Elastic 2D Modeling of Seismic Surveys

Joe Wong
Peter Manning
Dave Henley

UNIVERSITY OF CALGARY

CREWES

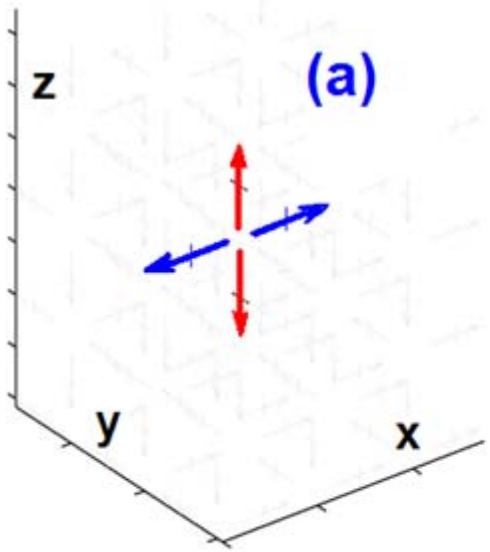
mFD2D - MATLAB software :

- *Designed for easy use;*
- *Models fairly complex geological structure;*
- *Output data written to SEG-Y files.*

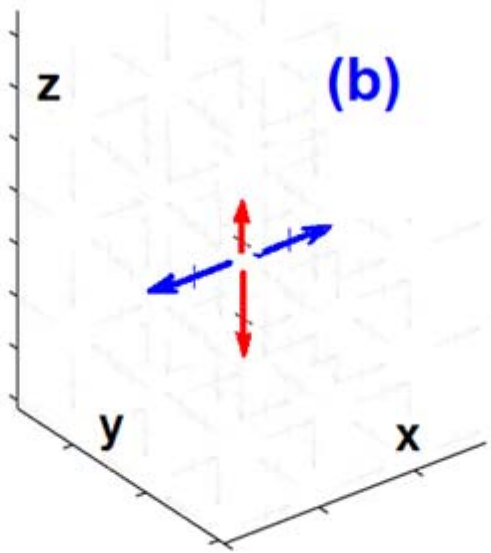
Produce realistic-looking synthetic data for :

- ***Reflection***
- ***Refraction***
- ***VSP***
- ***Microseismic***
- ***Crosswell***
- ***Time Lapse***

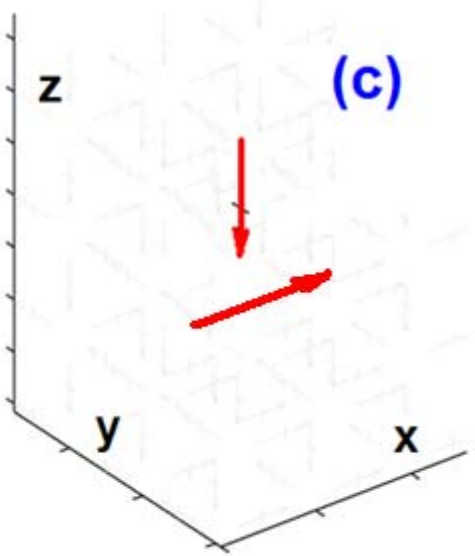
Source Force Vectors



Deep Explosion

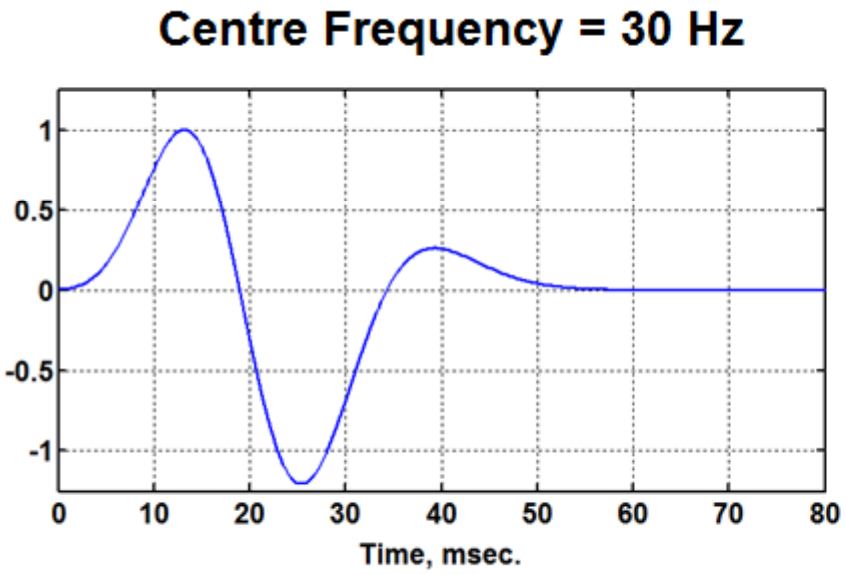


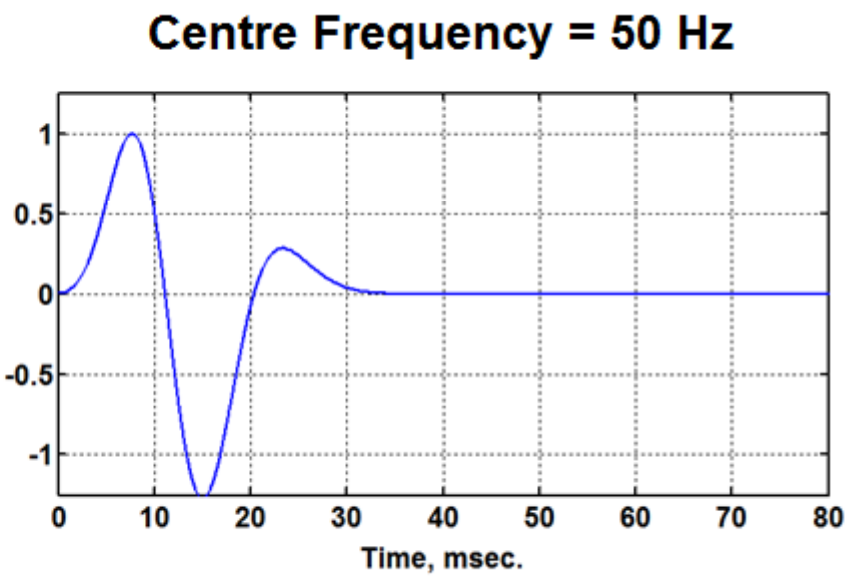
Near-surface Explosion

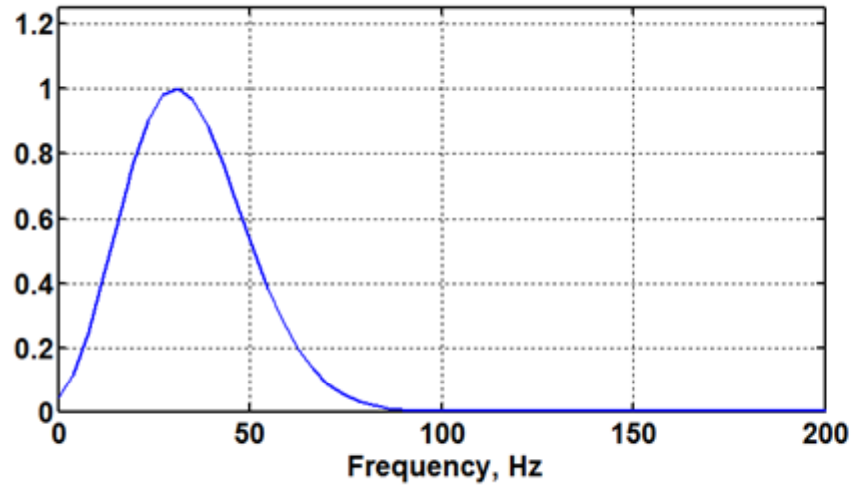


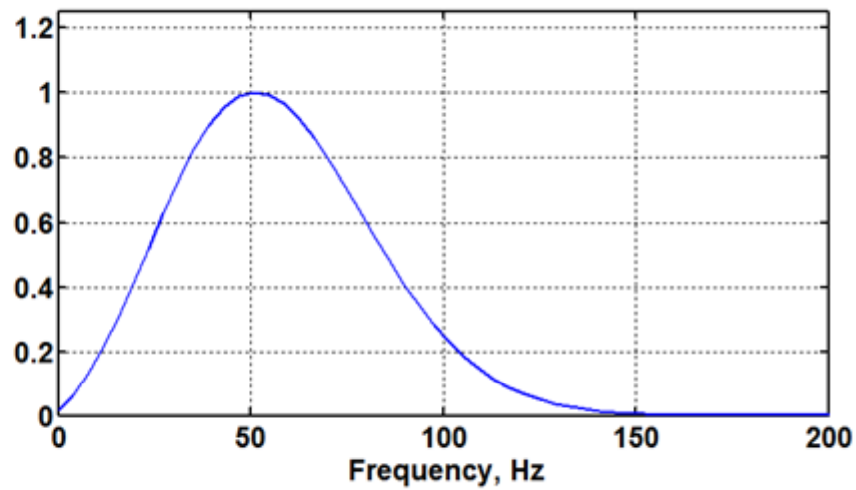
Vertical/Horizontal Vibrator

Source Wavelets



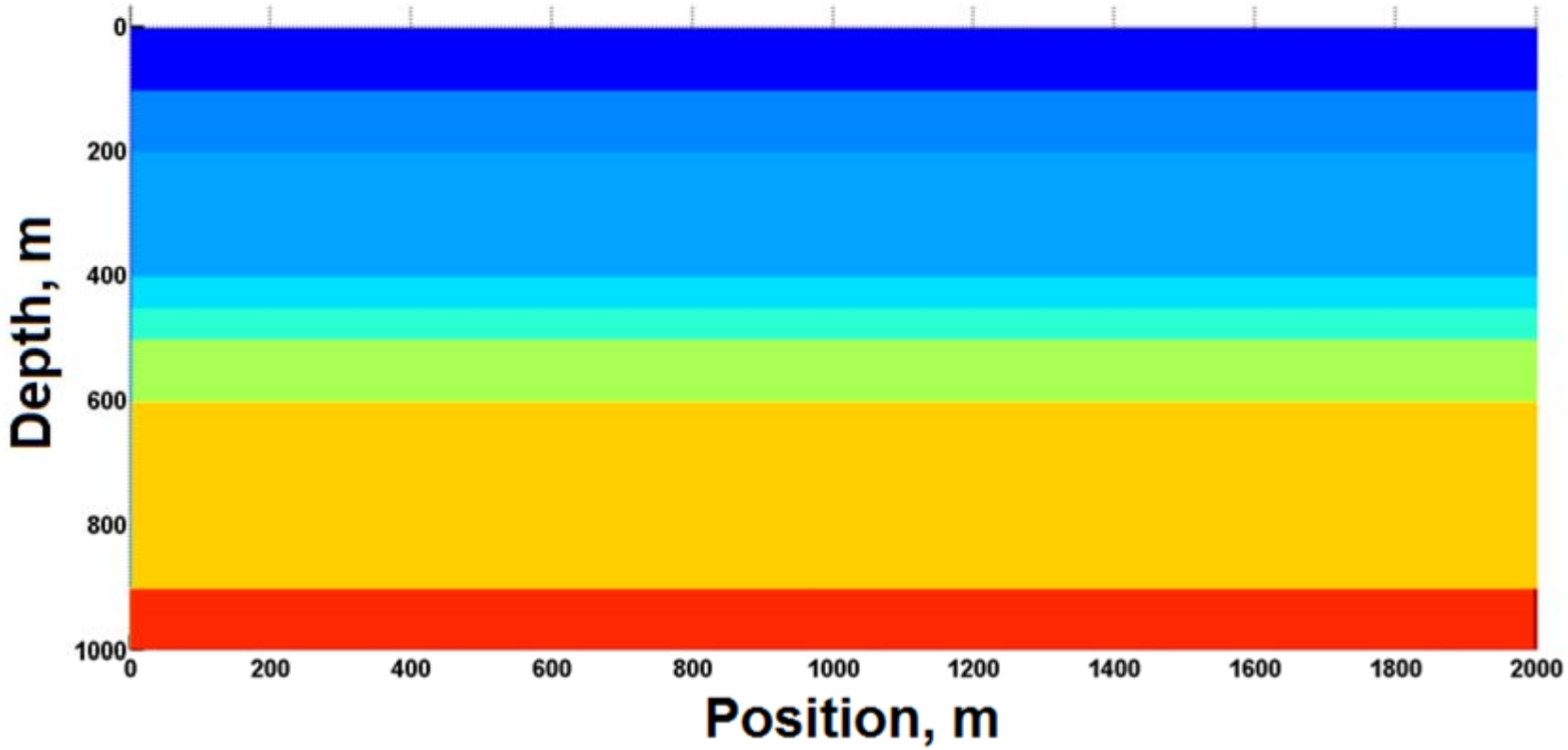


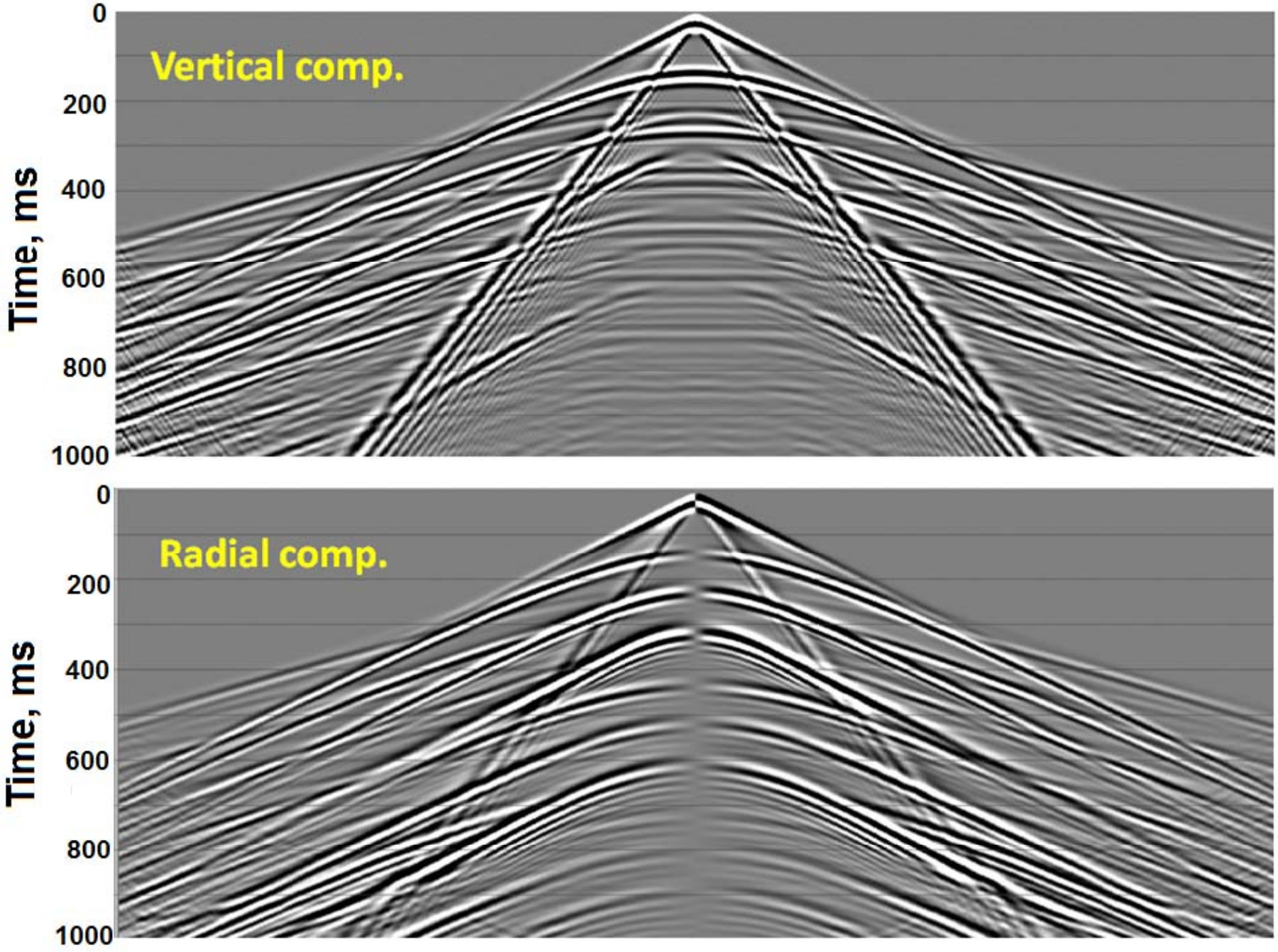


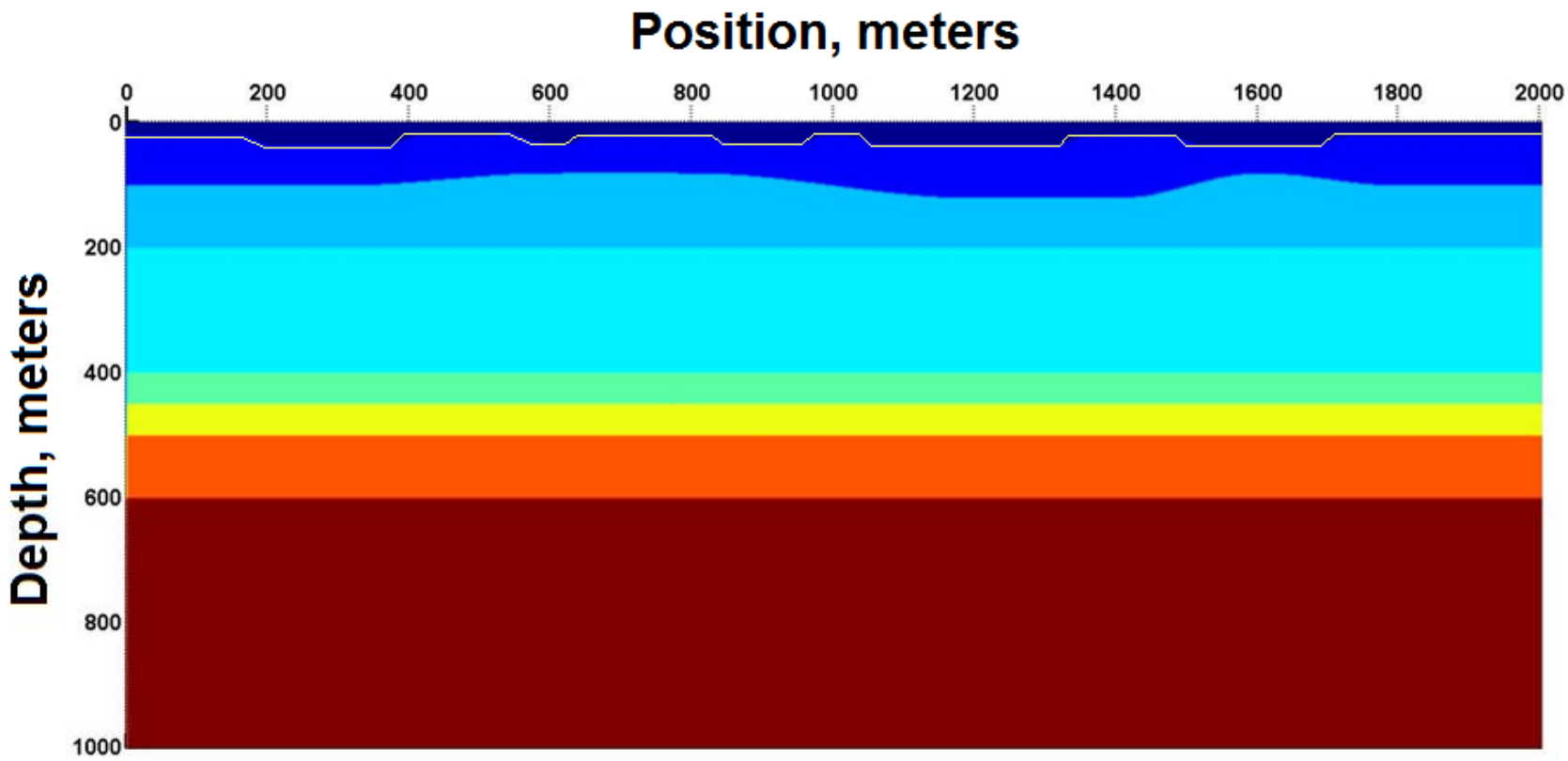


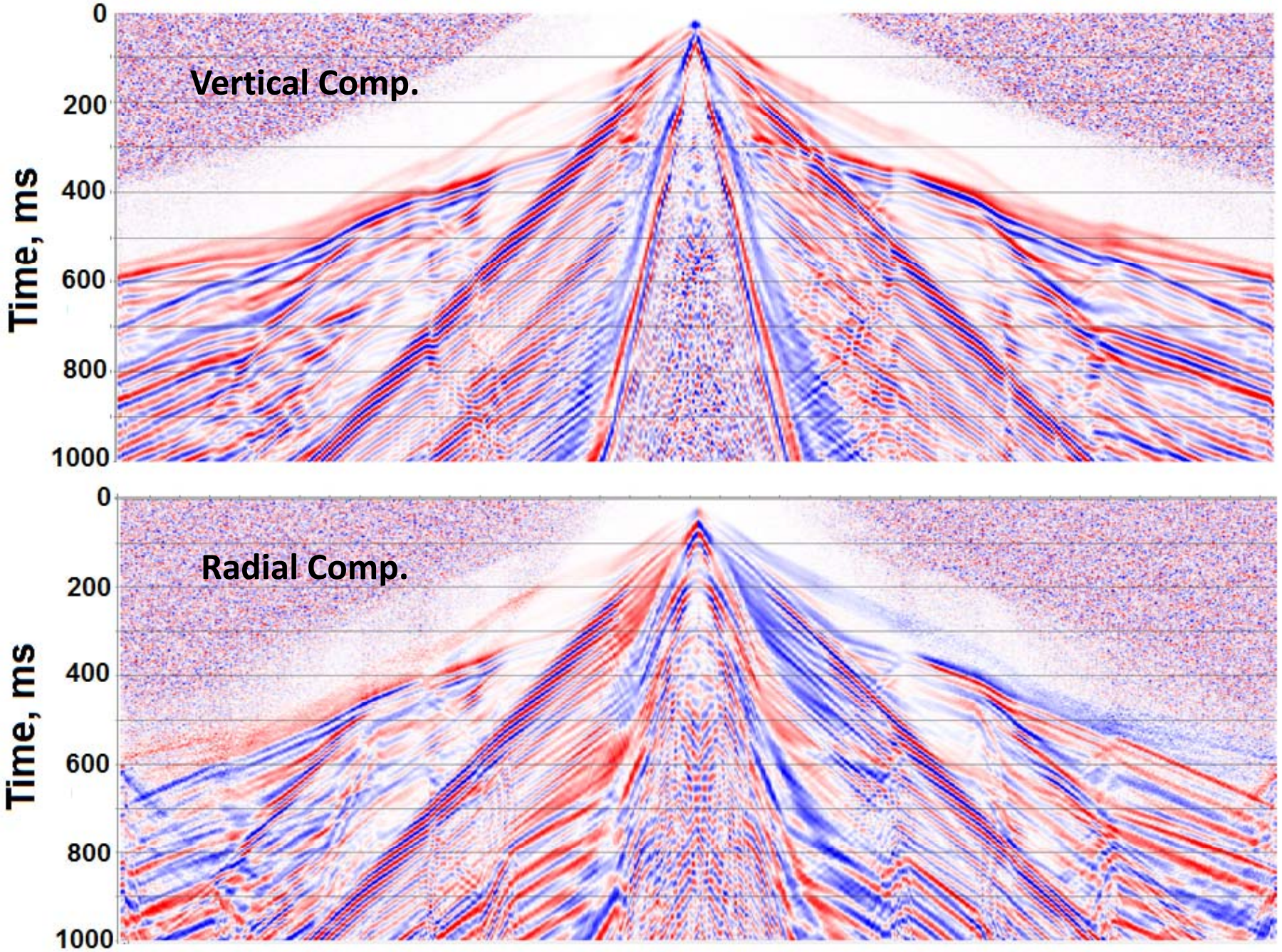
$\Delta x = \Delta z = 2.5$ meters

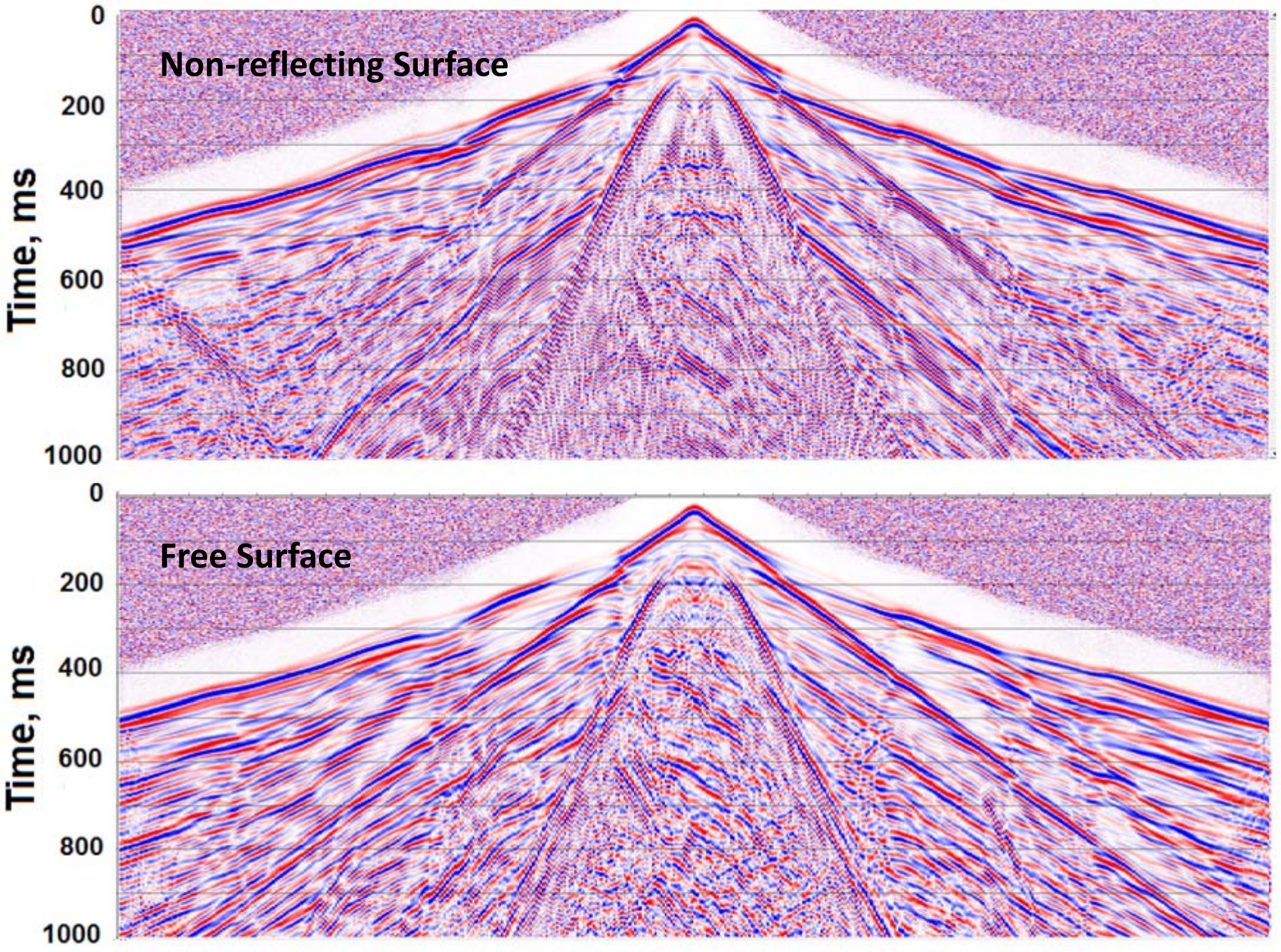
$\Delta t = .00025$ seconds



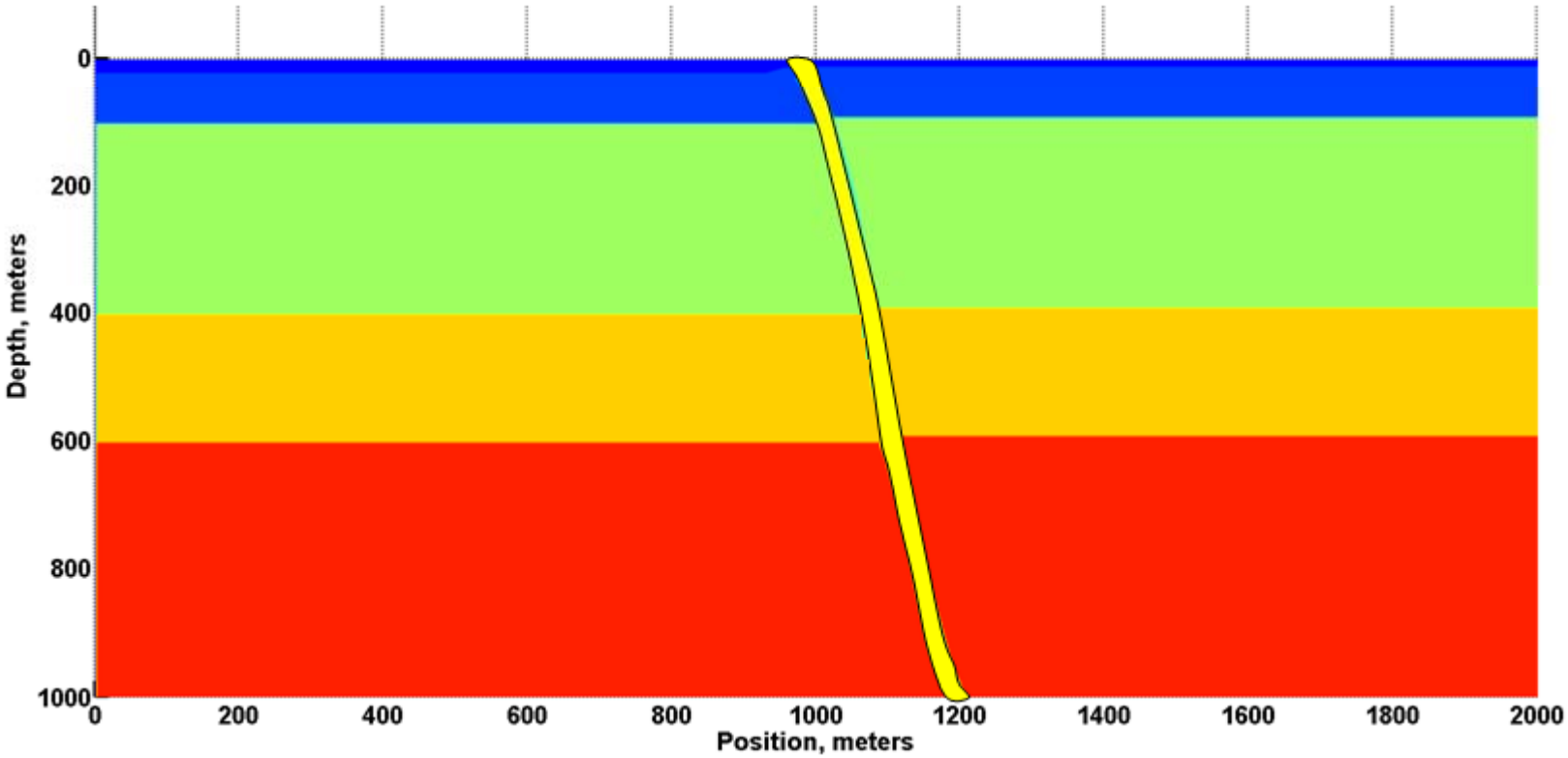

Vertical comp.
Radial comp.
Time, ms
0
200
400
600
800
1000


Position, meters
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Depth, meters
0
200
400
600
800
1000

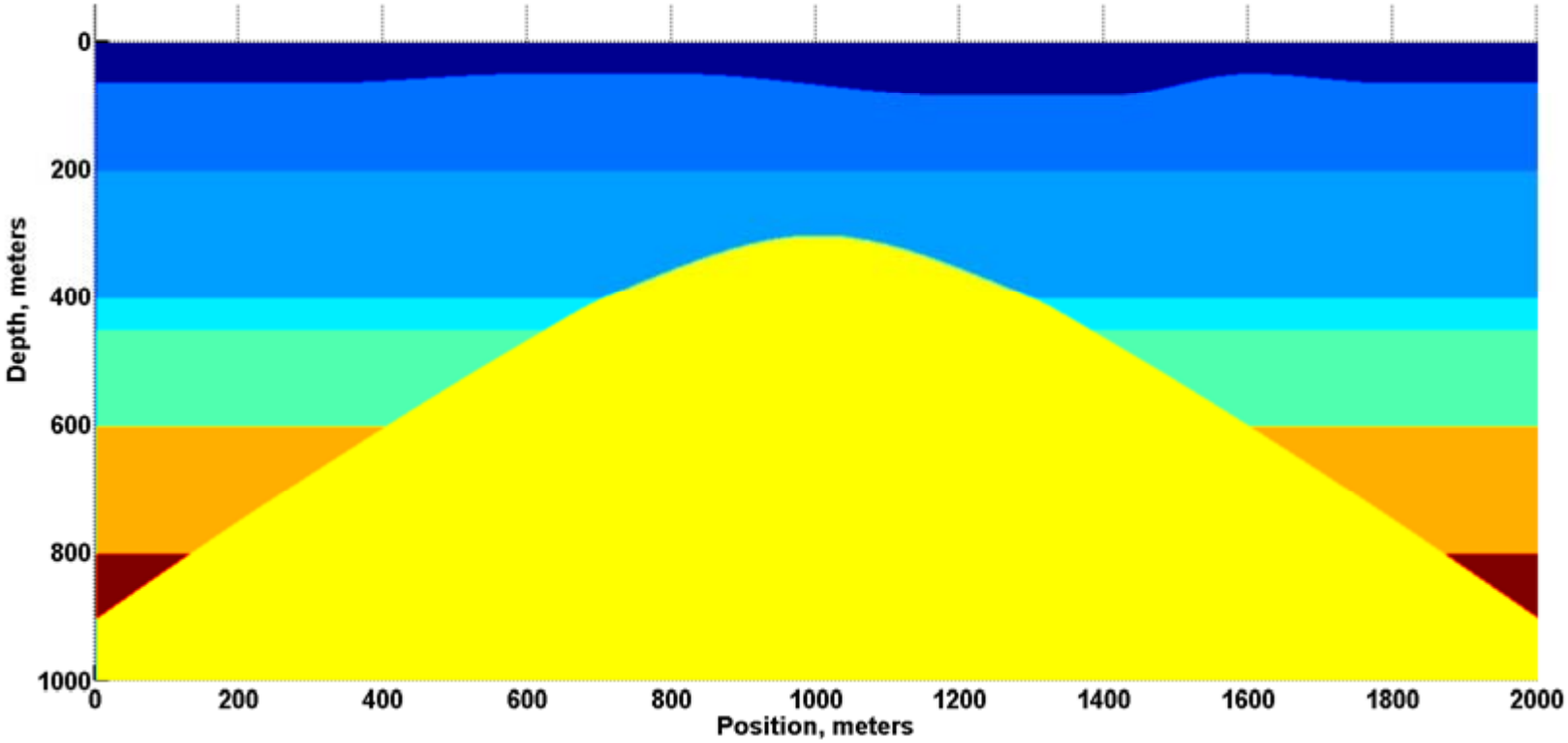

Vertical Comp.
Radial Comp.
Time, ms
0
200
400
600
800
1000


Non-reflecting Surface
Free Surface
Time, ms
0
200
400
600
800
1000

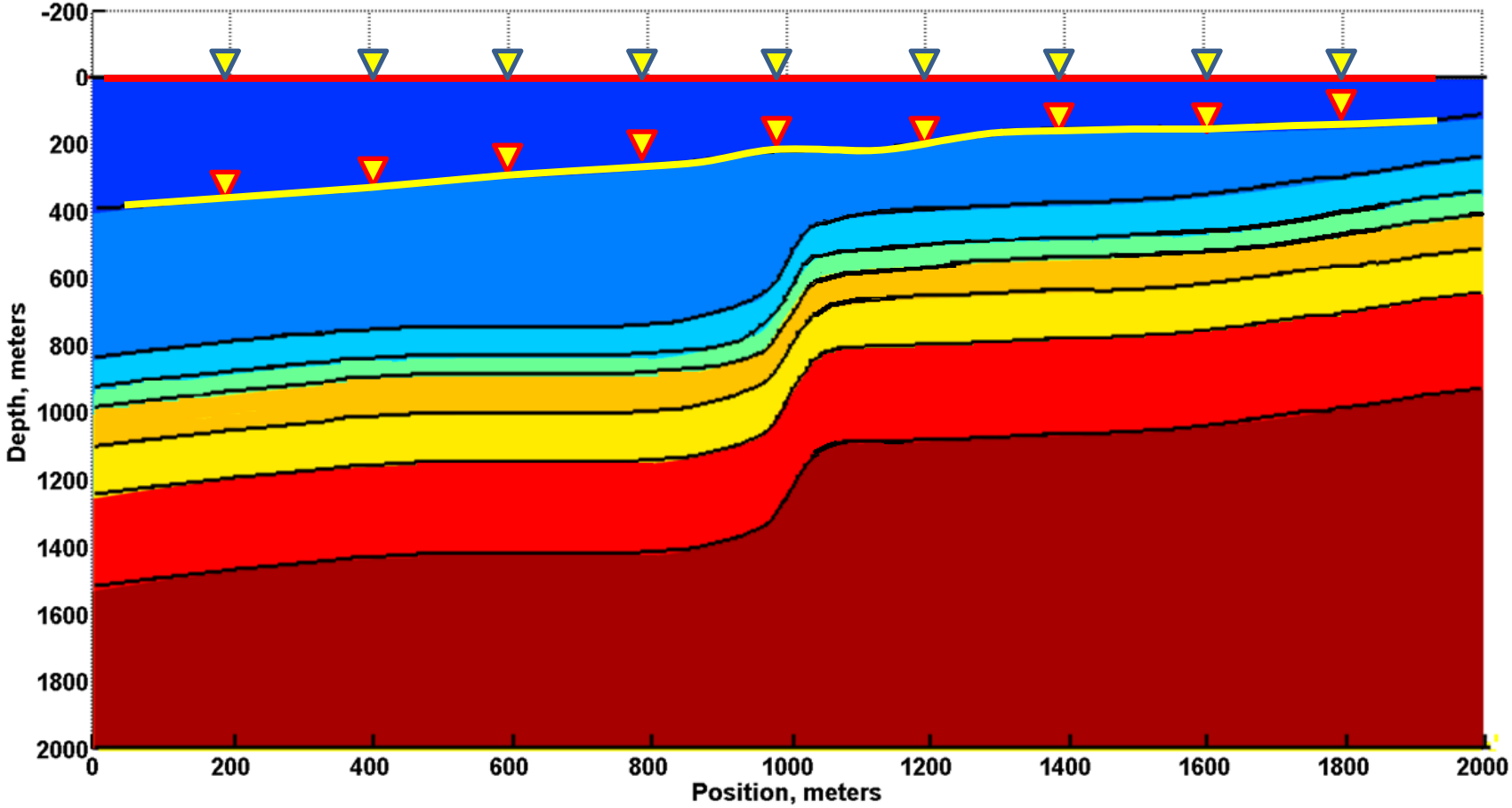
Dyke –Fault Model

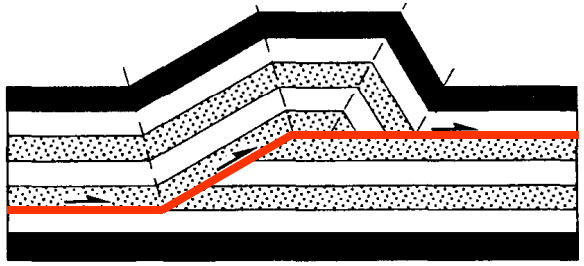


Anticline Model

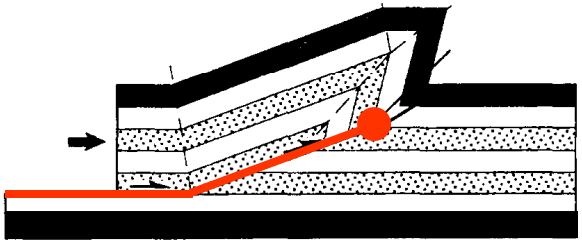


Fault-Fold Model

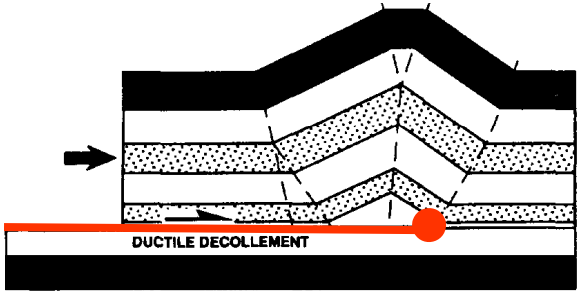




Fault bend fold

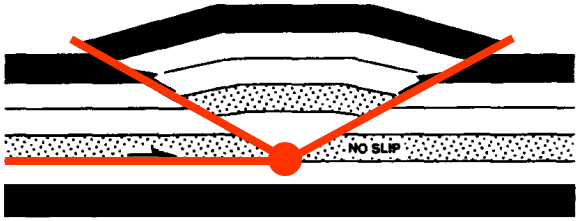


Fault propagation fold

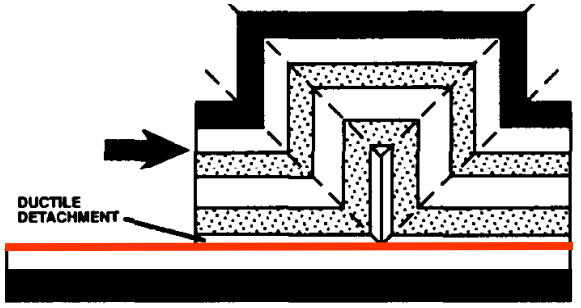


Detachment fold

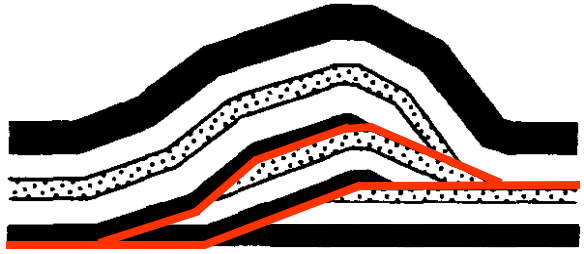
Duplex



Pop-up



Box fold



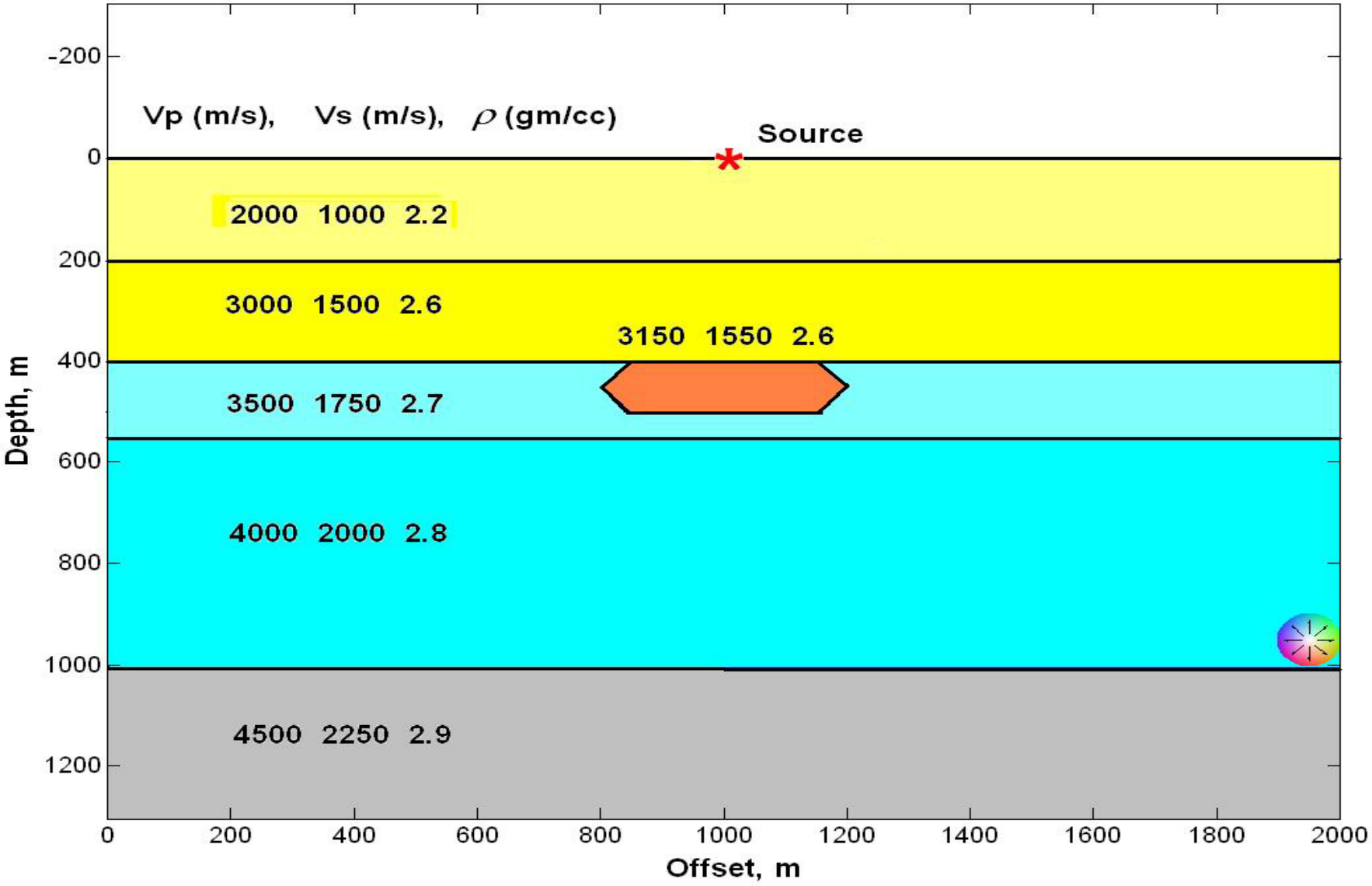
Antiformal stack

STRUCTURES WE WANT TO IMAGE

D. Spratt

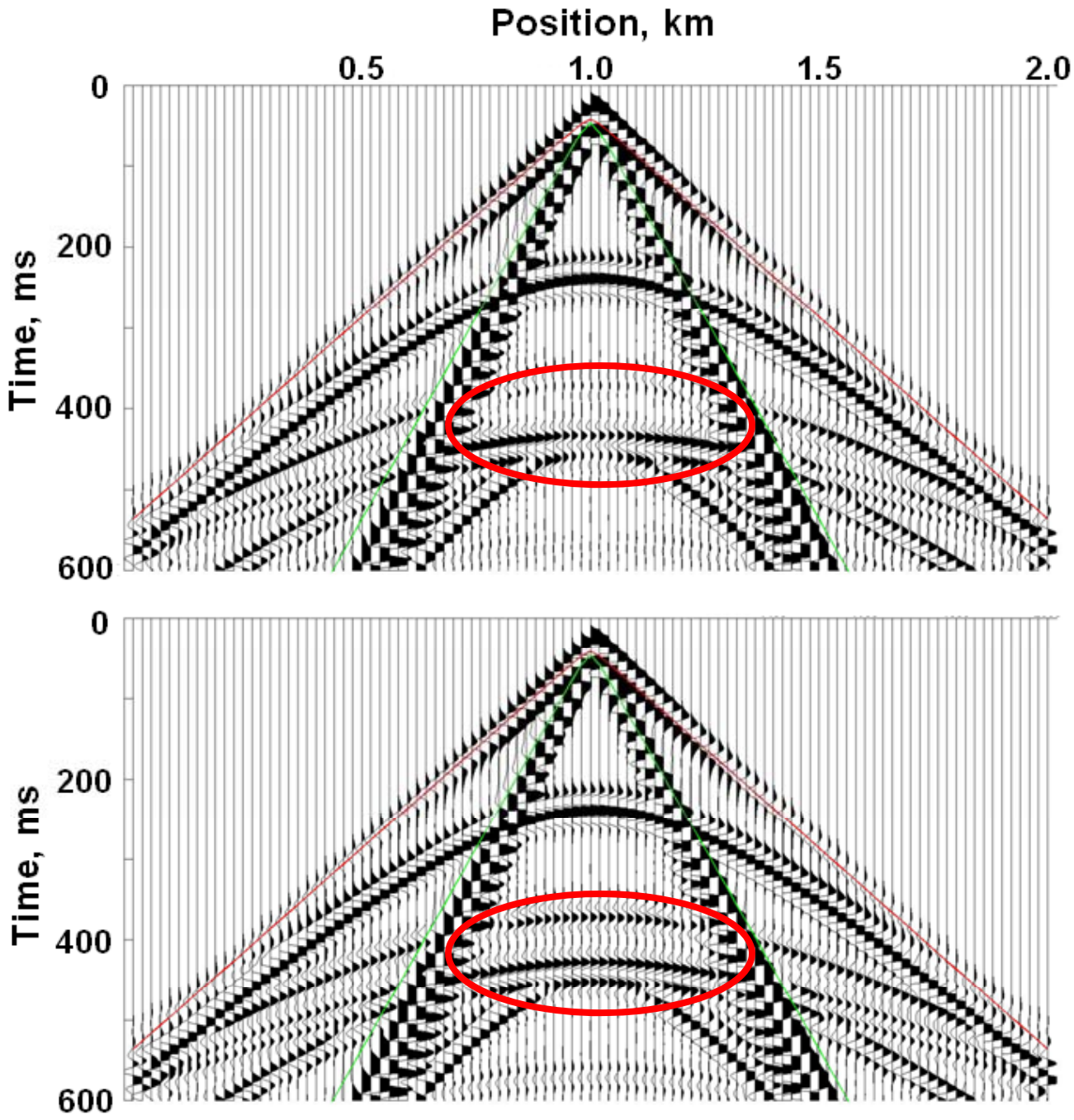
Time Lapse Example

Finite Difference 2D Elastic Modeling

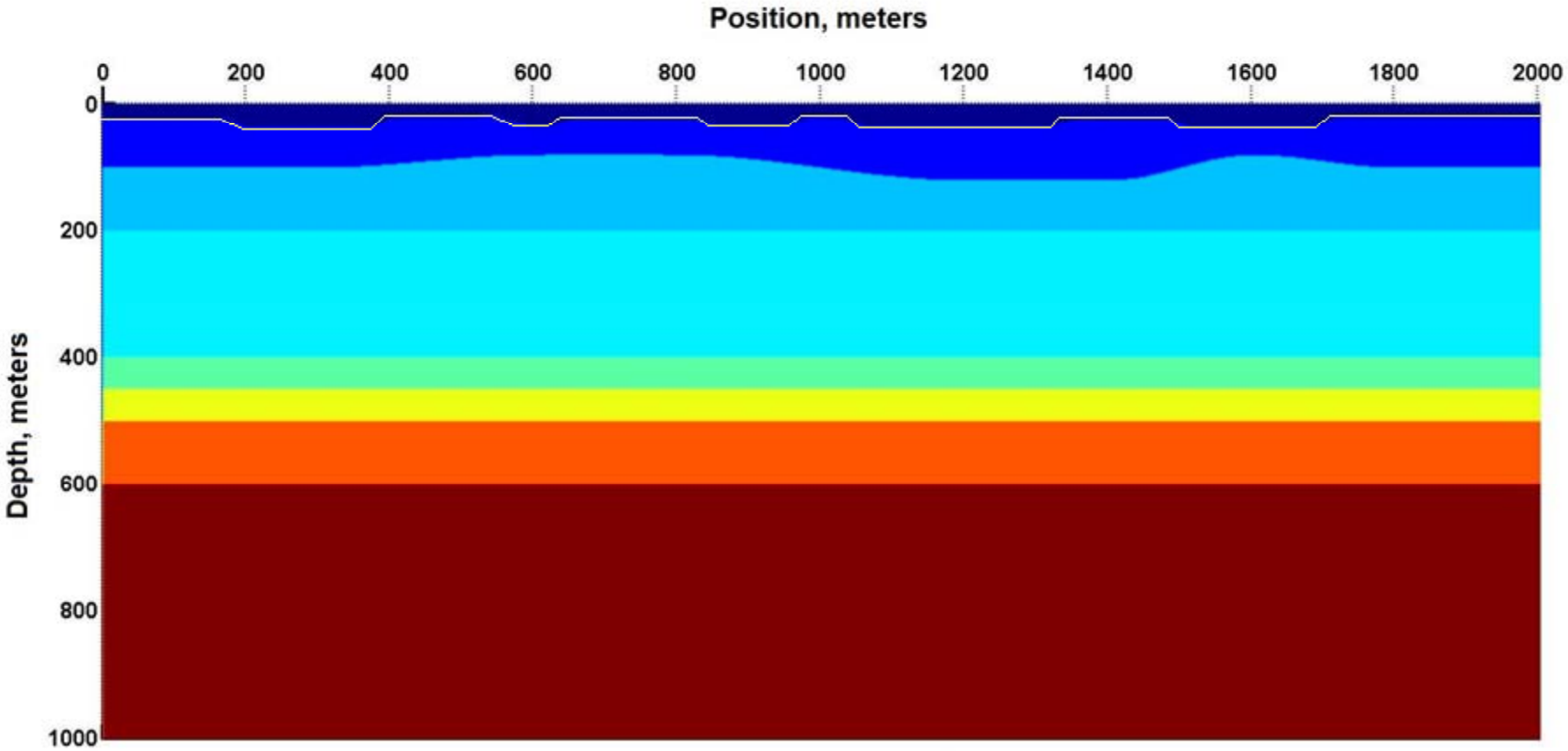


BEFORE:
TARGET HAS HOST ROCK PROPERTIES.

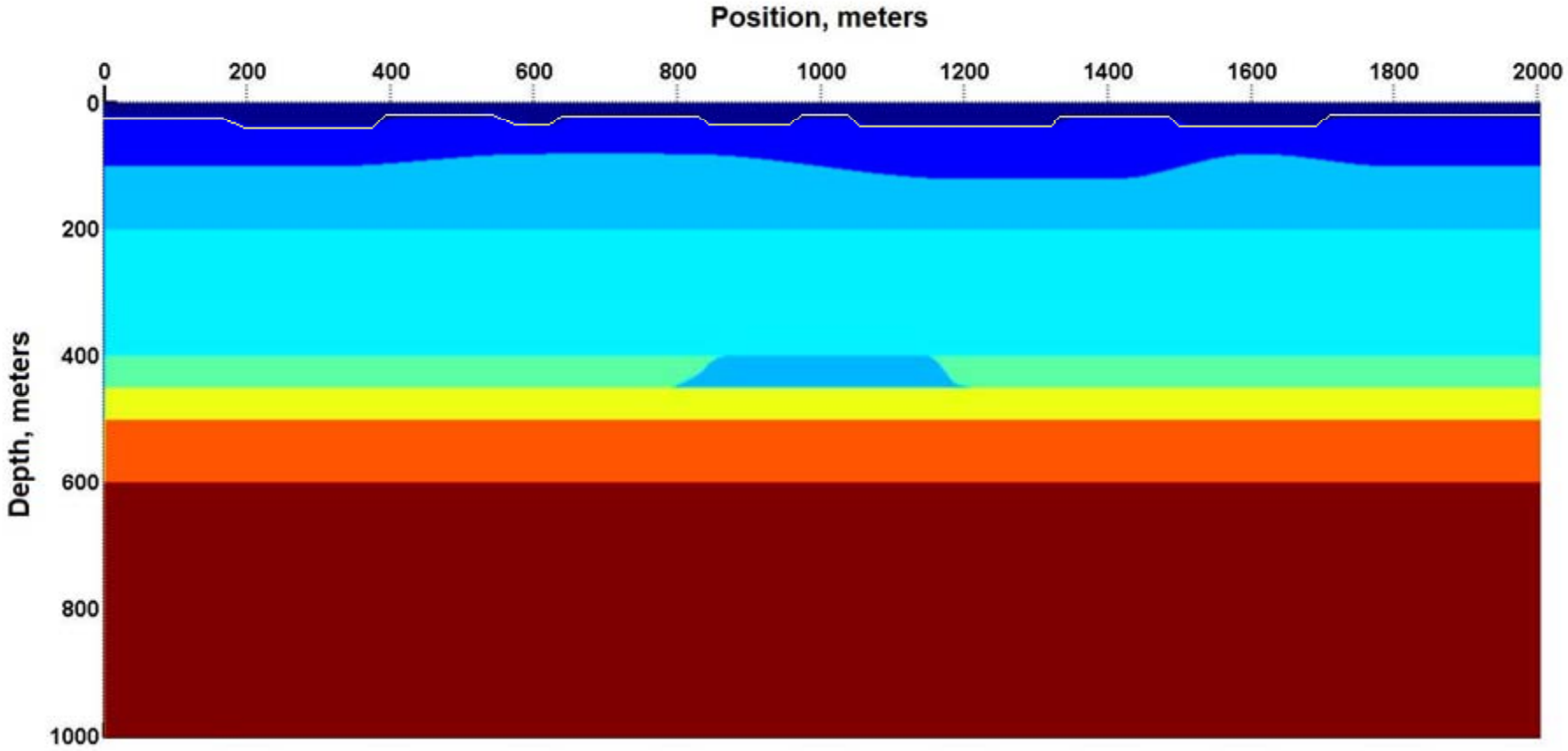
AFTER:
10% DROP IN TARGET PROPERTIES.



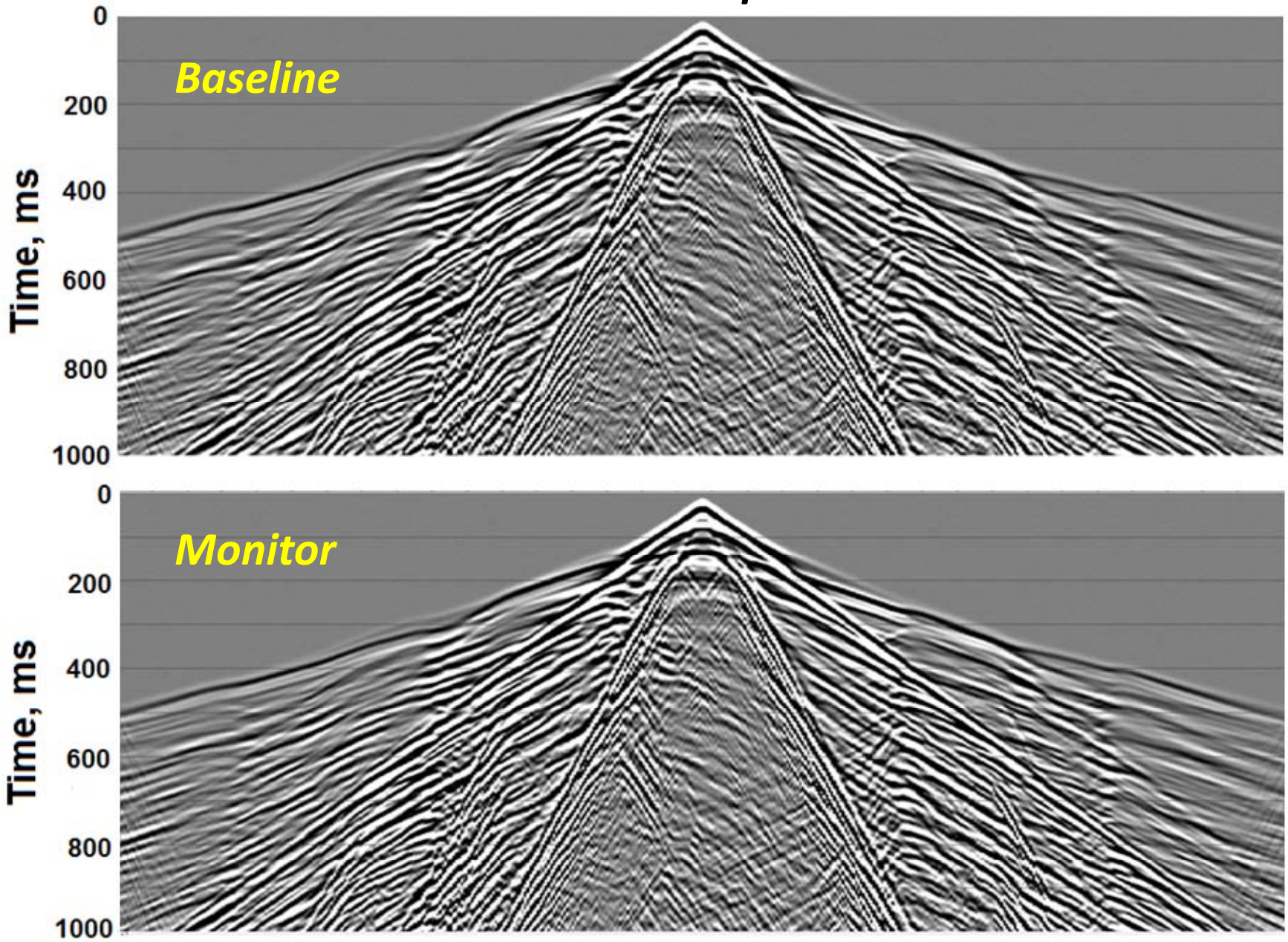
Baseline Model



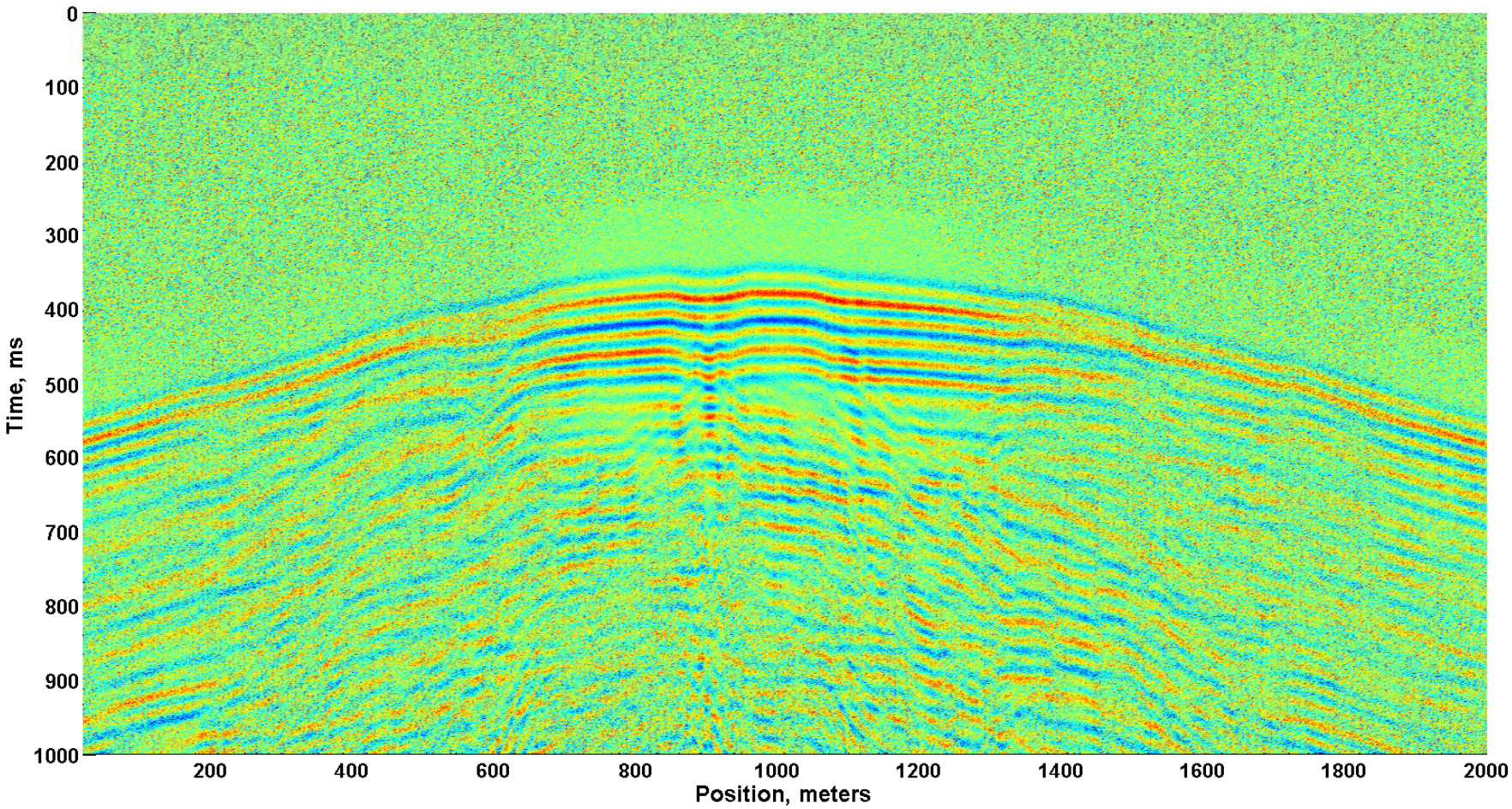
Monitor Model

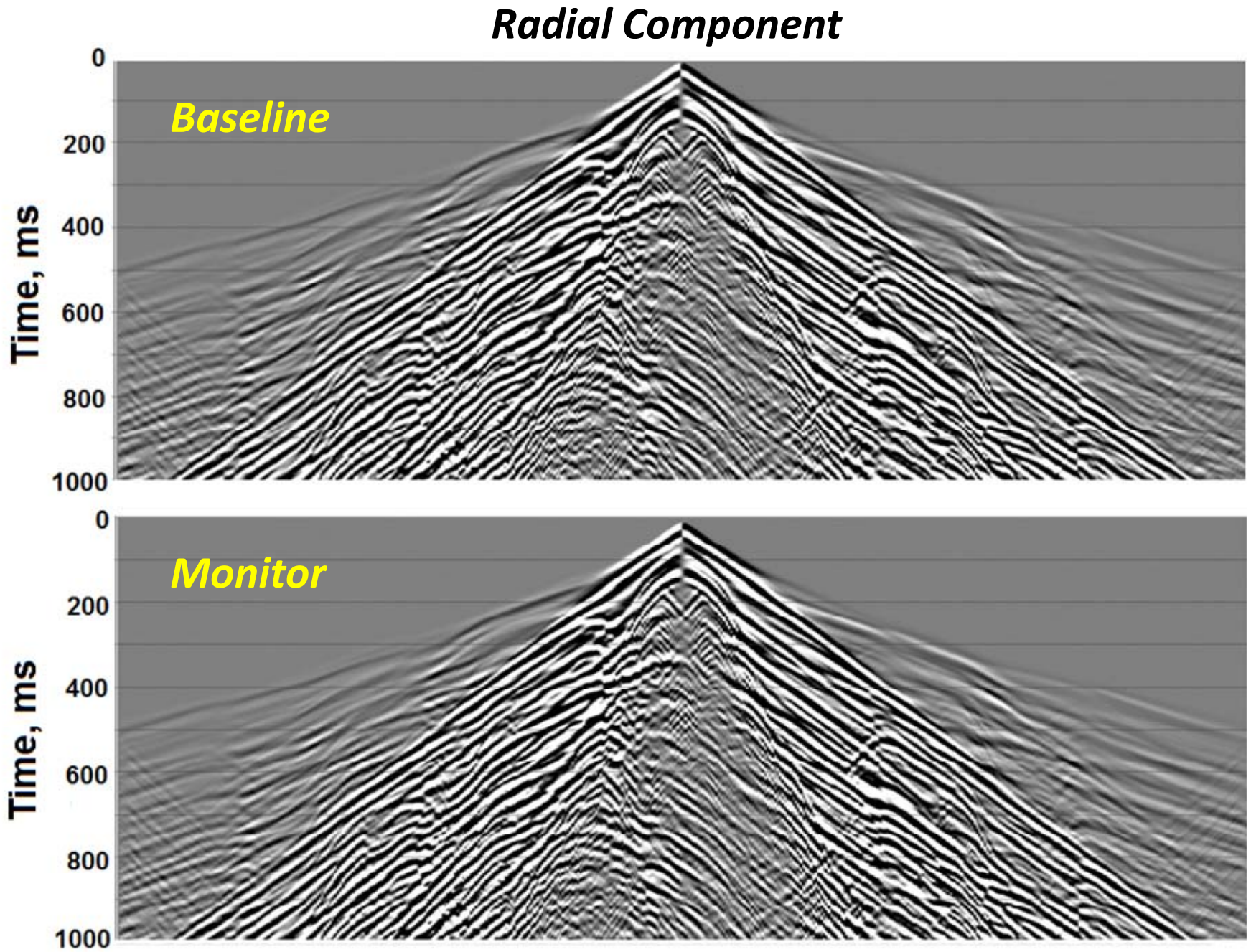


Vertical Component

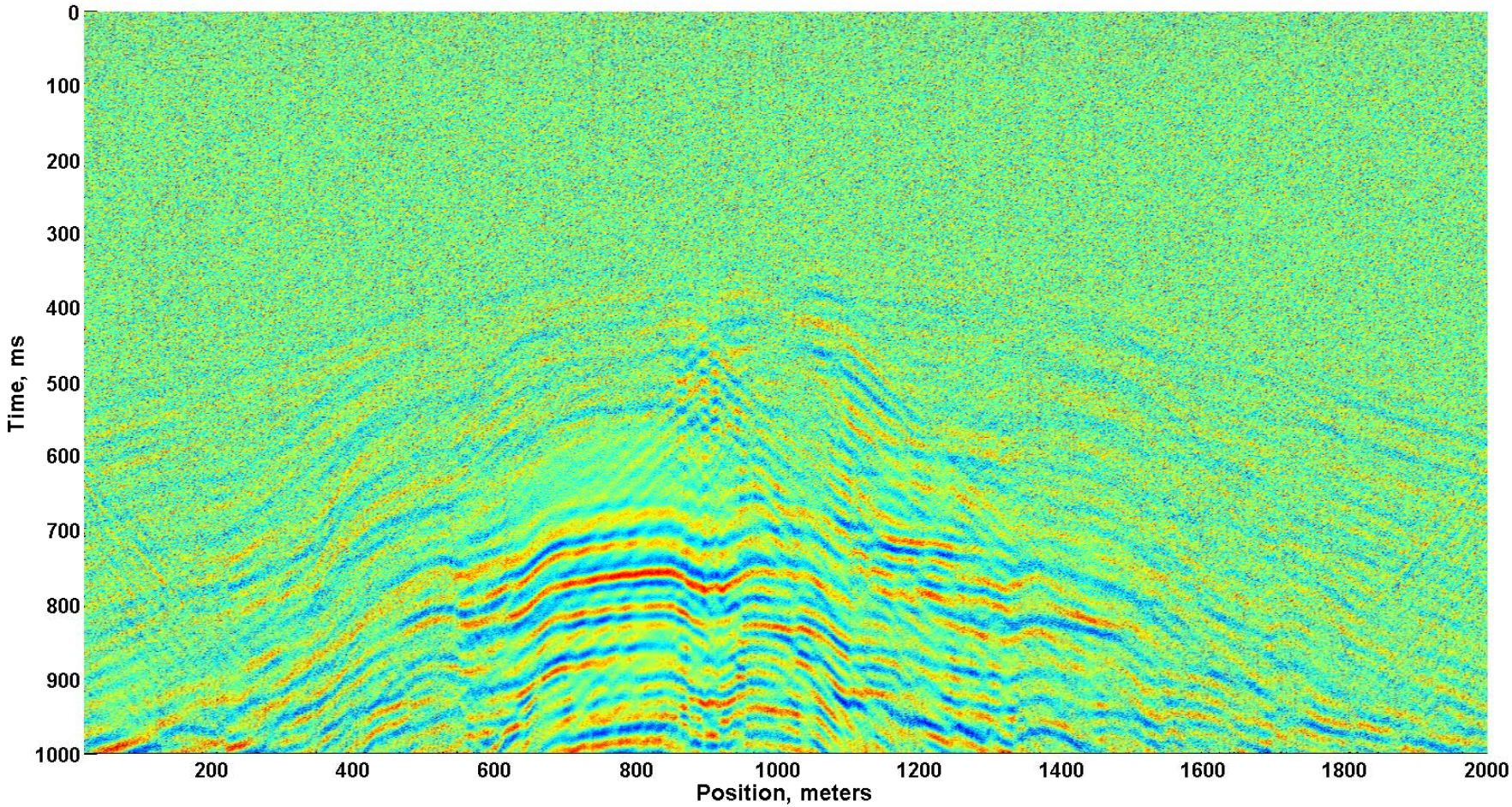


Vertical Component Difference




Radial Component
Baseline
Monitor
Time, ms
0
200
400
600
800
1000

Radial Component Difference



Relative Execution Speed

>> feature jit off

MATLAB 2009a	*jit on*	*49 sec*	*1*
MATLAB 2009a	*jit off*	*178 sec*	*3.6*
MATLAB 2010b	*jit off*	*120 sec*	*2.4*
MATLAB 2010b	*jit on*	*525 sec*	*10.7*

Execution Time

- *Model size : 800 by 400 pixels*
- *Time Steps : 4000*
- *No. of Shots : 100*
- *Run Time: 15 hours*

Multi-processor operation :

- *Start 3 separate MATLAB windows.*
- *In each window, run mFD2D from different folder names.*
- *In each window, run same model with inter-leaved shot points, or*
- *In each window, run a different model.*

Wish List Enhancements :

- *CPML - decrease edge reflections ;*
- *Attenuation – seismic Q ;*
- *Velocity Anisotropy - VTI/TTI ;*
- *Variable grid size ;*
- *Reverse-time migration (???).*

Acknowledgement

This research was supported by NSERC and the industrial sponsors of CREWS.