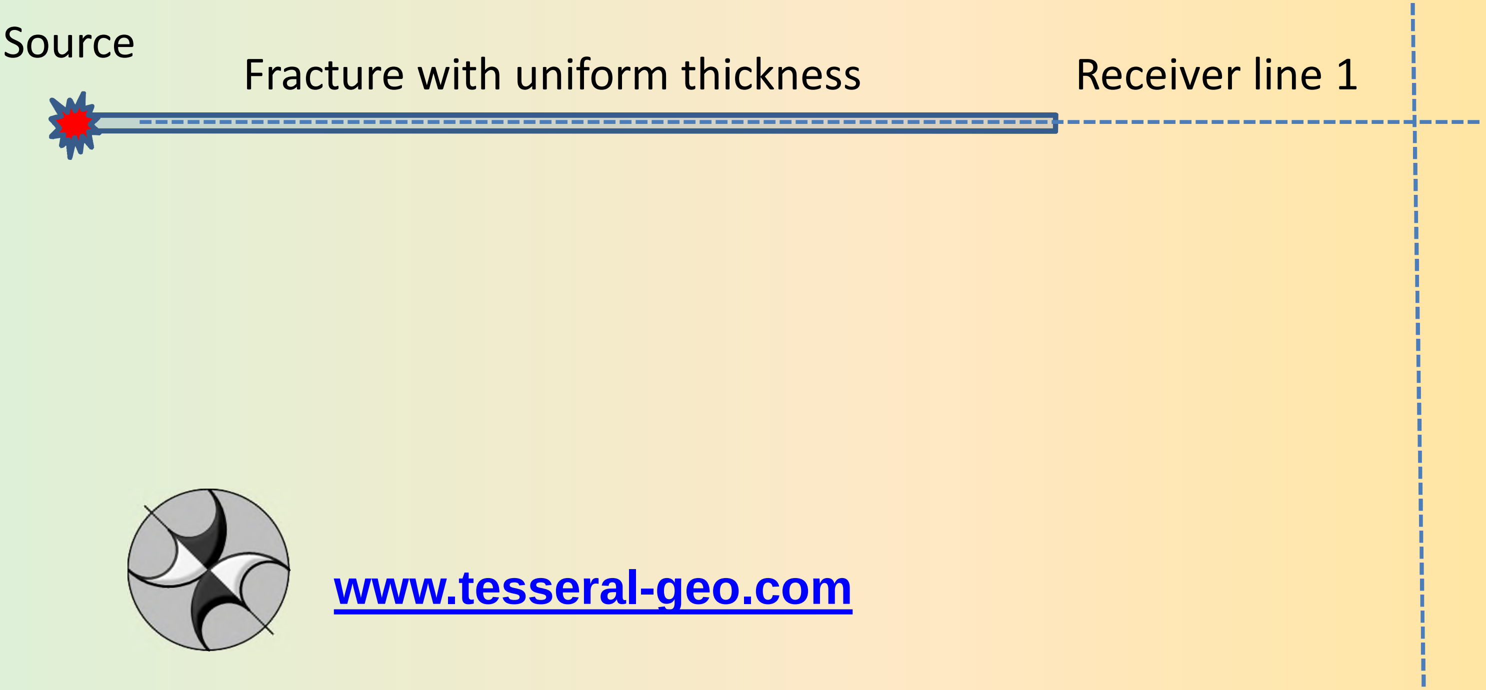
Modeling of Krauklis waves in Tesseral

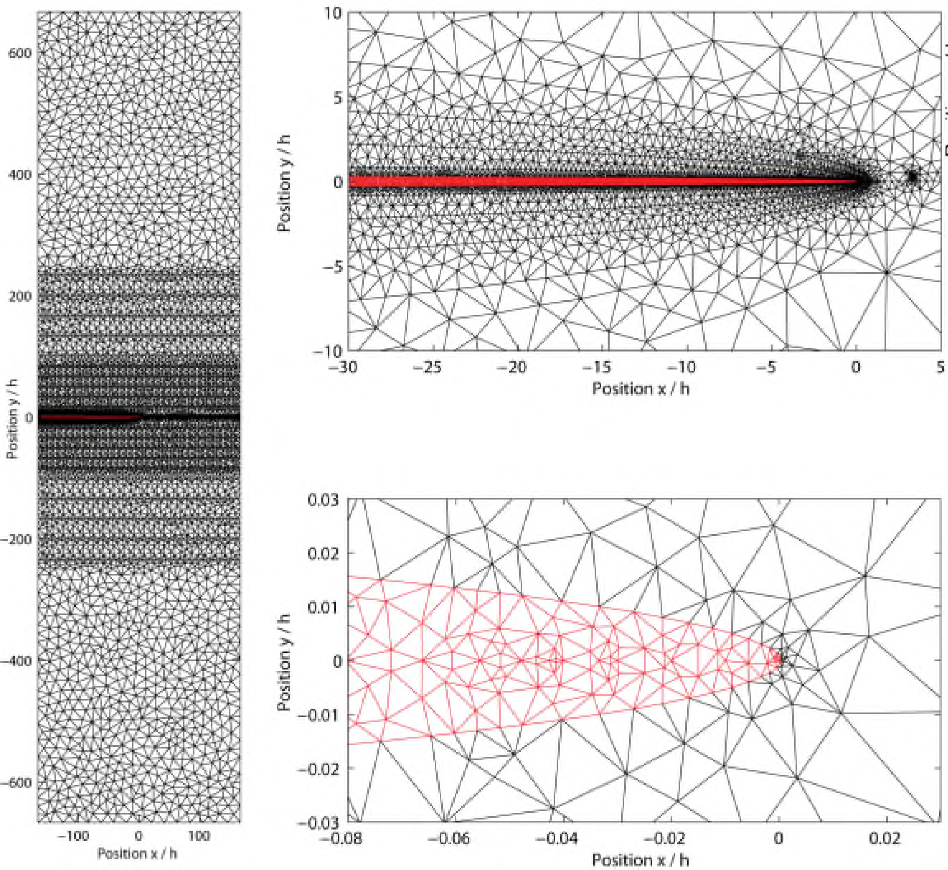
- Test Case Study



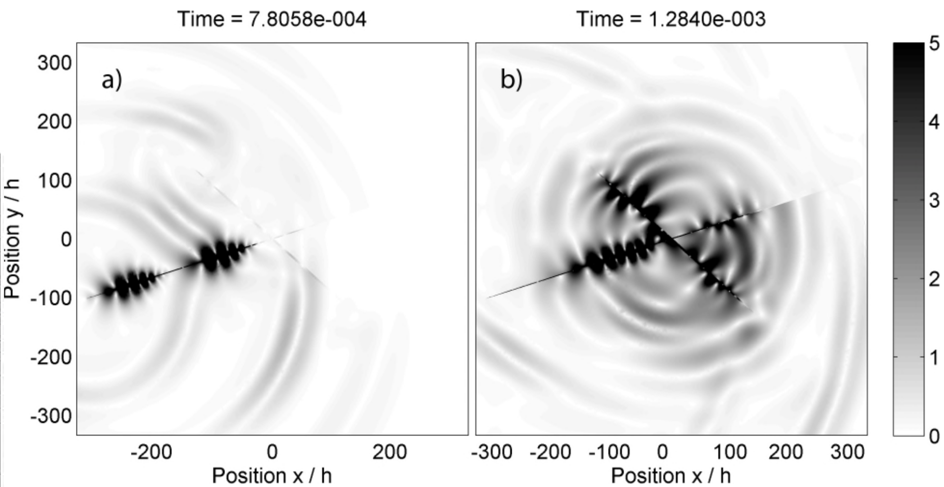
www.tesseral-geo.com

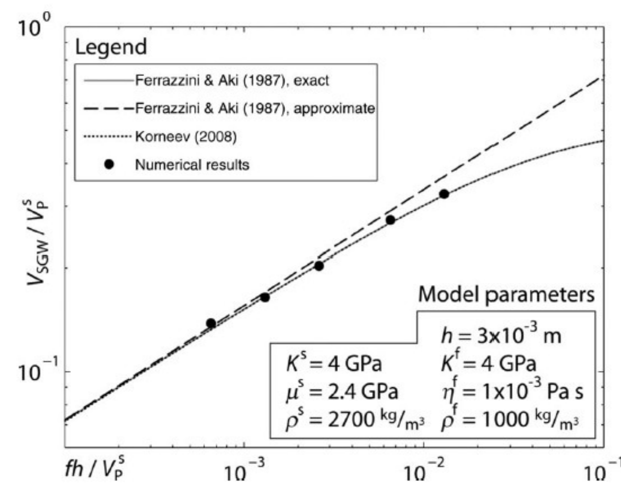
Finite-Element Simulations

FE grid

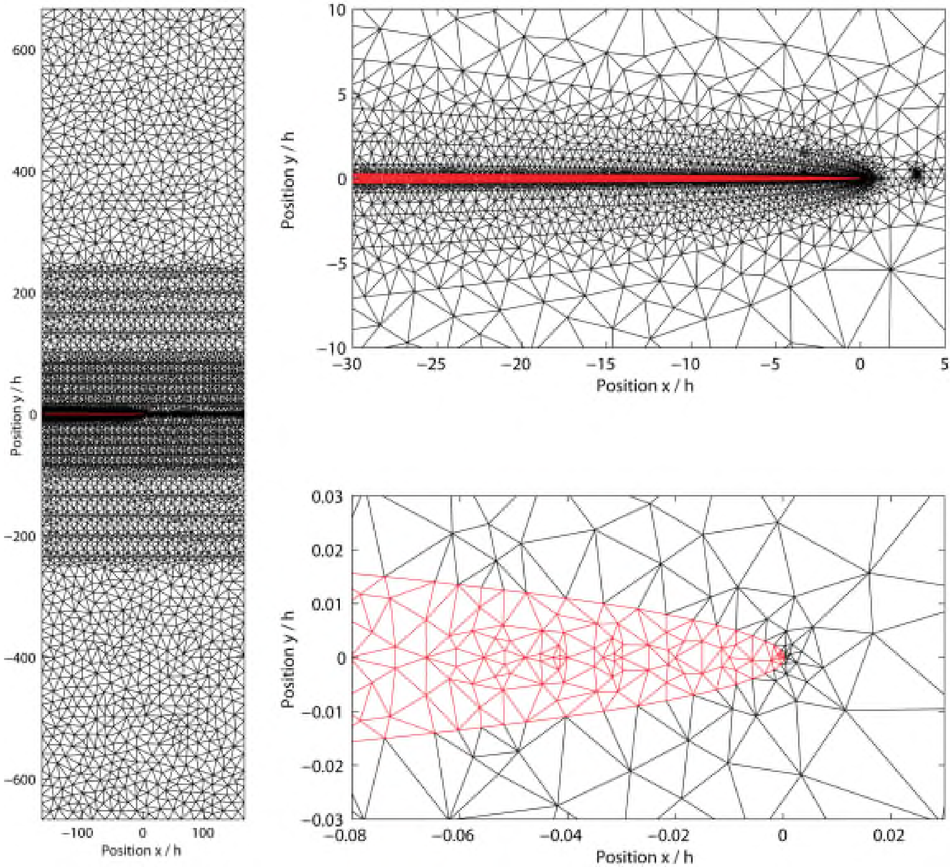


Two intersecting fractures model



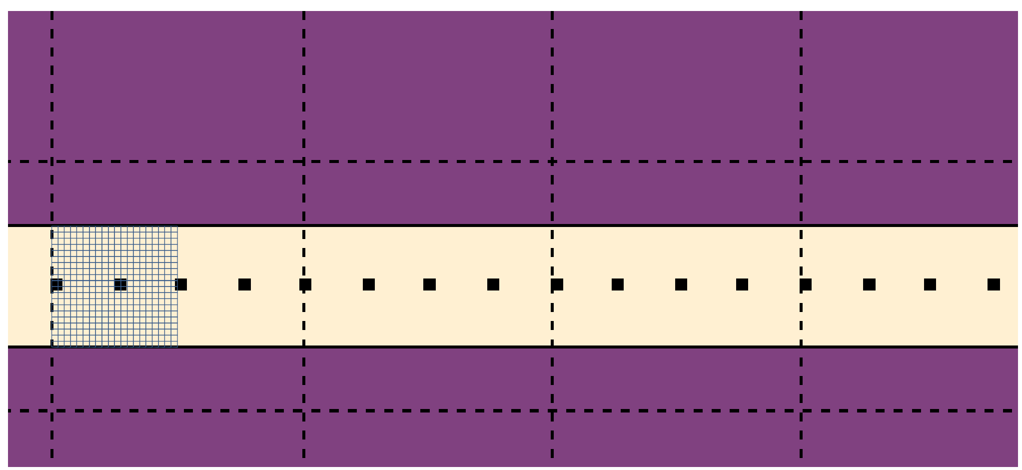


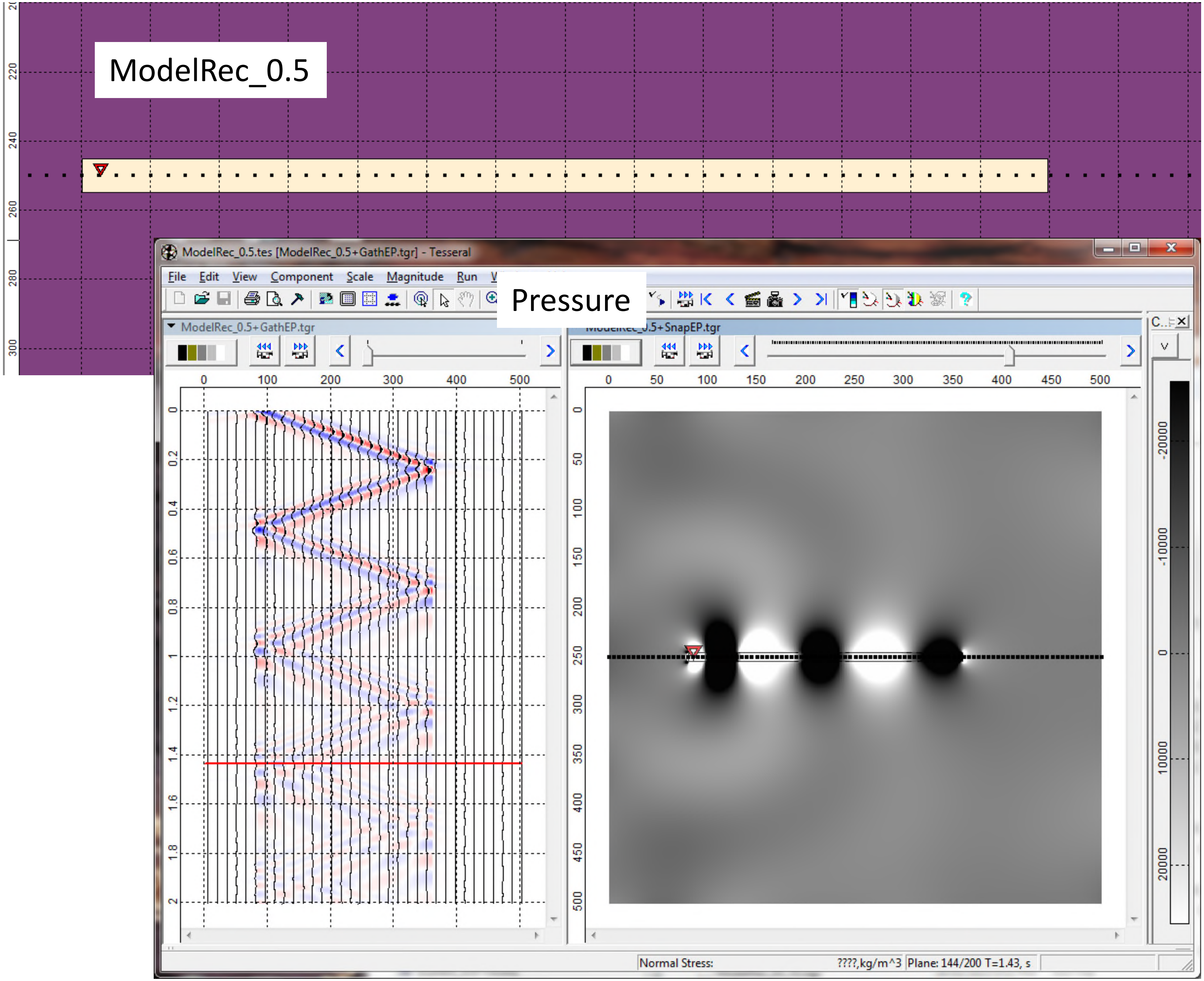
Frehner and Schmalholz, 2010



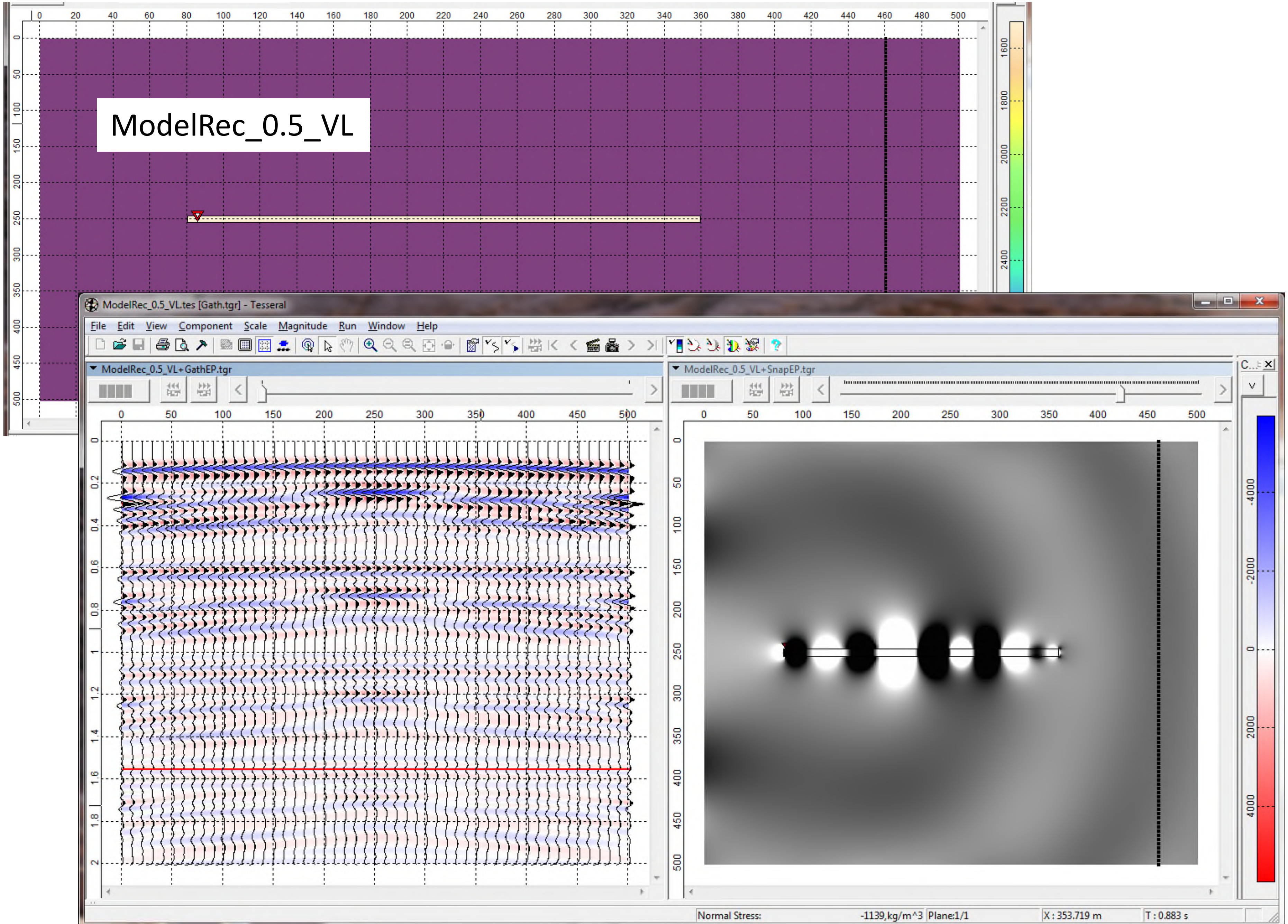
FE grid

Relative dimensions of Fracture with 10 cm width and computation grid cell size 0.5 cm (shown 20x20 cells) modeled in Tesseral FD grid



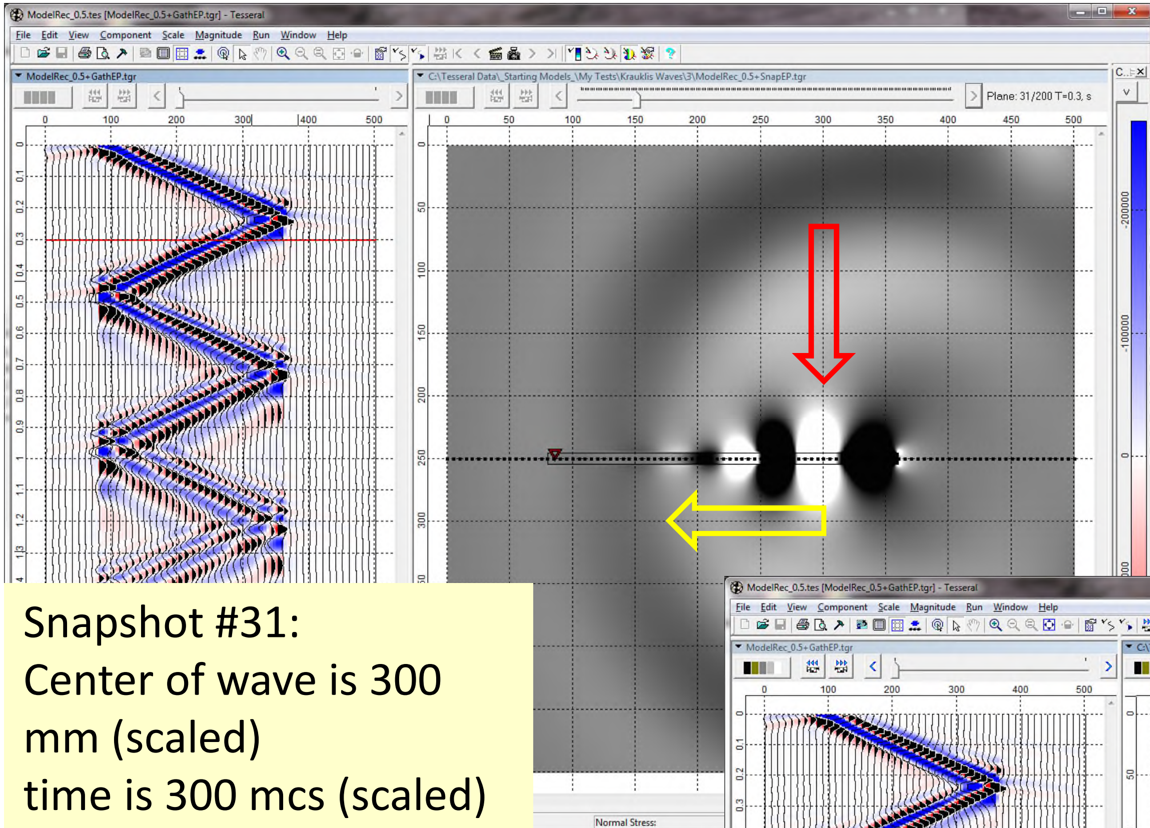


ModelRec_0.5
Pressure
ModelRec_0.5.tes [ModelRec_0.5+GathEP.tgr] - Tesseral
File Edit View Component Scale Magnitude Run
ModelRec_0.5+GathEP.tgr
Normal Stress:
????,kg/m^3 Plane: 144/200 T=1.43, s

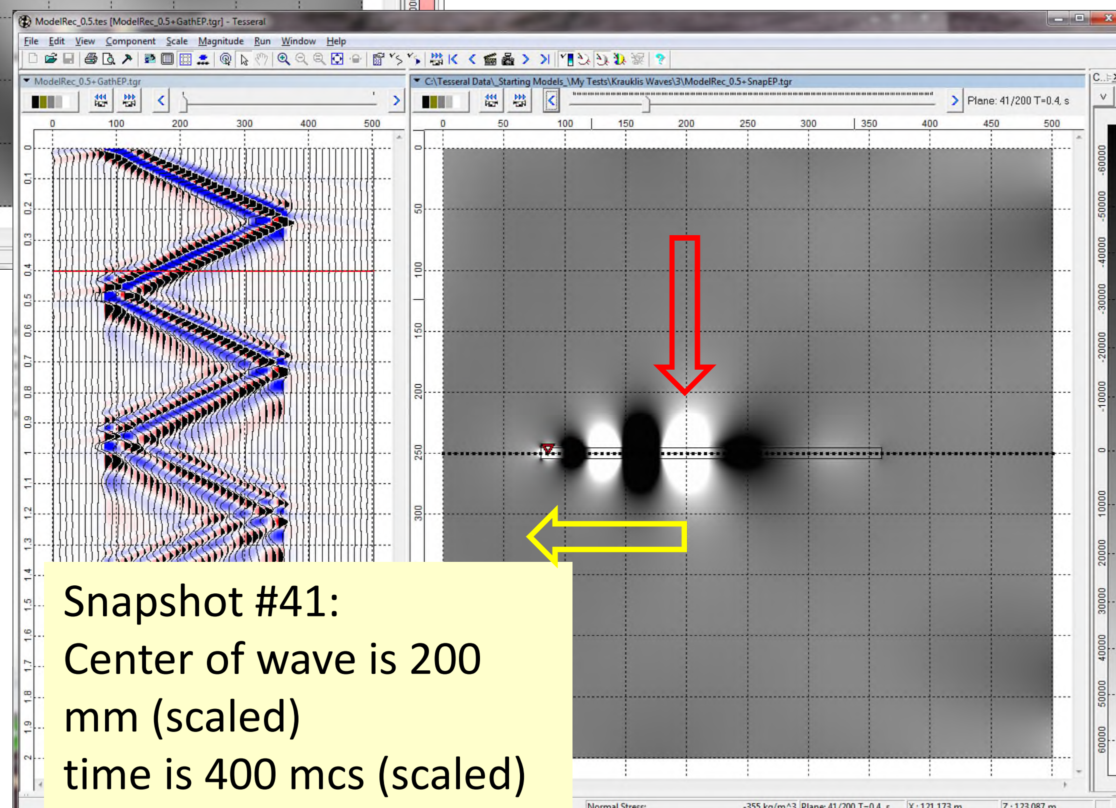

ModelRec_0.5_VL
ModelRec_0.5_VL.tes [Gath.tgr] - Tesseral
File Edit View Component Scale Magnitude Run Window Help
ModelRec_0.5_VL+GathEP.tgr
ModelRec_0.5_VL+SnapEP.tgr
Normal Stress:
-1139,kg/m^3
Plane:1/1
X : 353.719 m
T : 0.883 s

Propagation velocity of “beans” can be measured by series of wavefield snapshots

Shown with red arrow “bean” wave is propagating along fracture in direction shown with yellow arrow

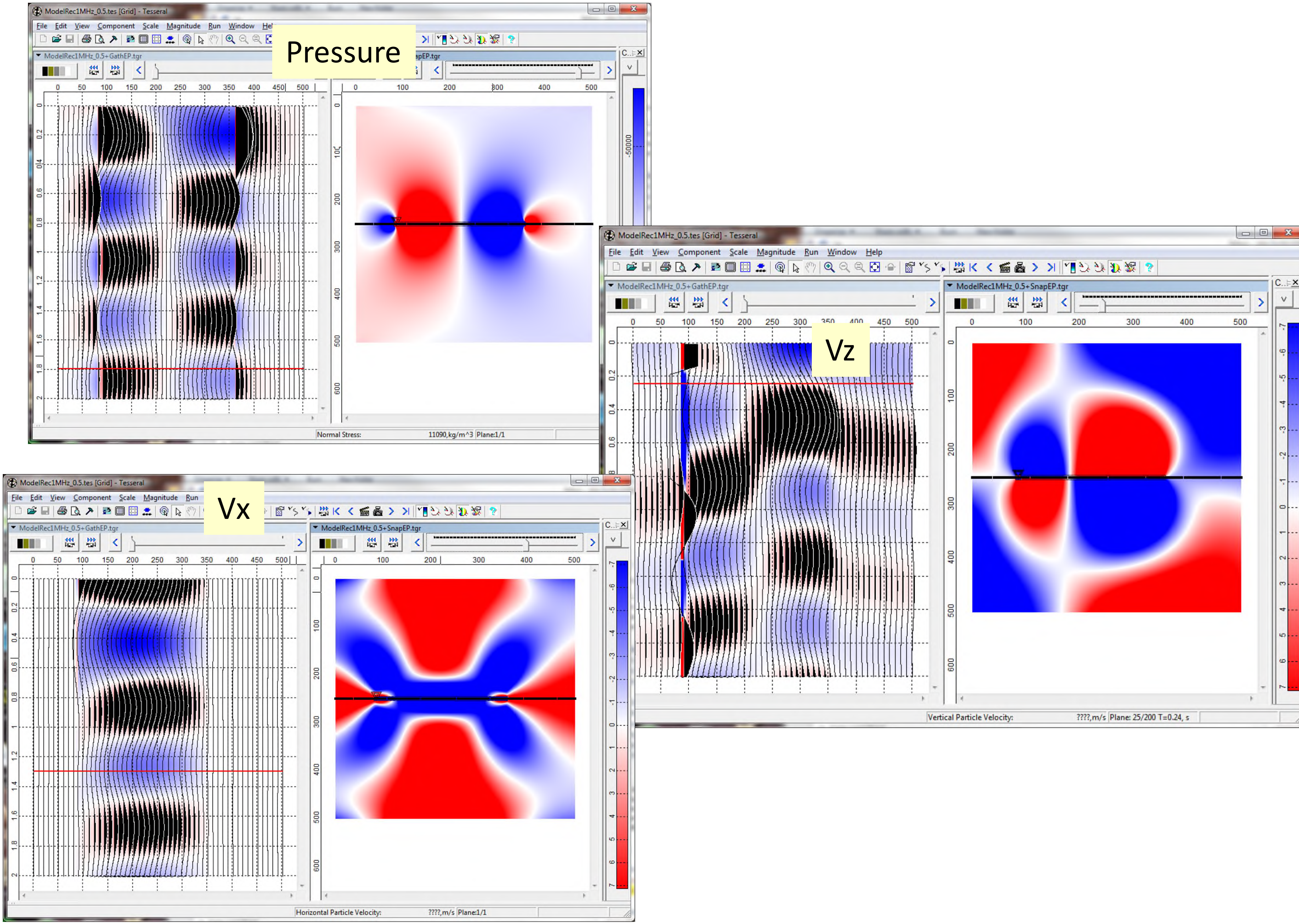


Snapshot #31:
Center of wave is 300 mm (scaled)
time is 300 mcs (scaled)

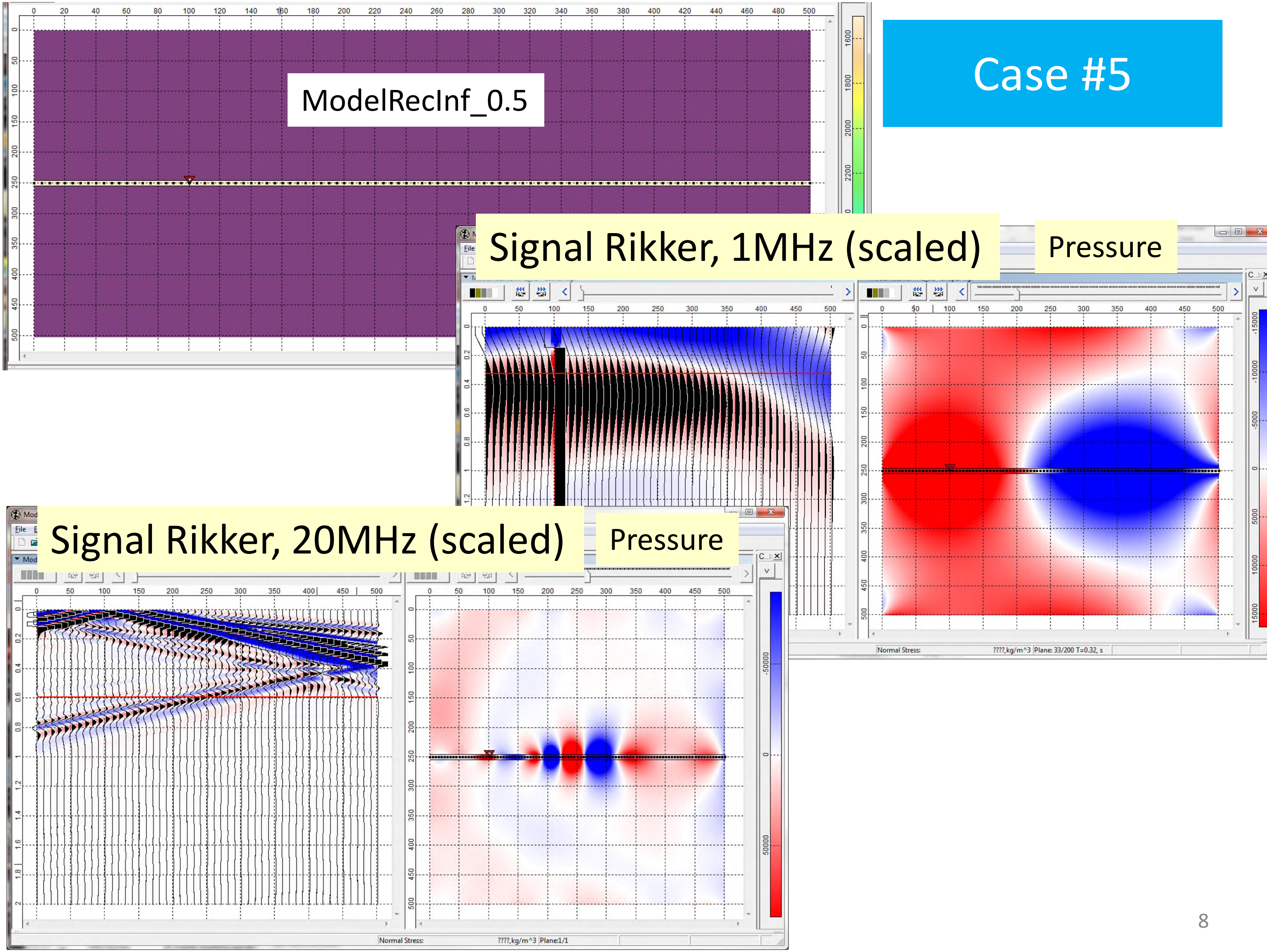


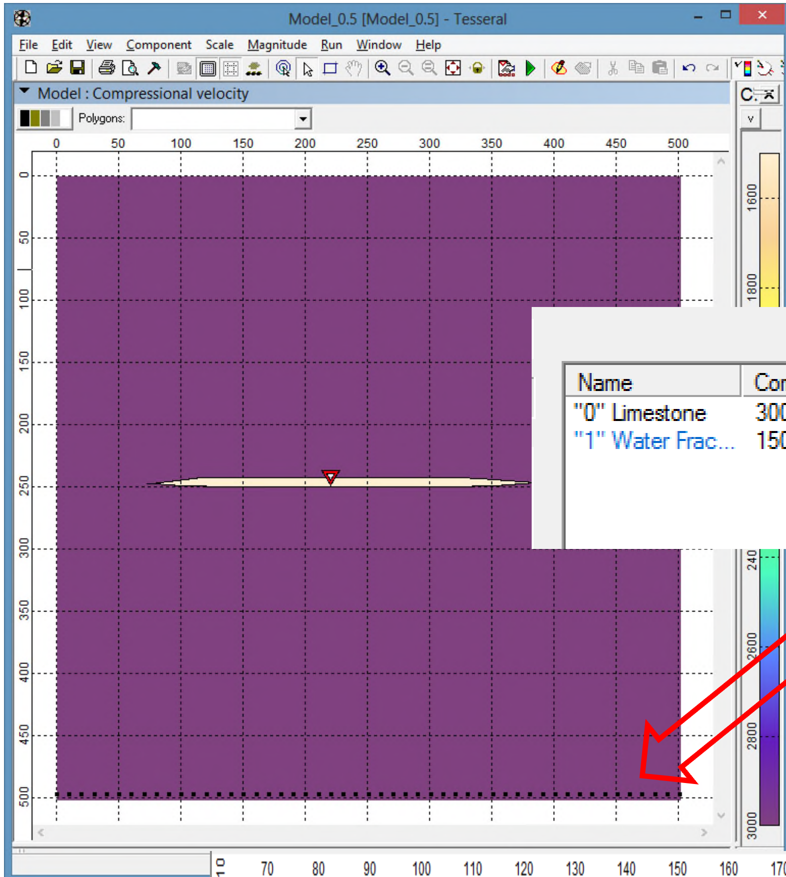
Snapshot #41:
Center of wave is 200 mm (scaled)
time is 400 mcs (scaled)

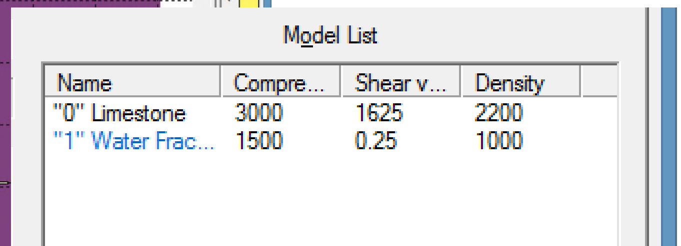
Calculated velocity of “bean” wave propagation is
100 mm/100 ms~=
1 mm/mcs=
1 m/ms=
1000 m/s


Pressure
Vz
Vx
ModelRec1MHz_0.5.tes [Grid] - Tesseral
ModelRec1MHz_0.5+GathEP.tgr
ModelRec1MHz_0.5+SnapEP.tgr
Normal Stress:
Vertical Particle Velocity:
Horizontal Particle Velocity:

Case #5


ModelRecInf_0.5
Signal Rikker, 1MHz (scaled)
Pressure
Signal Rikker, 20MHz (scaled)
Pressure





Model List

Name	Compre...	Shear v...	Density
"0" Limestone	3000	1625	2200
"1" Water Frac...	1500	0.25	1000

Scaling:
1m -> 1 mm
1Hz -> 1MHz
1ms -> 1mcs

Signal:
Rikker 20Hz -> 20KHz

Recording rate
1ms -> 1mcs

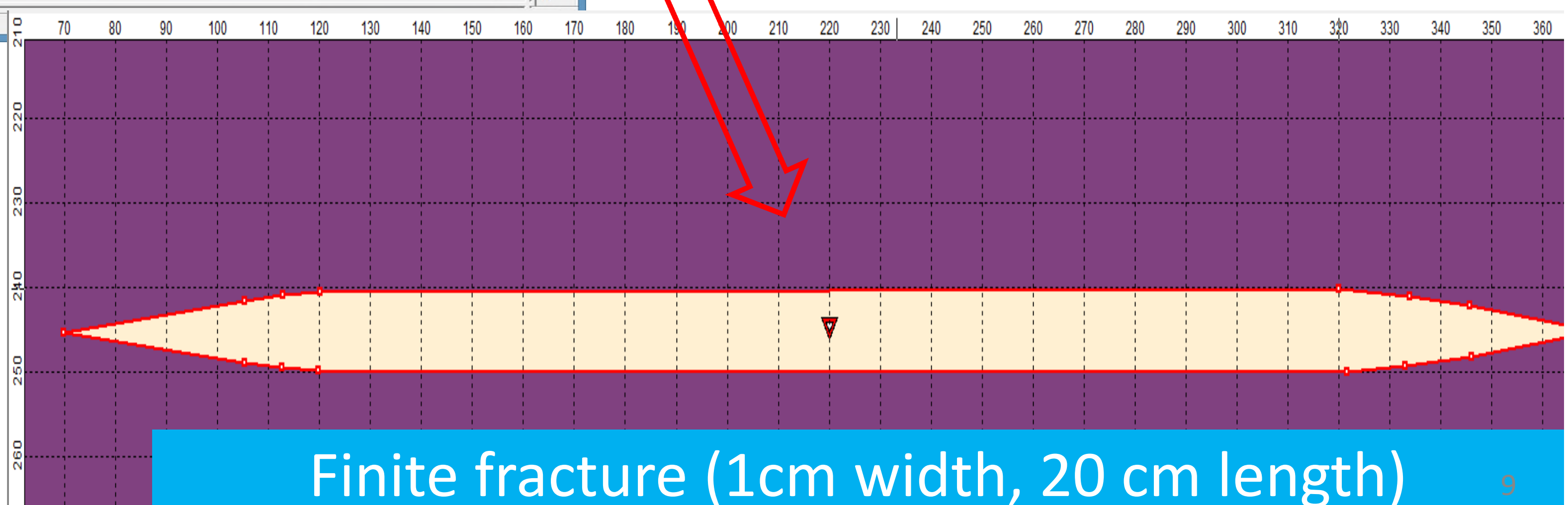
Snapshot rate
10ms – 10mcs

Grid cell:
0.5m -> 0.5 mm

Receiver line

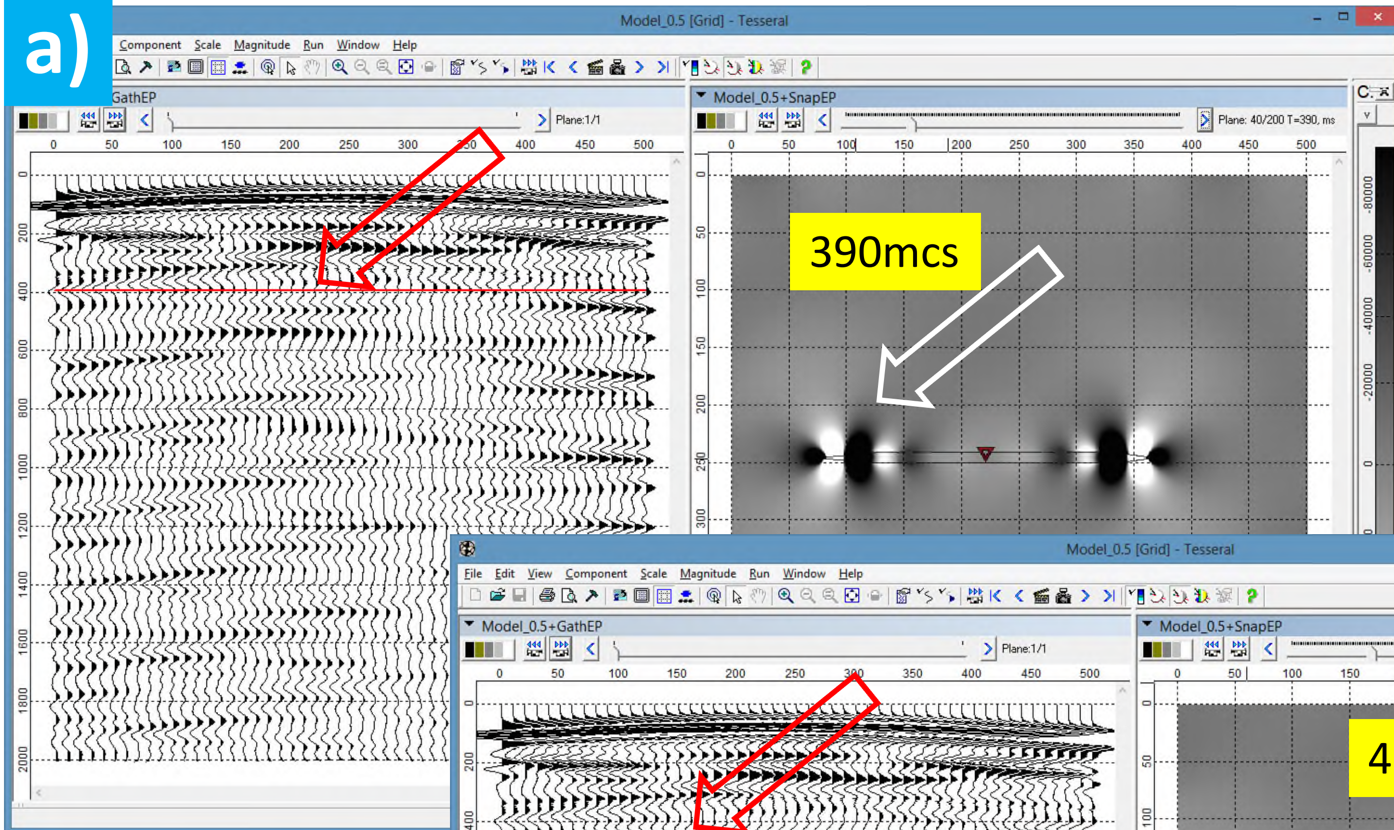
Source

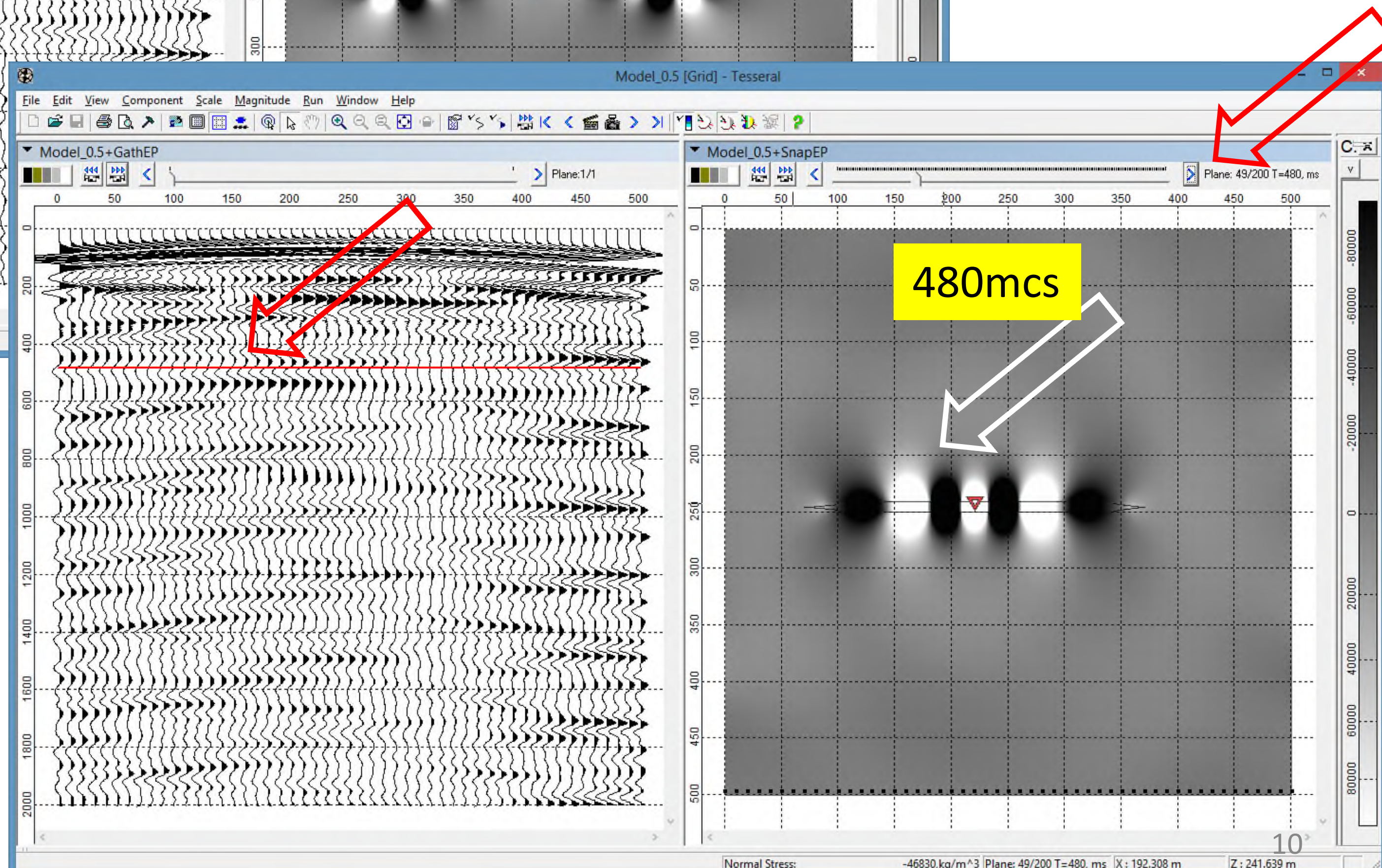
Fracture width
10 m -> 10 mm



Finite fracture (1cm width, 20 cm length)

a)





Elastic modeling

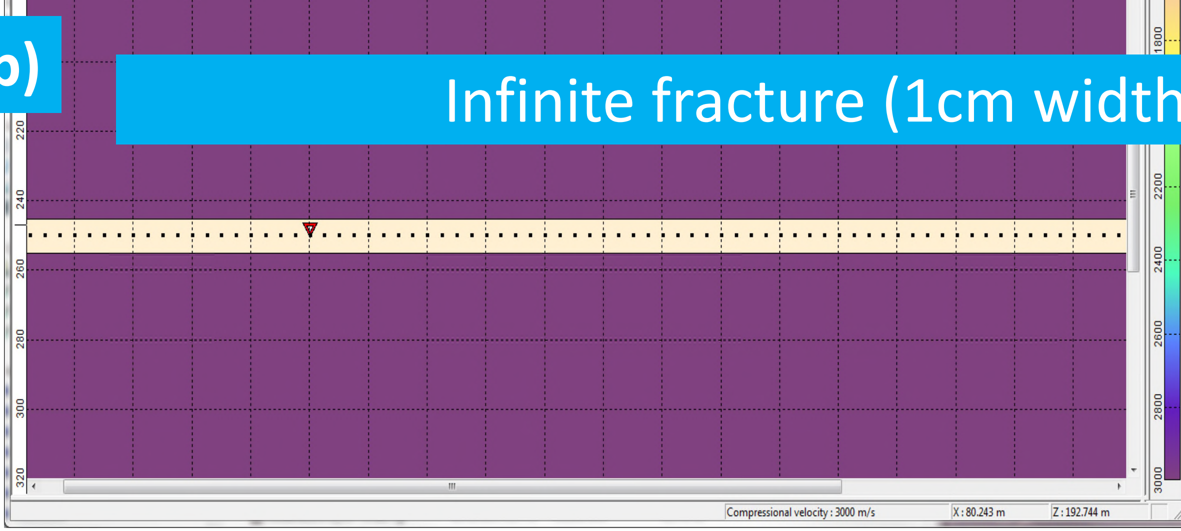
Pressure component

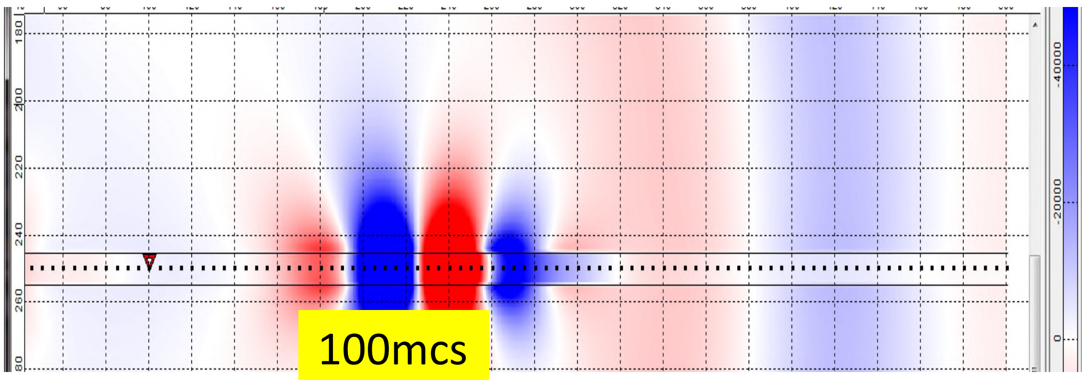
Rikker 20KHz

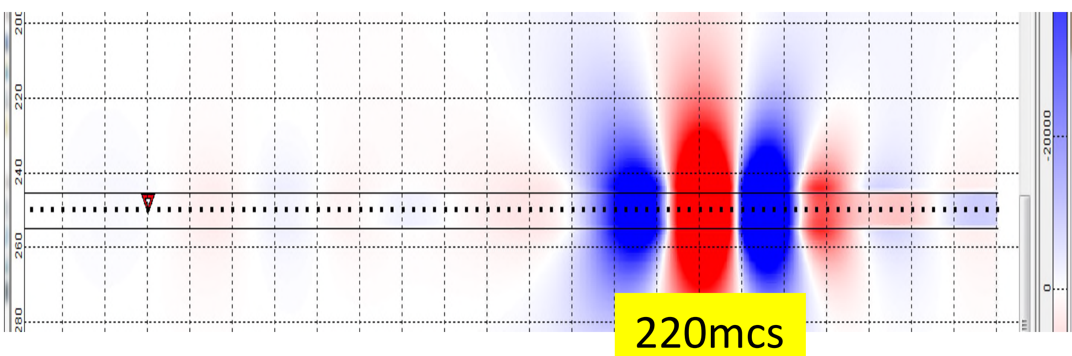
Propagation velocity of “beans” can be measured by series of wavefield snapshots (~195cm-110cm)/(480mcs-390mcs)= ~85cm/90mcs= ~950m/s

b)

Infinite fracture (1cm width)





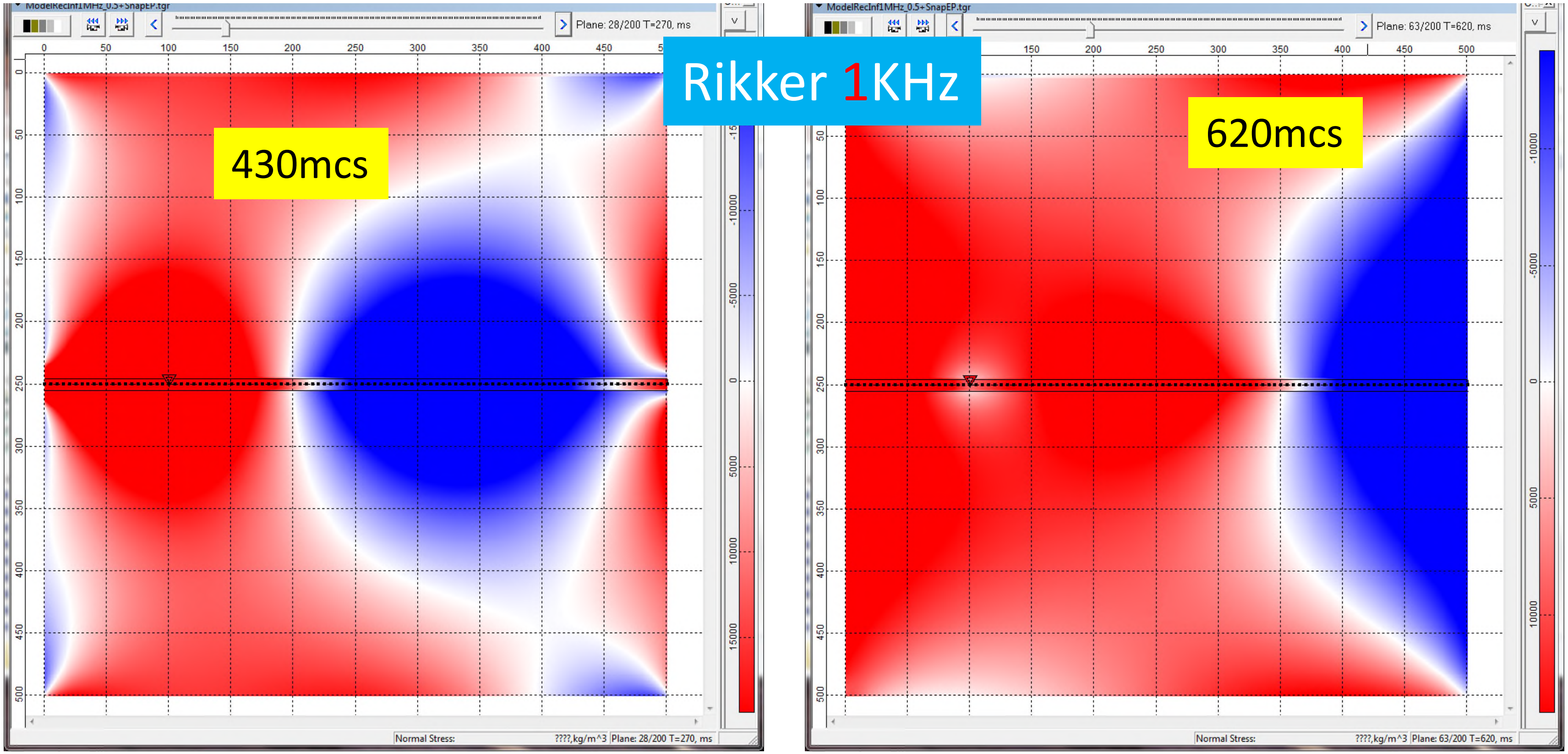


Rikker 20KHz

Propagation velocity of “beans” can be measured by series of wavefield snapshots (~360cm-240cm)/(220mcs-100mcs)= ~120cm/110mcs= ~1090m/s

c)

Infinite fracture (1cm width)



Propagation velocity of “beans” can be measured by series of wavefield snapshots (~350cm-250cm)/(620mcs-430mcs)= ~100cm/190mcs= ~530m/s

By analytical formulae:

For a model Vp=3000m/s,Vs=1625m/s, Density= 2.2g/cm3 and fracture thickness = 1 cm filled with water, the exact solution gives

Vk= 137 m/s for 10 Hz,

Vk= 601 m/s for 1 KHz, **(c)**

Vk= 1212 m/s for 20 KHz **(a,b)**

By numerical modeling experiments:

Model as above

a) fracture length 20 cm, Rikker 20 KHz:
(~195cm-110cm)/
(480mcs-390mcs)=
~85cm/90mcs= ~950m/s

b) “infinite” fracture length, Rikker 20 KHz
(~360cm-240cm)/
(220mcs-100mcs)=
~120cm/110mcs= ~1090m/s

c) “infinite” fracture length, Rikker 1 KHz
(~350cm-250cm)/
(620mcs-430mcs)=
~100cm/190mcs= ~530m/s

Summary

Comparison of velocity values provided and obtained by numerical modeling shows that “numerical” velocities are ~88-90% of the theoretical ones which is quite within used allowable numerical assumptions:

- ✓ Rikker wavelet with particular peak frequency (e.g. 1, 20 KHz) actually contain (amplitude spectrum) a band of frequencies and it may be a cause of discrepancies between theoretical and “numerical” velocities.