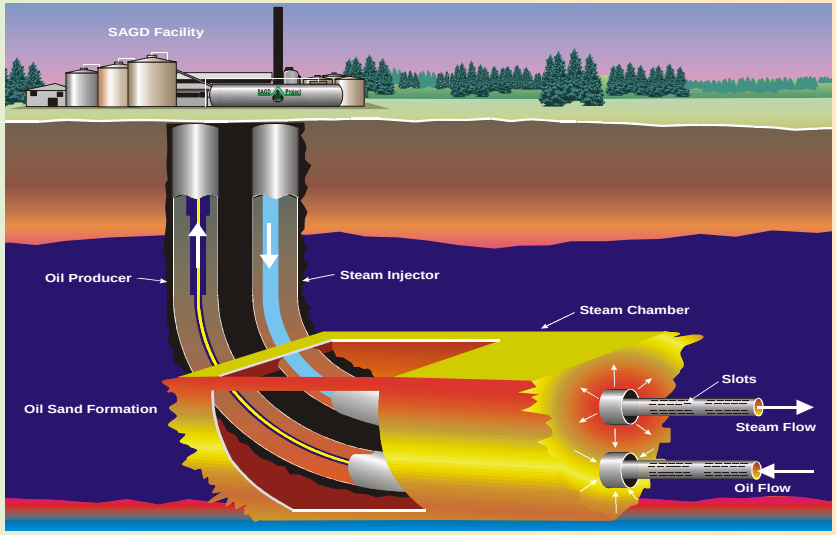
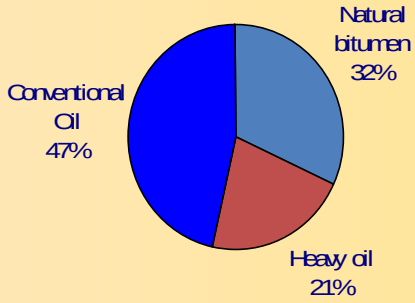
Time Lapse Seismic Modeling SAGD (enhanced oil recovery)



Region	Heavy oil	Natural bitumen
North America	35.3	530.9



10° C

90° C

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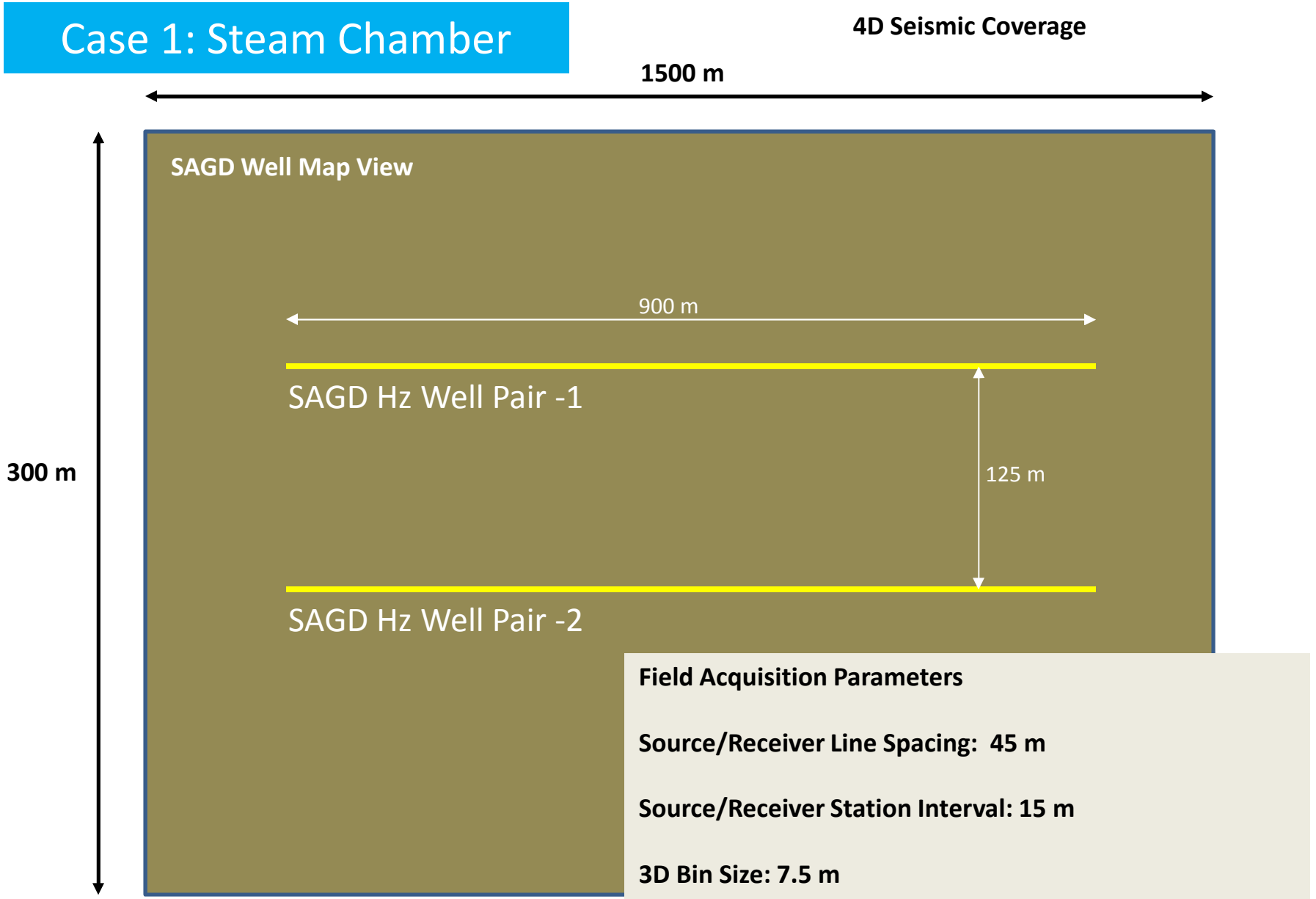
Case 1: Steam Chamber



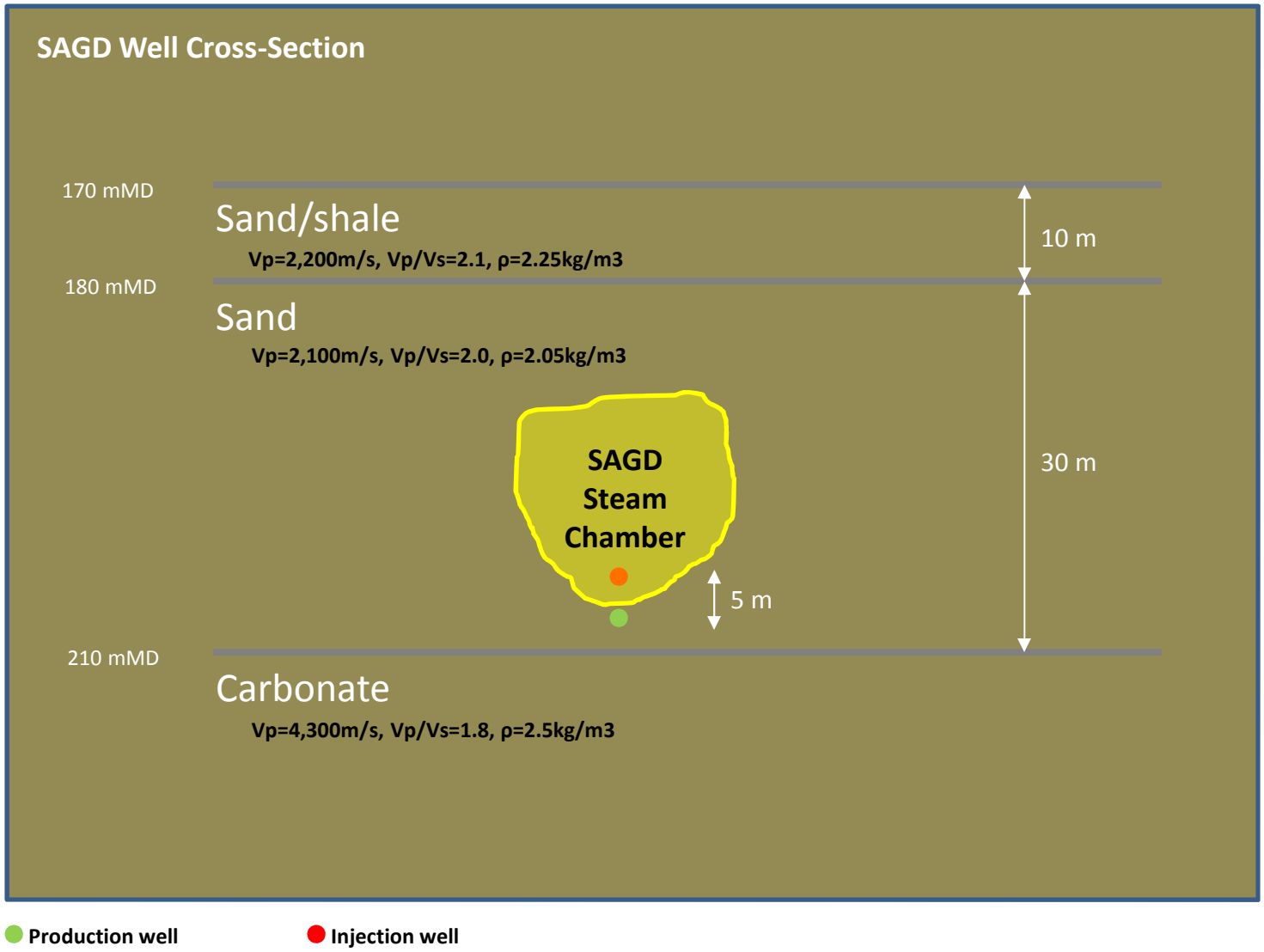
Field Acquisition Parameters

Source/Receiver Line Spacing: 45 m

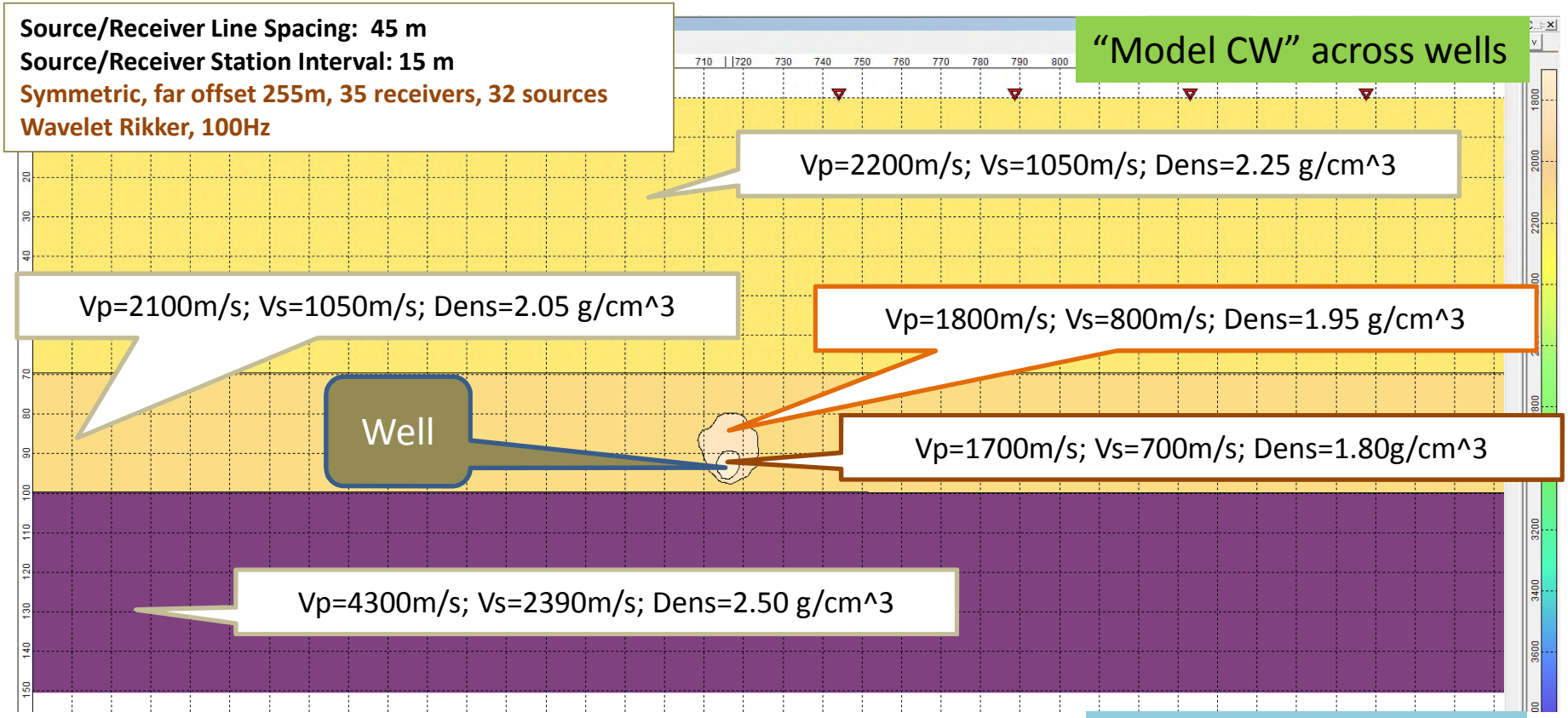
Source/Receiver Station Interval: 15 m

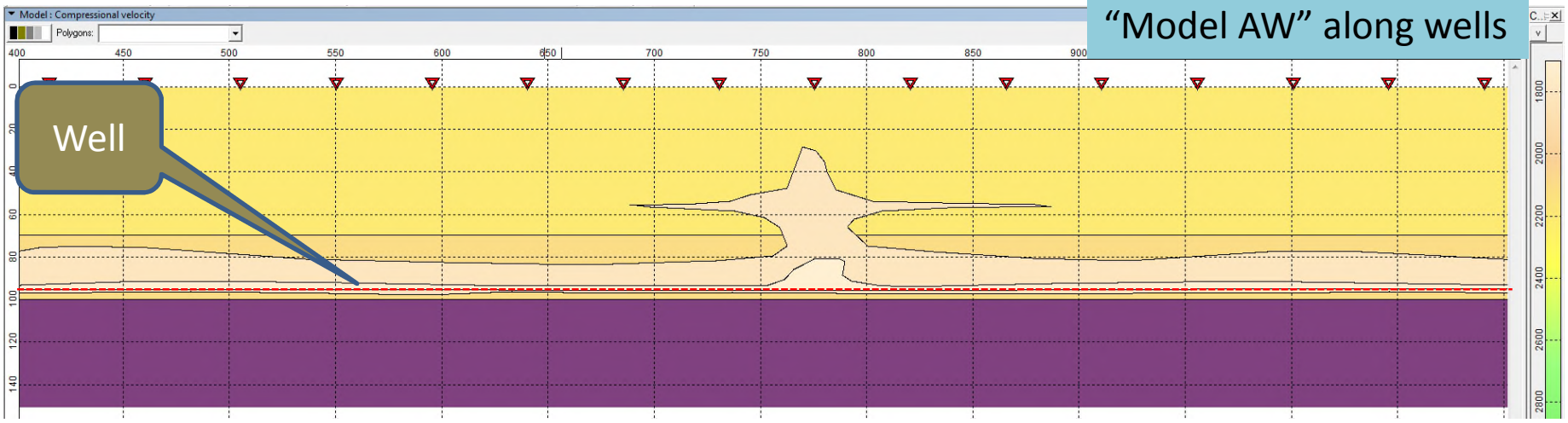
3D Bin Size: 7.5 m

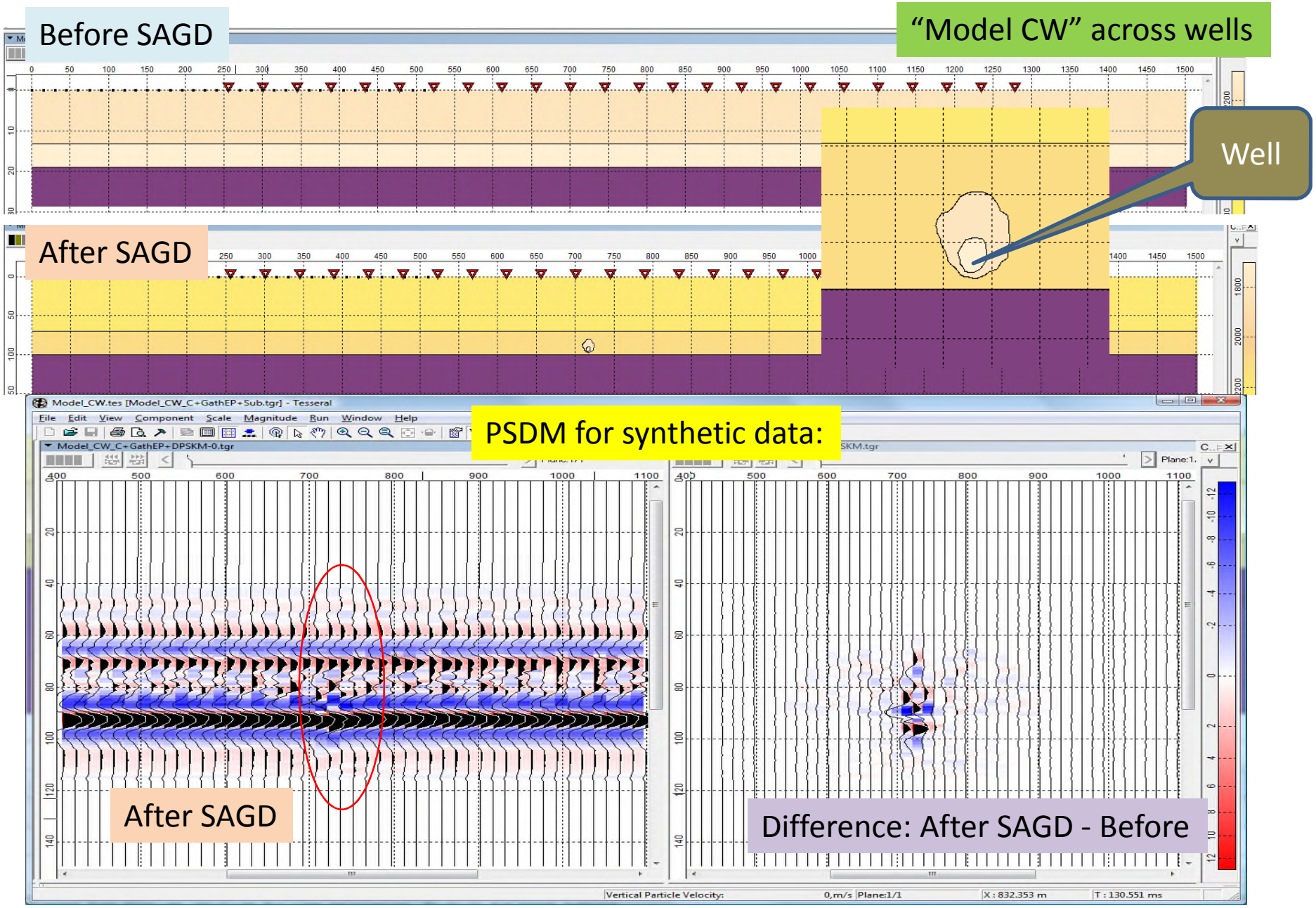
Orthogonal Cross Spread Shooting Geometry

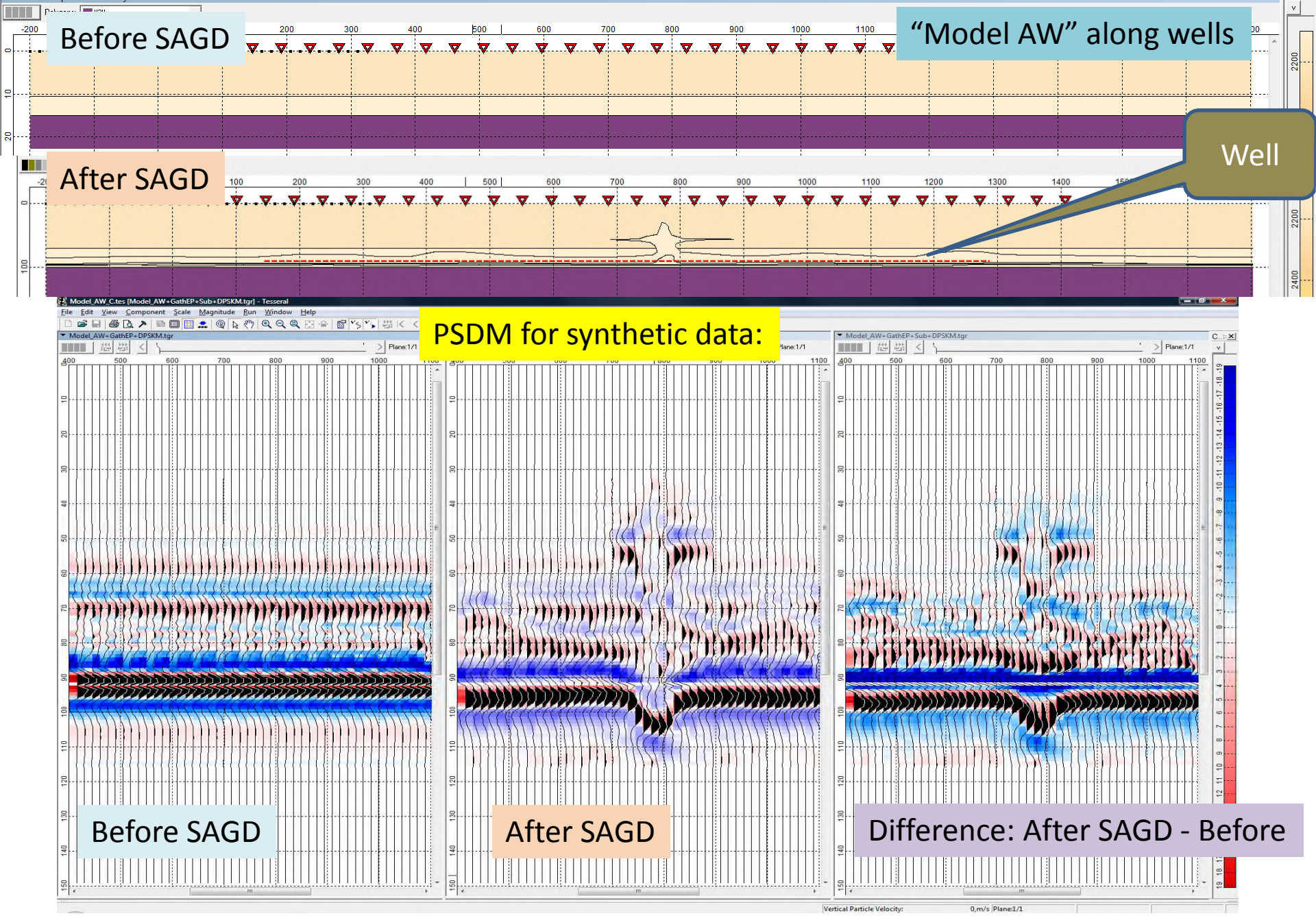

SAGD Well Cross-Section
170 mMD
Sand/shale
Vp=2,200m/s, Vp/Vs=2.1, ρ=2.25kg/m3
10 m
180 mMD
Sand
Vp=2,100m/s, Vp/Vs=2.0, ρ=2.05kg/m3
SAGD
Steam
Chamber
30 m
5 m
210 mMD
Carbonate
Vp=4,300m/s, Vp/Vs=1.8, ρ=2.5kg/m3
Production well
Injection well

Source/Receiver Line Spacing: 45 m
Source/Receiver Station Interval: 15 m
Symmetric, far offset 255m, 35 receivers, 32 sources
Wavelet Rikker, 100Hz






Before SAGD
"Model CW" across wells
Well
After SAGD
PSDM for synthetic data:
Model_CW.tes [Model_CW_C+GathEP+Sub.tgr] - Tesseral
File Edit View Component Scale Magnitude Run Window Help
Model_CW_C+GathEP+DPSKM-0.tgr
After SAGD
Difference: After SAGD - Before
Vertical Particle Velocity: 0,m/s Plane:1/1 X : 832.353 m T : 130.551 ms


Before SAGD
"Model AW" along wells
After SAGD
Well
PSDM for synthetic data:
Before SAGD
After SAGD
Difference: After SAGD - Before

Case 1: Summary

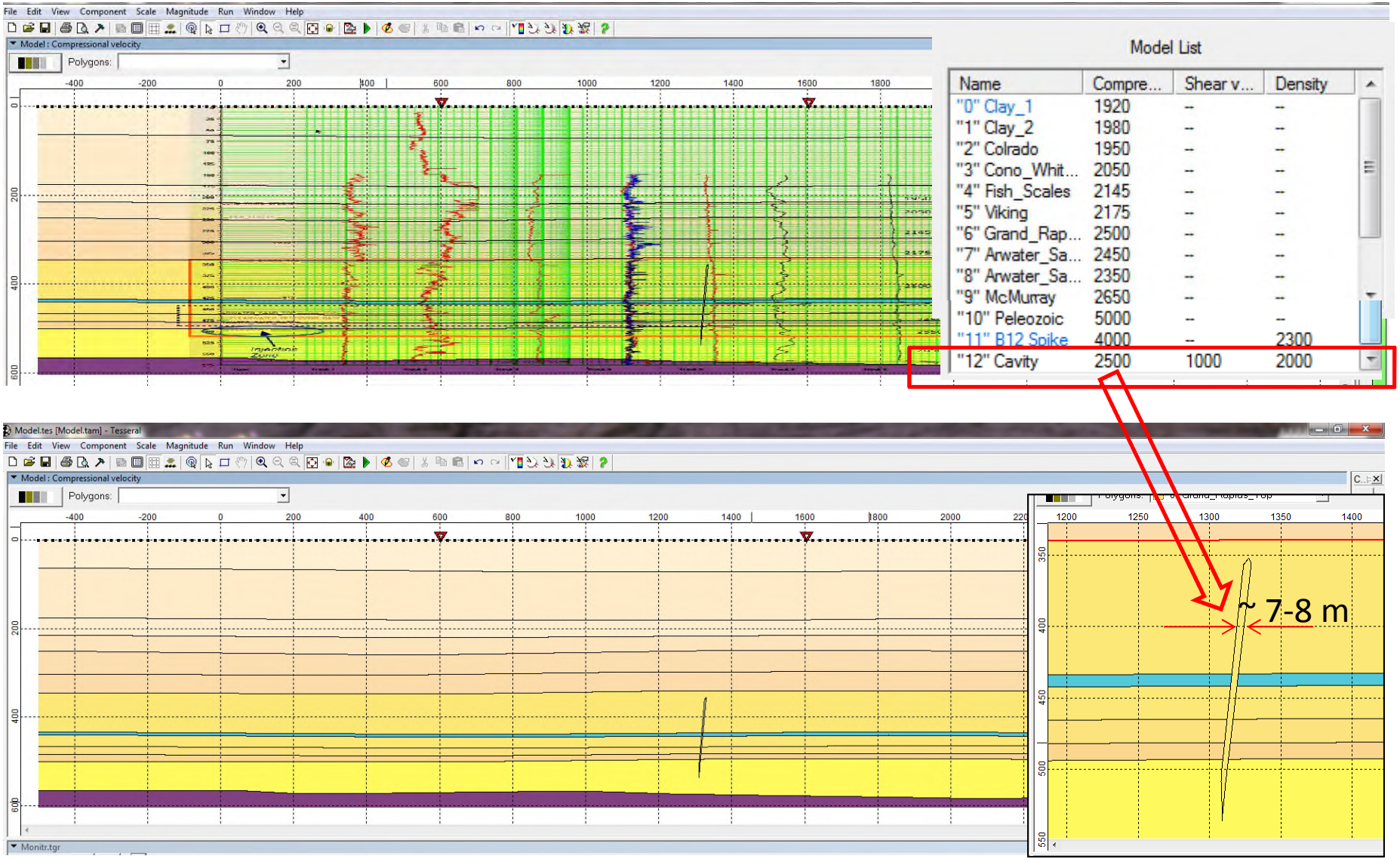
From very initial 2D modeling for two models along and across horizontal well it can be noticed:

- ✓ Source/receiver spacing 45/15m may be too sparse for good enough imaging of SAGD zone, especially in direction across horizontal well.
- ✓ Should be achieved record frequency 200- 300 Hz for good enough resolution of SAGD zone, correspondingly sampling rate should be 0.2-0.5 msec.
- ✓ Time lapse 4D survey theoretically can provide information about SAGD zone, especially across well direction.
- ✓ Along well direction there is quite considerable interference (for <=100Hz) of reflection from bottom of SAGD zone and top of carbonates, which may prevent recognition of bottom of SAGD zone, even using 4D time lapse data.

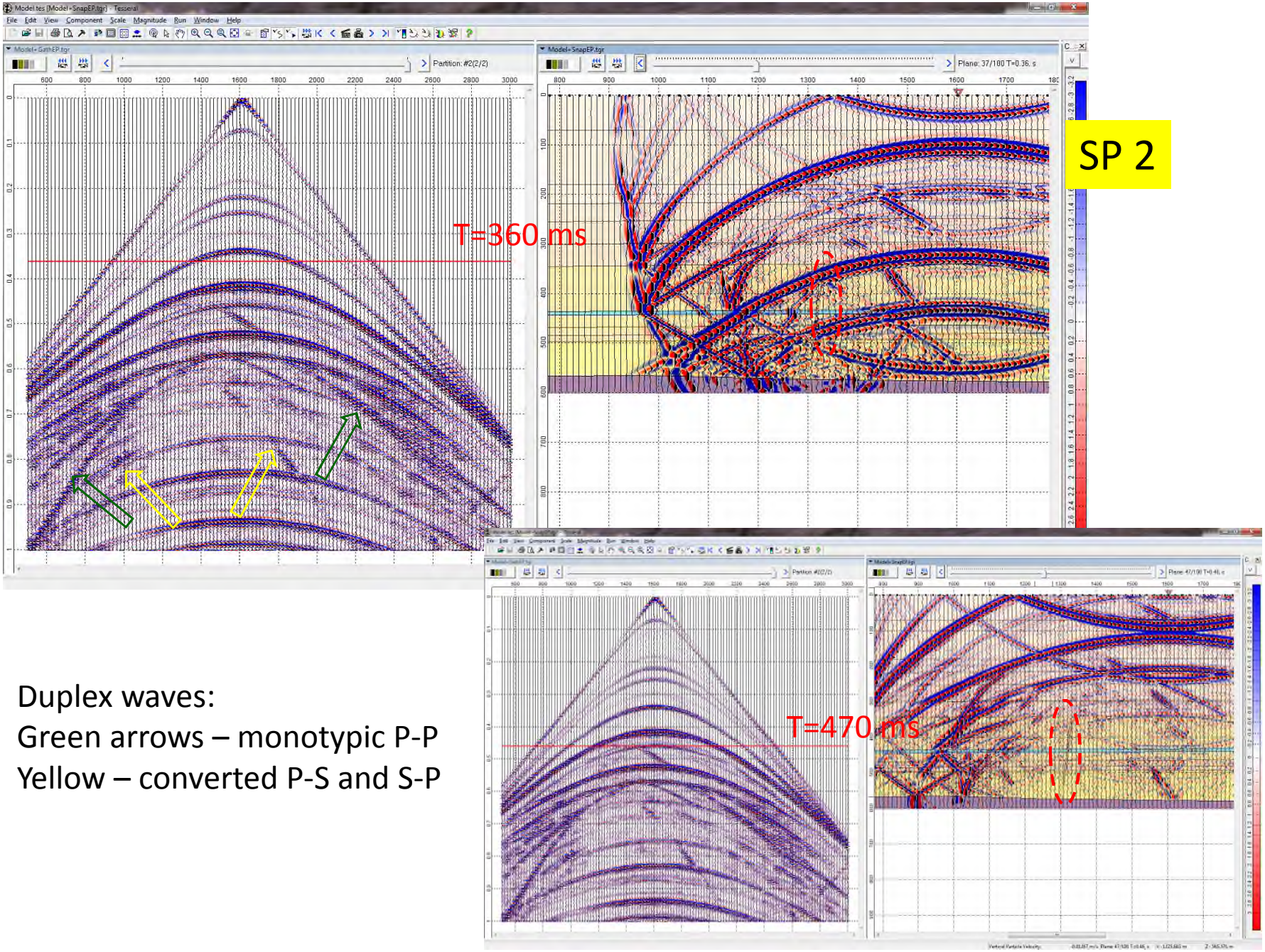
20 m receiver interval

Source peak Frequency 140Hz, wavelet Rikker

Case 2: "SAGD-Induced cavity in oil sands"



Initial Model: a) building using with pad image; b) resulting (pad image invisible)



Duplex waves:
Green arrows – monotypic P-P
Yellow – converted P-S and S-P

Case 2: Summary

- ✓ Used frequency band 140-160 Hz allows to clearly identify events from modeled “cavity” on synthetic shotgathers.
- ✓ For survey with bin size 20m, special processing procedures may be required to image such kind of sub-vertical features.
- ✓ Time lapse 4D survey with bin size 10-20m theoretically can provide information about SAGD-induced cavernous zones (with relatively mild difference in seismic impedance with surrounding rocks) from about 3 and more meters width at depth 400-500 m.