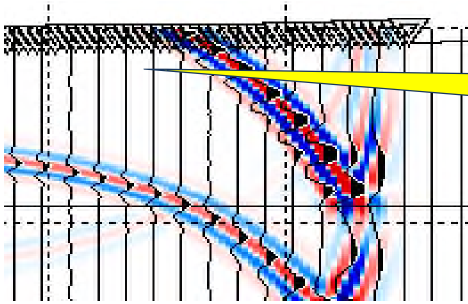
Example of Ground Surface Modeling
-Invisible-Free-

www.tesseral-geo.com

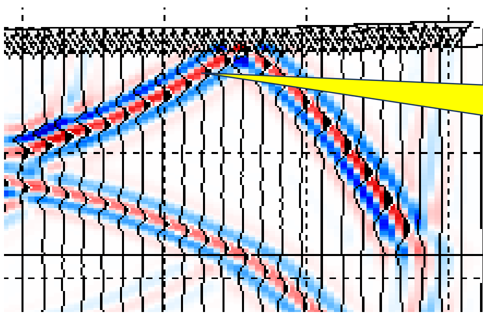
"Surface" group buttons:

- "Invisible" box when checked allows to model seismic field in a way where surface is not reflecting.



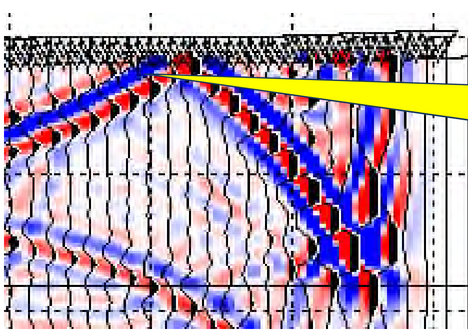
No reflected from surface wave

- "*Free*" produces a "true" free surface, where the real surface conditions are modeled.



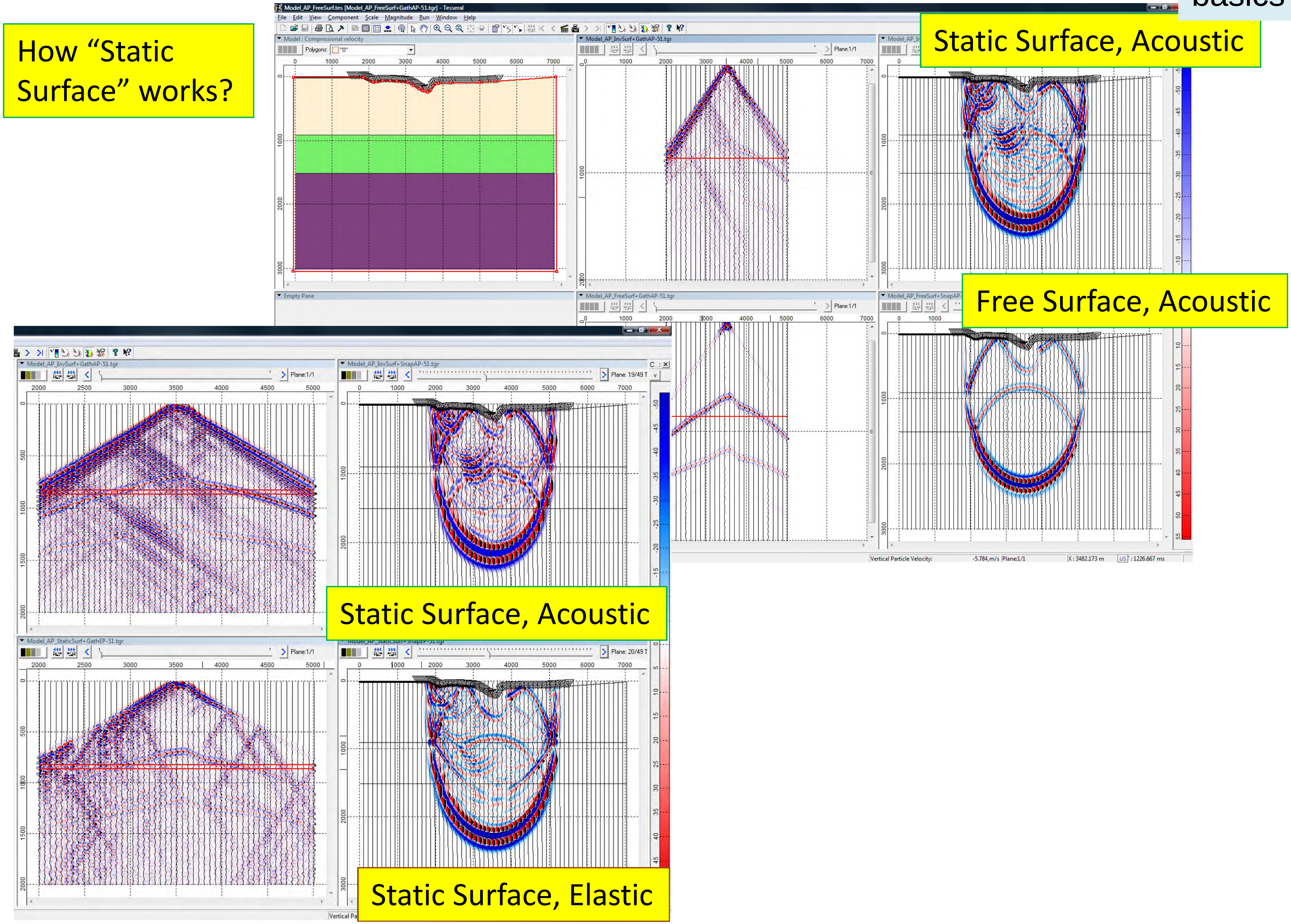
Reflected from surface wave has the same phase (reflection from boundary with significantly lower seismic impedance)

- "*Static*" option allows simulating reflections from the model surface, which will have the same phase as the incoming waves (as in case of velocity/density skipping to higher values). If source is placed near the surface its initial impulse will be altered by positive reflection from the model surface. "*Static*" option does not work for *"Scalar"* equation type (§1.2).

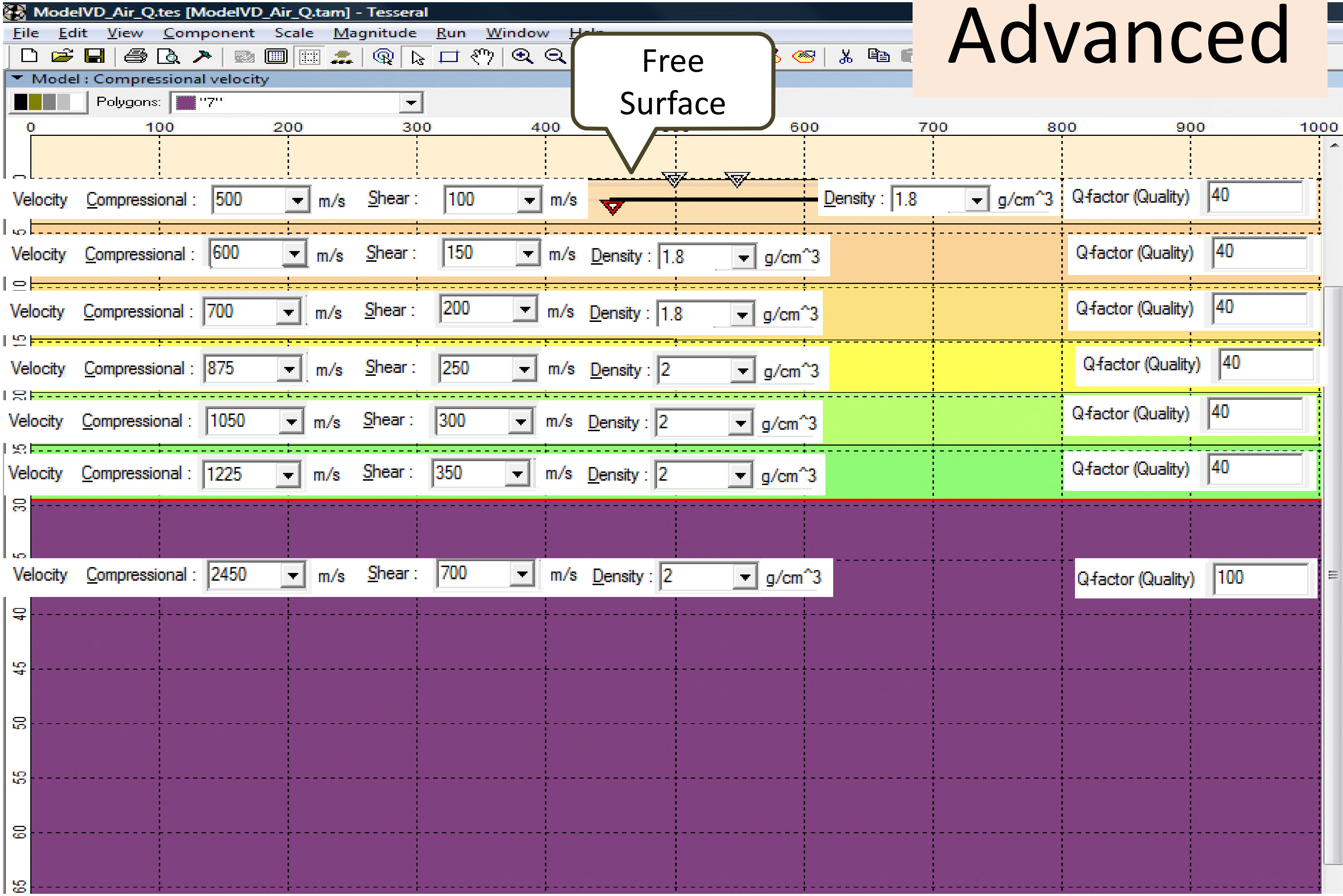


Reflected from surface wave changes phase on opposite (reflection from boundary with significantly higher seismic impedance)

How “Static Surface” works?



Advanced

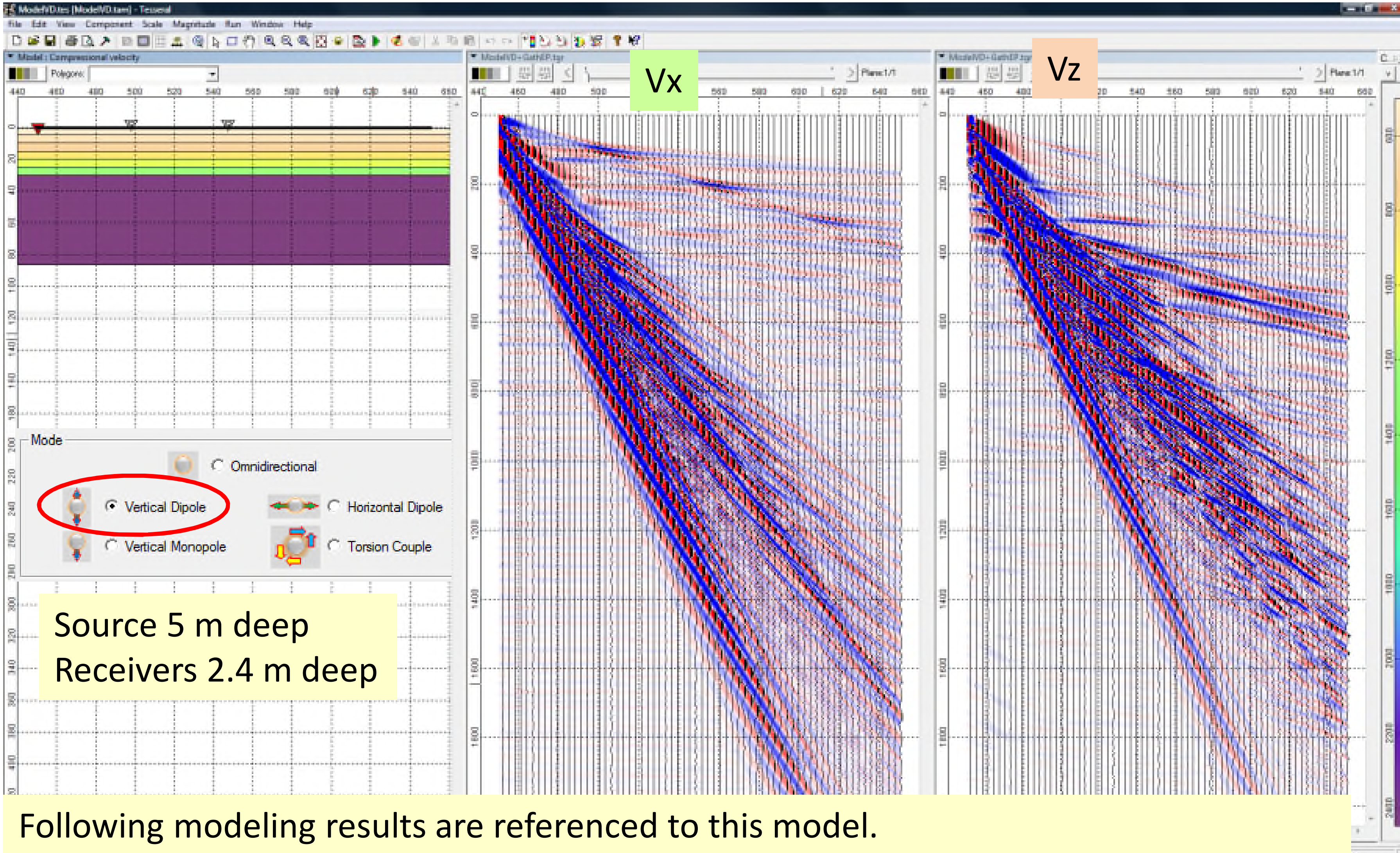


ModelVD_Air_Q.tes [ModelVD_Air_Q.tam] - Tesseral
File Edit View Component Scale Magnitude Run Window Help
Model : Compressional velocity
Polygons: "7"
Free Surface
0 100 200 300 400 500 600 700 800 900 1000
Velocity Compressional : 500 m/s Shear : 100 m/s Density : 1.8 g/cm^3 Q-factor (Quality) 40
Velocity Compressional : 600 m/s Shear : 150 m/s Density : 1.8 g/cm^3 Q-factor (Quality) 40
Velocity Compressional : 700 m/s Shear : 200 m/s Density : 1.8 g/cm^3 Q-factor (Quality) 40
Velocity Compressional : 875 m/s Shear : 250 m/s Density : 2 g/cm^3 Q-factor (Quality) 40
Velocity Compressional : 1050 m/s Shear : 300 m/s Density : 2 g/cm^3 Q-factor (Quality) 40
Velocity Compressional : 1225 m/s Shear : 350 m/s Density : 2 g/cm^3 Q-factor (Quality) 40
Velocity Compressional : 2450 m/s Shear : 700 m/s Density : 2 g/cm^3 Q-factor (Quality) 100
30 40 45 50 55 60 65

ModelVD

Elastic wave equation, PF- (peak frequency) attenuation (Q) used

advanced



Source 5 m deep
Receivers 2.4 m deep

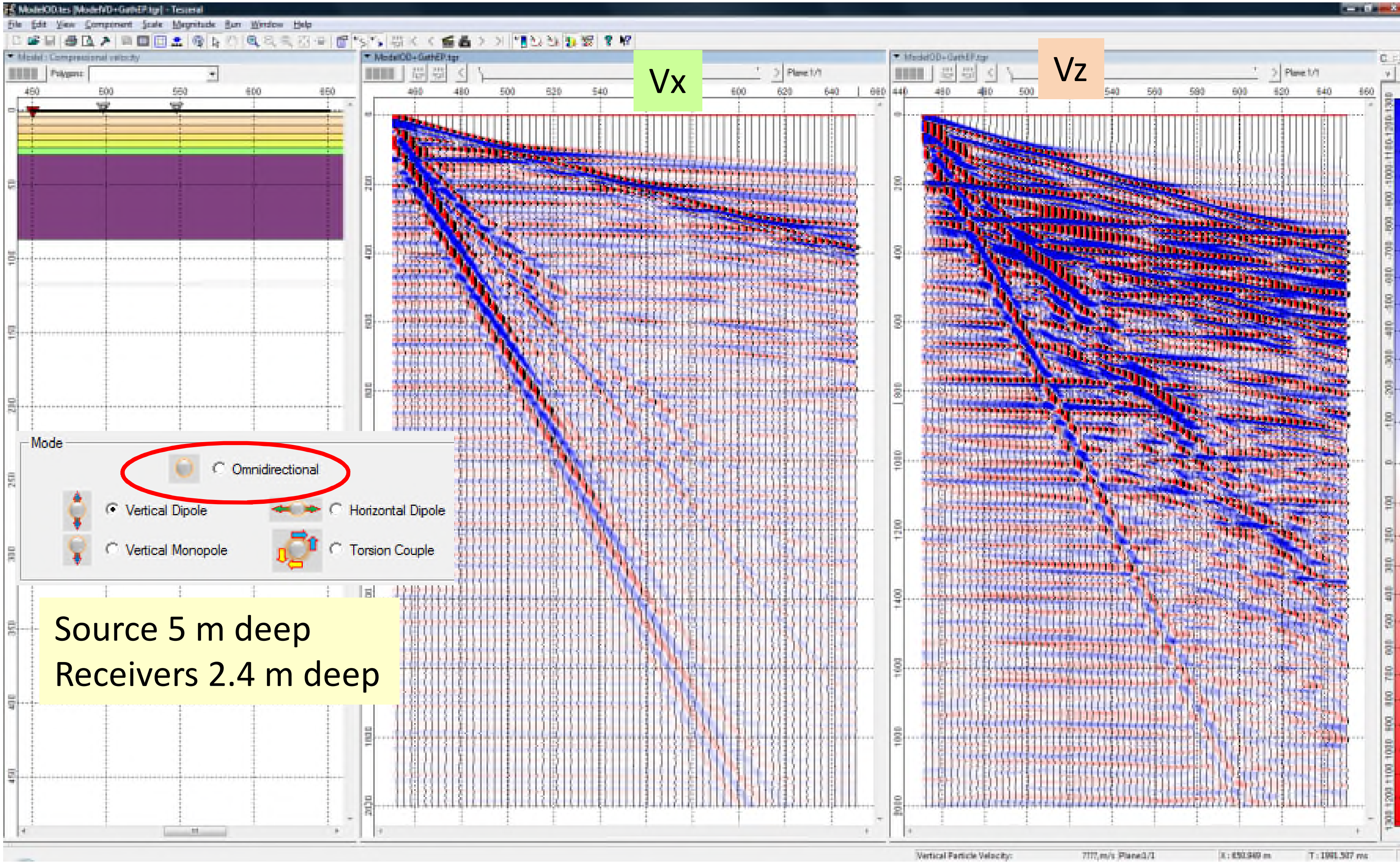
Following modeling results are referenced to this model.

✓ If source and receivers are on the model surface, for computations, they are automatically “deepened” inside the medium at the computational grid 4 cell sizes (here, 0.6 m*4=2.4 m).

ModelOD

Elastic wave equation, PF- (peak frequency) attenuation (Q) used

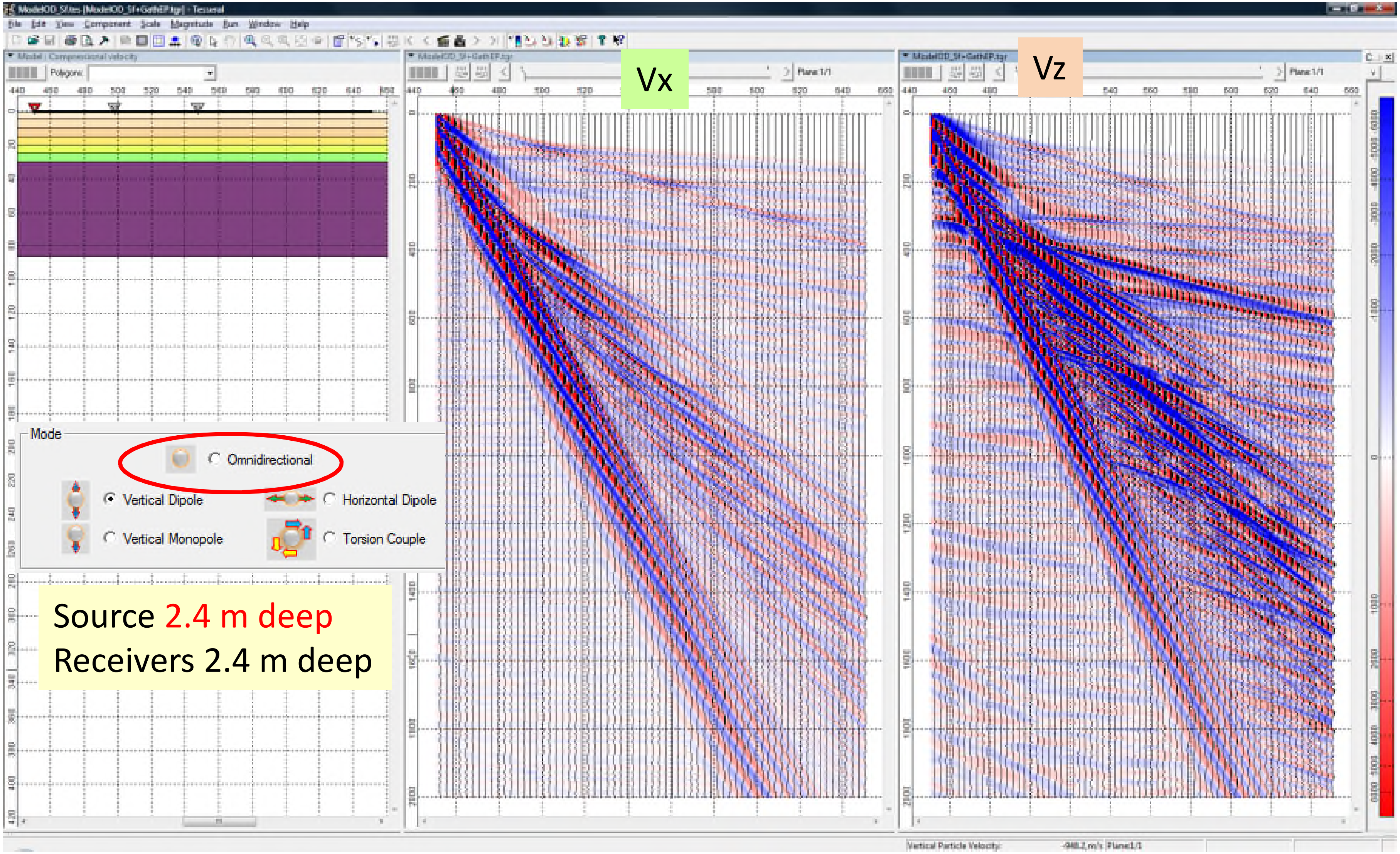
advanced



Source 5 m deep
Receivers 2.4 m deep

advanced

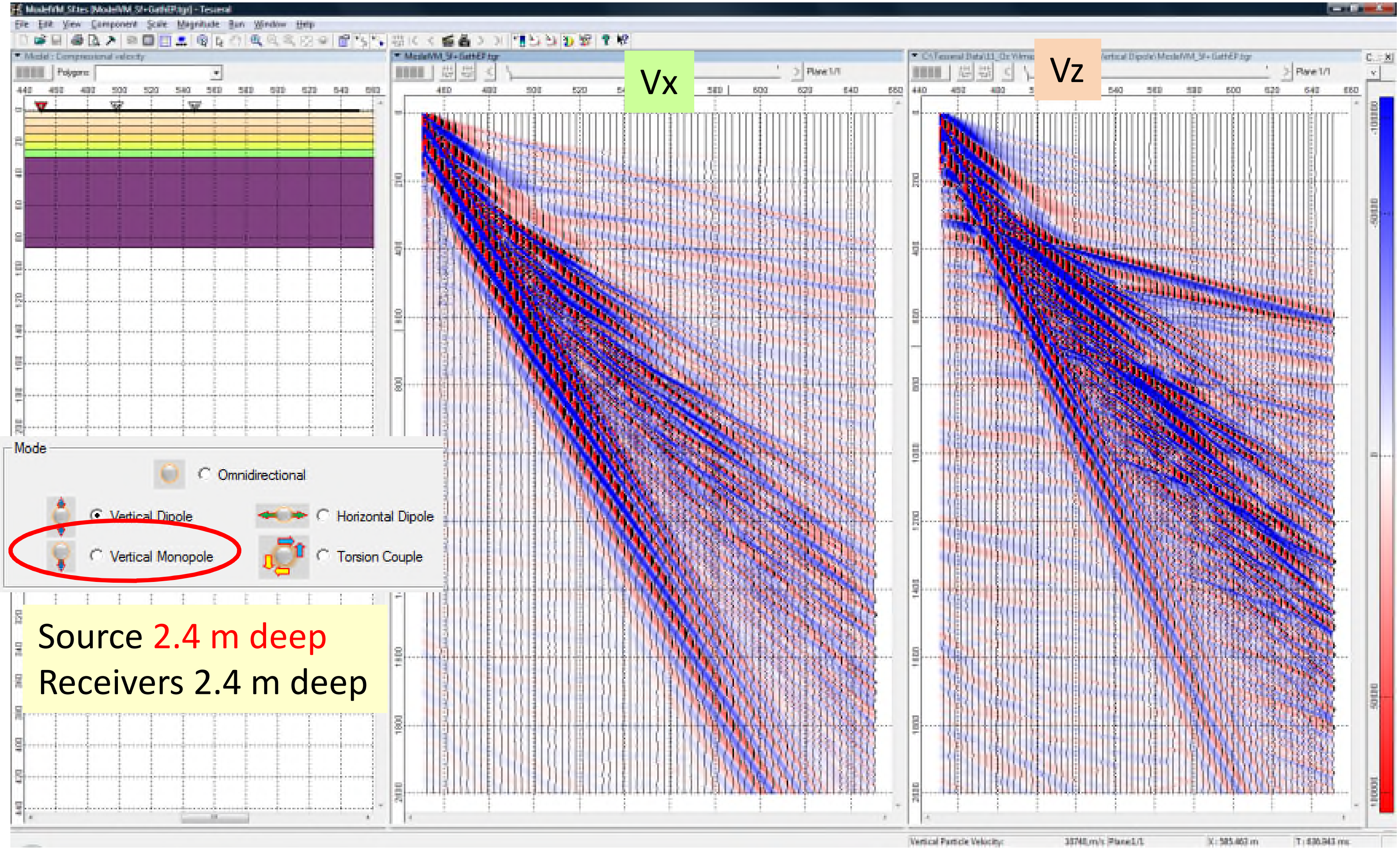
ModelOD_Sf Elastic wave equation, PF- (peak frequency) attenuation (Q) used



ModelVM_Sf

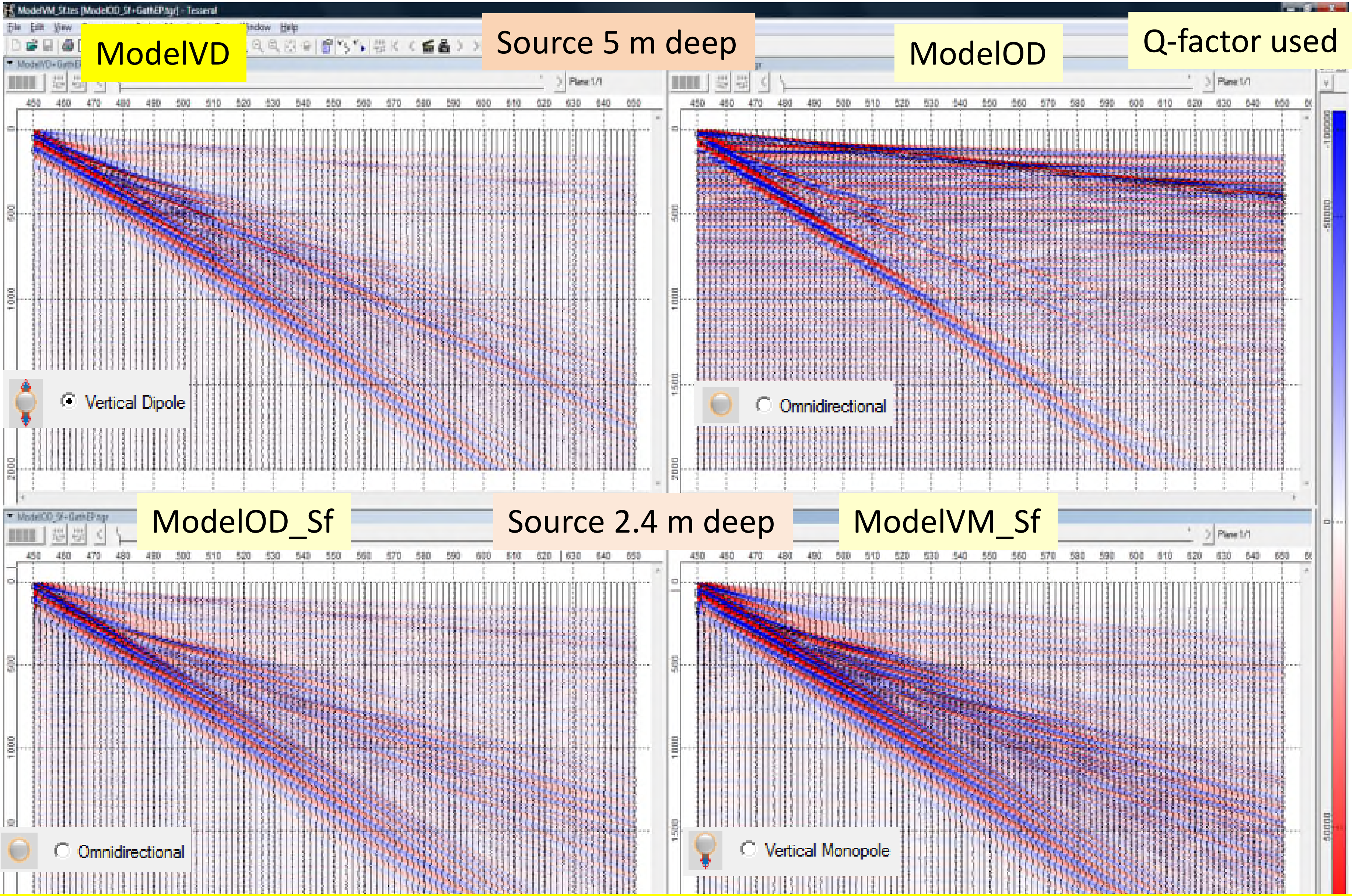
Elastic wave equation, PF- (peak frequency) attenuation (Q) used

advanced



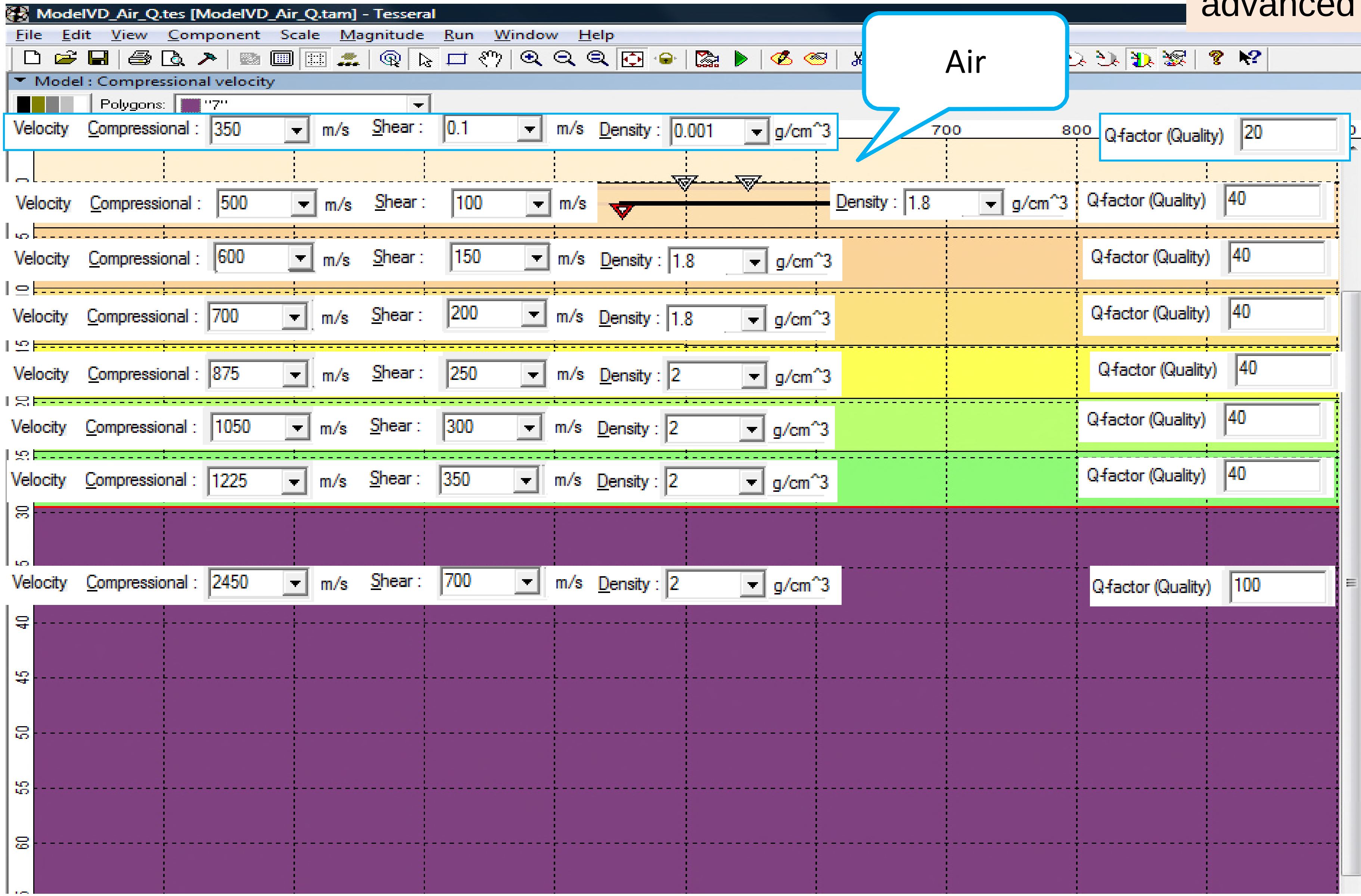
Source 2.4 m deep

Receivers 2.4 m deep



Modeling results show identical times for same events, but they have different relative magnitude depending on source mode and depth. For example, ***surface waves vs others, P-waves vs S-waves, Vz vs Vx***, etc.

advanced


ModelVD_Air_Q.tes [ModelVD_Air_Q.tam] - Tesseral
File Edit View Component Scale Magnitude Run Window Help
Model : Compressional velocity
Polygons: "7"
Air
700
800
Velocity Compressional : 350 m/s Shear : 0.1 m/s Density : 0.001 g/cm^3 Q-factor (Quality) 20
Velocity Compressional : 500 m/s Shear : 100 m/s Density : 1.8 g/cm^3 Q-factor (Quality) 40
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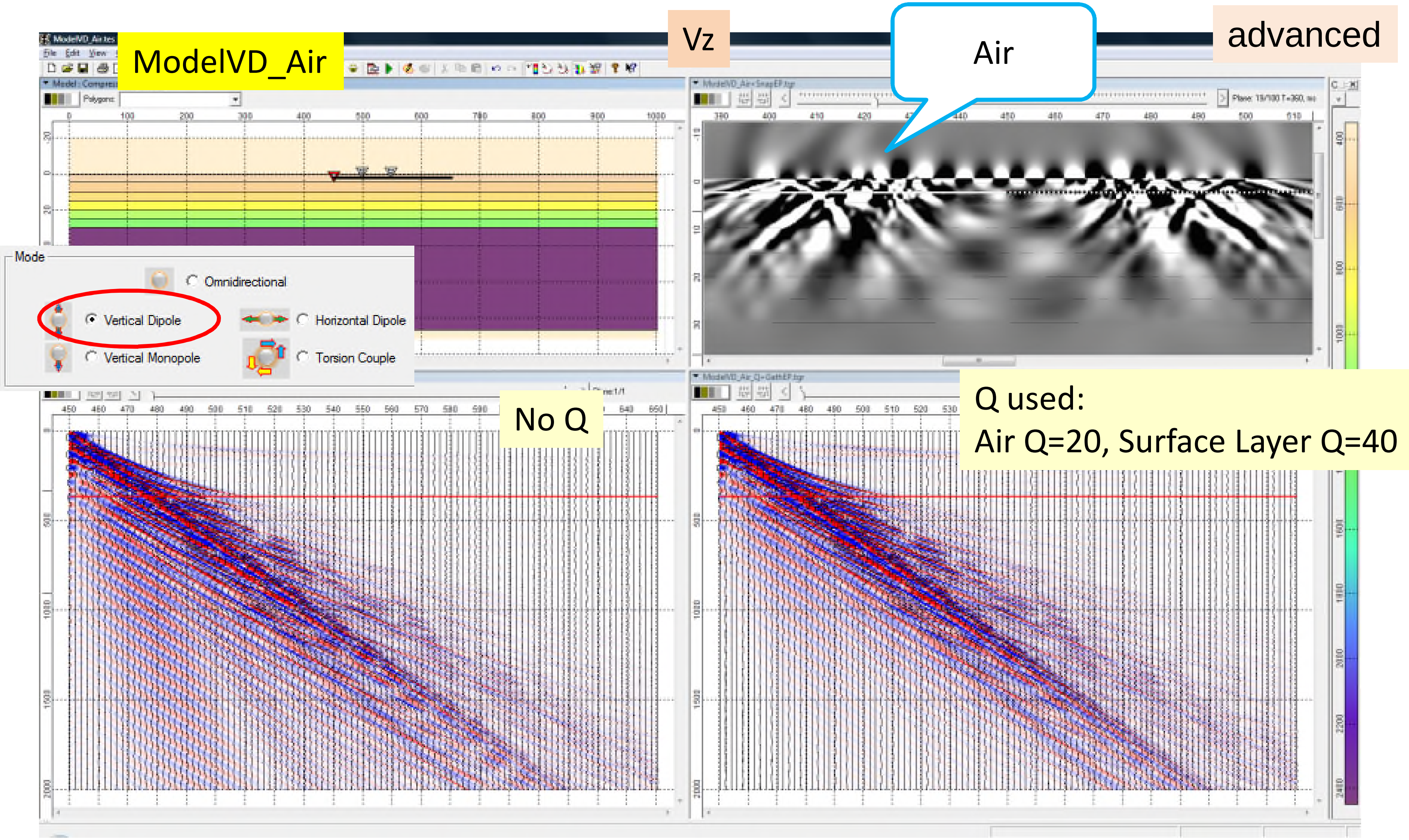
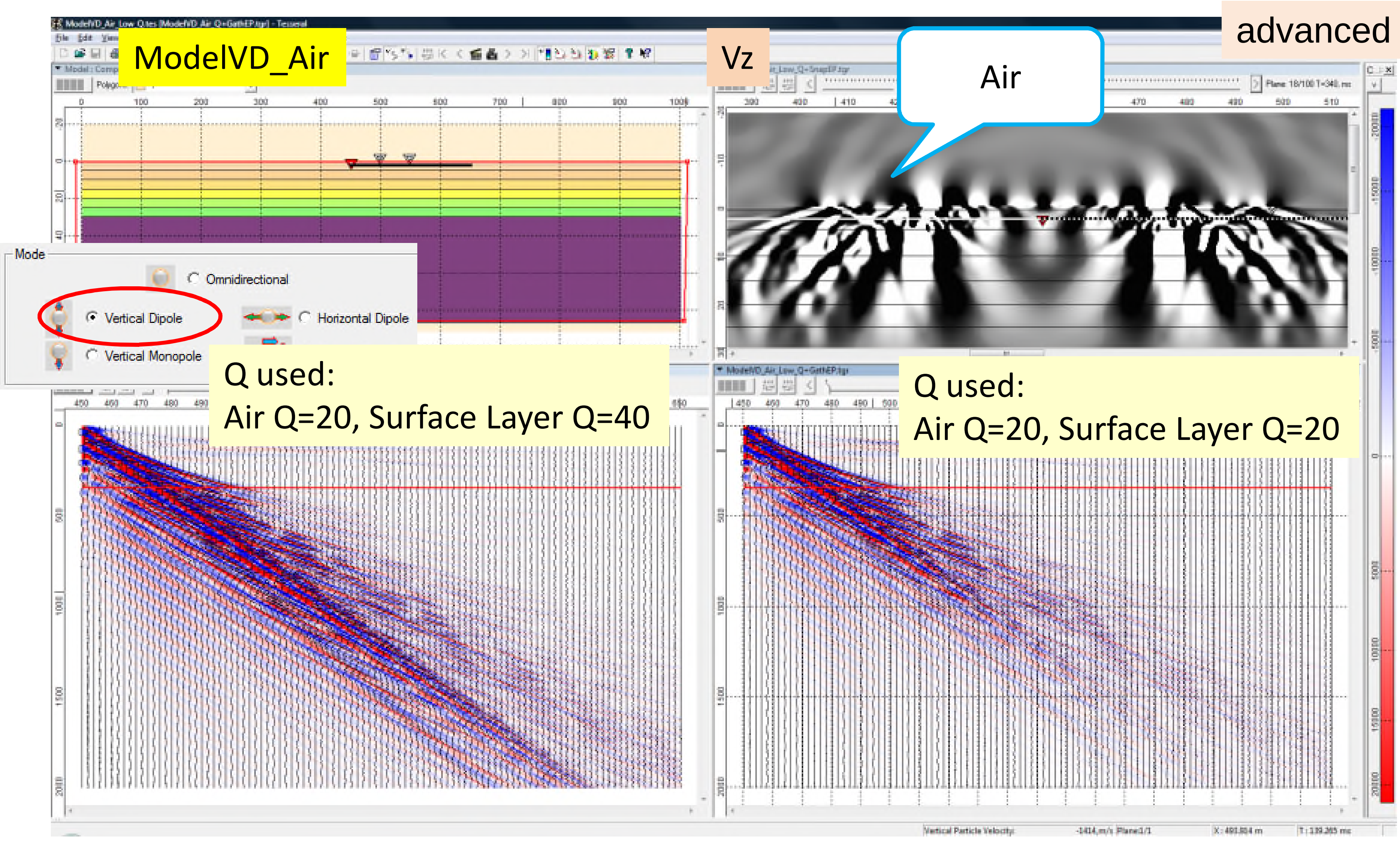
30
40
45
50
55
60



Comparison of ***modeling with upper Air half-space***.
Using of Q-factor considerably attenuates “day surface ringing” skin-effect.



Comparison of ***modeling with upper Air half-space***.
Smaller value of Q-factor in upper layer (loose soil) is even more decreasing “day surface ringing” skin-effect.

Sharp surface and Lamb-Stoneley waves

Definitions of ***Stoneley wave*** on the Web:

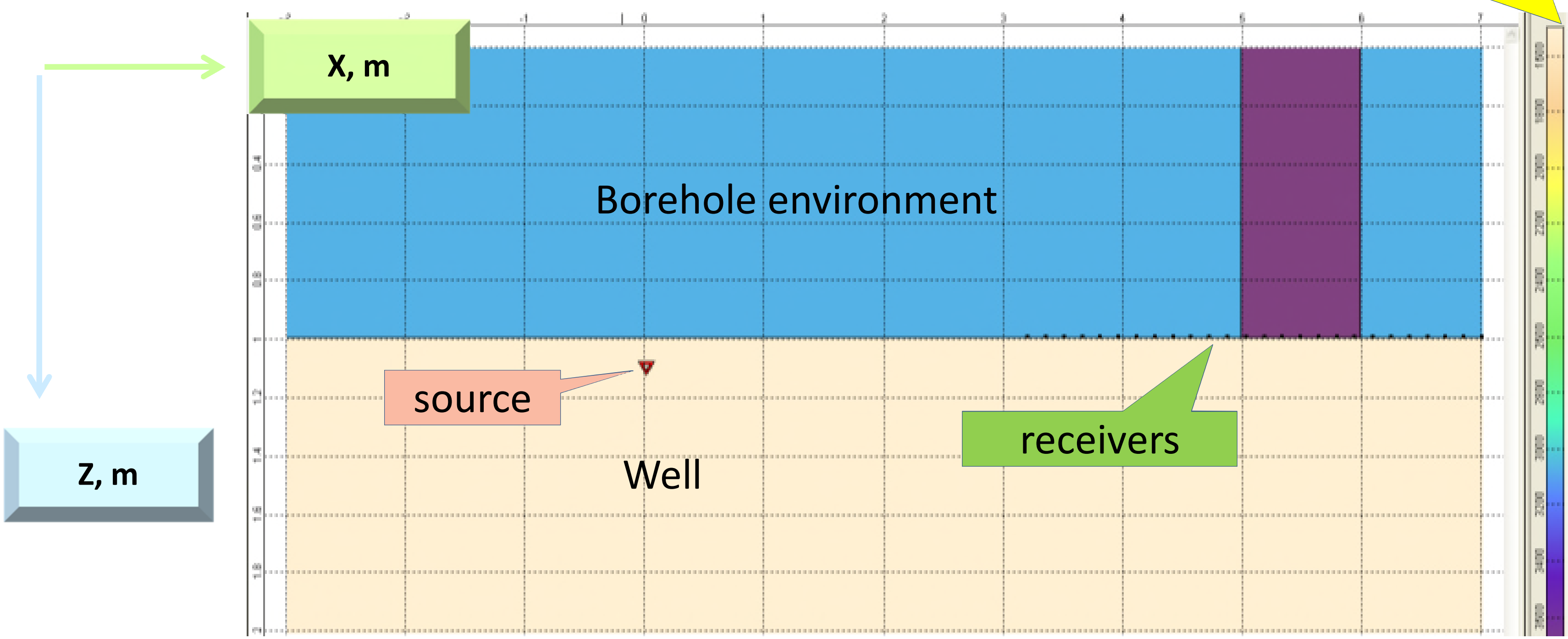
- A surface wave (interface wave) associated with the interface between two solid media. The wave is of maximum intensity at the interface and decreases exponentially away from the interface into both solids.

en.wikipedia.org/wiki/Stoneley_wave

✓ Relating to ***Lamb-Stoneley*** - ... accociated with the interface between solid and liquid media. Air formally also may be related to liquid (acoustic) media, with only difference that gas is considerably less dense (and consequently more compressible).

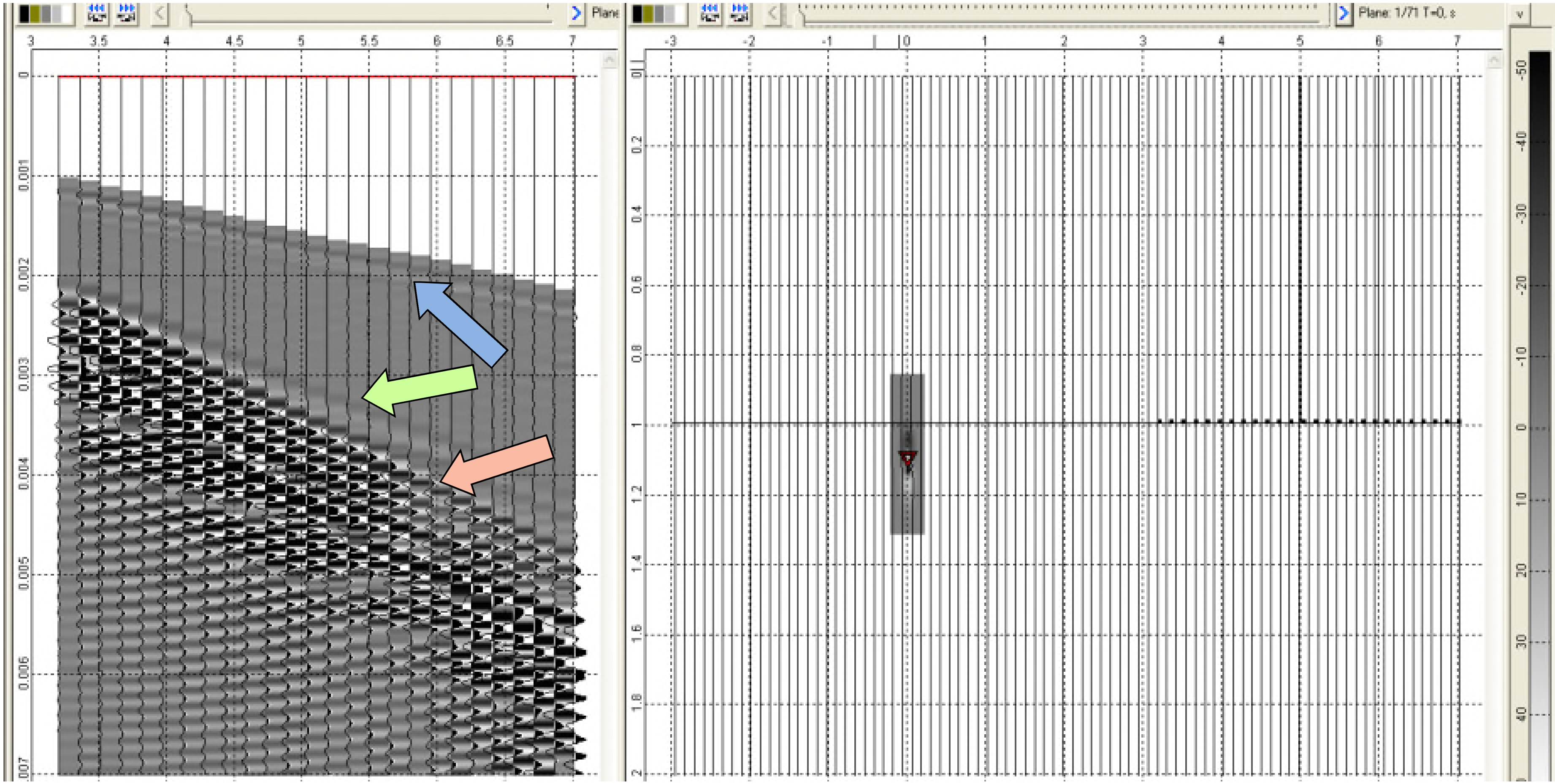
2D-2C modeling case

Model of well sonic logging



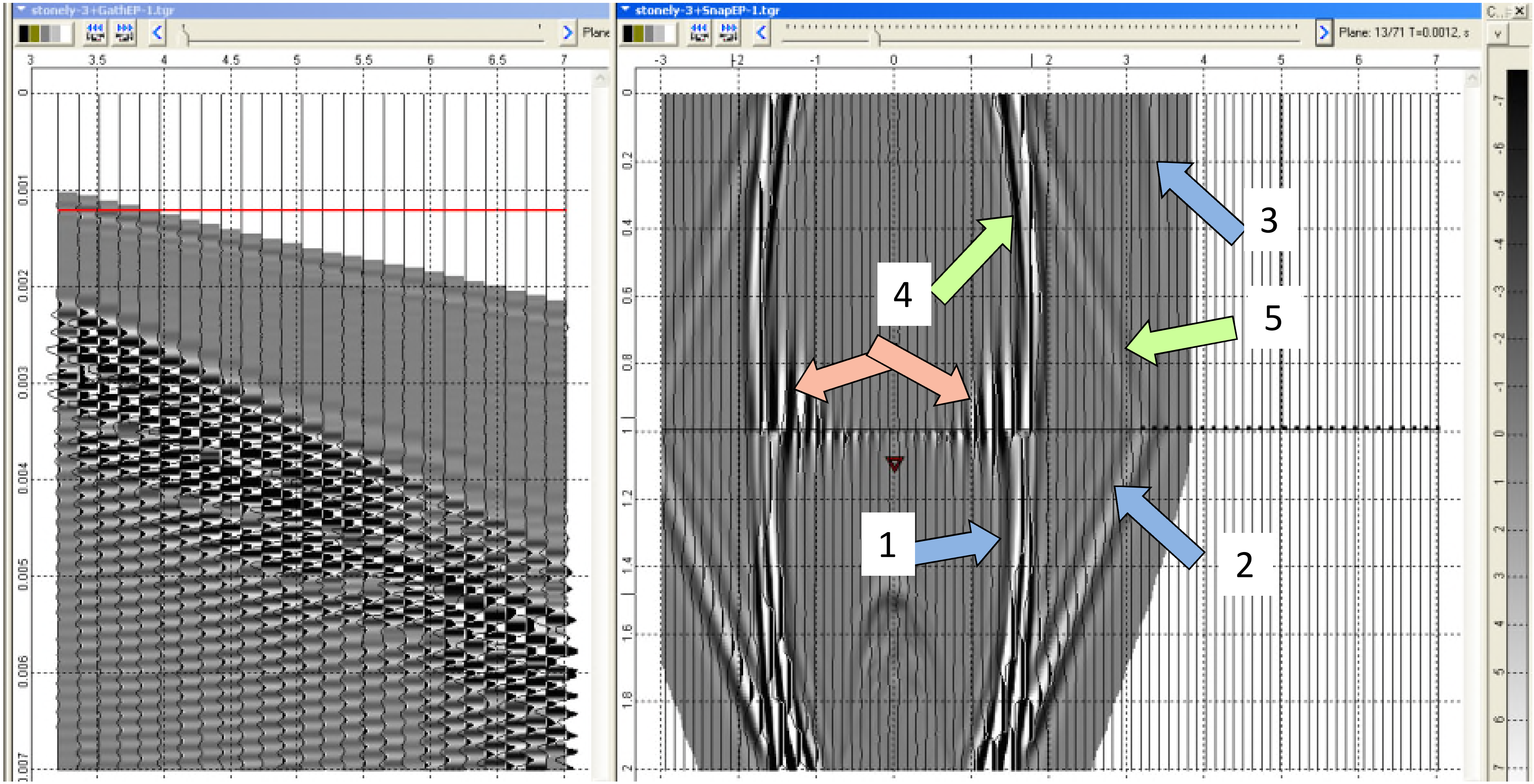
- ✓ Well is presented horizontally, source at coordinate X=0 inside of the well filled with clay drilling mud (acoustic medium).
- ✓ Borehole environment represents homogeneous medium (elastic) complicated with horizontal (with this orientation – vertical) higher velocity layer.

Receivers are positioned at the side of hole from 3 m to 7 m with interval 0.152 m.
Source pick frequency 10 000 Hz.
The computation grid cell size 0.01 m.
Recording sampling 0.000 000 5 sec.



Left picture represents modeled shotgather; right picture – seismic wave field snapshot (at starting)
Red line on shotgather – current time of the snapshot

Blue arrow – ***compressional*** wave propagating along side of the borehole
Green arrow – ***converted shear*** PS-wave;
Red arrow –***Stoneley wave***, forming train, which is characteristic for surface waves

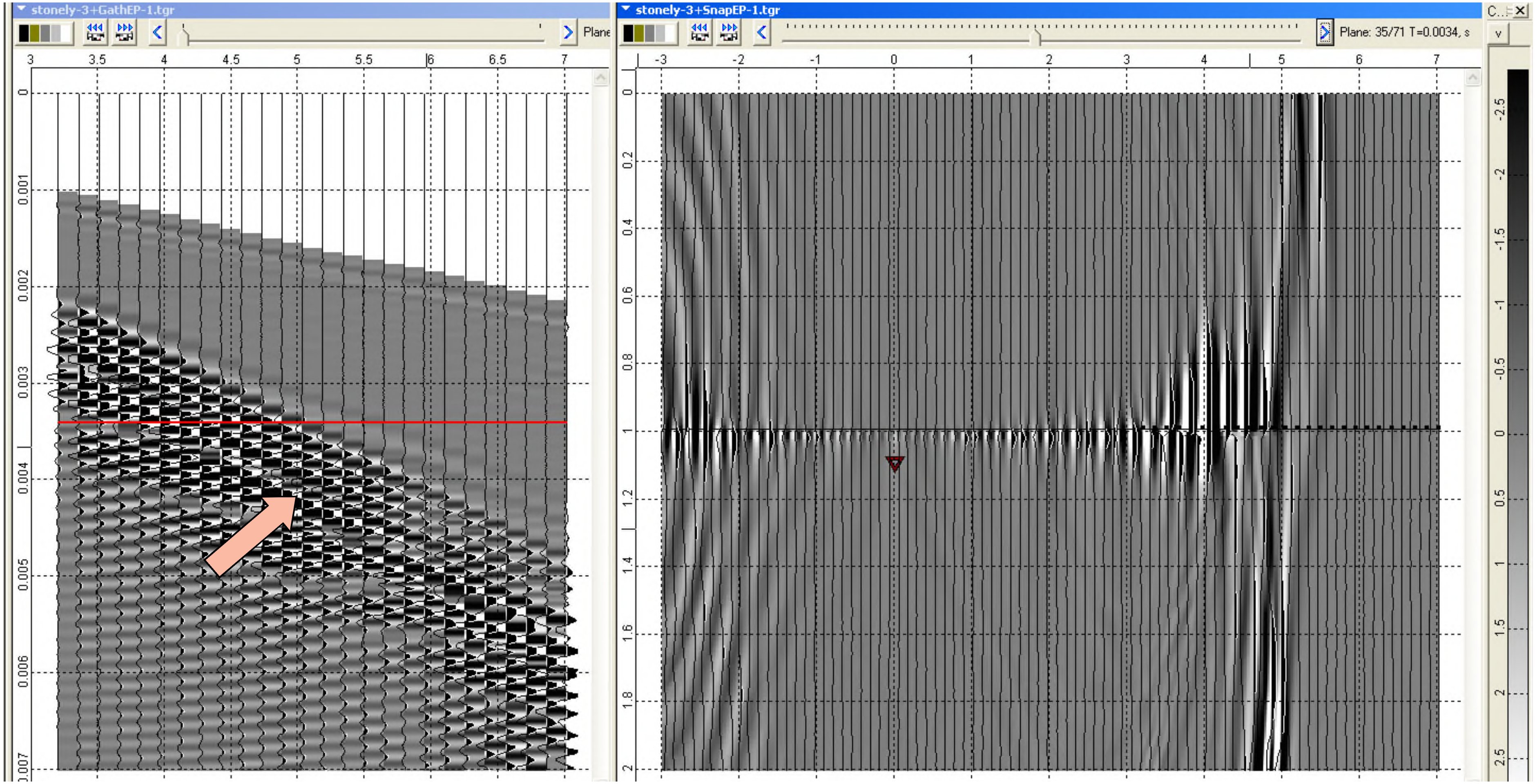


Left picture – snapshot at time 0.0012 sec

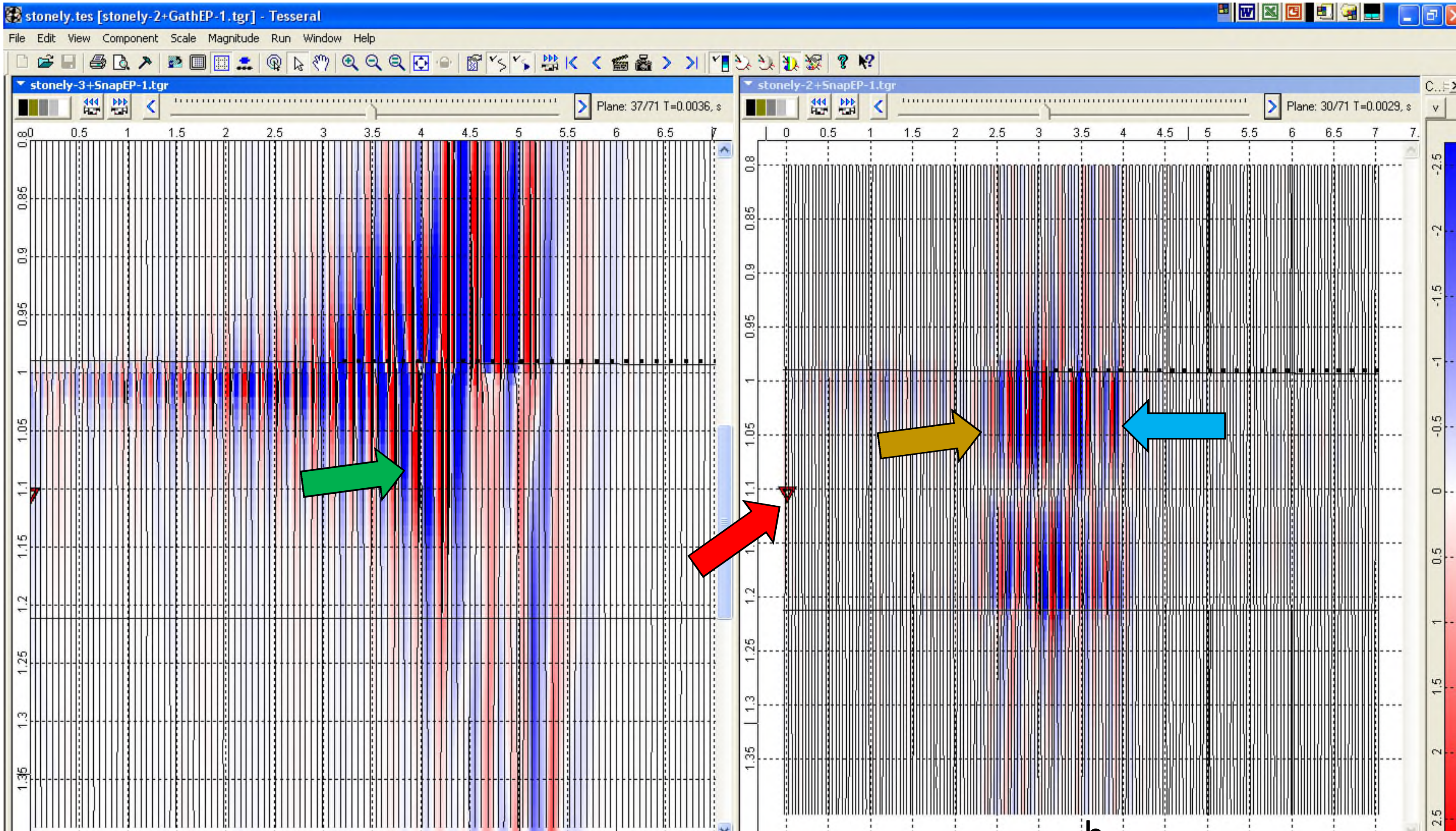
Blue arrows - ***compressional*** waves: 1- direct wave from the source, 2- head (conical) wave, 3- direct wave propagating in borehole environment;

Green arrows – ***converted PS***-waves: 4- direct wave propagating in borehole environment, 5- head (conical) wave;

Red arrows – ***Stoneley waves***, sharply attenuating outside of boundary. Intensiveness of those waves is considerably higher than of compressional and converted waves, velocity is smaller than one of shear wave, characteristic feature - forming continuous train.



From this moment (t~ 0.004 sec) ***reflected from the borehole side converted waves and Stoneley waves begin to interfere***. Complicated with such interference part of the shot record is shown with arrow.



a b

a- ***snapshot in case of one boundary*** (upper) over source (shown with ***red arrow***) point ; **b**- ***snapshot in case of two boundaries*** (analogue of well filled with clay drilling mud (acoustic medium) in which was generated wave.

More exactly in this (2D) modeling it is not a cylindrical well but thin infinite hollow.

With ***blue arrow*** is shown ***first arrival*** of ***compressional*** wave propagating in liquid.

With ***brown arrow*** – ***tube wave***, velocity of which is considerably smaller than of compressional wave.

With ***green arrow*** are shown ***waves relating to discontinuity***.

Model of well sonic logging "with casing"