CREWES

Using Interferometry for Solving Non-stationary Shear Wave Statics

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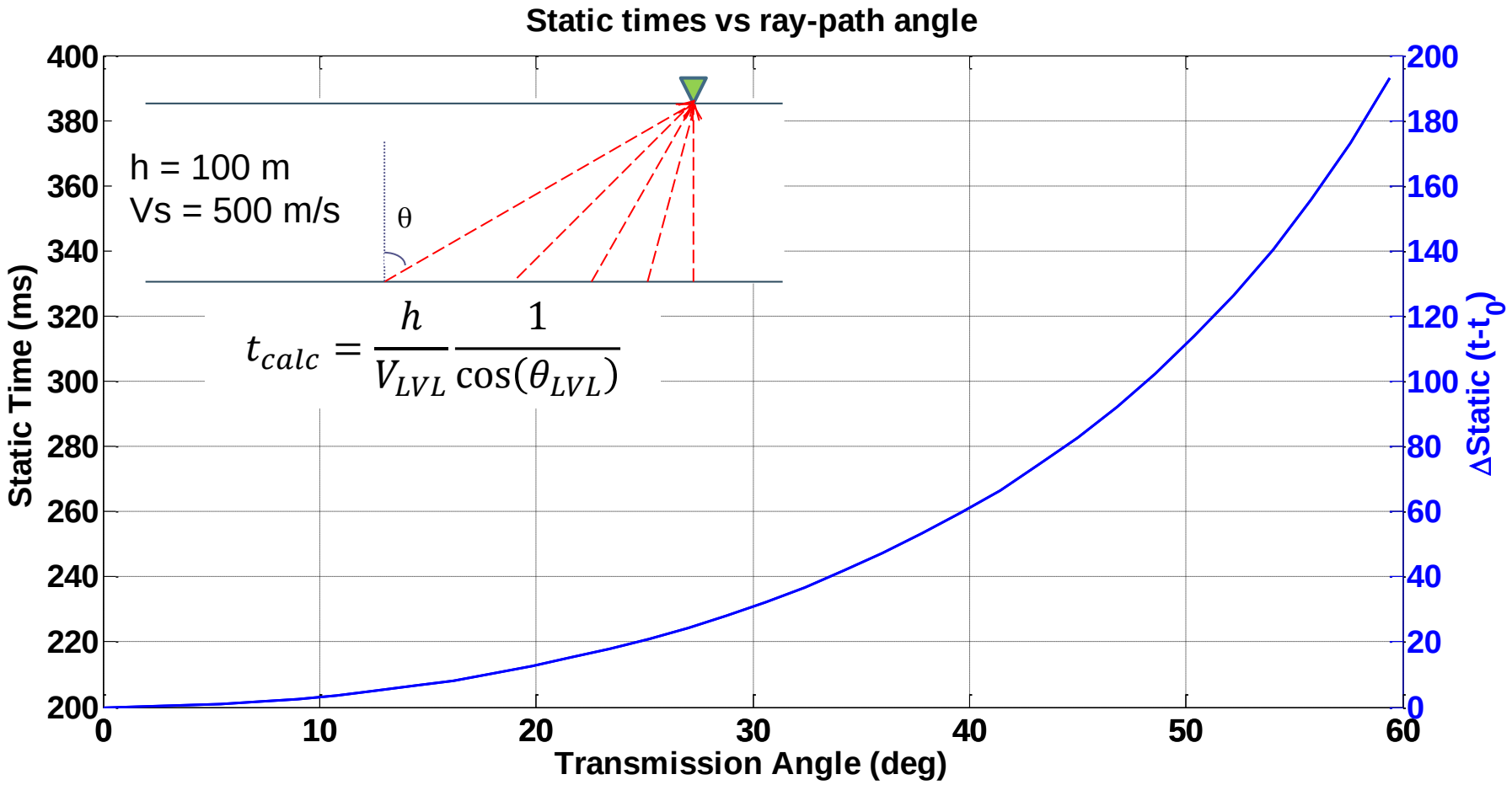
Introduction

- The S-wave statics problem:
  - The near surface “seen” by S-waves is different than the one seen by P-waves (e.g. water table depth).
  - S-wave statics solutions may be independent of P-wave statics.
  - Slow velocities magnify the effect of small changes in the propagation.
  - Non-Stationarity? Why? How to correct them?

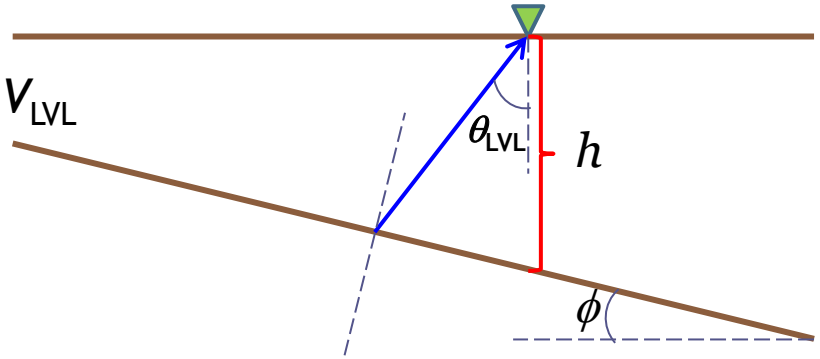
Surface Consistency?



- ✓ Different transmission angles produce different delay times even for a fixed receiver location

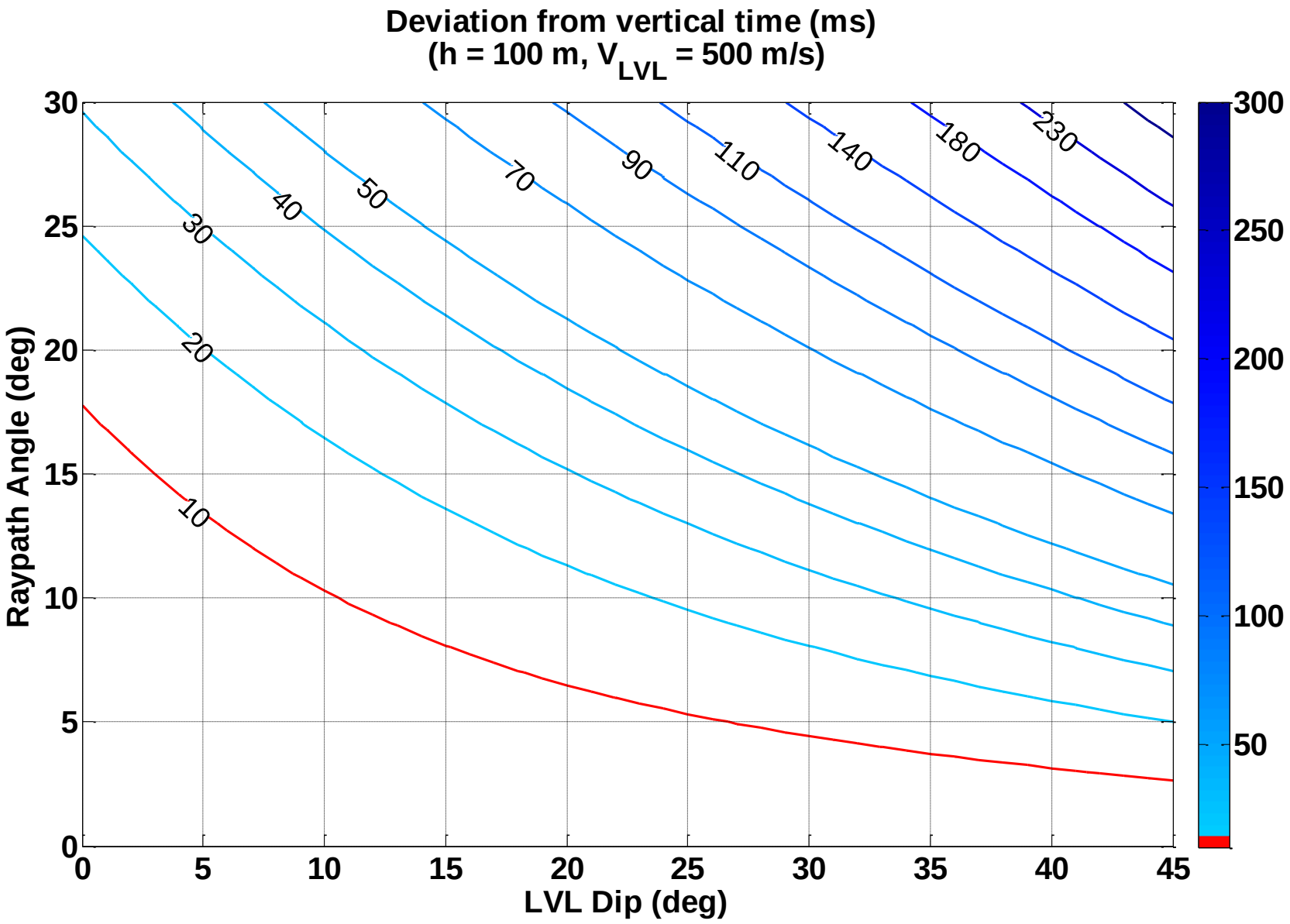
Geometry of the problem

Travel times for a dipping LVL:

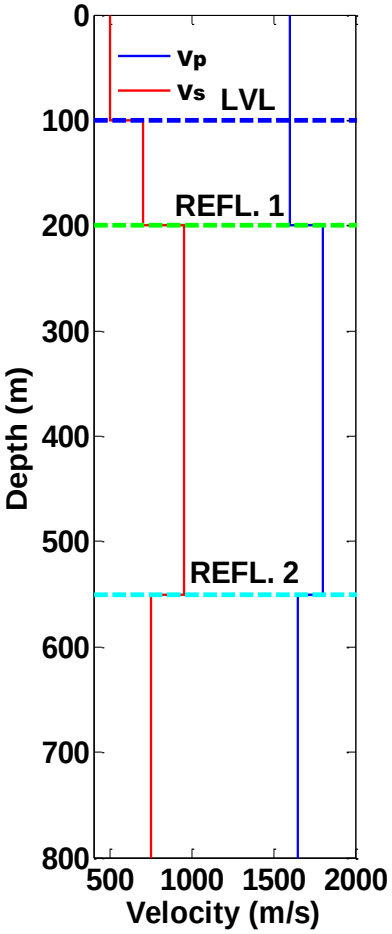


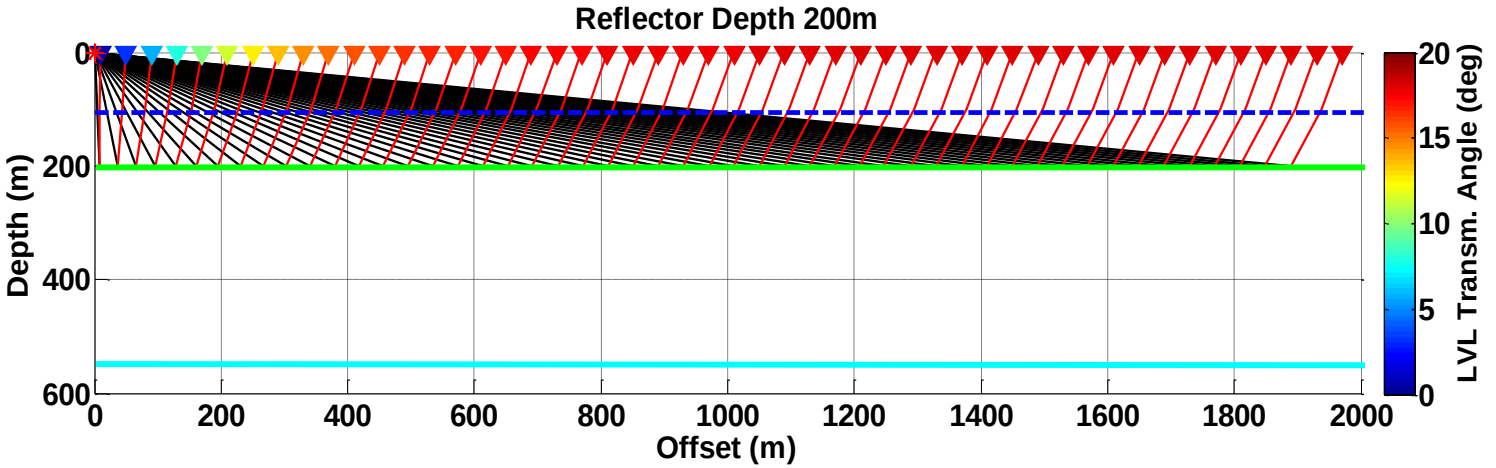
h : Vertical thickness
V : Shear wave velocity
ϕ : Dip of the base of the LVL
θ : Raypath angle

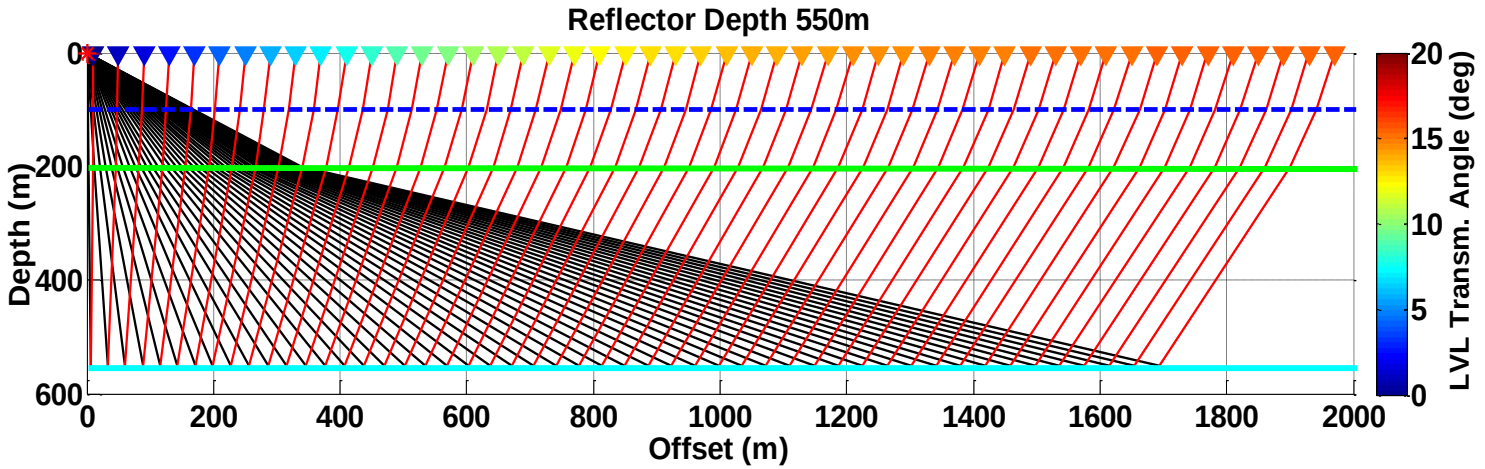
$$t_{calc} = \frac{h}{V_{LVL}} \frac{\cos(\phi)}{\cos(\theta_{LVL} + \phi)}$$


Deviation from vertical time (ms)
(h = 100 m, V LVL = 500 m/s)
Raypath Angle (deg)
LVL Dip (deg)
0
5
10
15
20
25
30
35
40
45
10
20
30
40
50
70
90
110
140
180
230
300
250
200
150
100
50

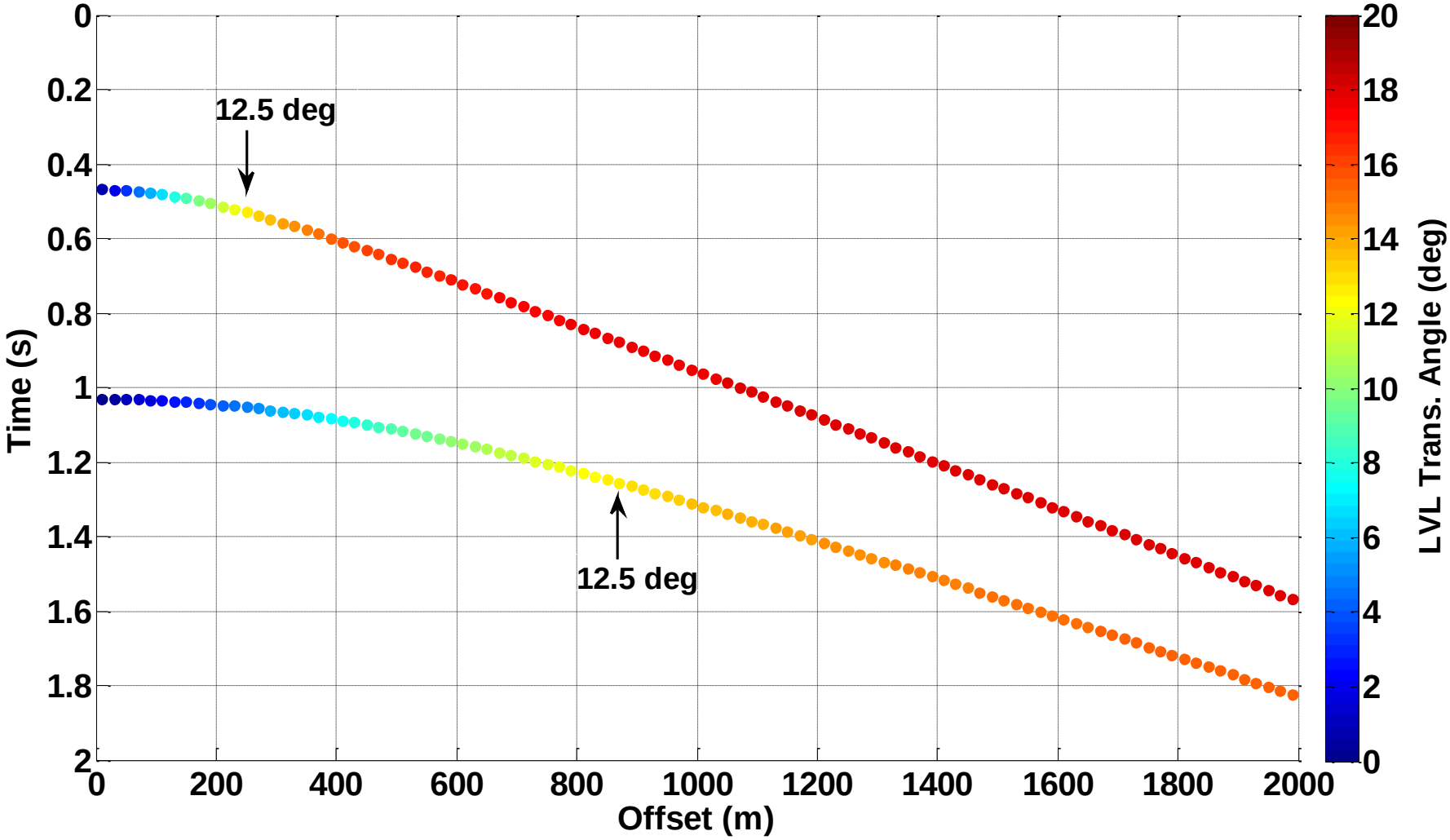
PS Ray-Tracing





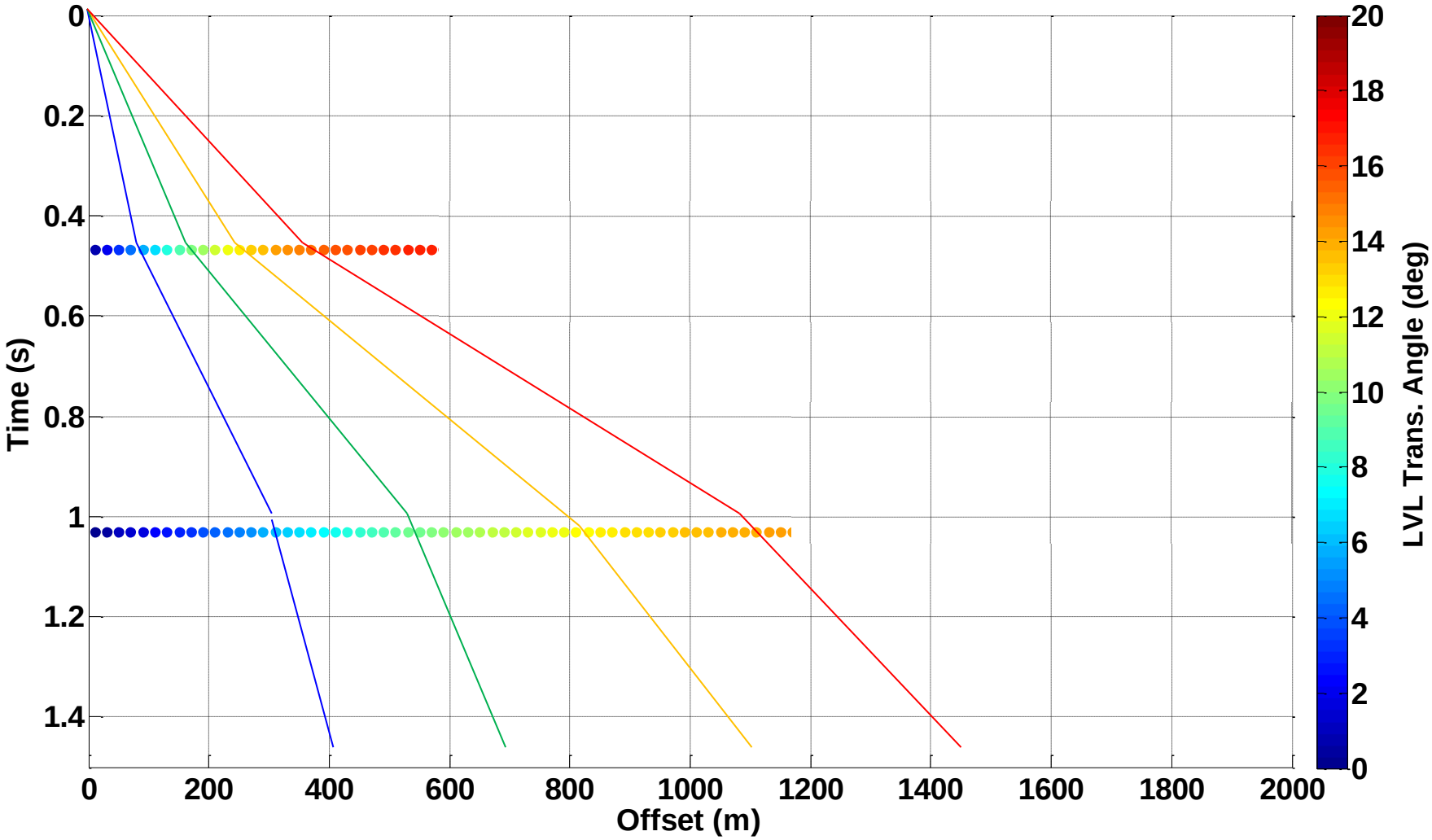


Ray-Tracing

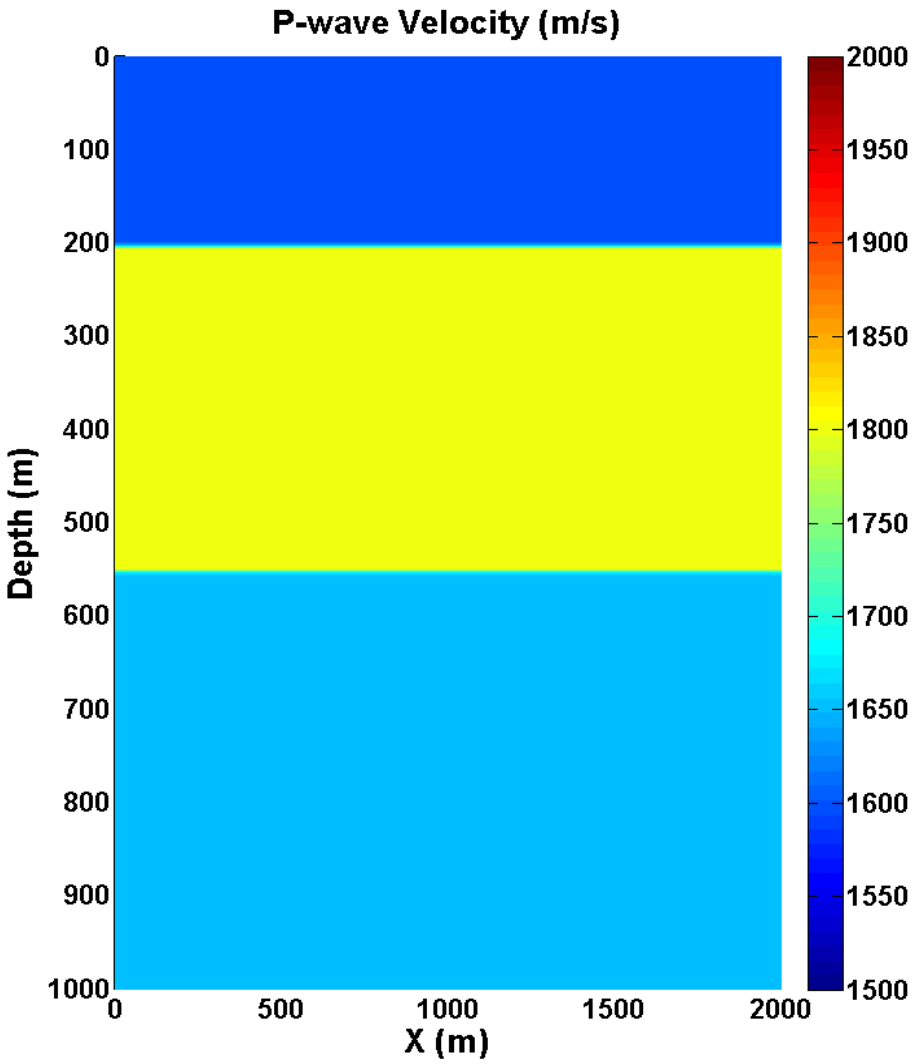


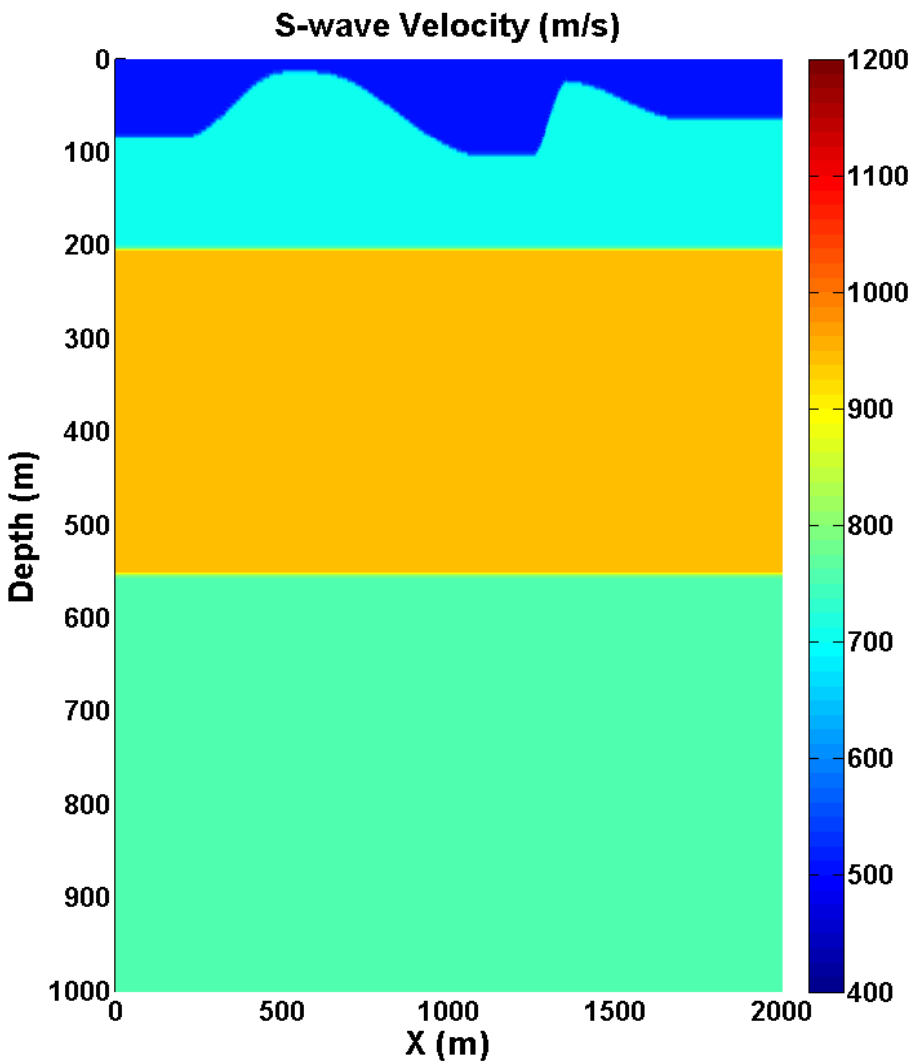
- ✓ Reflection times with the same transmission angle are recorded at different offsets

Ray-Tracing

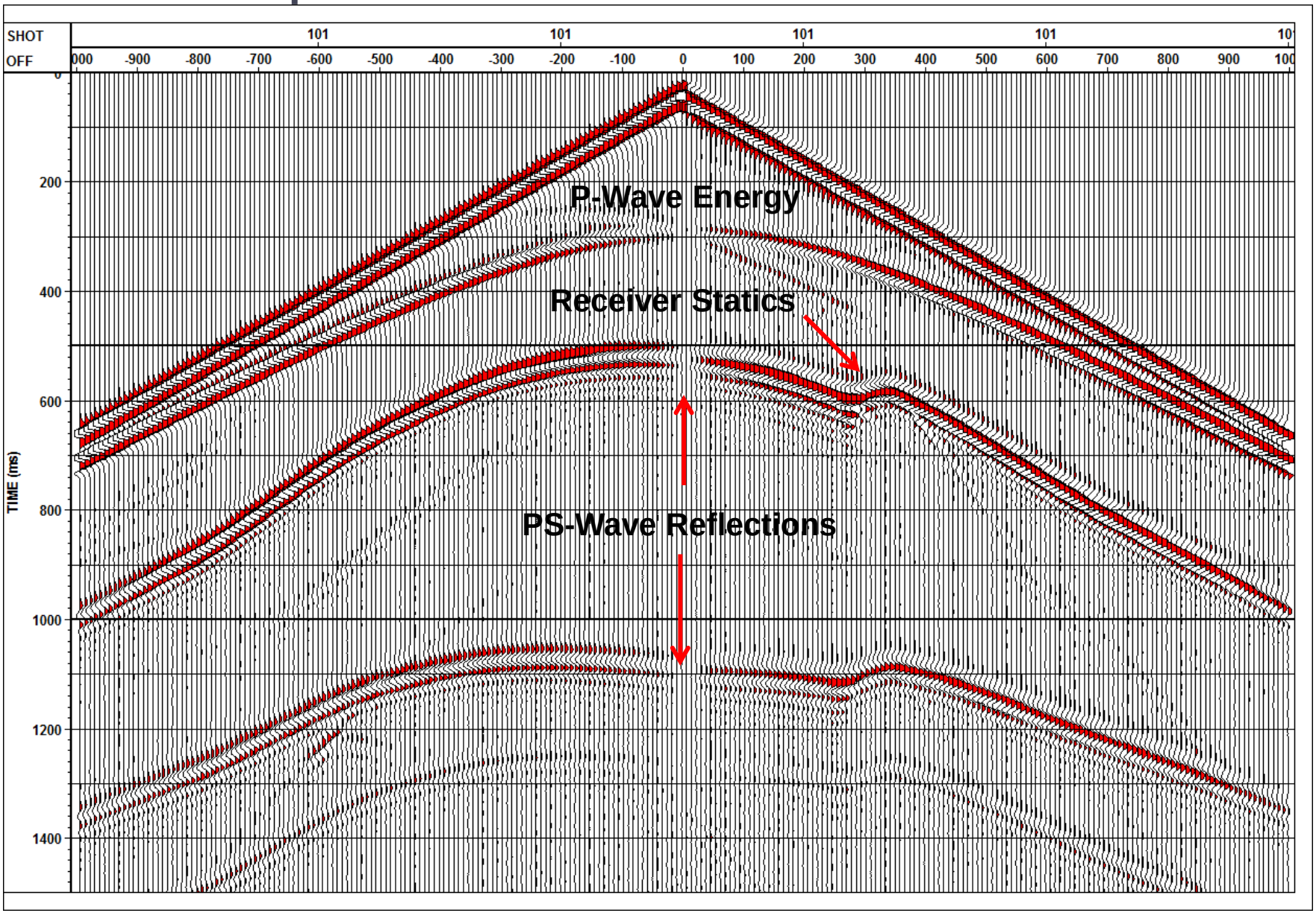

Time (s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Offset (m)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
LVL Trans. Angle (deg)
0
2
4
6
8
10
12
14
16
18
20

Finite-Difference Modeling

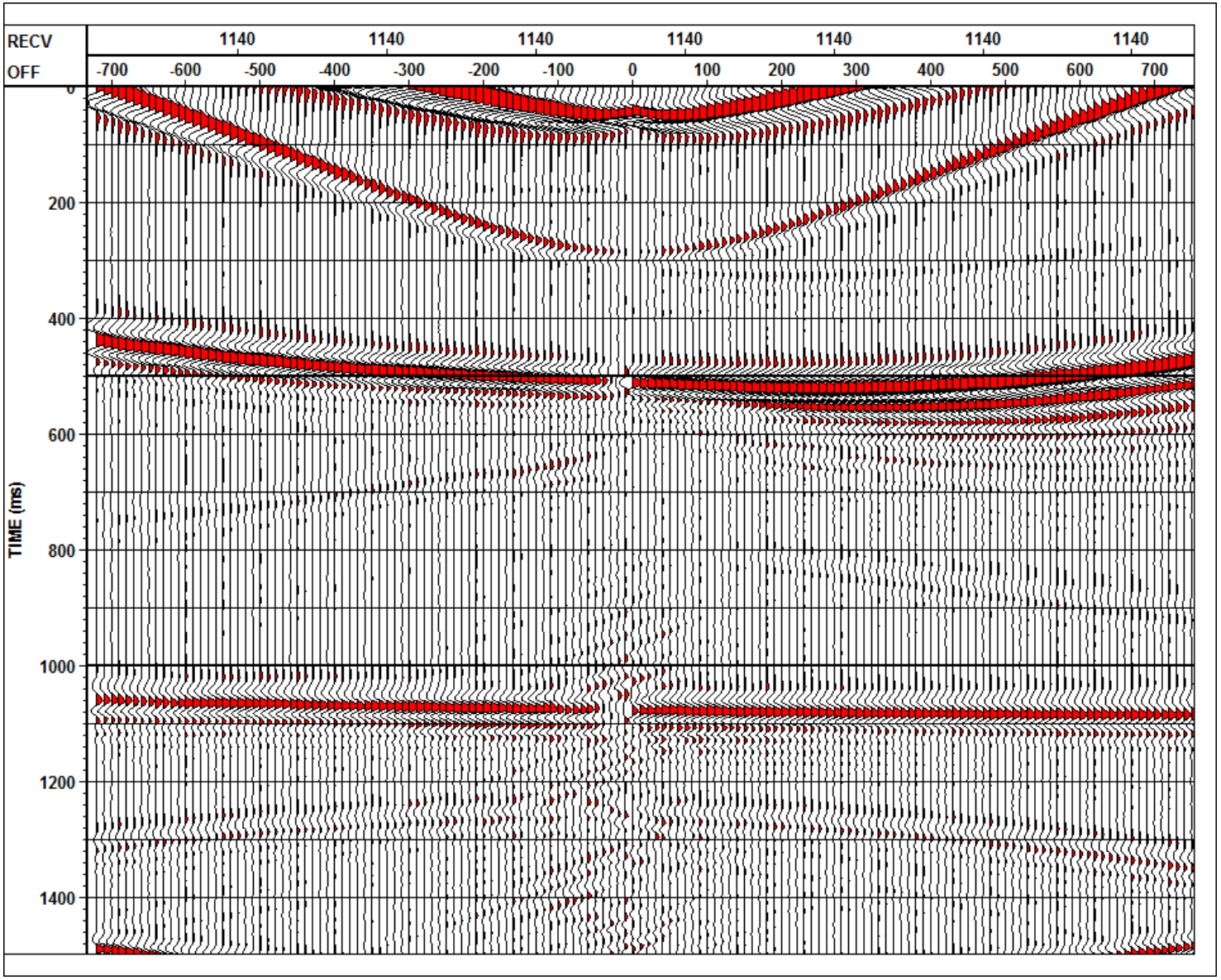




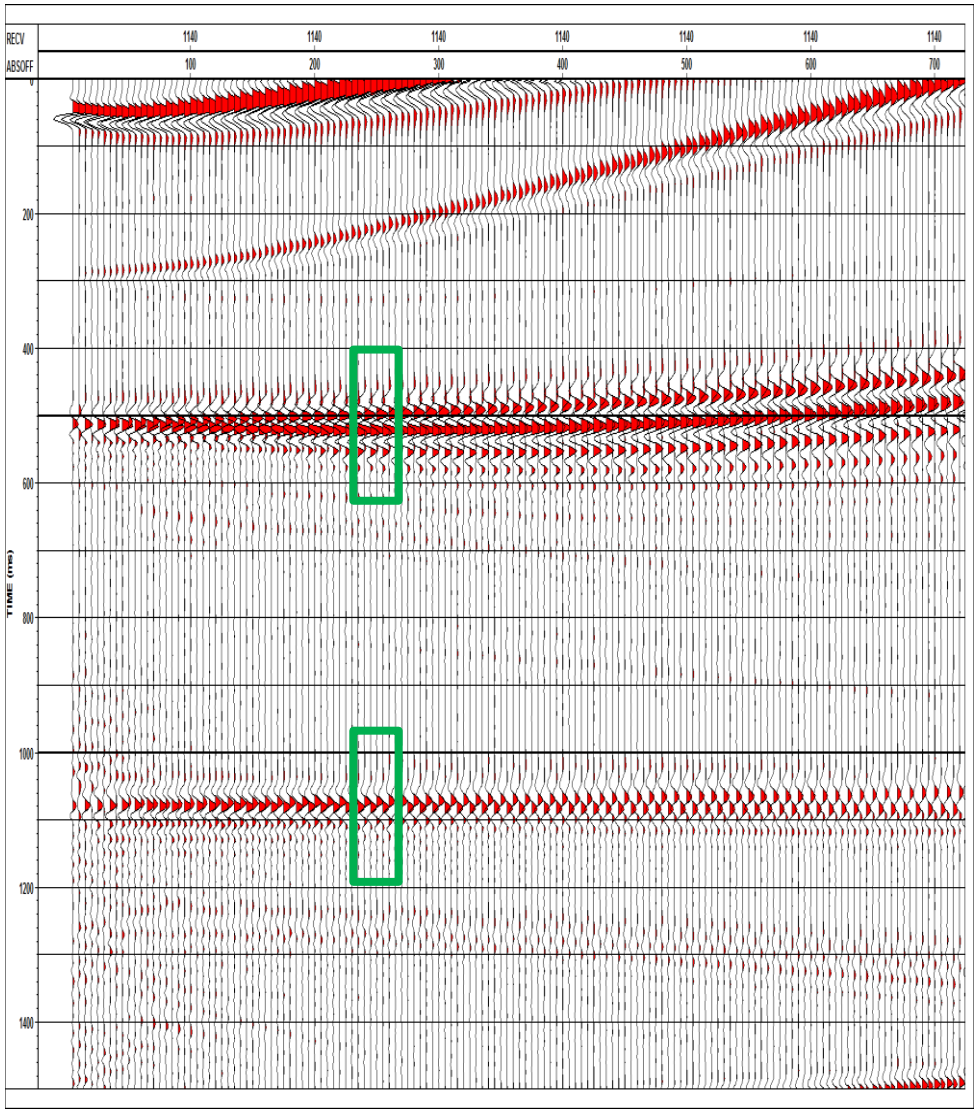
Raw X-component Shot Gather

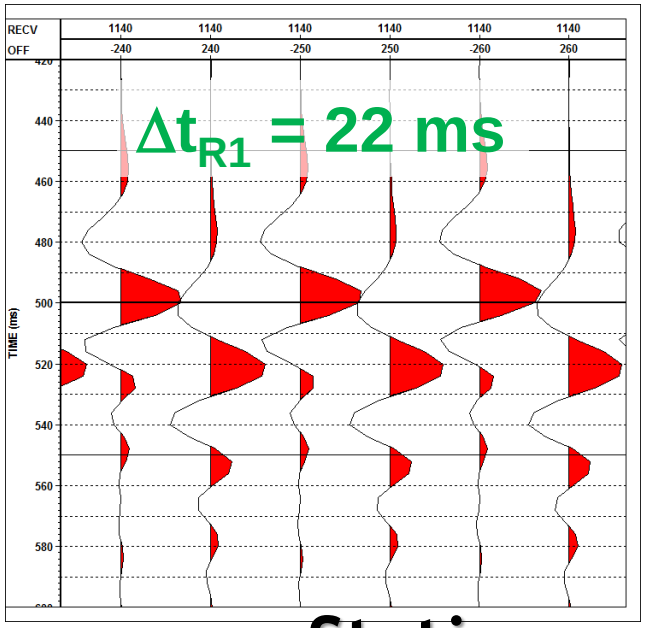


Receiver Gather

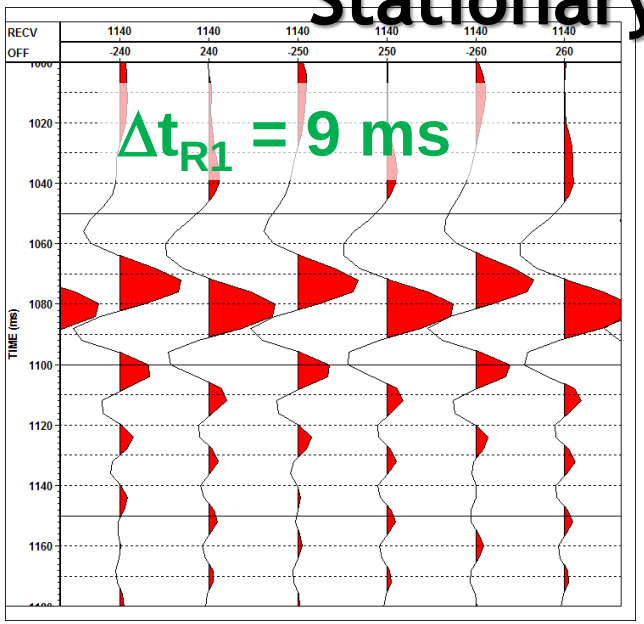


Receiver Gather

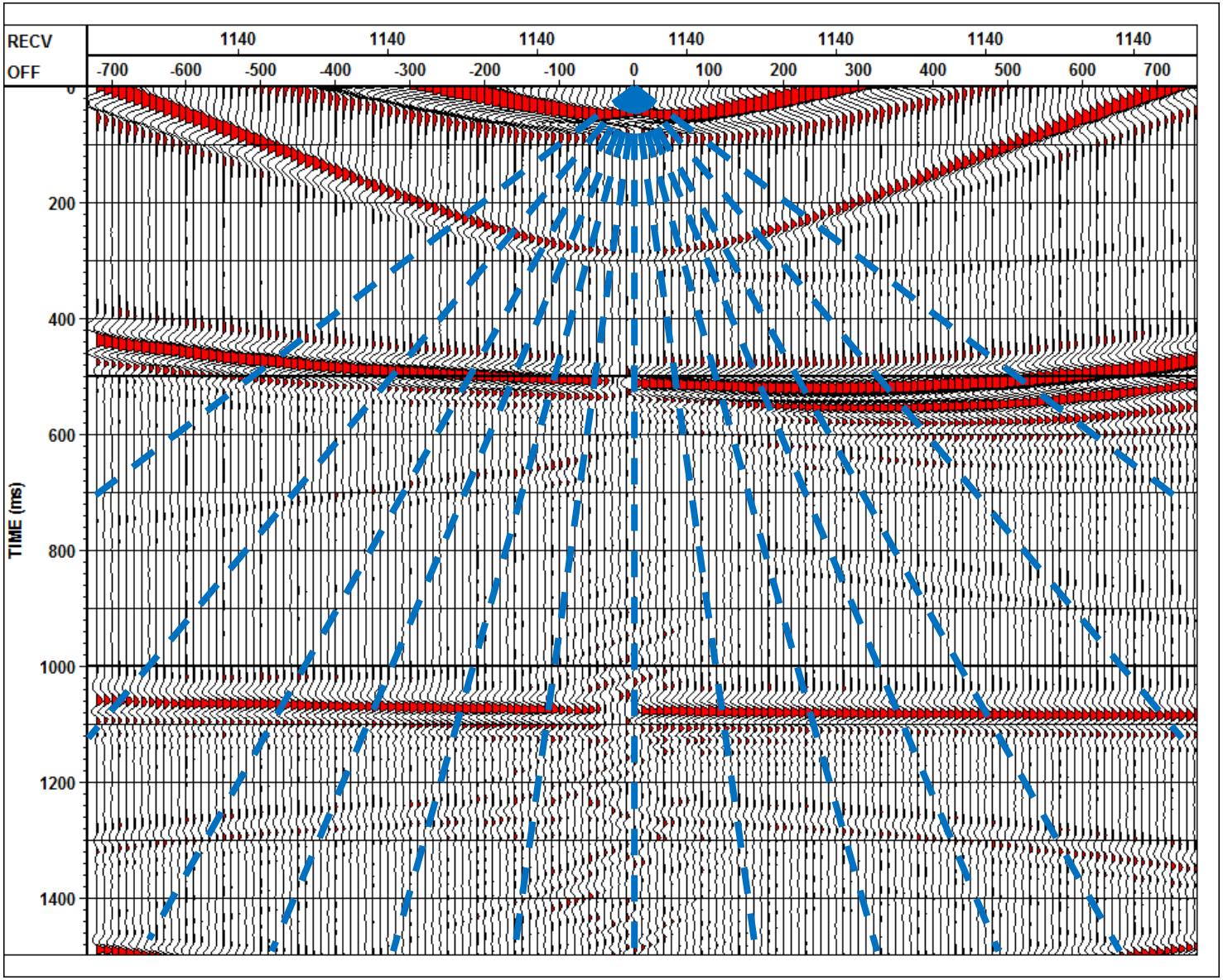




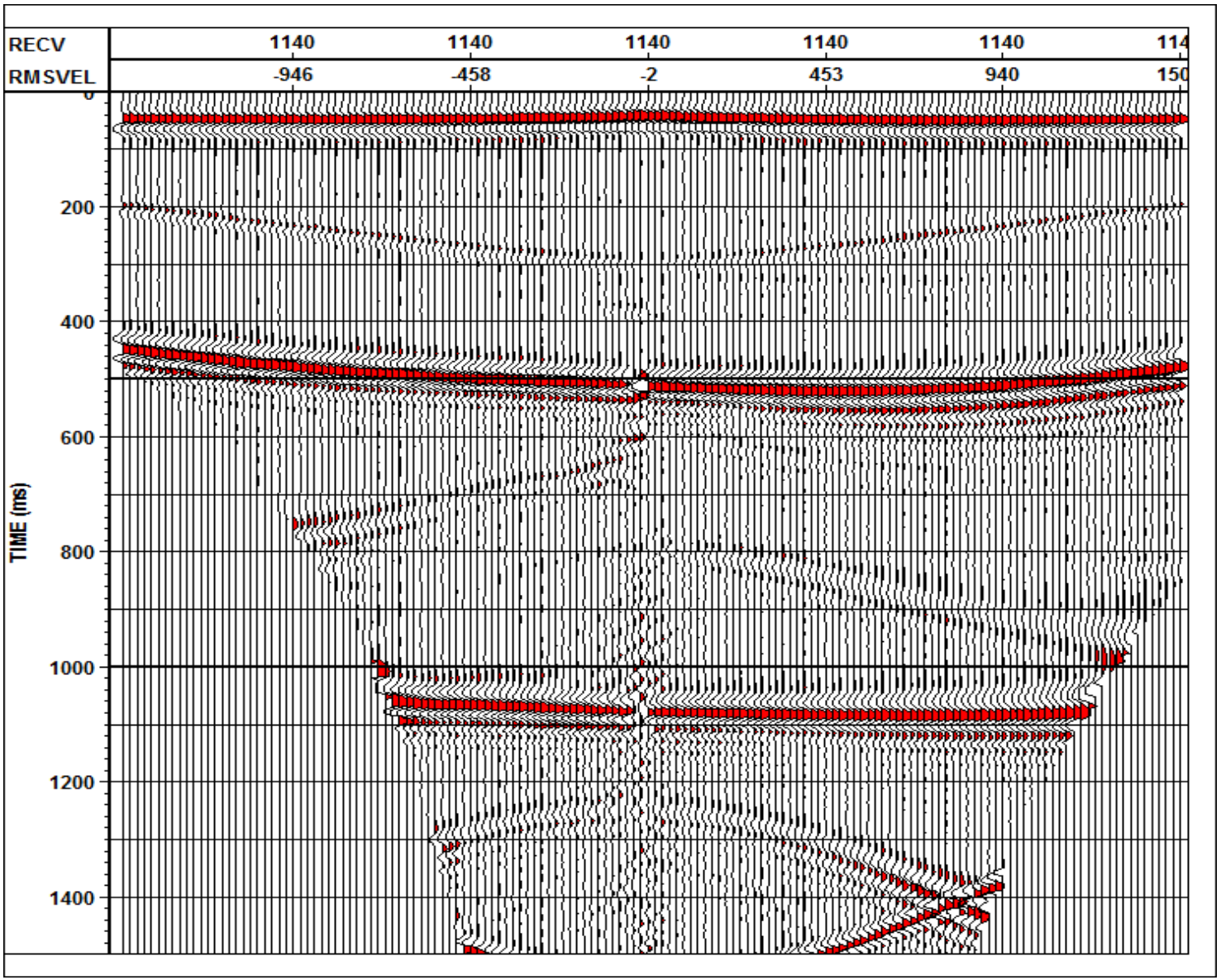
Stationary???



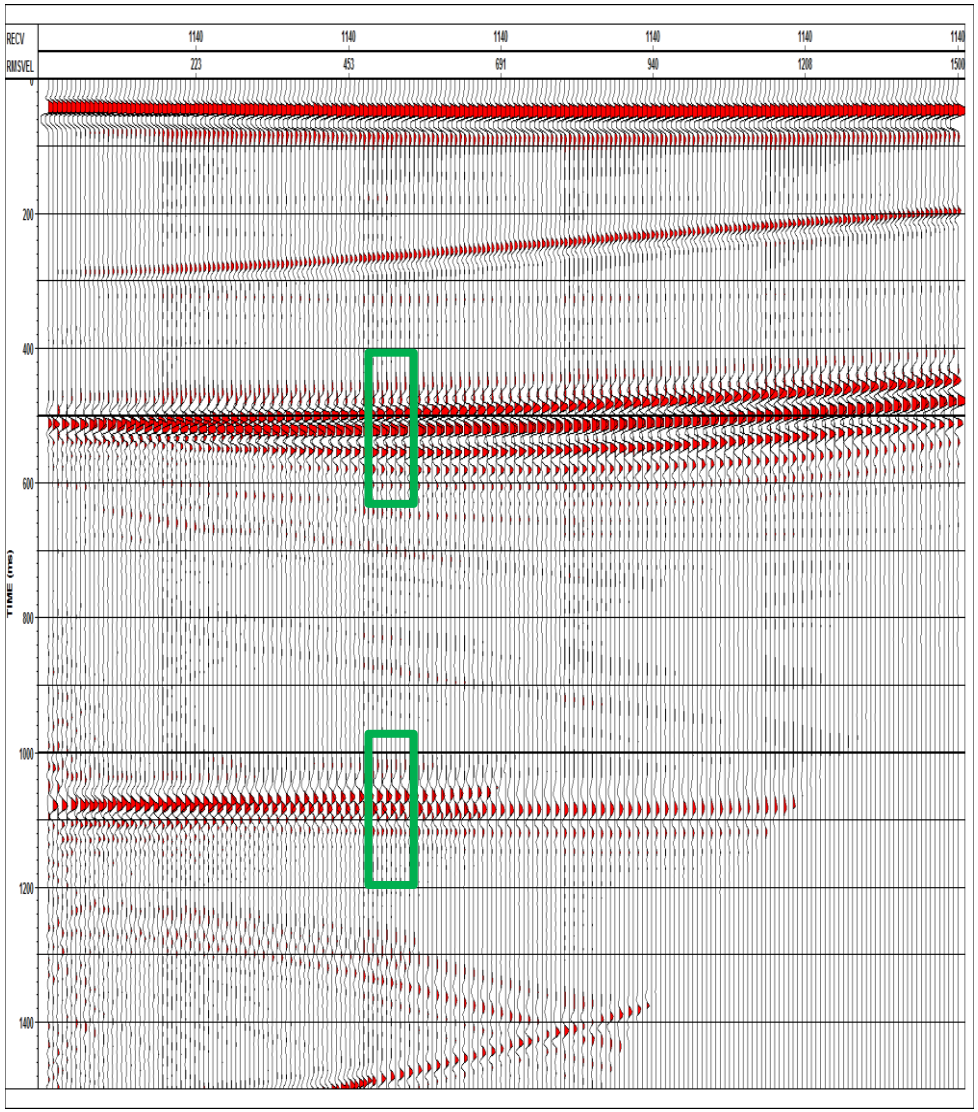
Receiver Gather

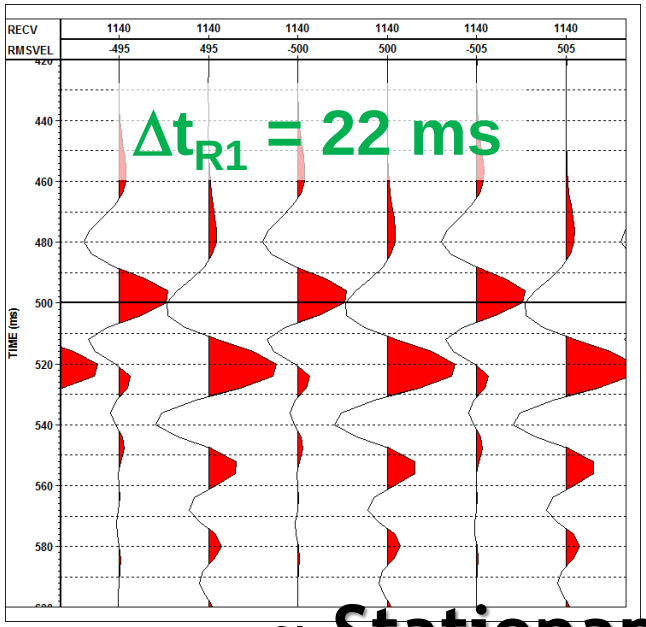


Radial-Trace Gather

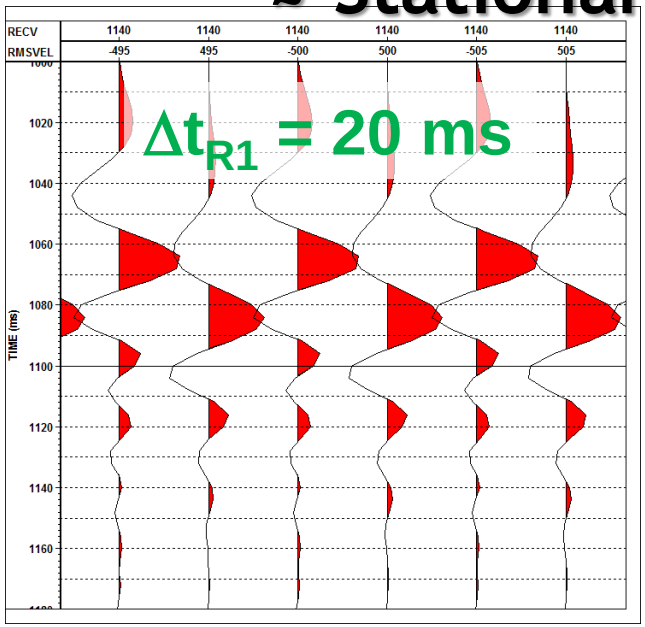


RT Gather

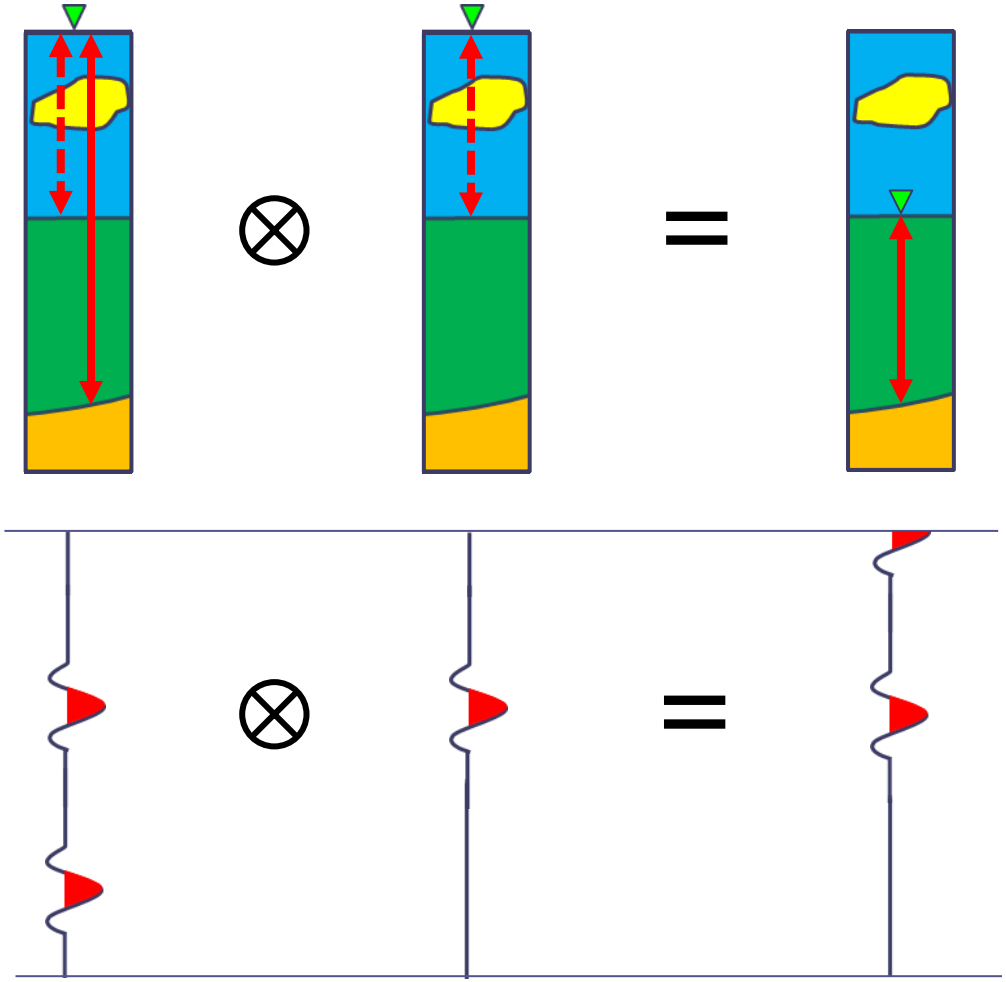




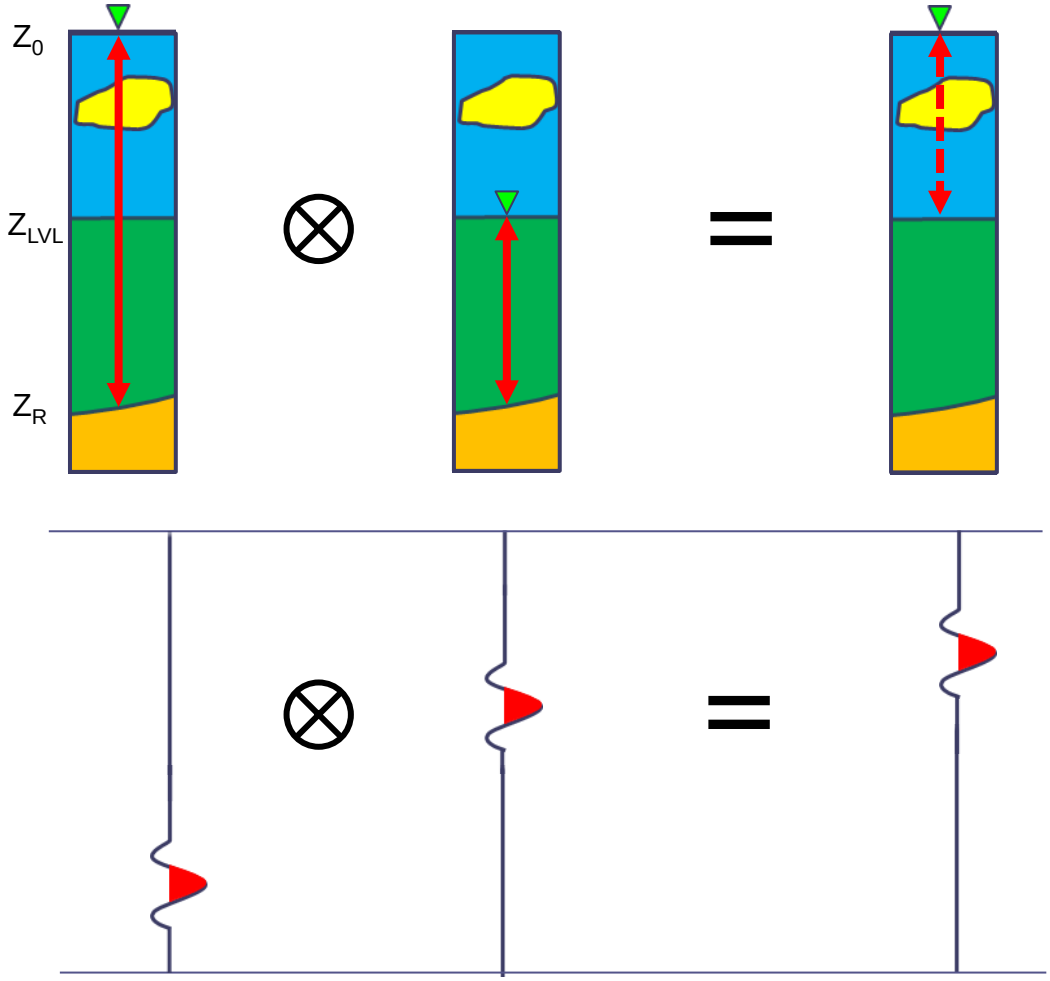
≈ Stationary



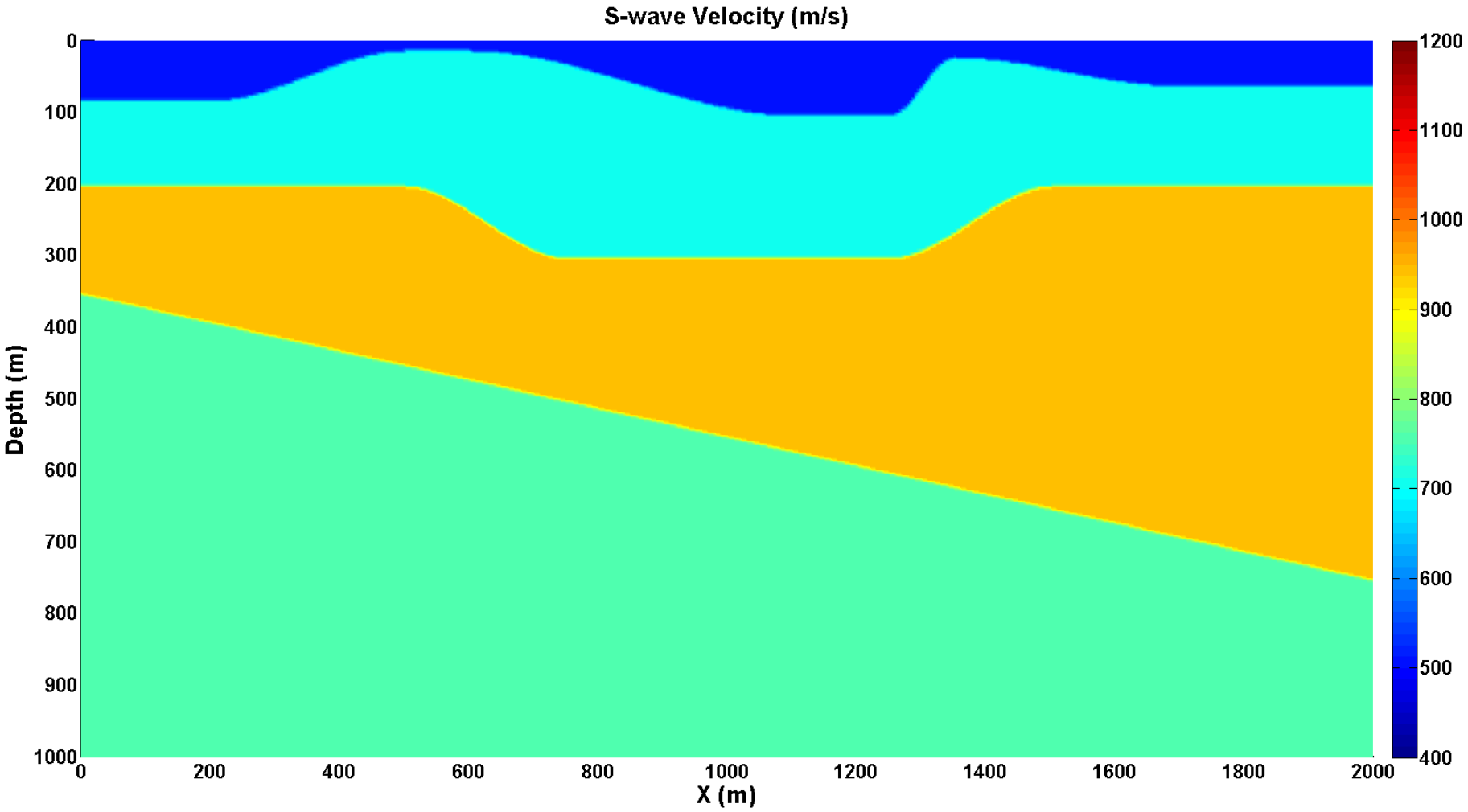
Interferometry



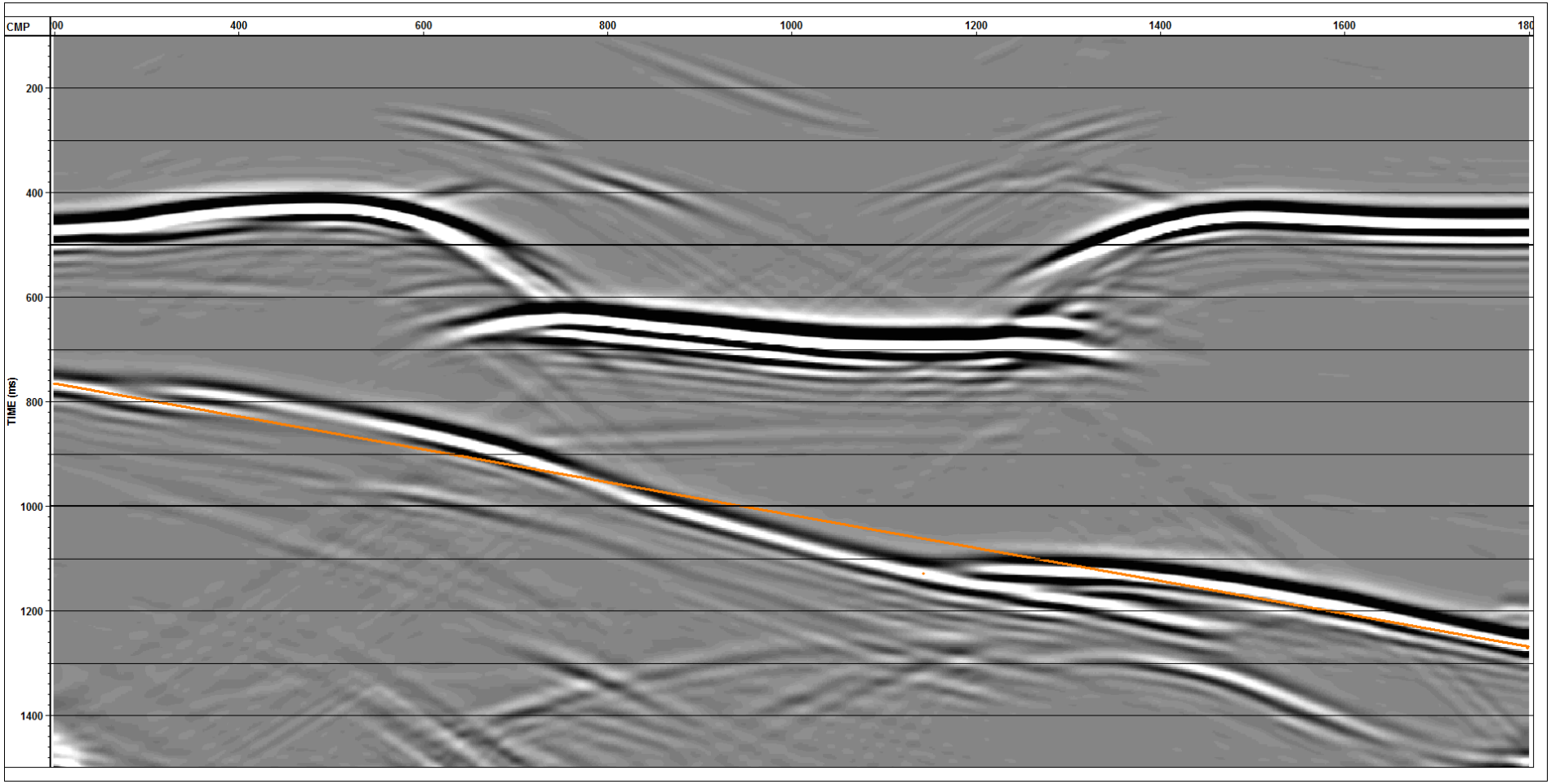
Interferometry



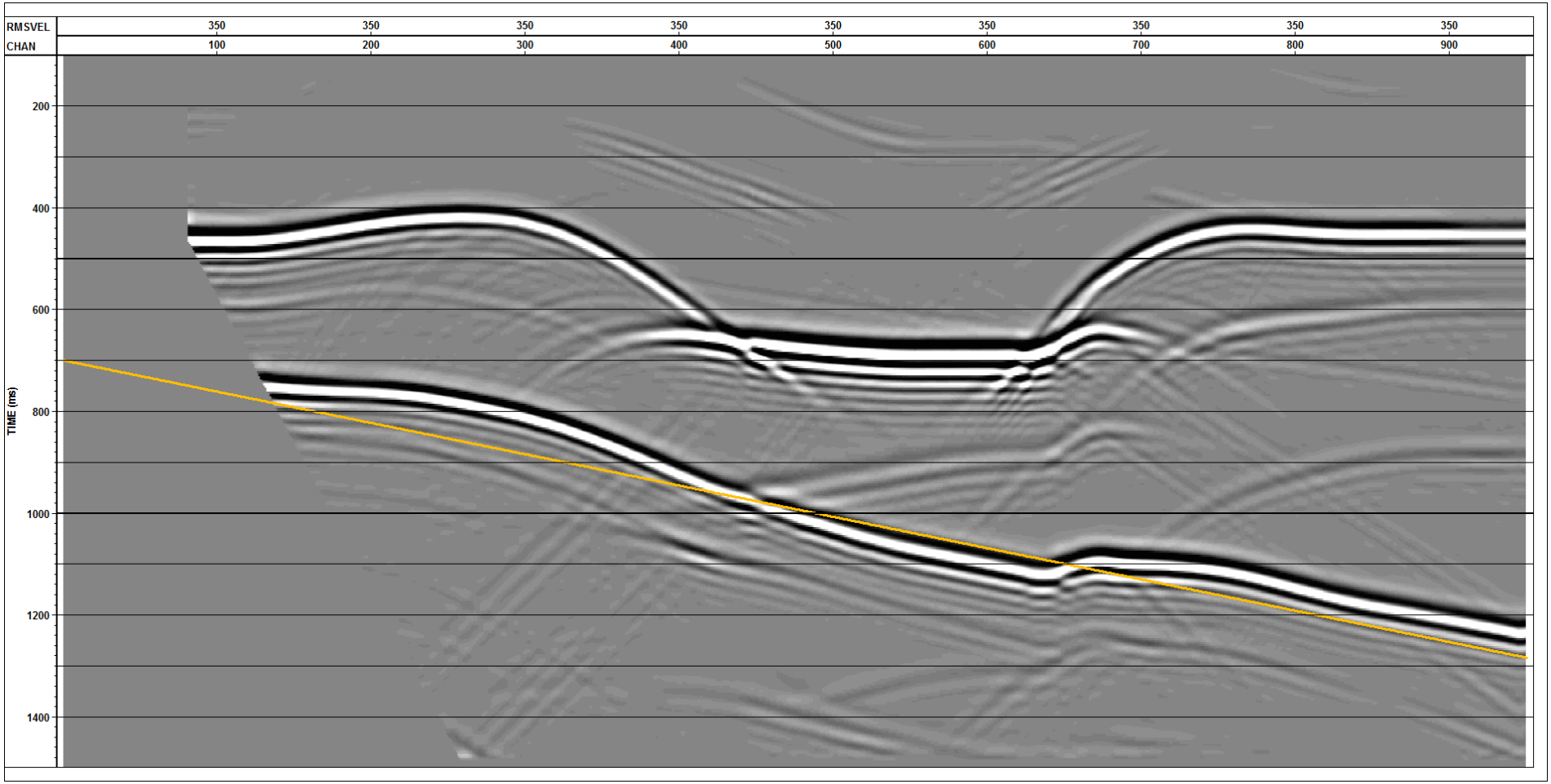
Finite-difference modeling



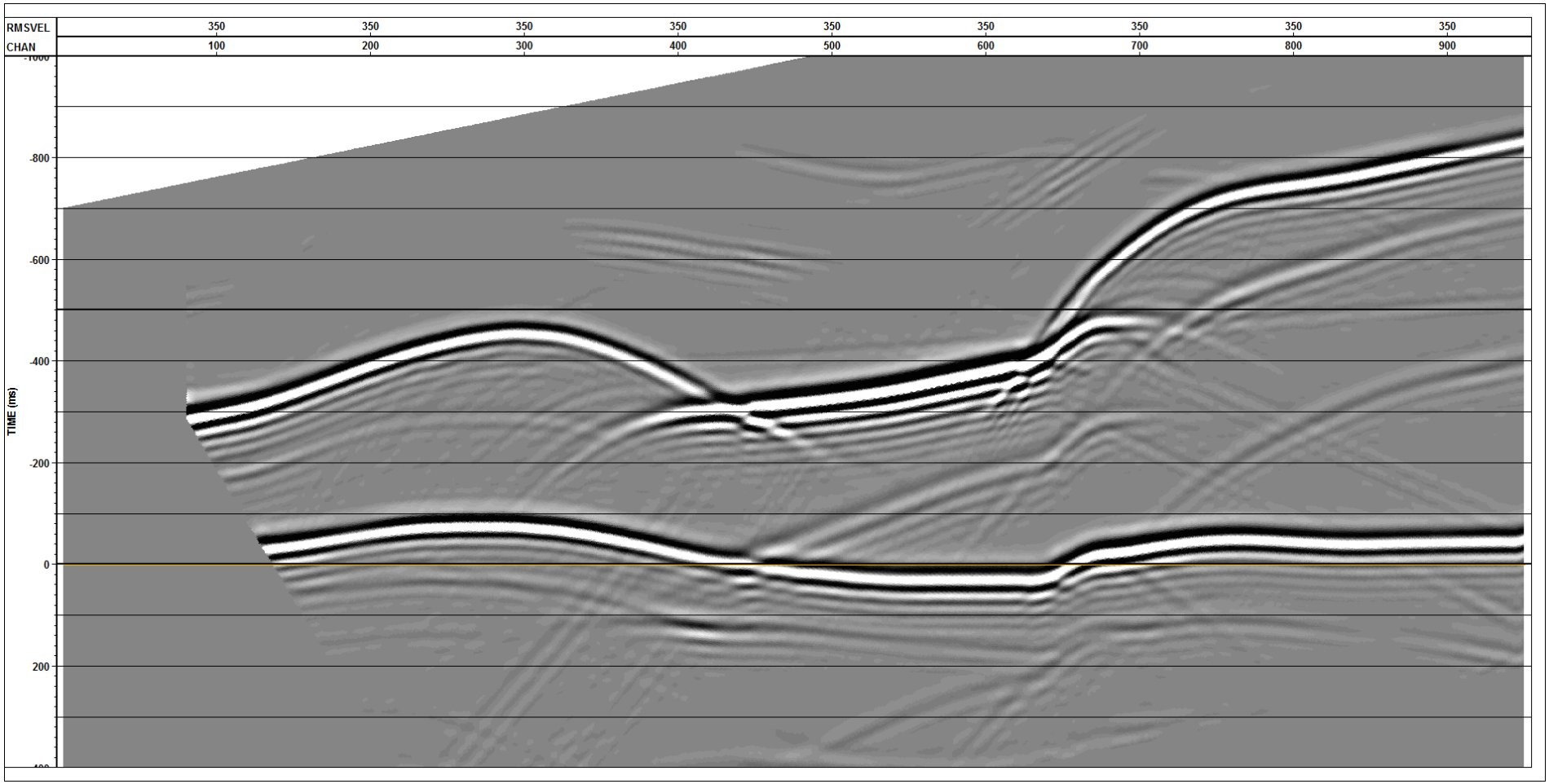
ACP Stack w/o statics



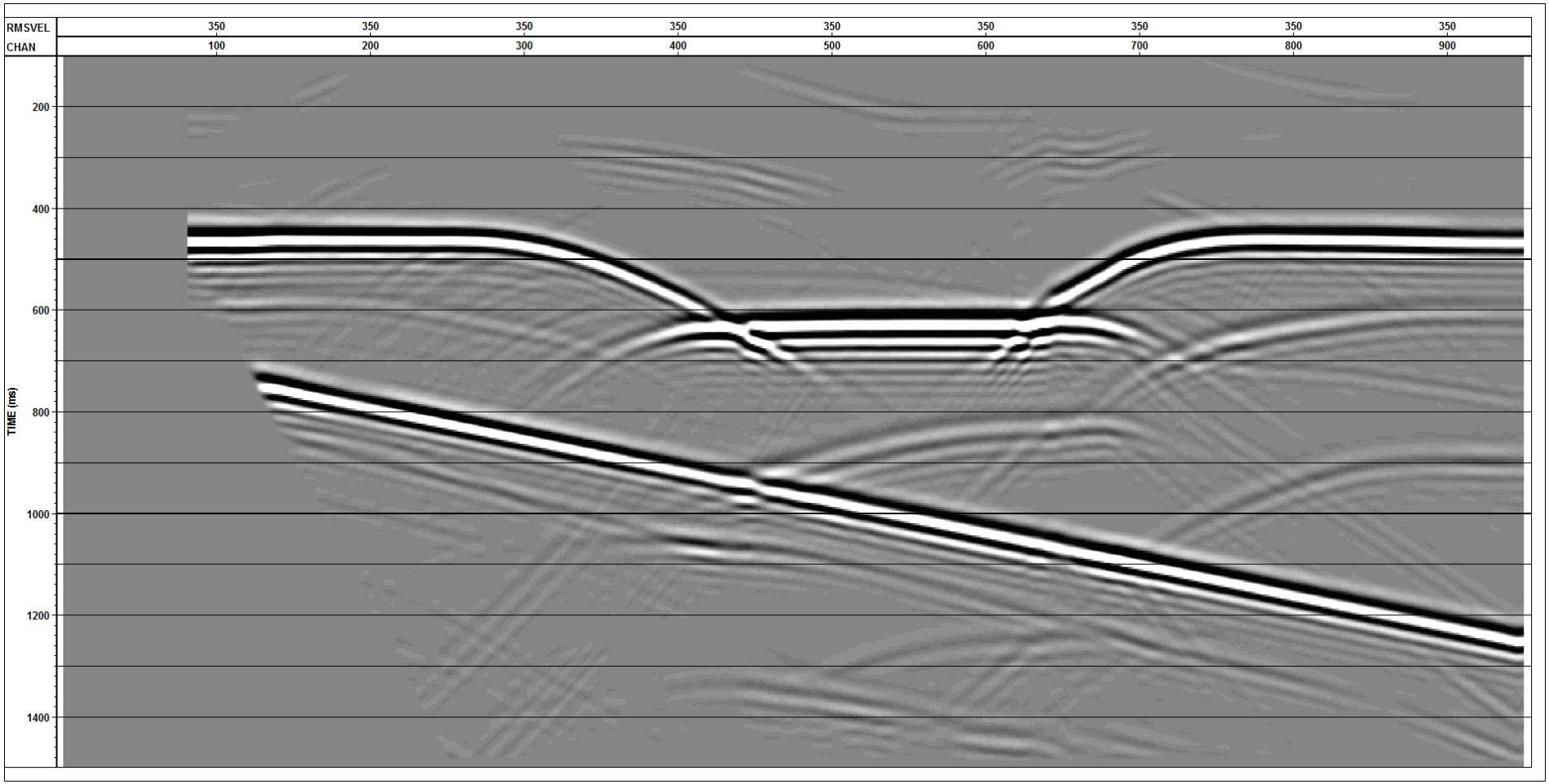
Common ray parameter gather (350 m/s)



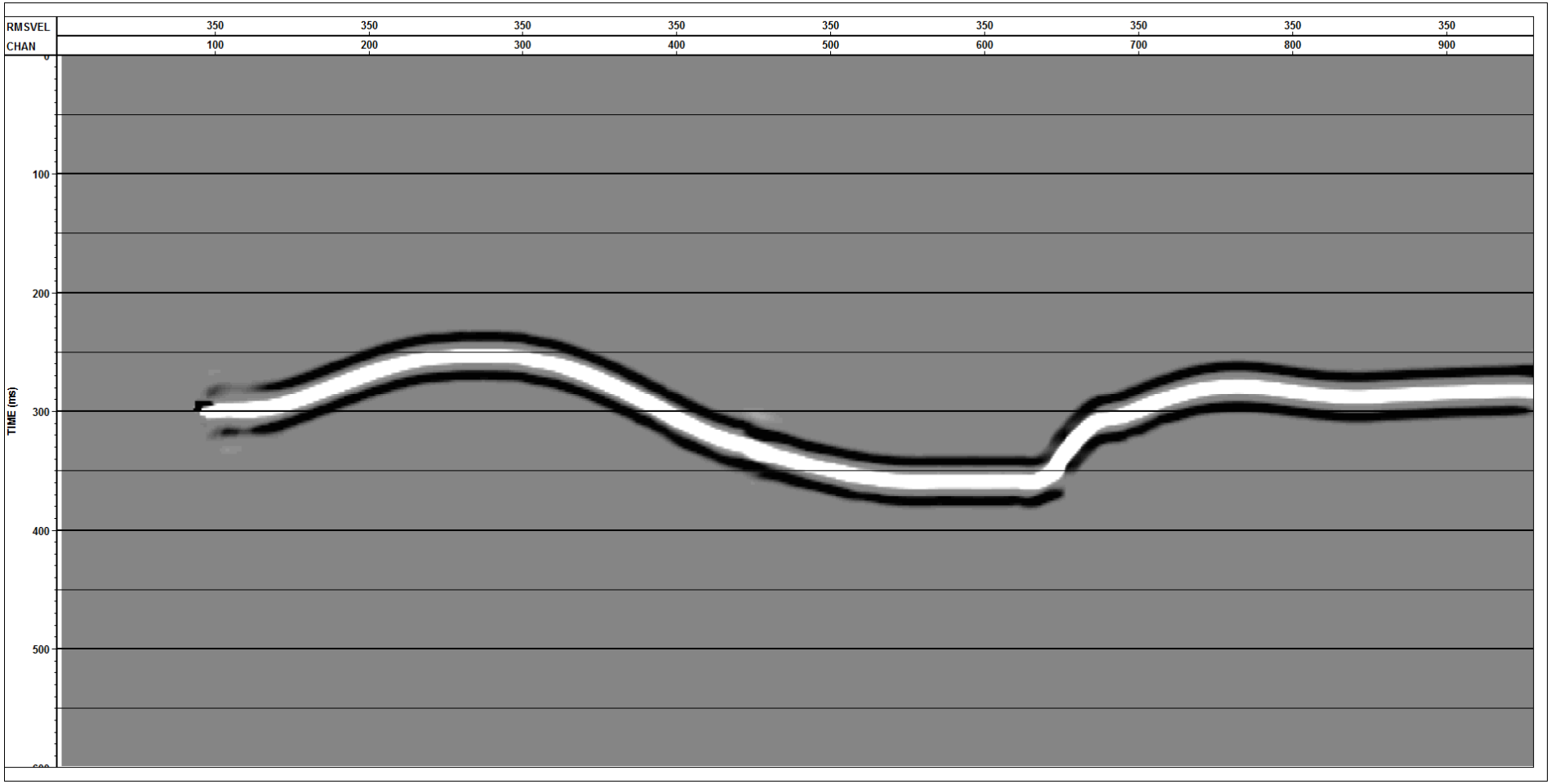
De-structured ray parameter gather



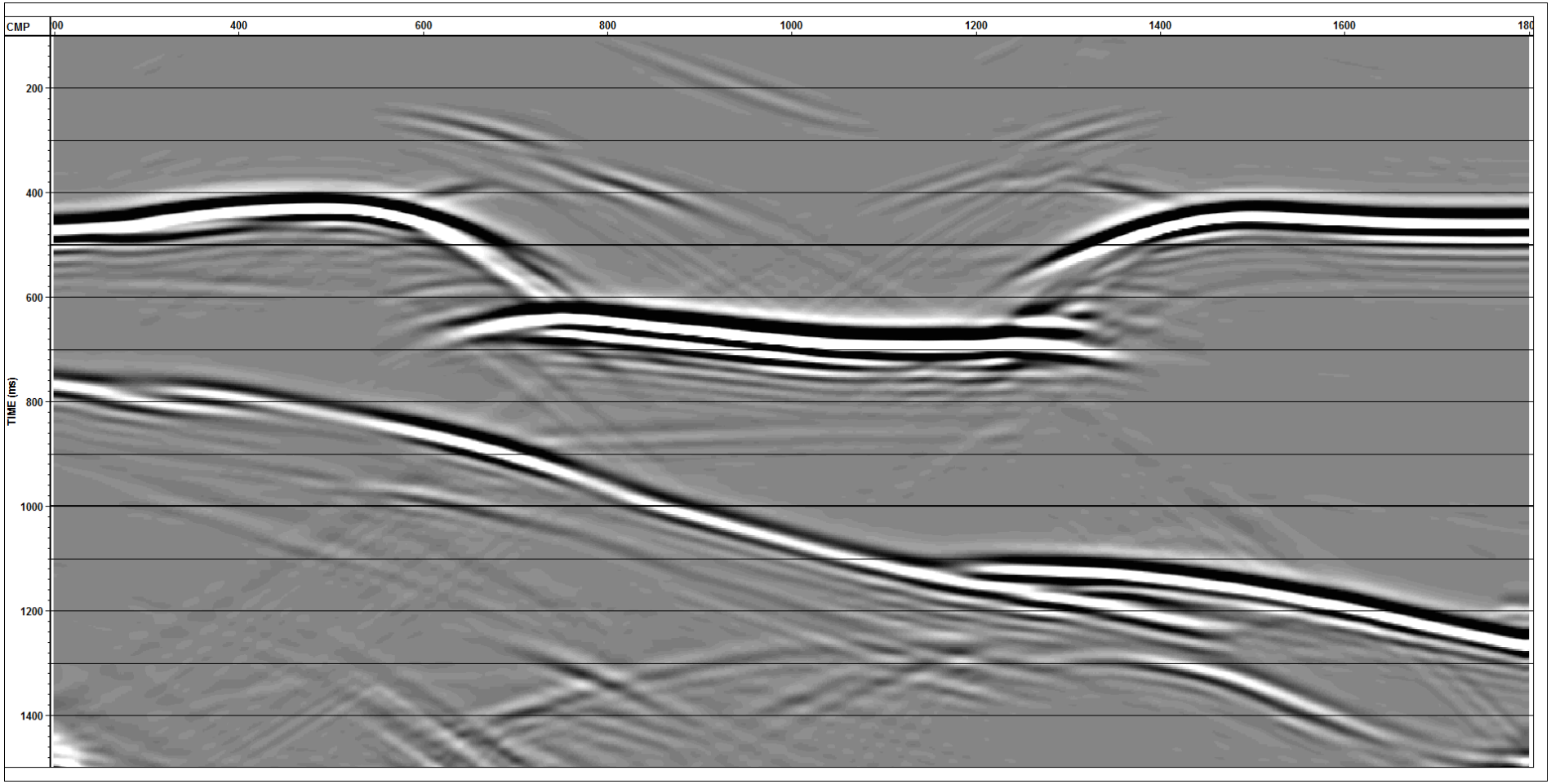
Ray parameter gather after convolution with xcorrelation functions



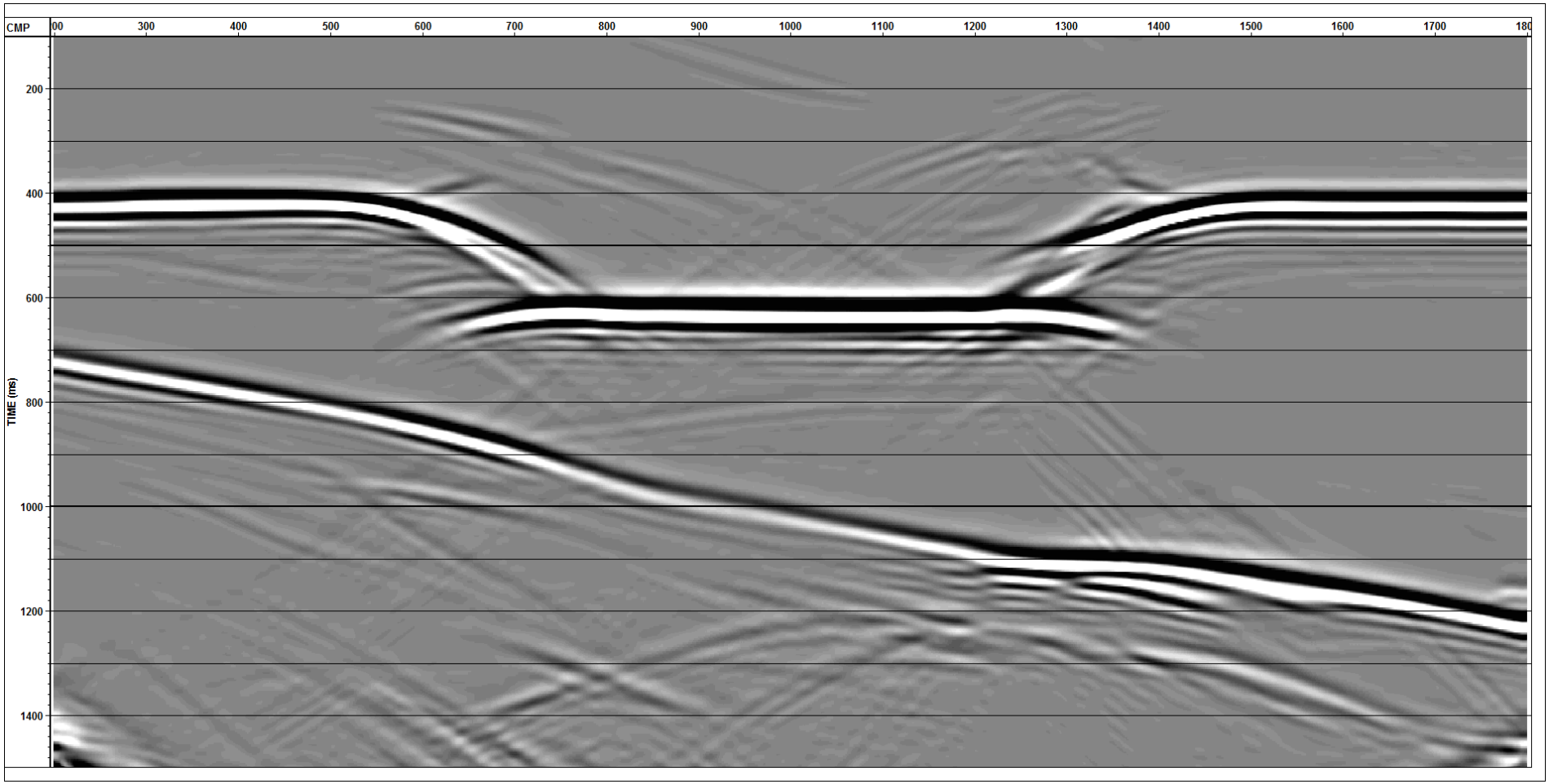
Xcorrelation functions



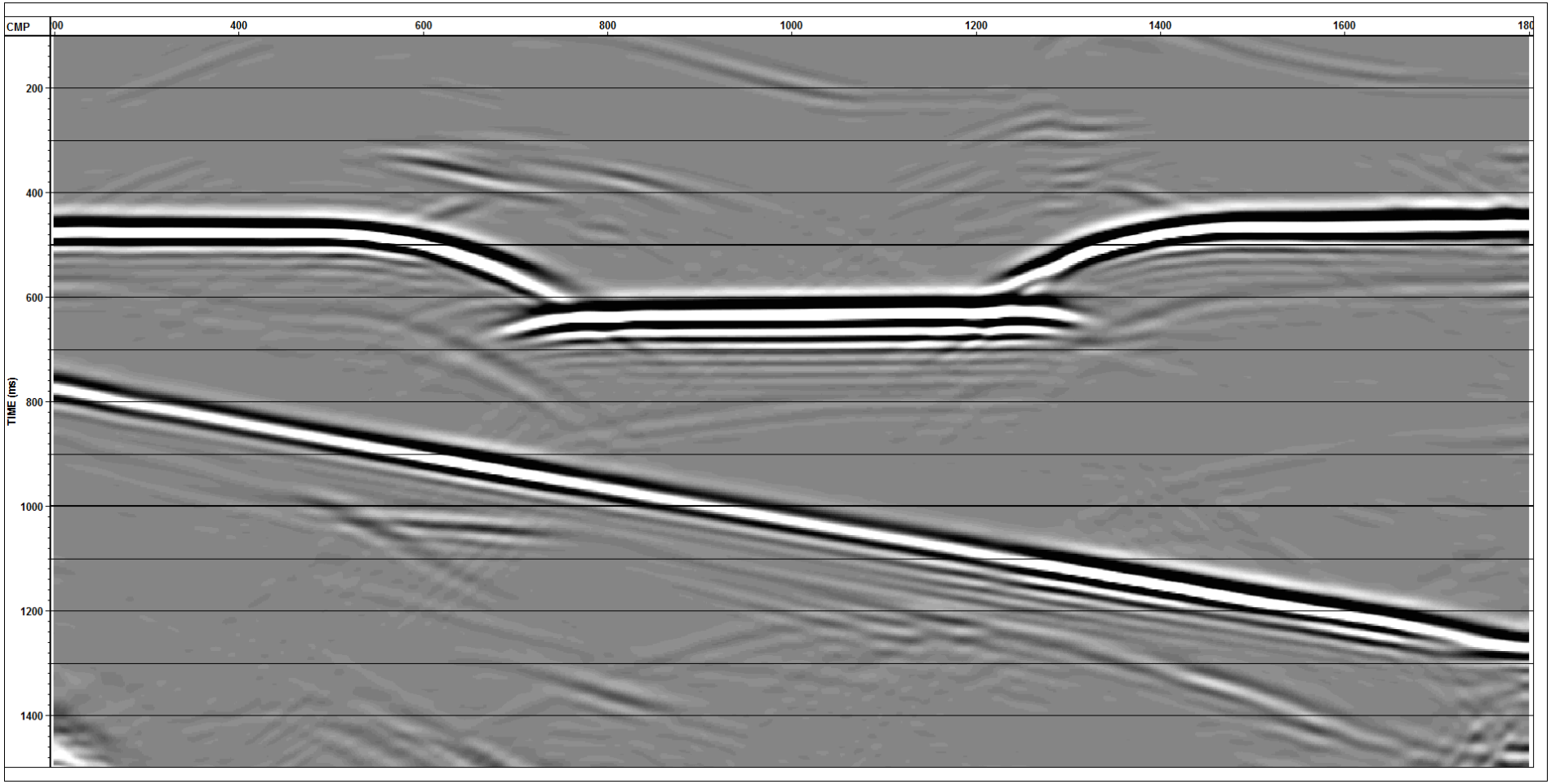
ACP Stack w/o statics



ACP Stack w surface consistent statics



ACP Stack w ray-path consistent statics



Conclusions

- If velocity contrasts at the near surface are not large, S-wave statics may show ray-path dependency
- Ray-path dependency implies a non-stationary behavior in time domain.
- Interferometric statics applied in the R-T domain showed to solved the problem.
- Straight ray-path assumptions for applying the radial transform may not be enough. Snell ray transform can be the next step.
- Inversion of the cross-correlations peaks time may be used for computing a velocity model for the near surface.

Acknowledgements

- David Henley
- Kris Innanen
- CREWES

… THANKS!!!