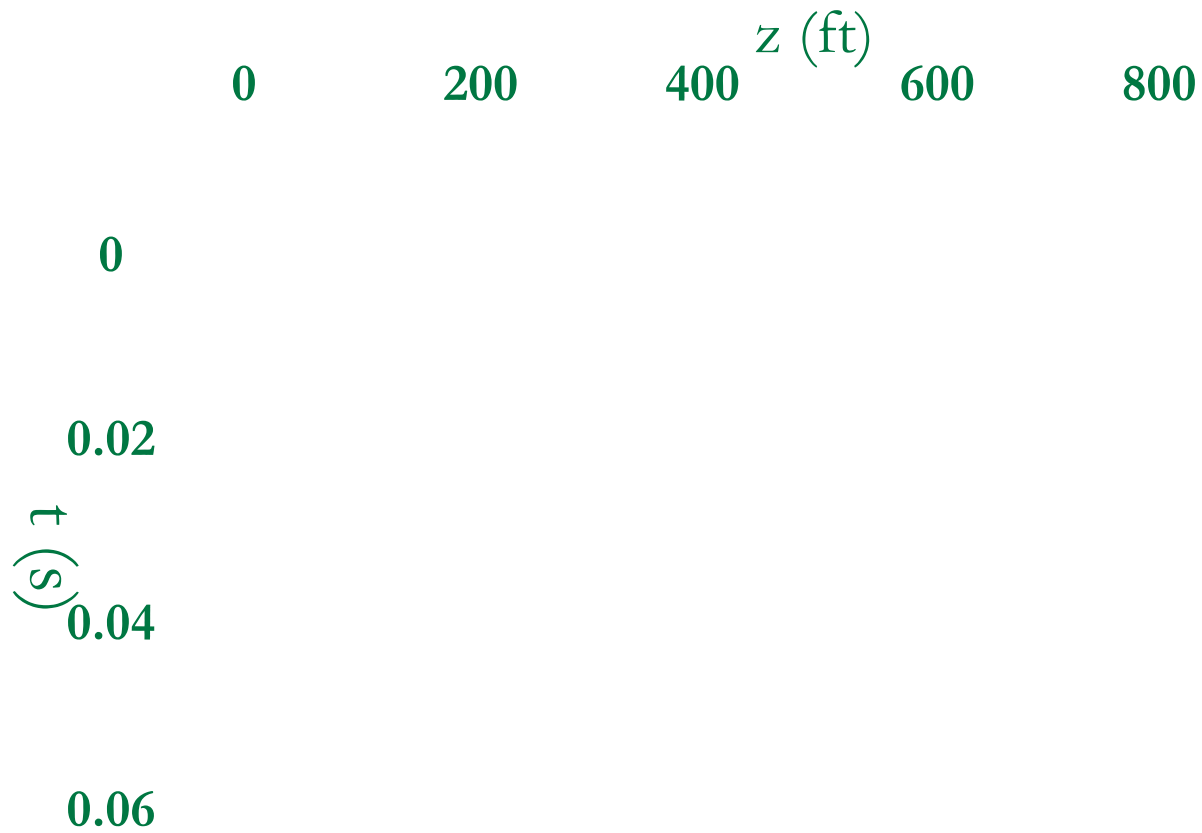
Starting velocity

from first-break traveltimes tomography

(Zelt and Barton, 1998)

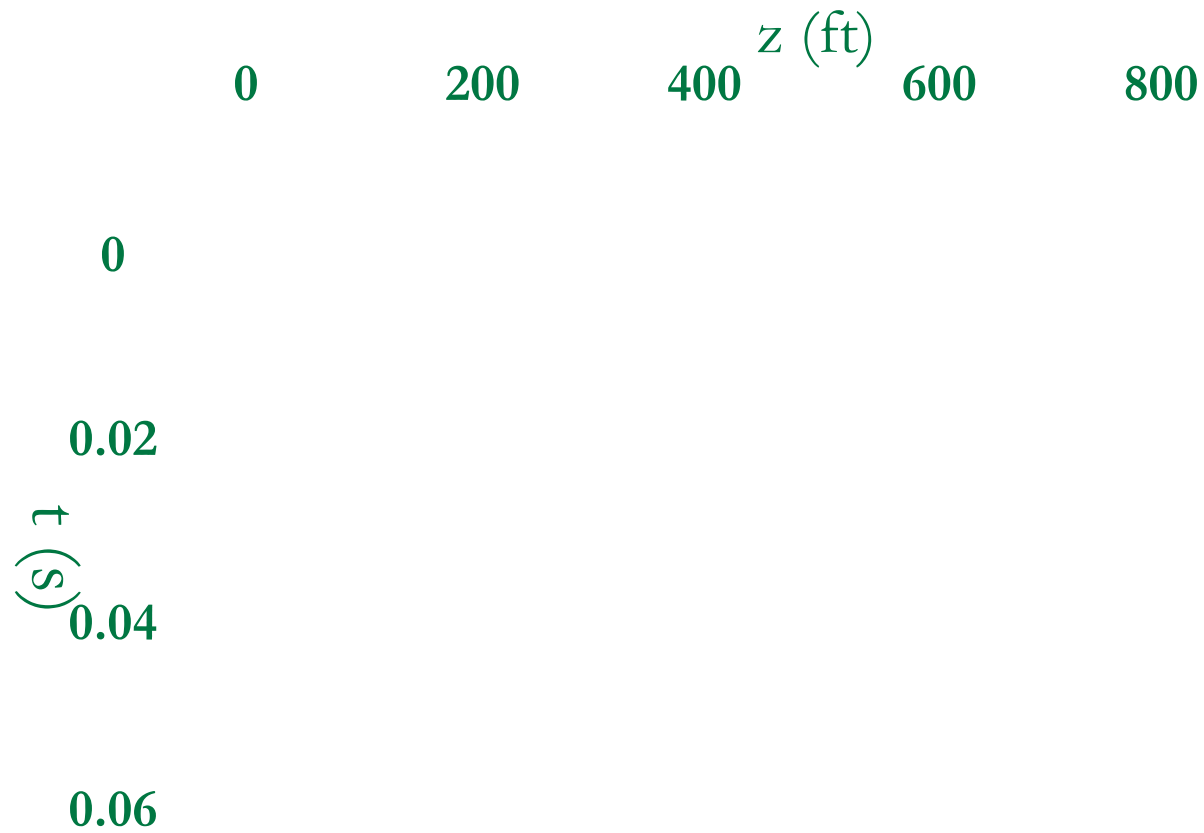


Source wavelet



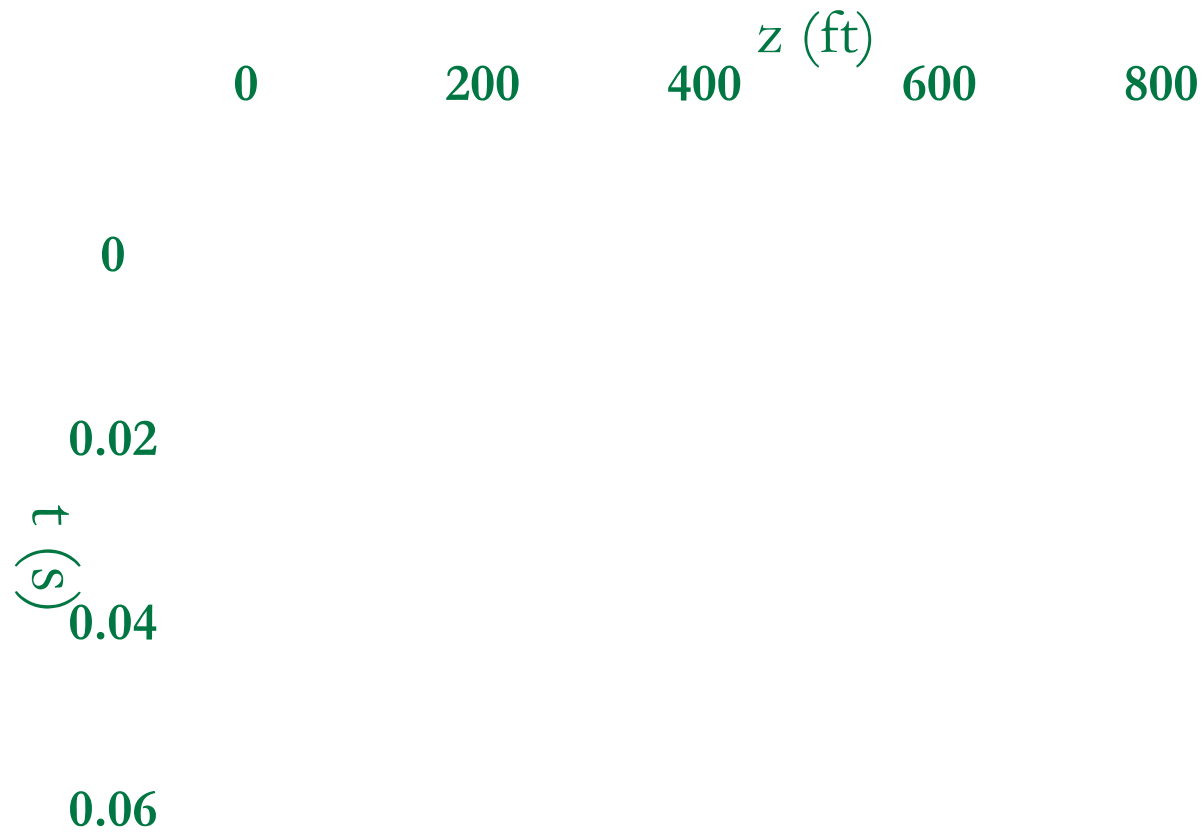
Shot gather

Source wavelet



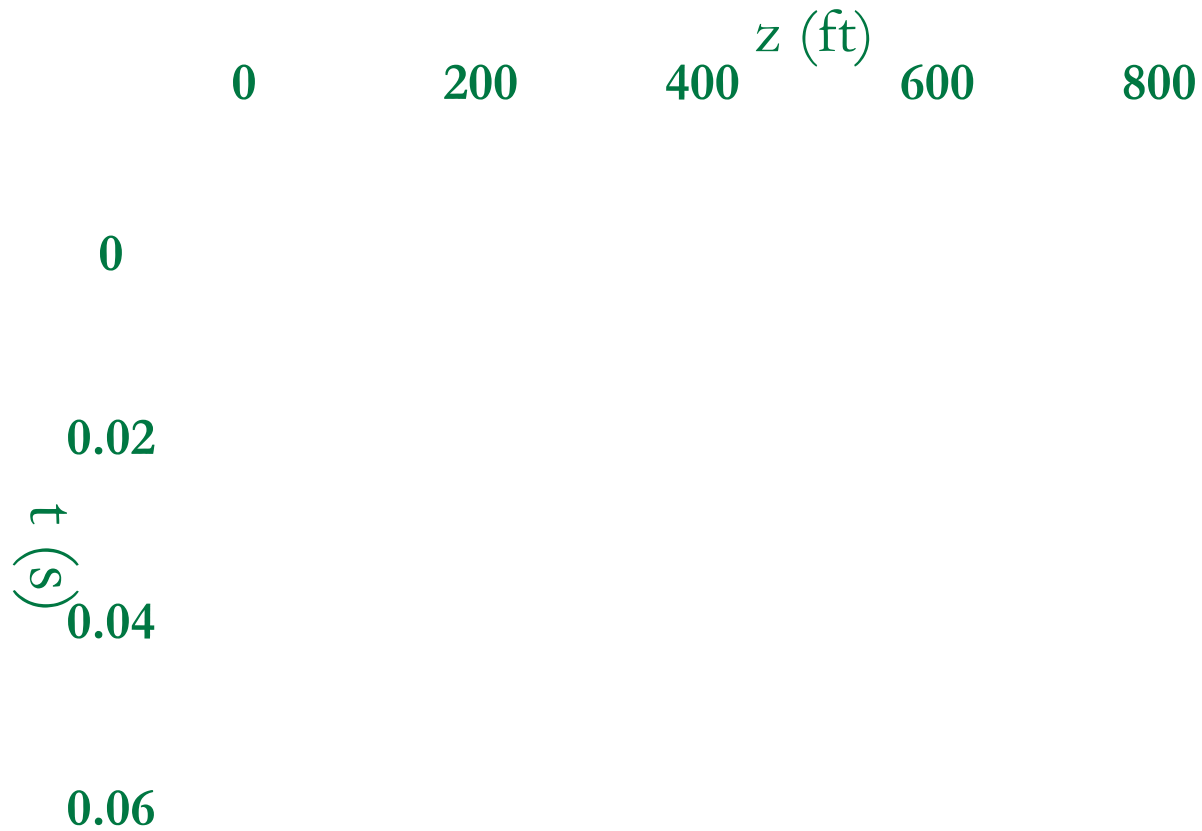
Shifted Shot gather

Source wavelet



Masked Shifted Shot gather

Source wavelet Stack to obtain the source wavelet



Masked Shifted Shot gather

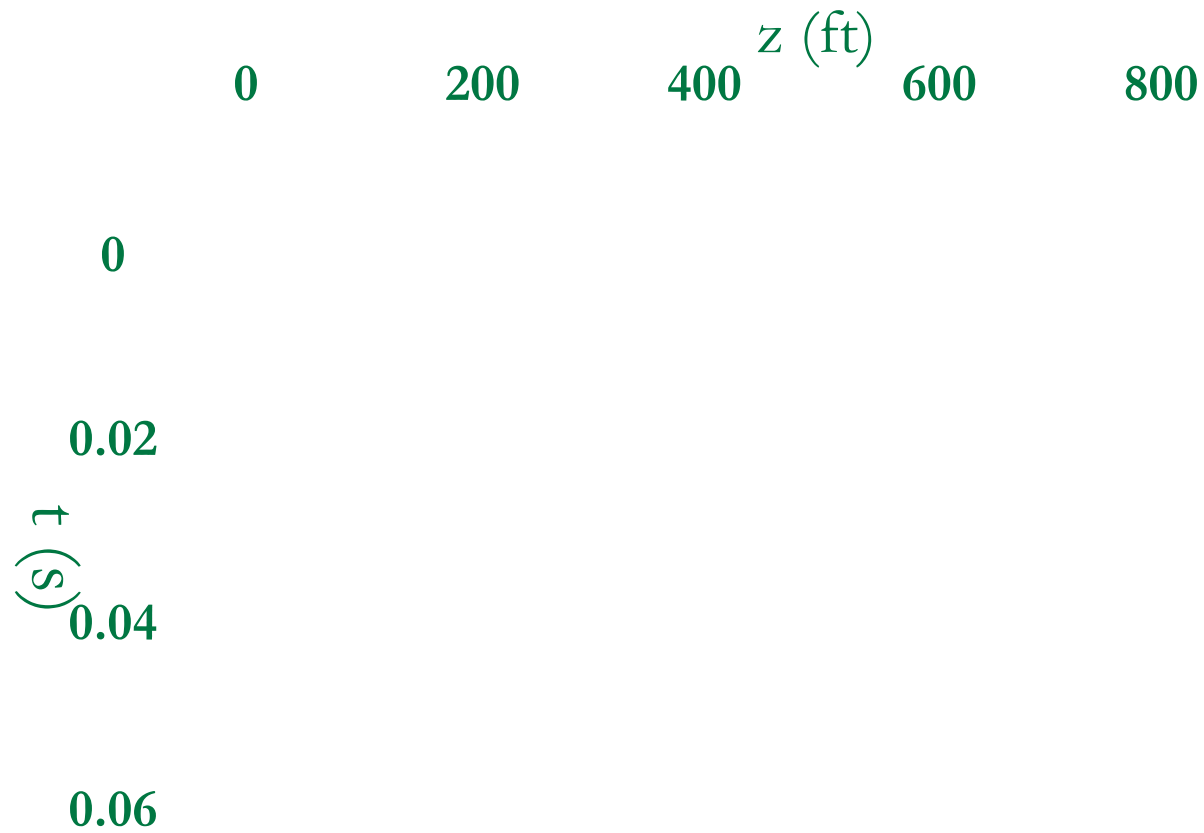
Sources and receivers locations

Nearest neighbor binning

original interval: 1 ft

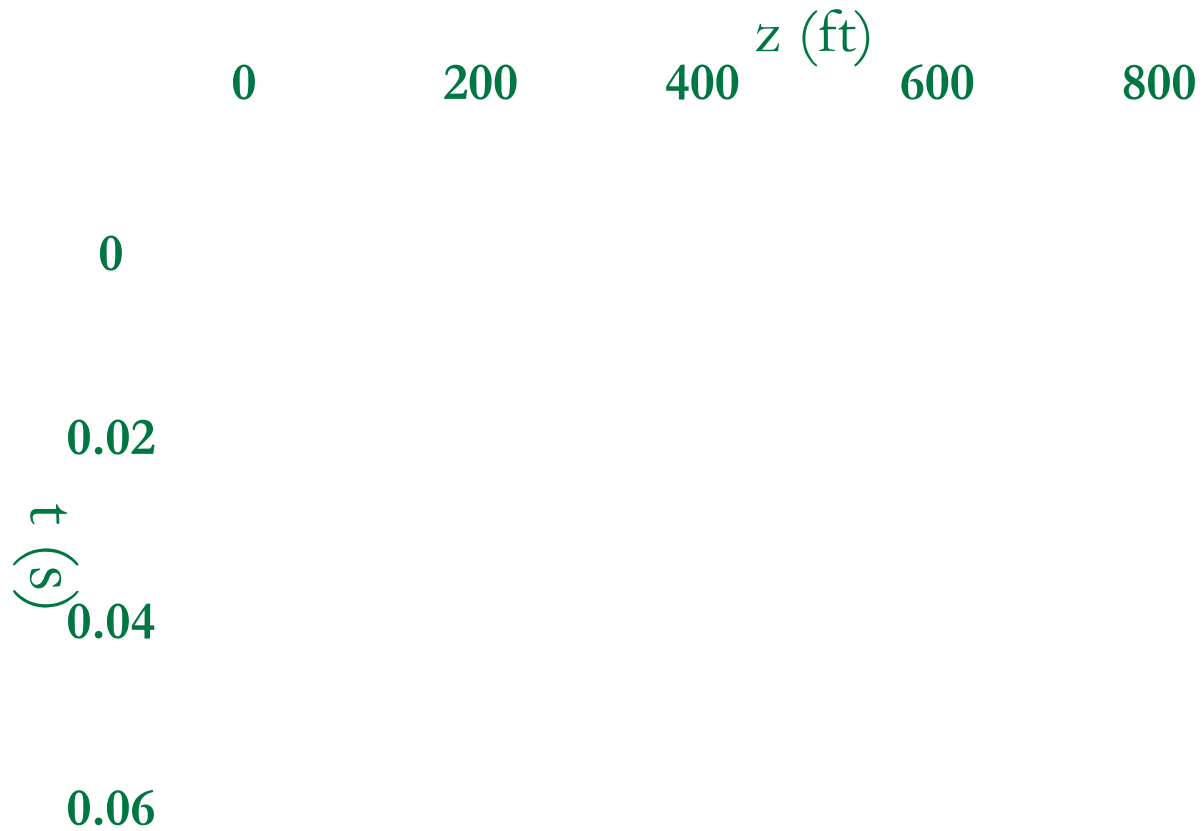
binned interval: 5 ft

Data mask



Shot gather

Data mask: Keep first-arrival only



Masked Shot gather

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Shot spacing: 5ft

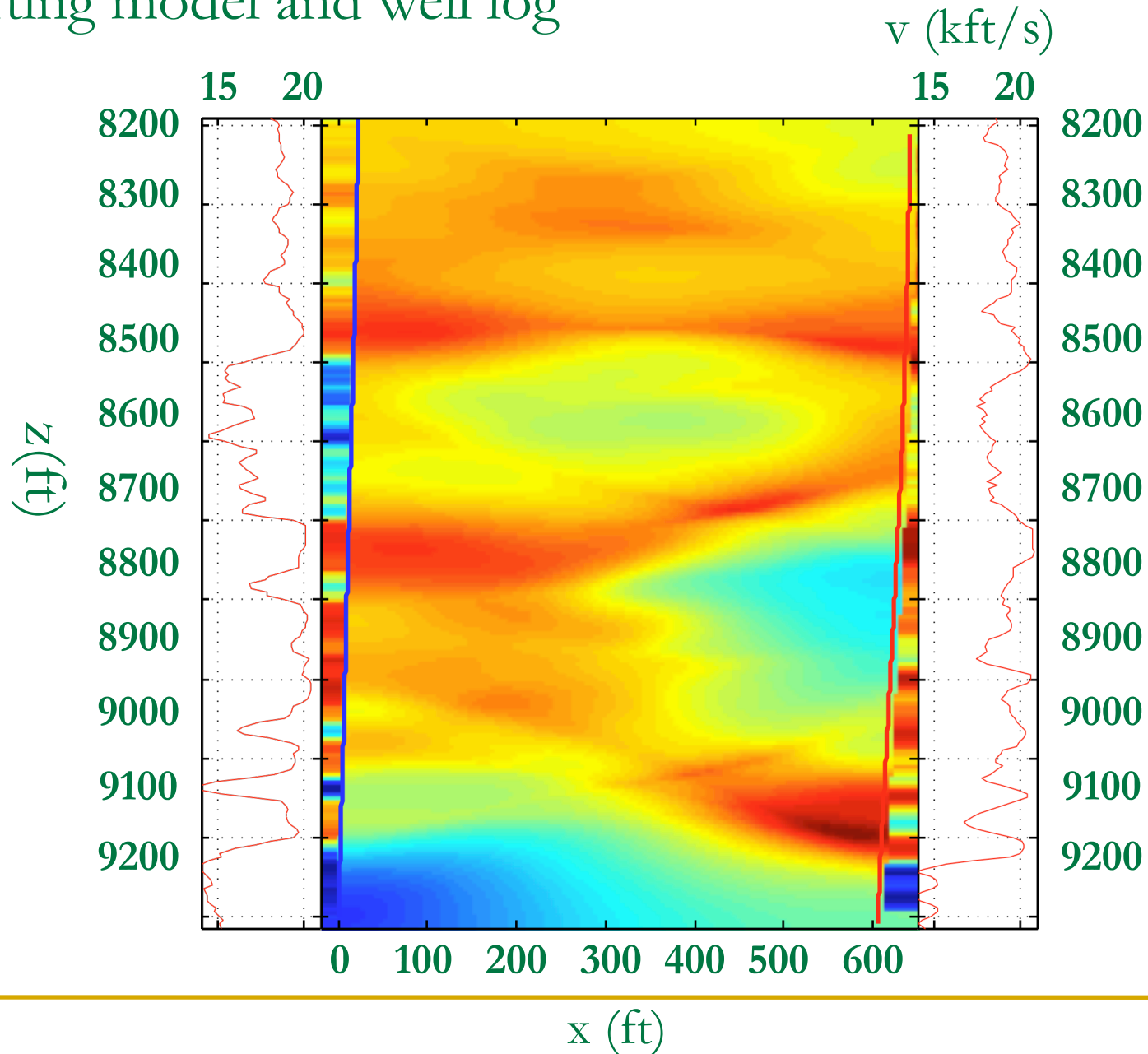
Receiver spacing: 5ft

Two passes of inversion

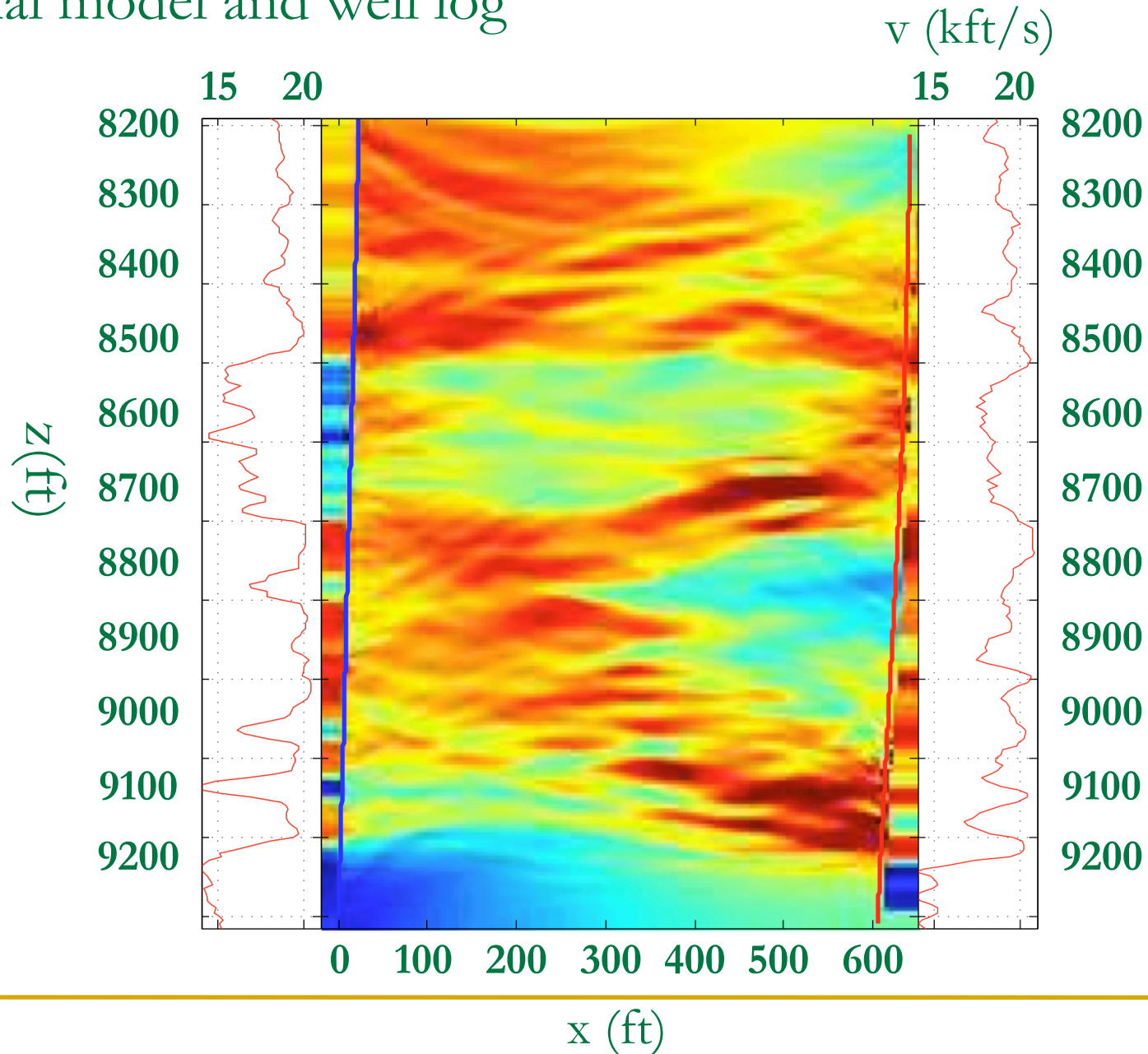
200~400 Hz data

200~700 Hz data

Starting model and well log



Final model and well log



Starting Residual

z (ft)

z (ft)

200~400 Hz inversion

200~700 Hz inversion

Final Residual

z (ft)

z (ft)

200~400 Hz inversion

200~700 Hz inversion

Modeling Comparison

z (ft)

Observed
data

Modeling Comparison

z (ft)

Modeling data from tomography result

Modeling Comparison

z (ft)

Modeling data from waveform inversion result

Modeling Comparison

z (ft)

Observed
data

Conclusions

- **Waveform inversion is able to better determine the boundary of potential reservoir compared with travel-time tomography method**
- **Waveform inversion result matches well log data better**

Acknowledgments

- **Chevron for providing the data for this research**
- **SEP sponsors for the financial support of this research**

Thank you

Questions & Suggestions