2 & 3-D Seismic Data Over Horizontally Transverse Isotropic (HTI) Fracture Model

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Key Points:

- fracture seismic response vs. S-R offset, fracture azimuth
- various indicators of fracture density and azimuth
- physical modeling system useful for attenuation study

OUTLINE

I. Motivation

II. Methods – physical modeling system, fracture model

III. Data – CMP, Common-offset (solid vs. fracture), 3D

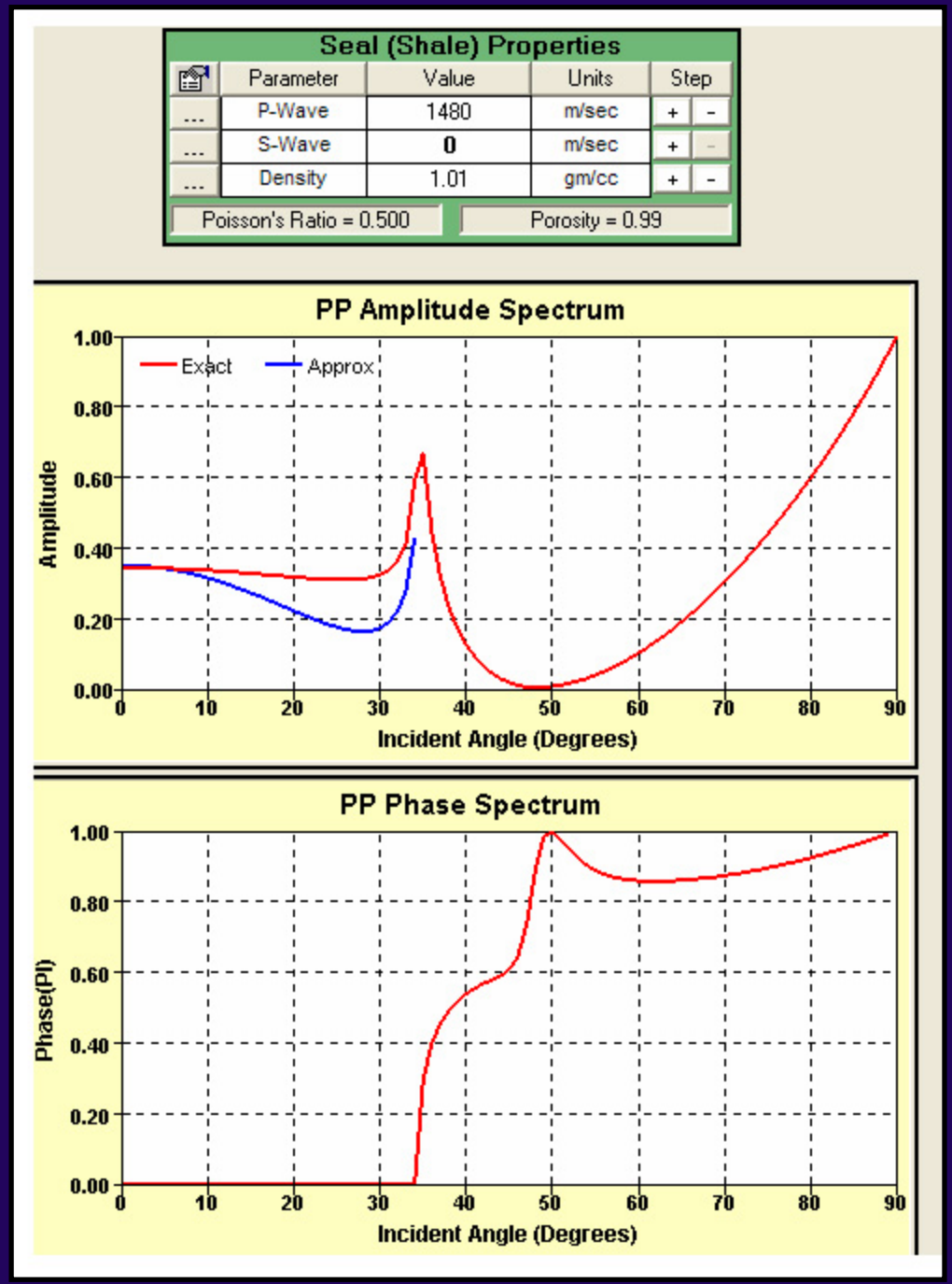
IV. Findings

V. Conclusions – 8 fracture indicators

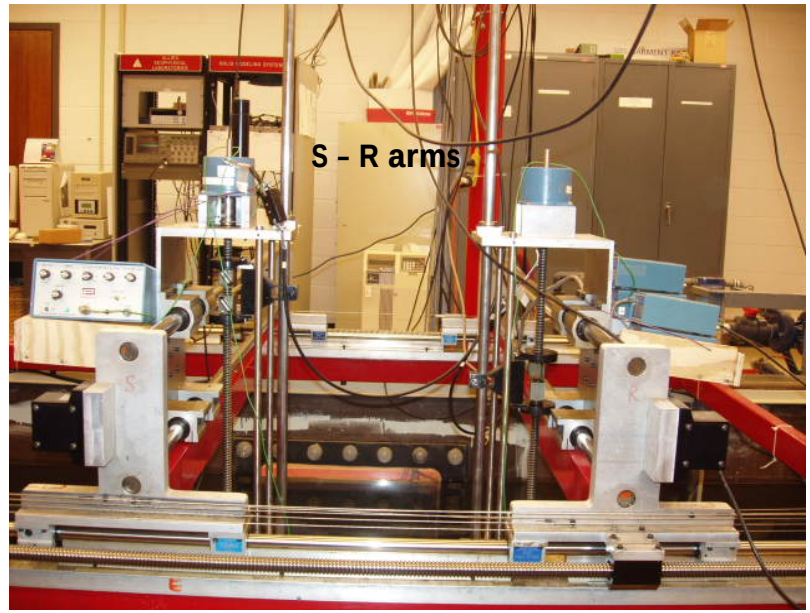
VI. Future work

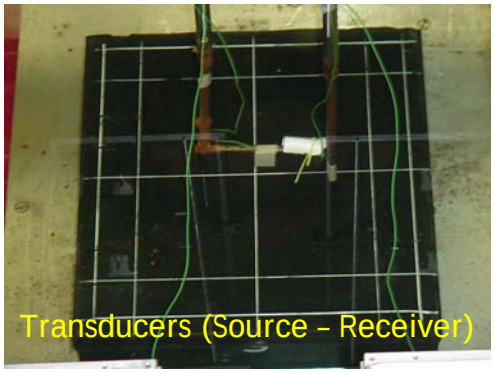
I. Motivation

- Characterize P-P reflections from HTI – fractured bondaries
- Test viability of physical modeling for fracture-porosity studies




Desktop PC


S – R arms


Transducers (Source – Receiver)


Signal Amp and Pulse Generator


nuDrive
nuDrive
Motion Controller

II. Methods – Physical Modeling System

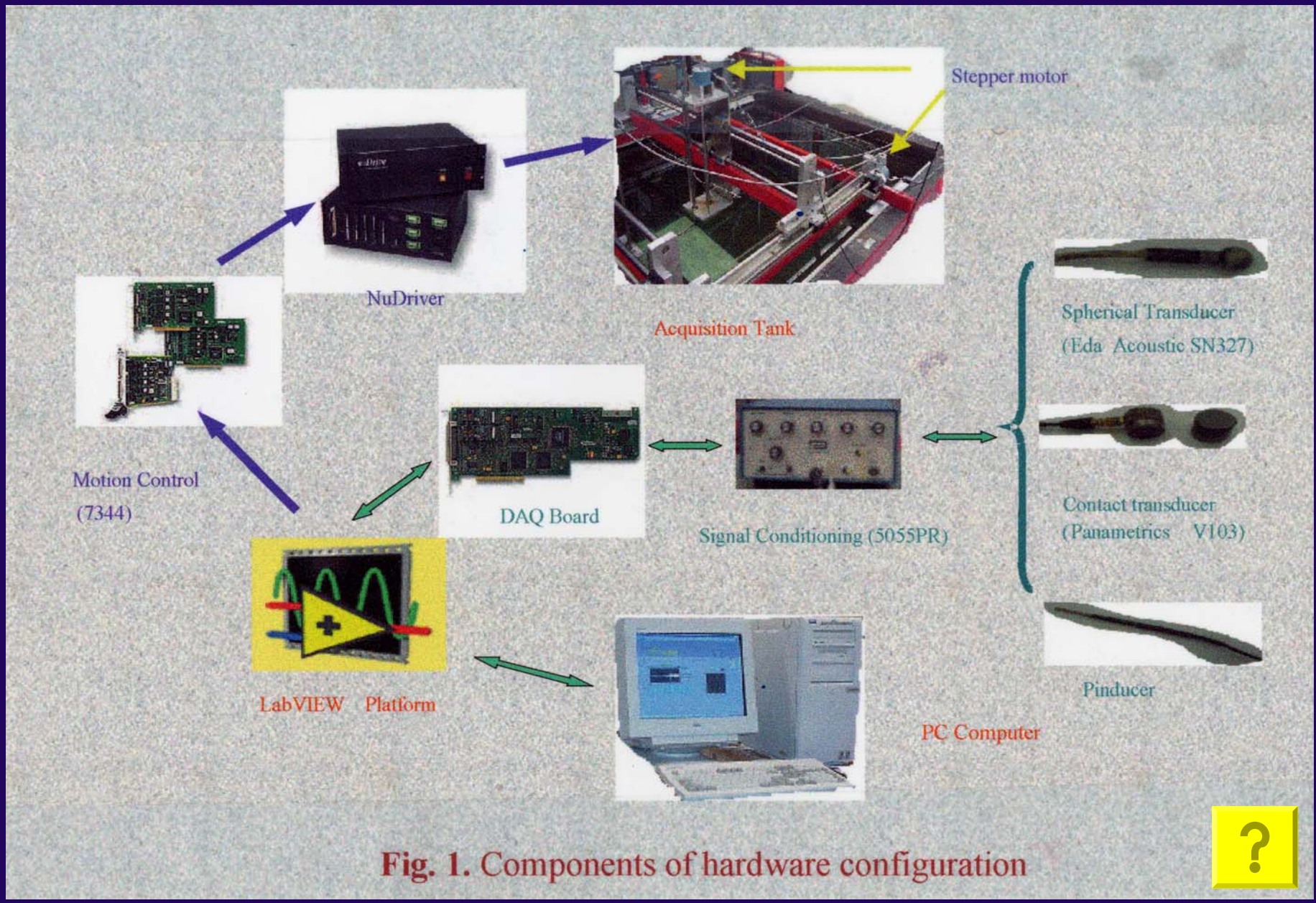
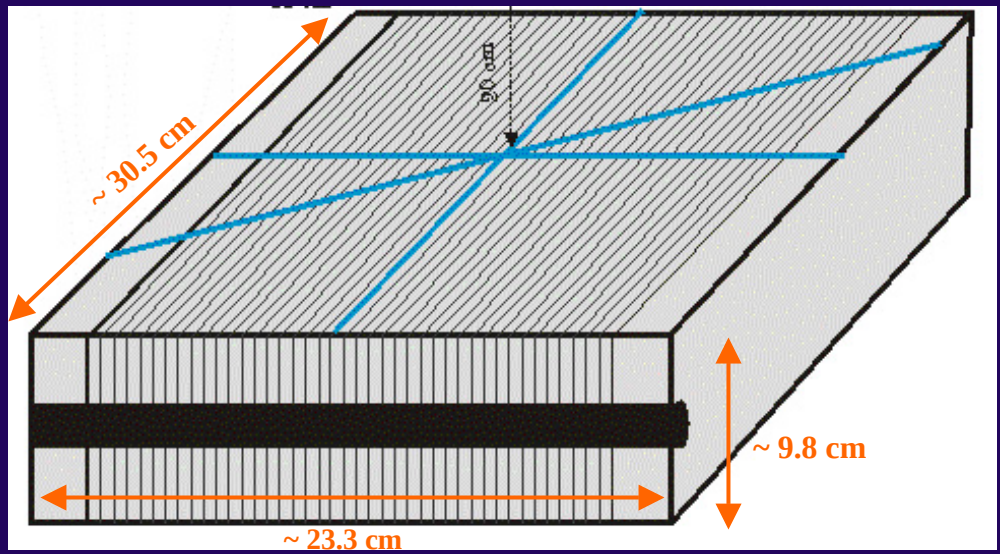
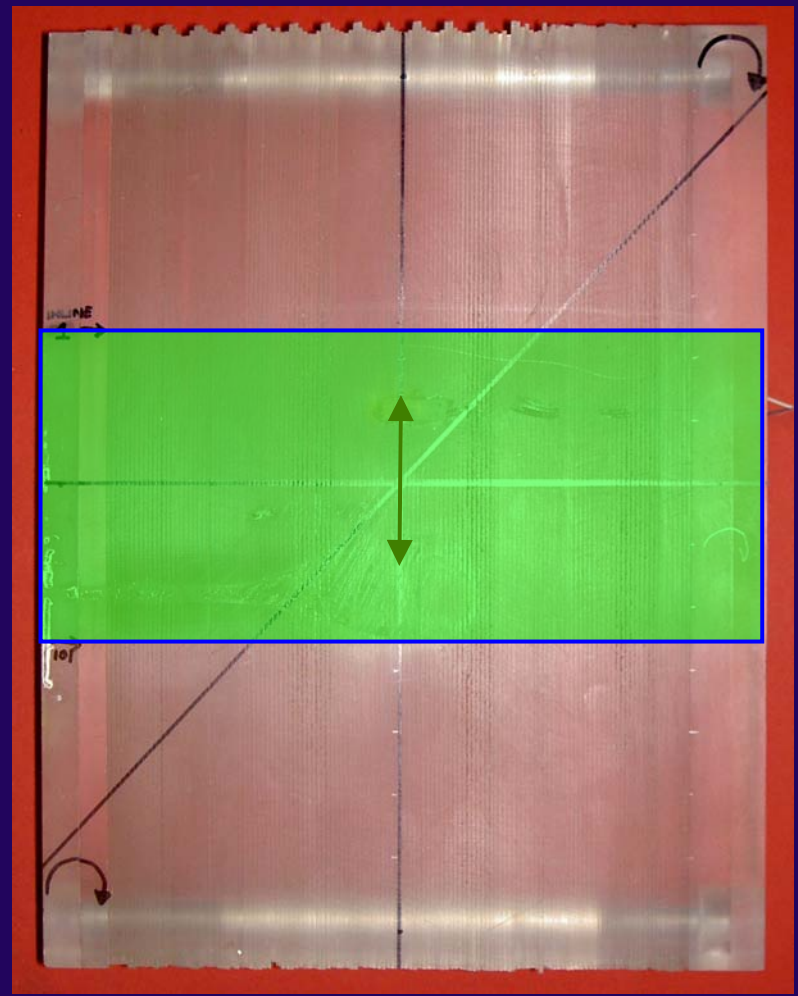


Fig. 1. Components of hardware configuration

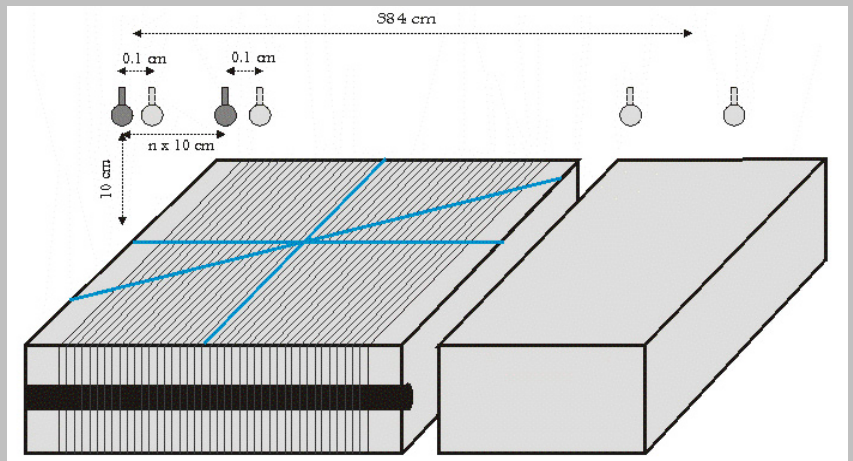
II. Methods – HTI Fracture Model



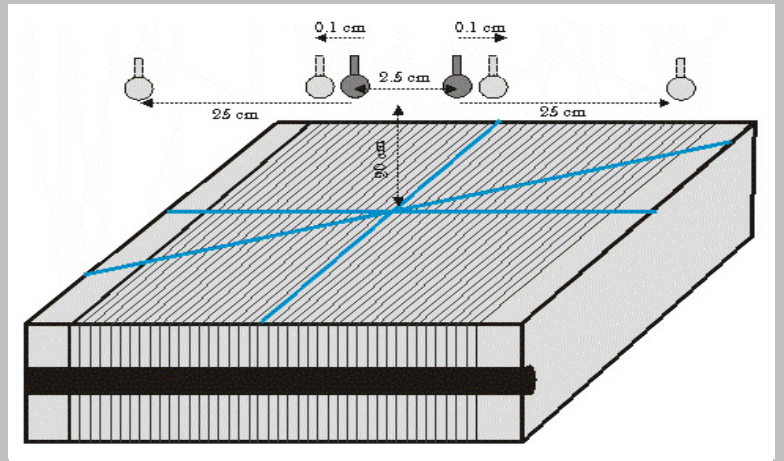


- Plexiglas thin sheets ~ 1.6 mm thick each
- >180 thin sheets stacked side-by-side (*i.e.* HTI fracture model)
- axis of fracture model rotated about pivot for various azimuth experiments

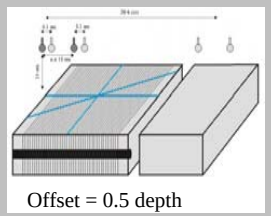
II. Methods – 3 Sets of Seismic Experiments



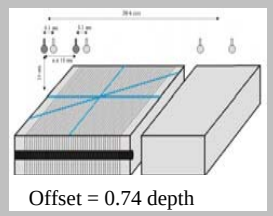
Common-Offset 2D line Fracture vs. Solid



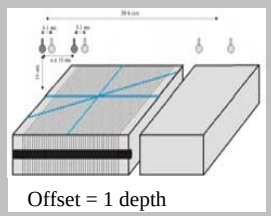
Common-Midpoint 2D line Fracture vs. Solid



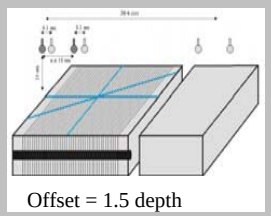
Offset = 0.5 depth



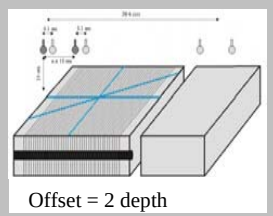
Offset = 0.74 depth



Offset = 1 depth



Offset = 1.5 depth



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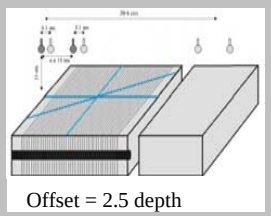

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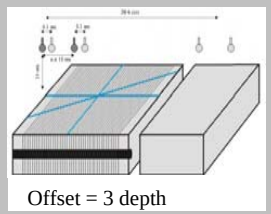
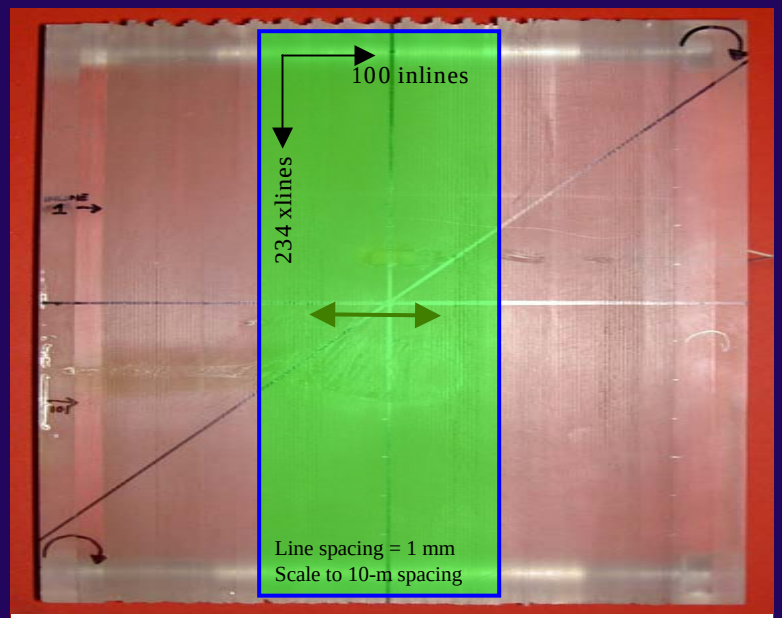
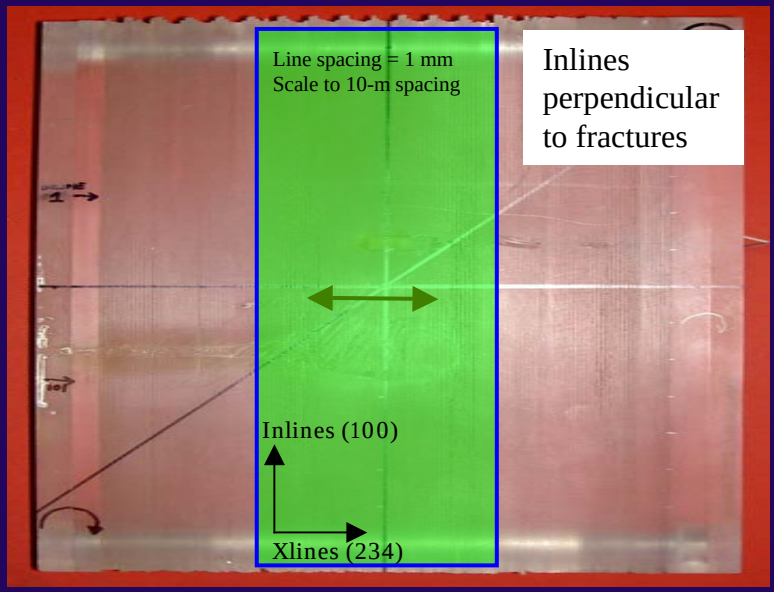
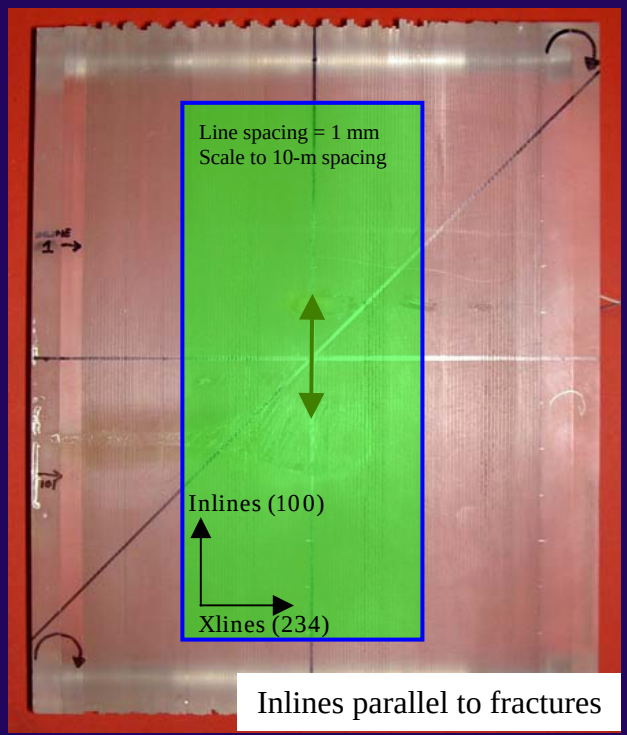


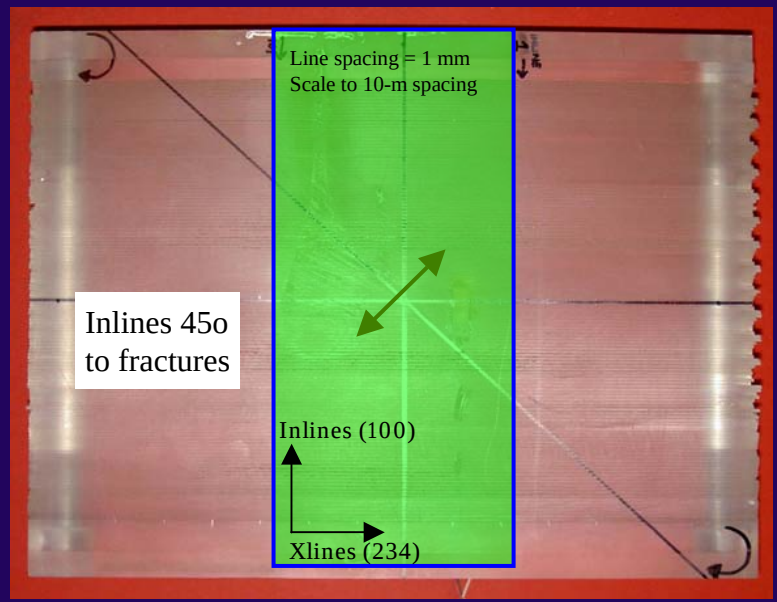
Offset = 3 depth



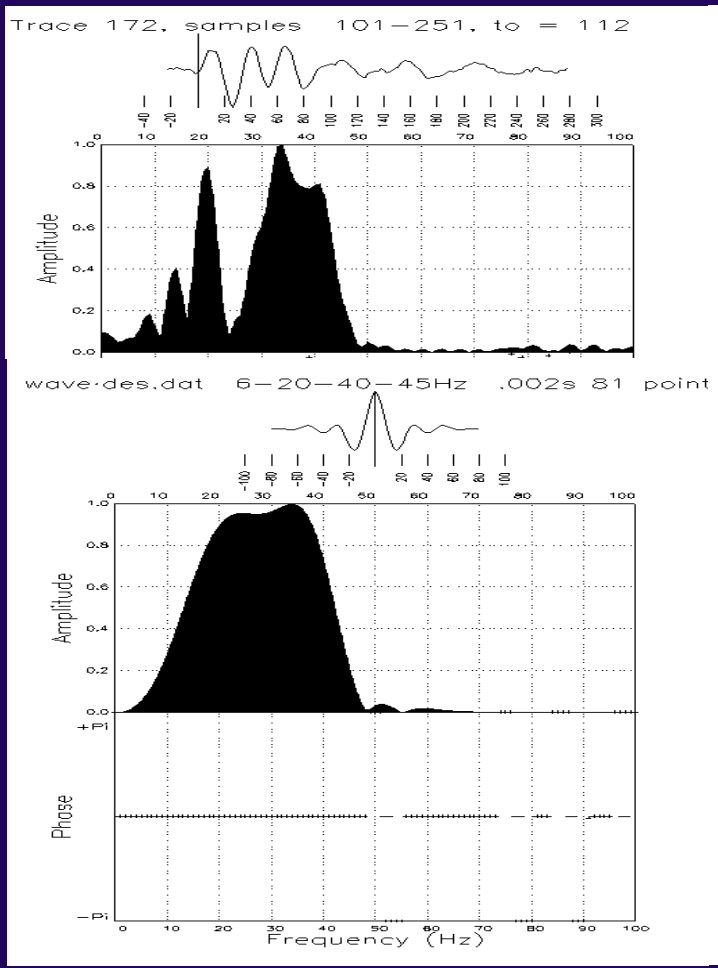
3D Survey over HTI Fracture at Different Azimuths

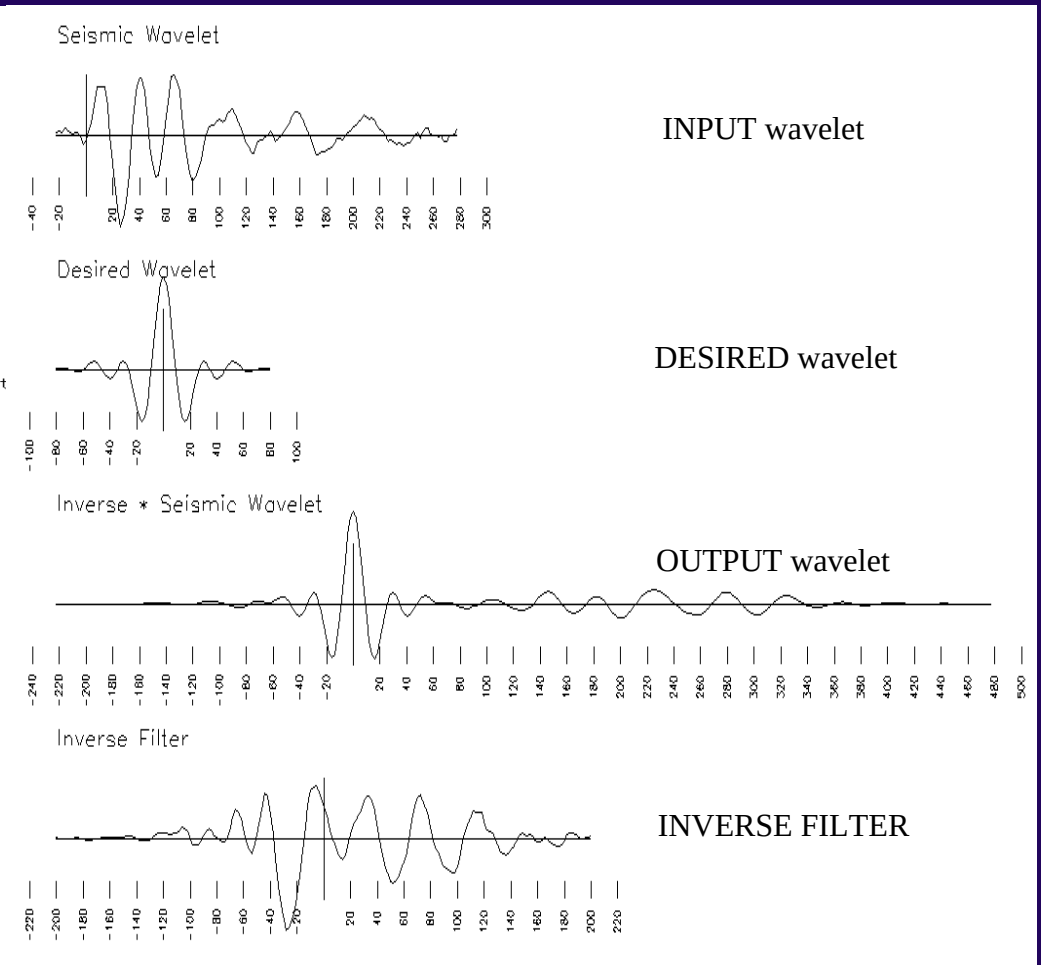

Line spacing = 1 mm
Scale to 10-m spacing
Inlines perpendicular to fractures
Inlines (100)
Xlines (234)


Line spacing = 1 mm
Scale to 10-m spacing
Inlines (100)
Xlines (234)
Inlines parallel to fractures


Line spacing = 1 mm
Scale to 10-m spacing
Inlines 45o to fractures
Inlines (100)
Xlines (234)

II. Methods – Wavelet Shaping





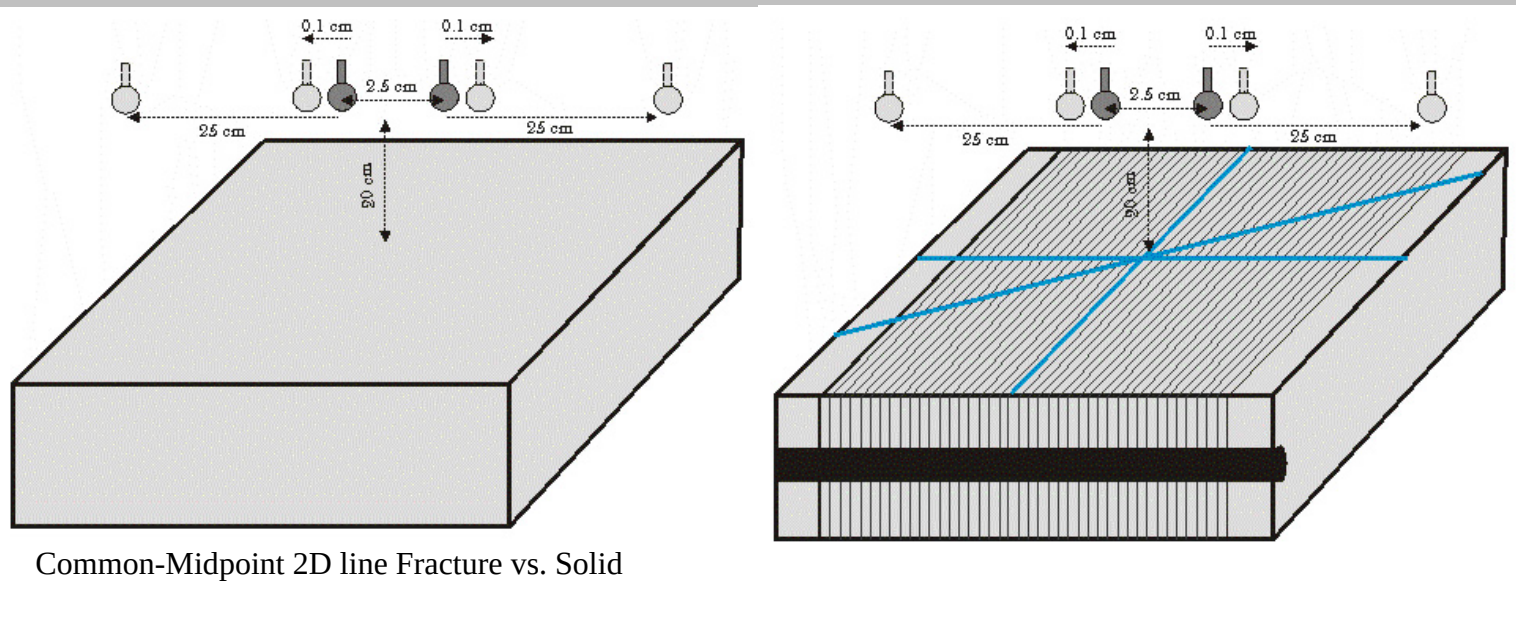
INPUT wavelet

DESIRED wavelet

OUTPUT wavelet

INVERSE FILTER

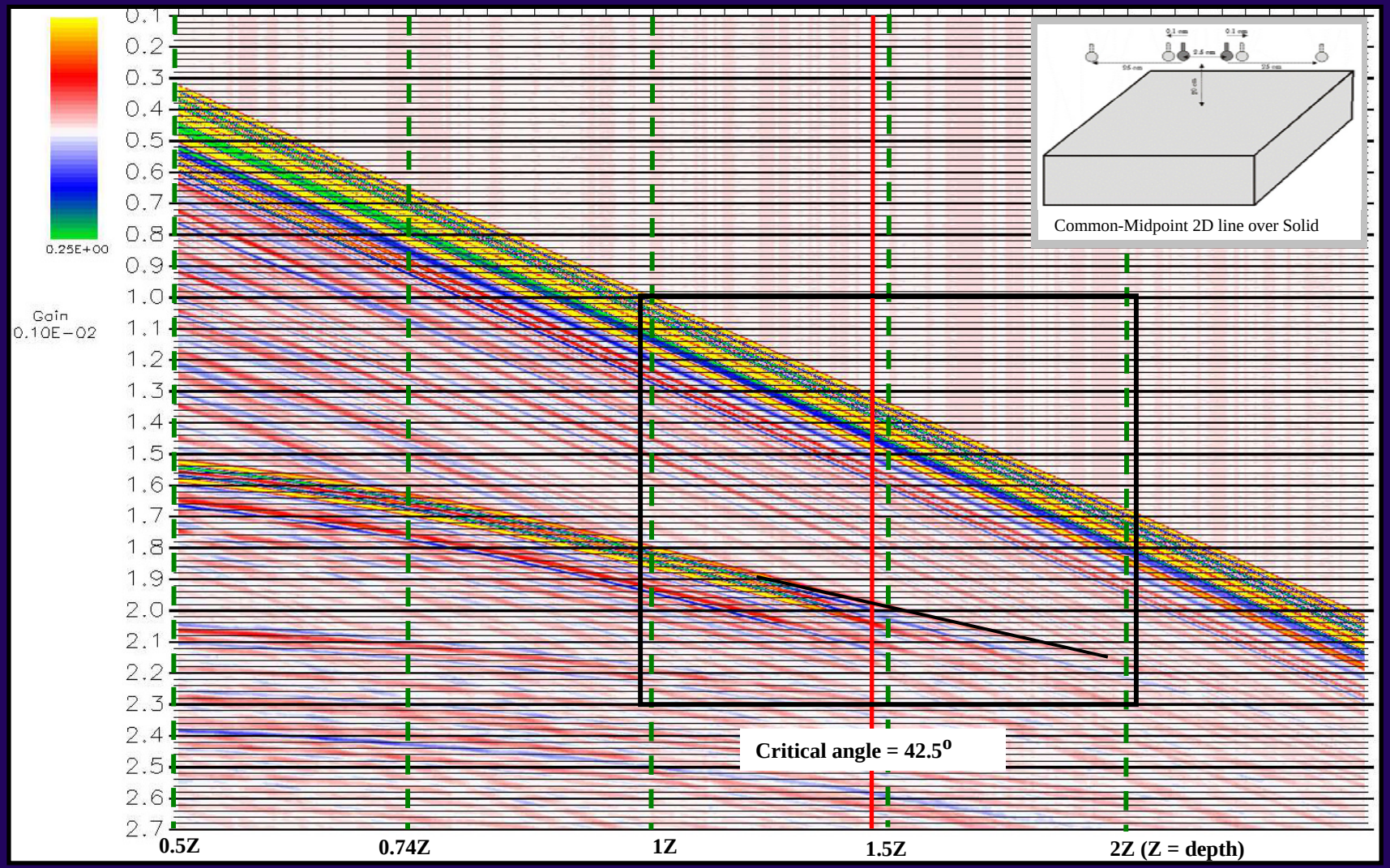
III. Data – 2D Lines (CMP setup)



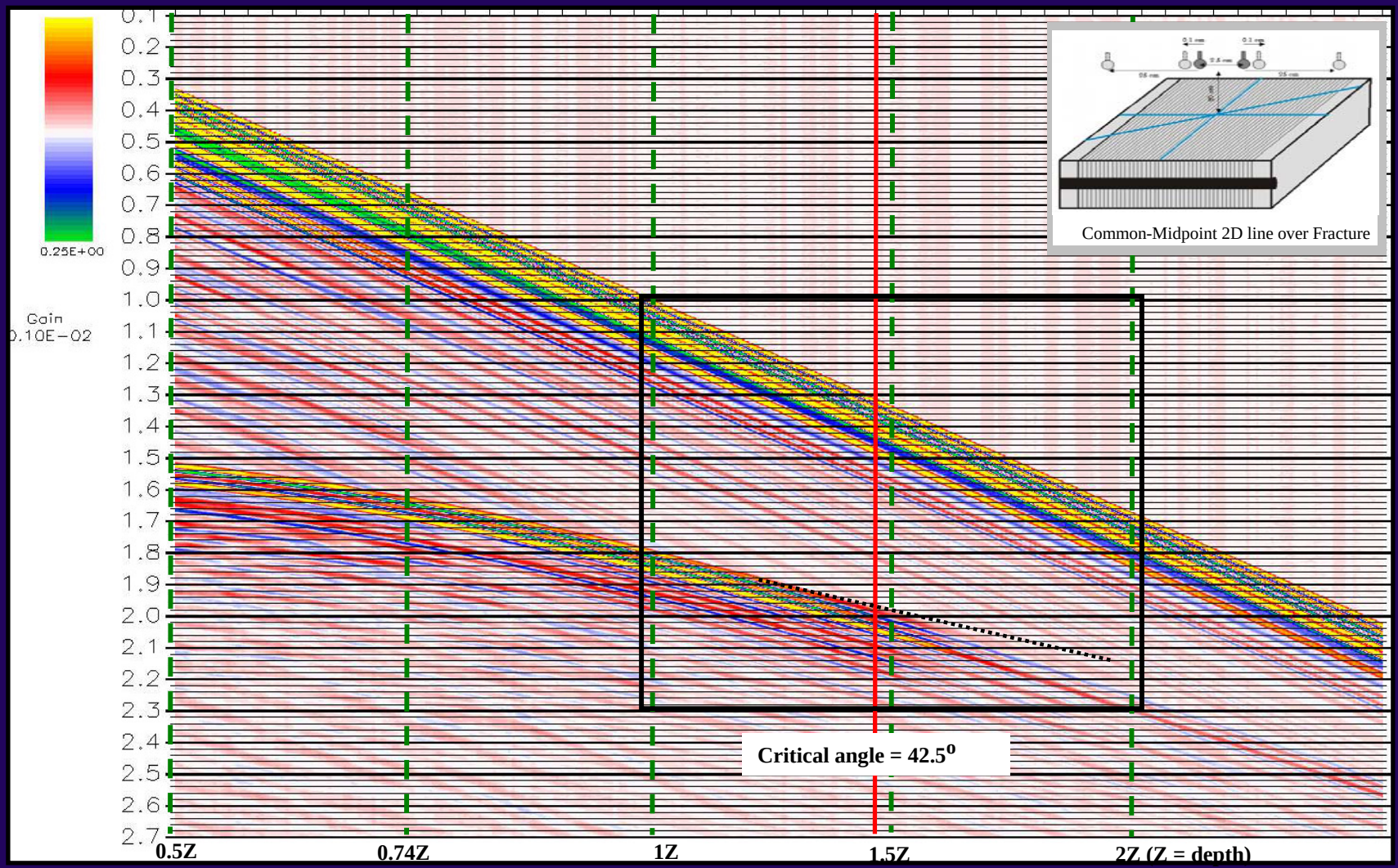
Common-Midpoint 2D line Fracture vs. Solid

Q1? Energy partitioning at post-critical incident angles?

III. Data – 2D Lines (CMP)

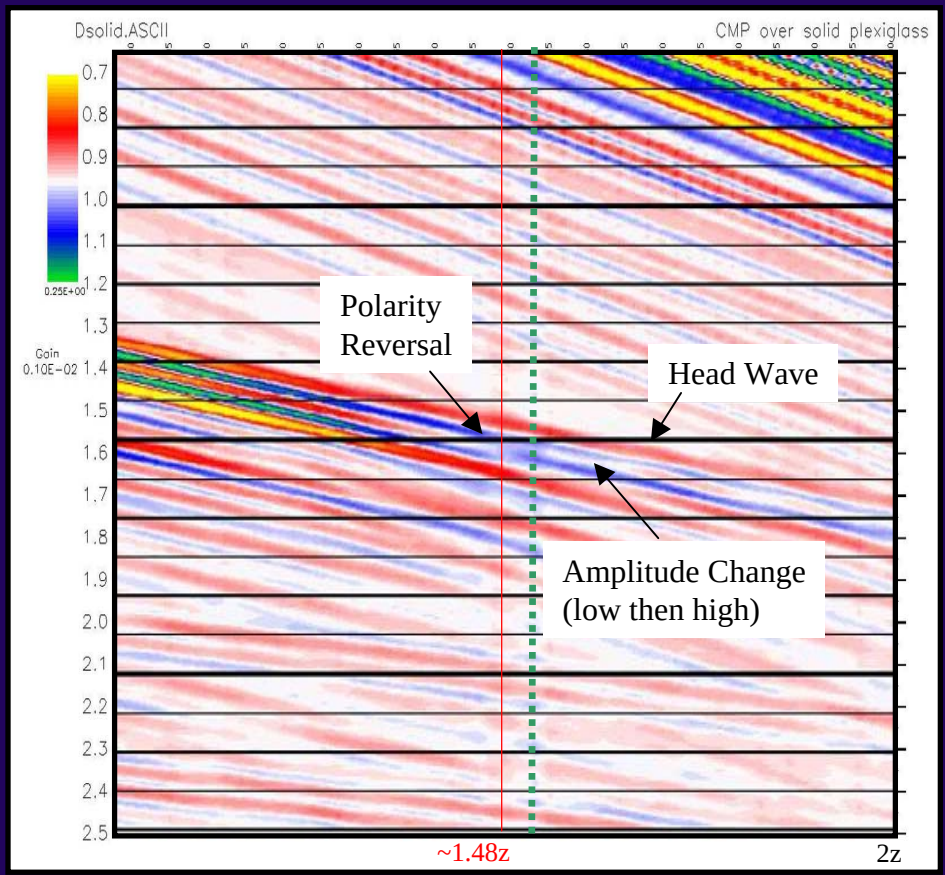


III. Data – 2D Lines (CMP)

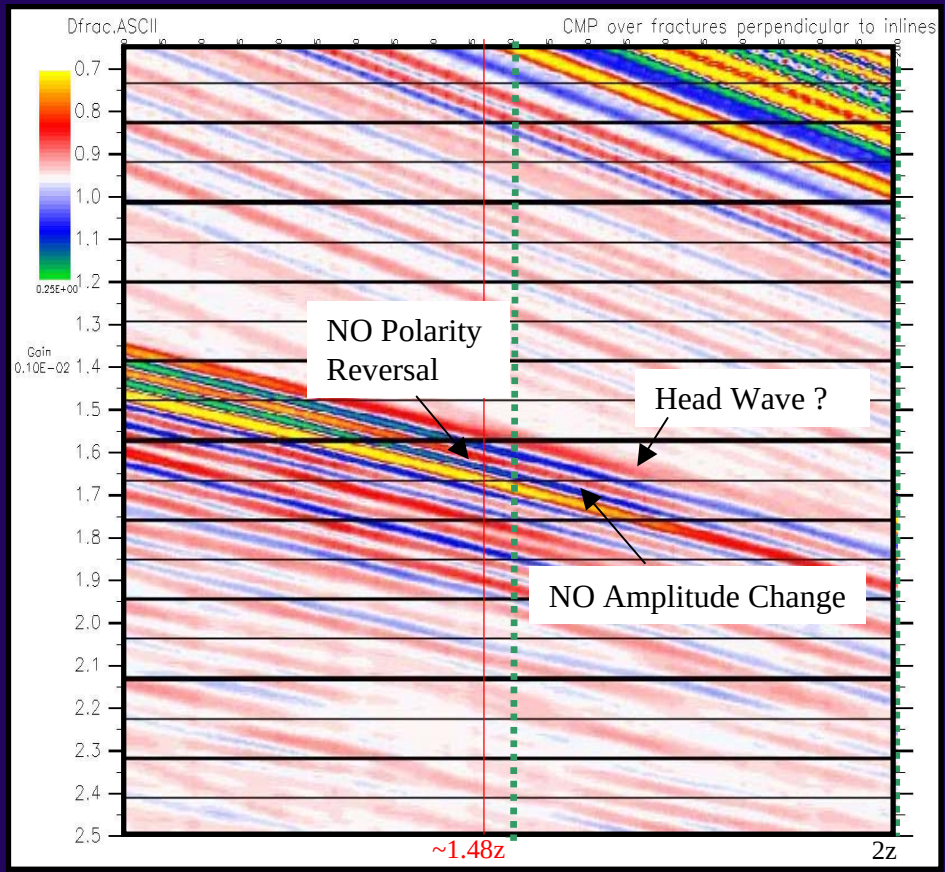


IV. Findings (CMP over Fracture vs. Solid)

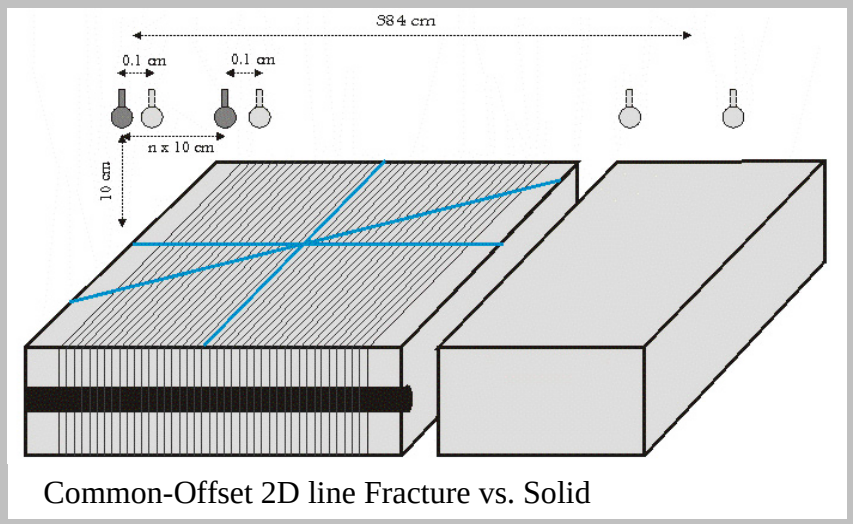
CMP over SOLID



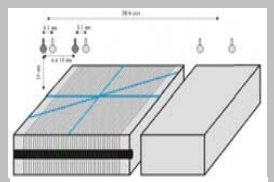
CMP over FRACTURE



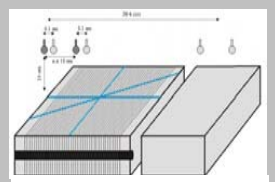
III. Data – 2D Lines (Common-Offset Gather)



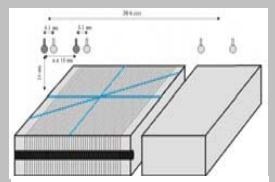
Common-Offset 2D line Fracture vs. Solid



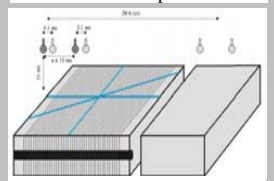
Offset = 0.5 depth



Offset = 0.74 depth



Offset = 1 depth



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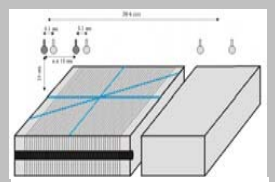
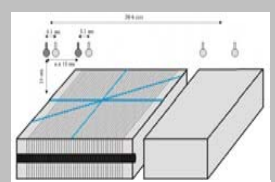
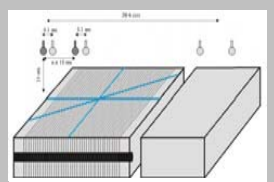


Offset = 2 depth



Offset = 2.5 depth



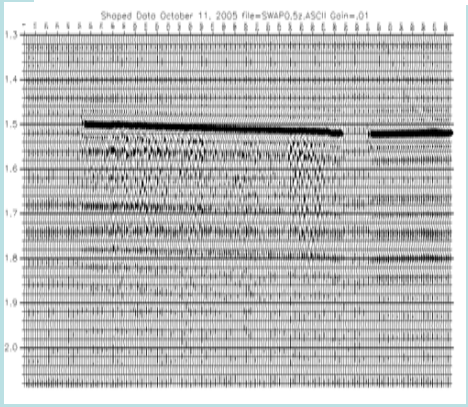
Offset = 3 depth

Q2? Kinematic expressions of head waves in seismic section?

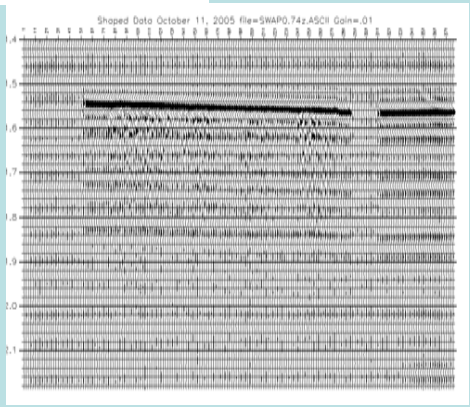
Q 2.1: pre- vs. post-critical angle

Q 2.2: (Fracture) at 90^{o}azimuth but varying offset

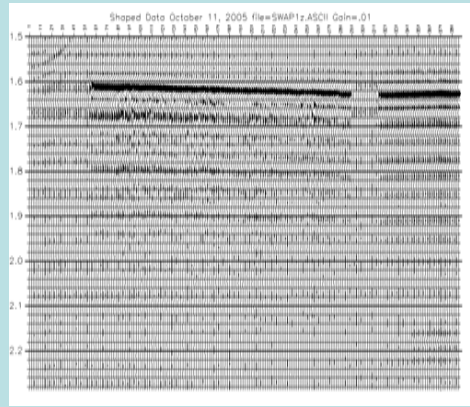
Sub-Critical to Critical Angle



Offset = 0.5 depth



Offset =0.74 x depth



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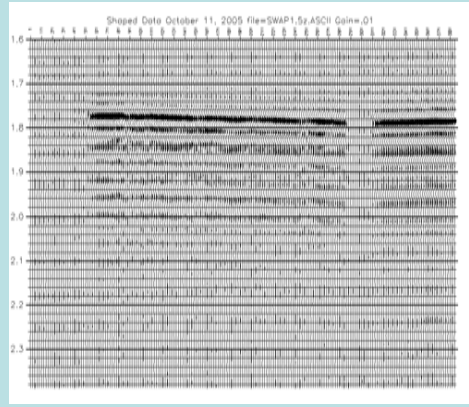
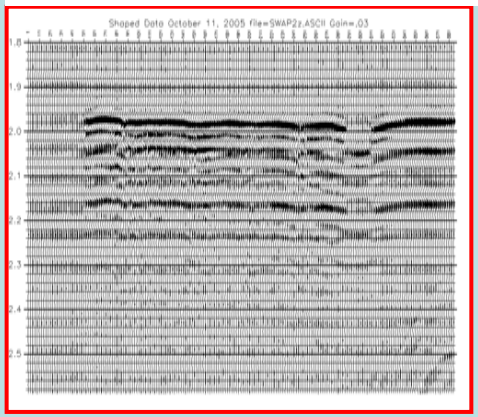
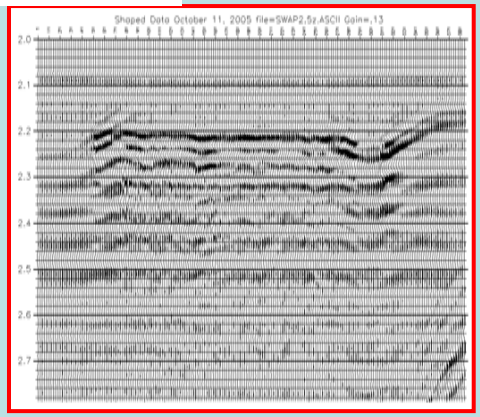


Offset = 1.5 x depth

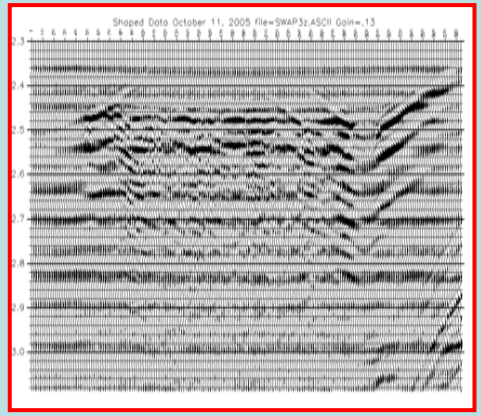
Post Critical Angle



Offset = 2 x depth



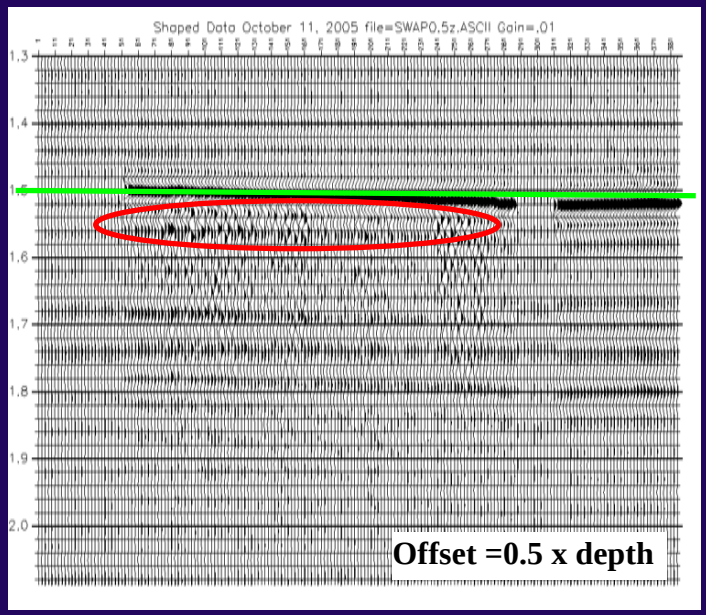
Offset =2.5 xx depth

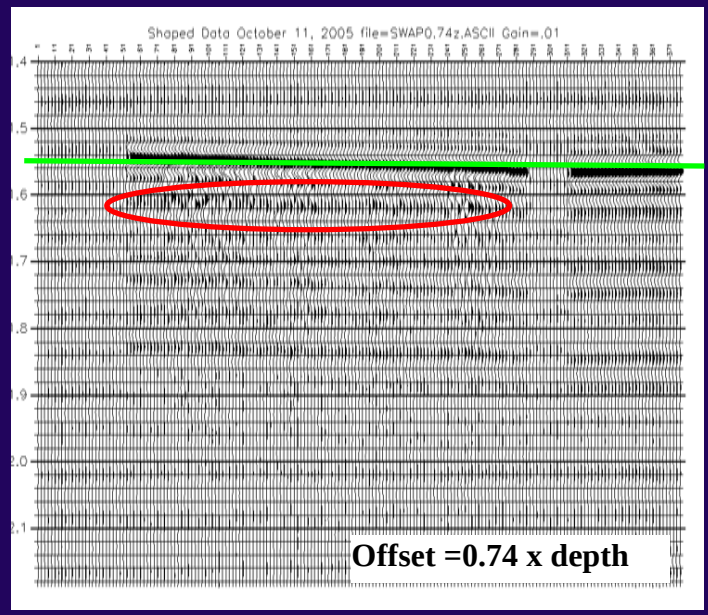


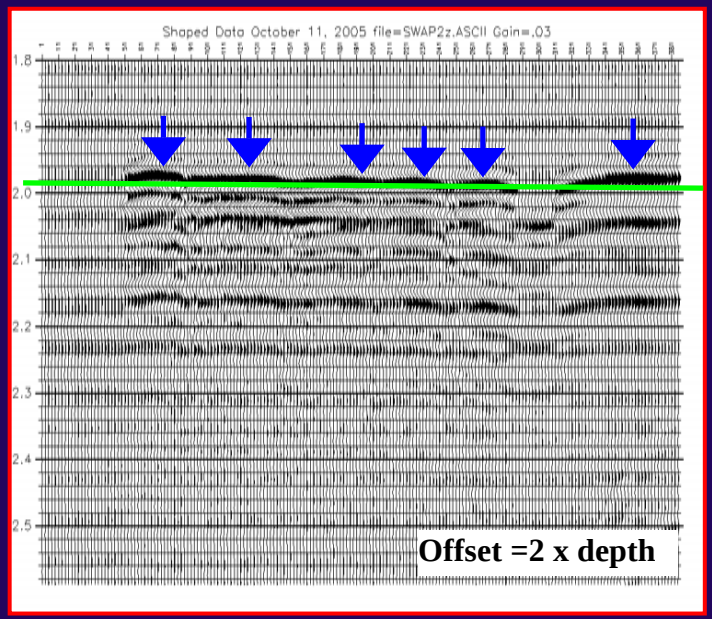
Offset = 3 x depth

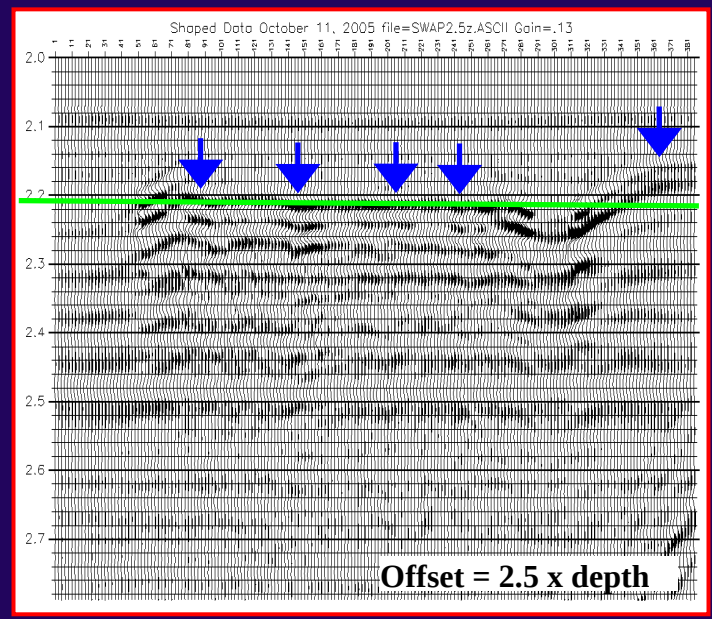
MOVIE

IV. Findings (2D Common-Offset Gathers)



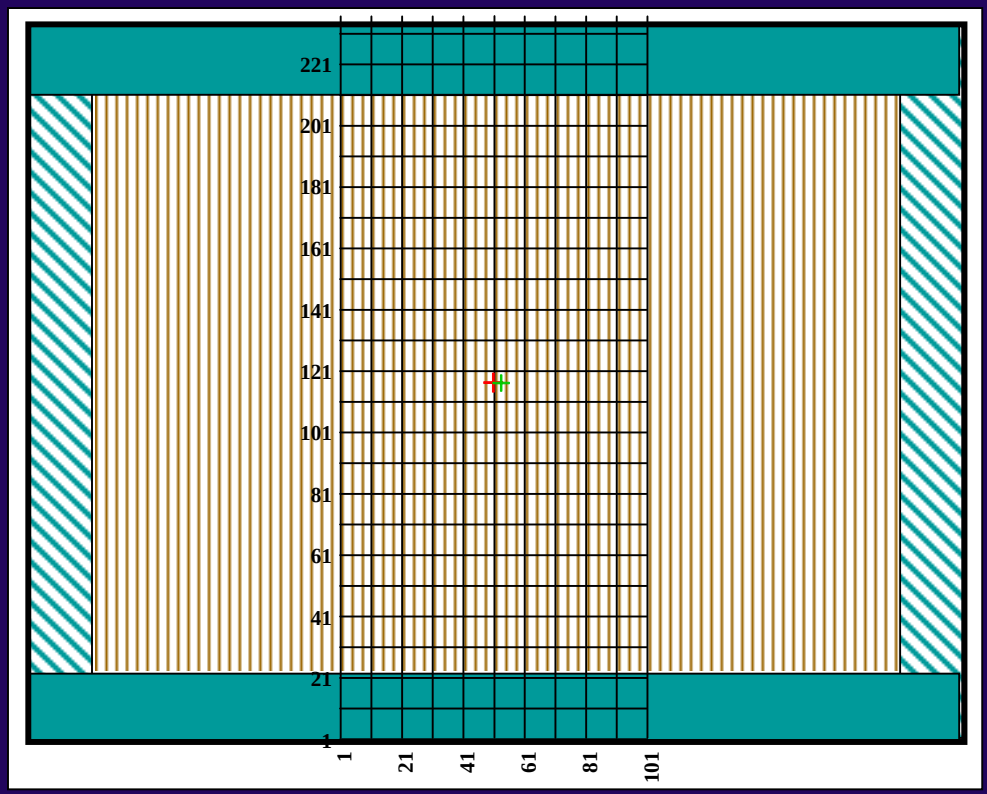


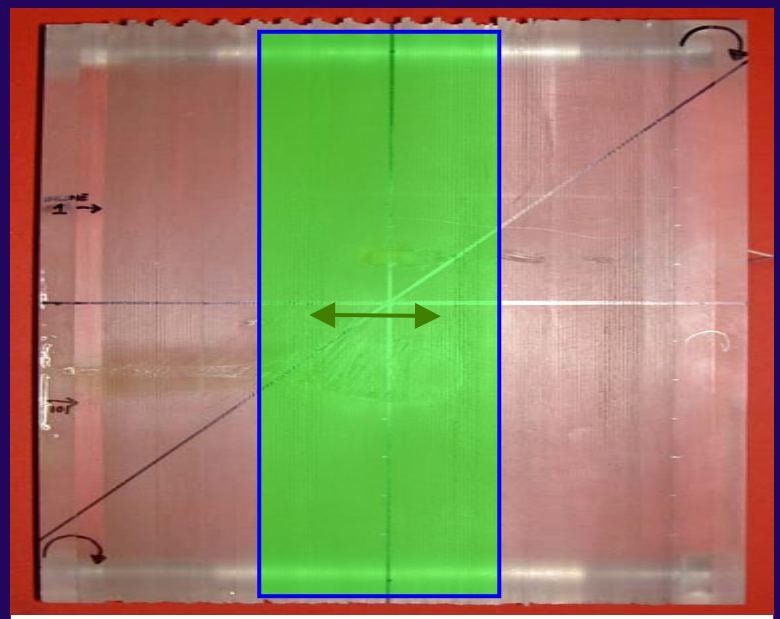




III. Data – 3D Volumes

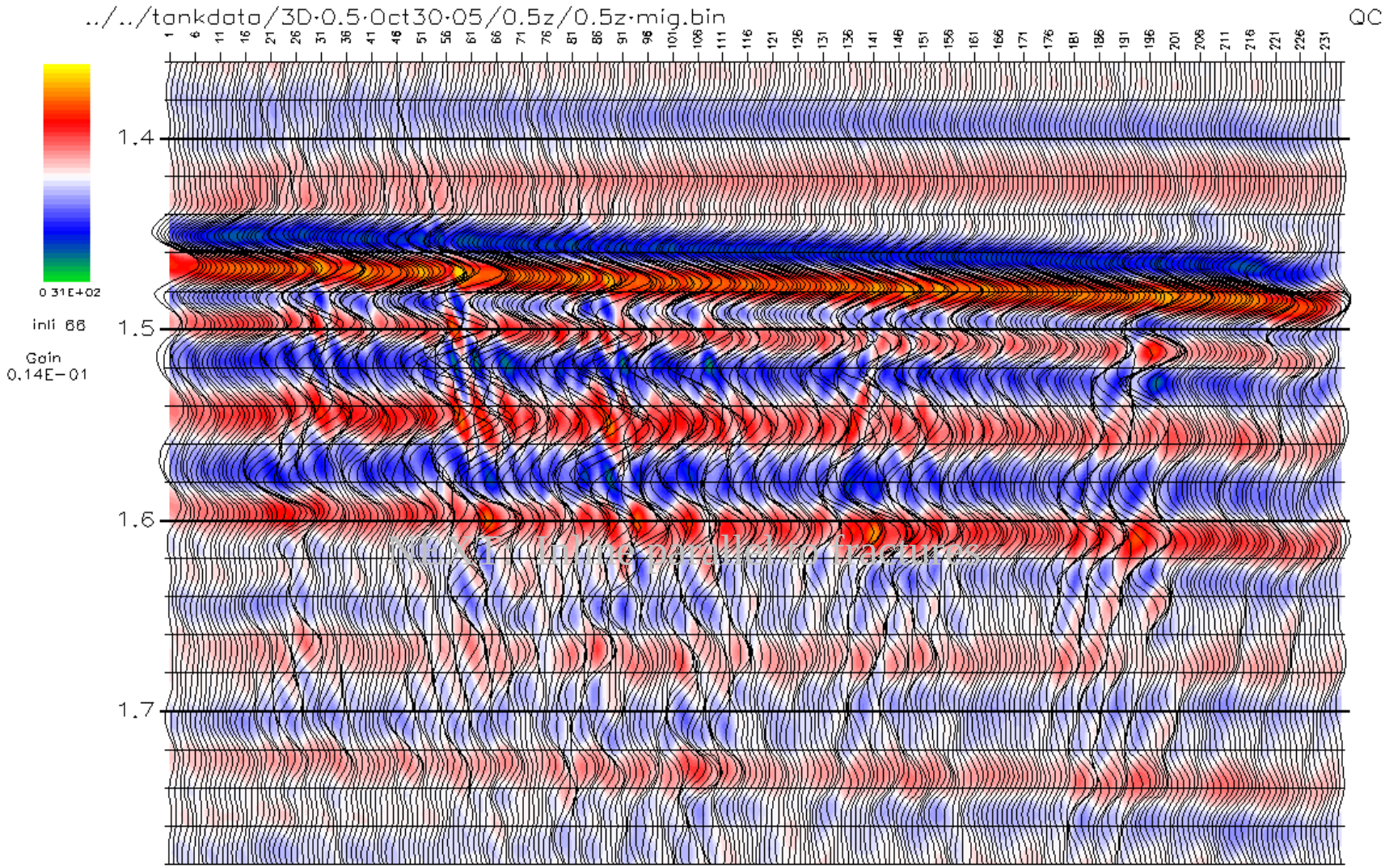
Q3? Differentiate out-of-plane scattering from fracture



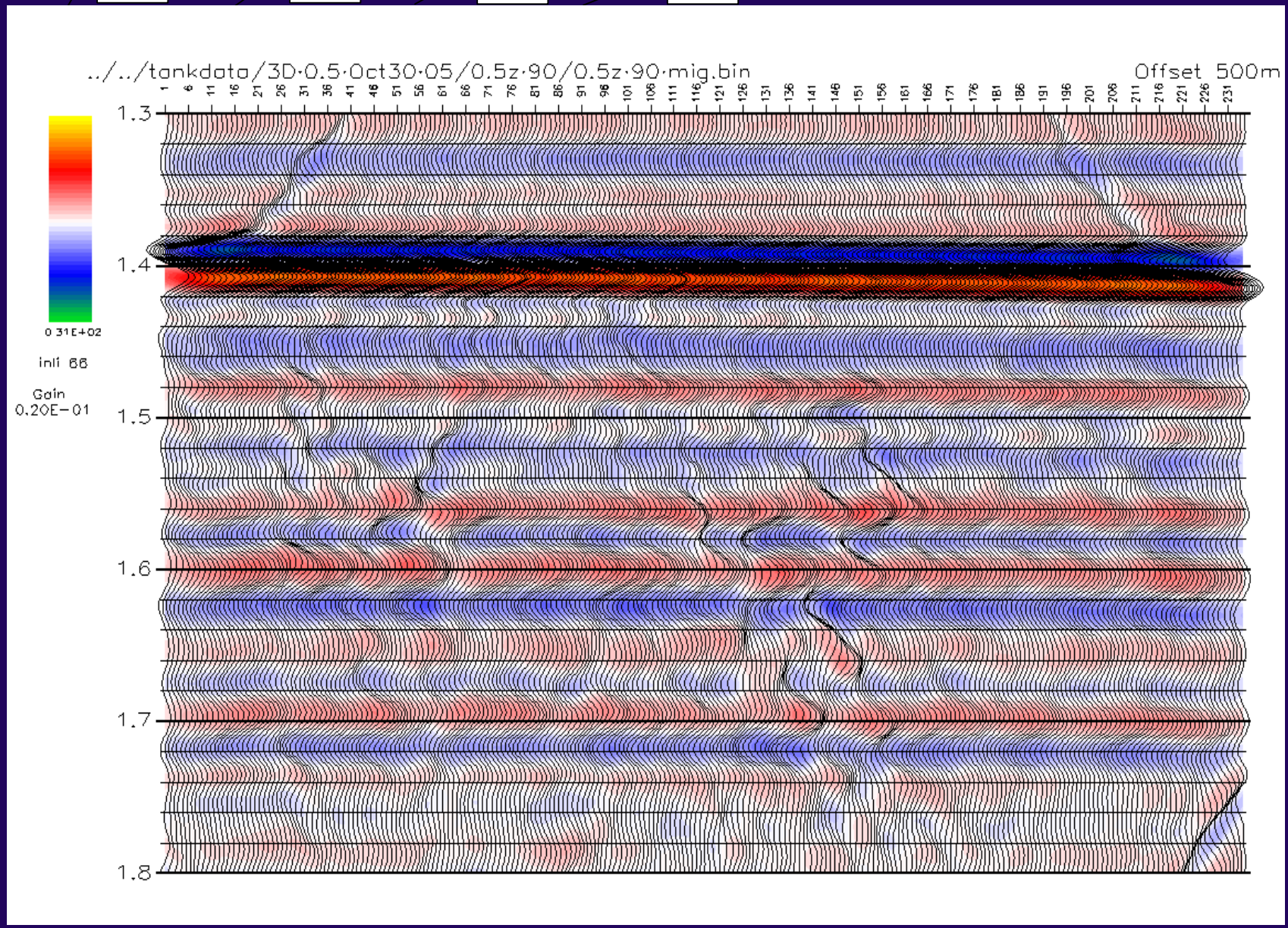


3D Survey over HTI Fracture at Different Azimuths

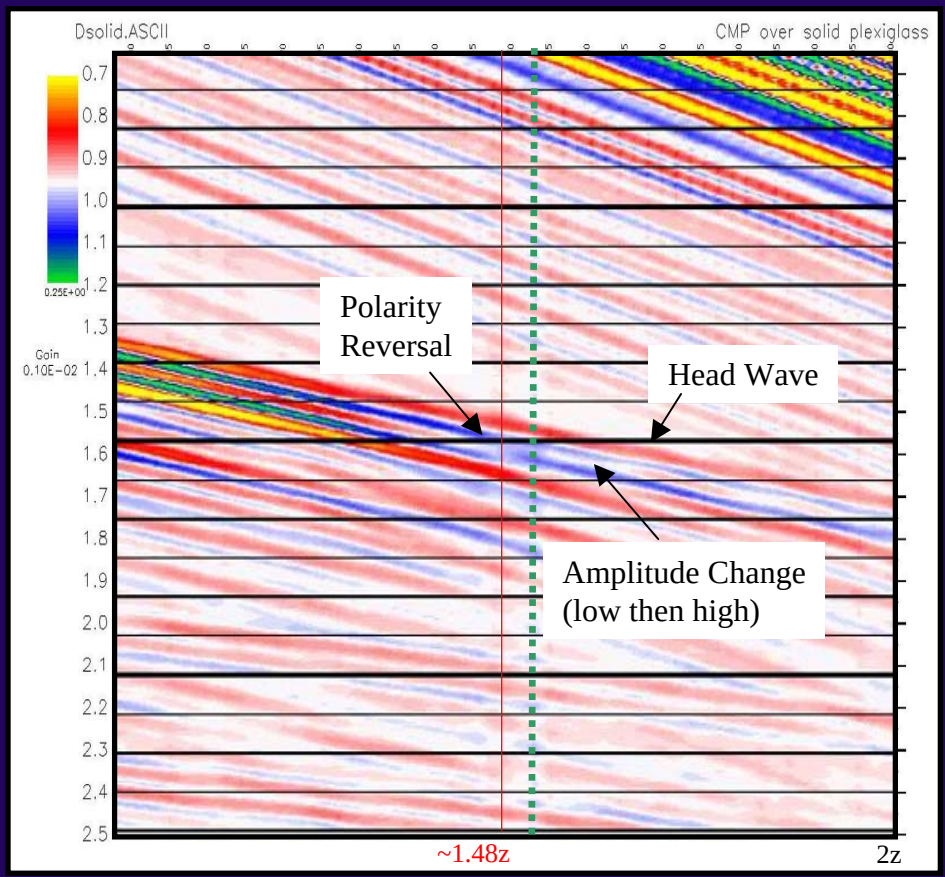
IL36 IL46 IL56 IL66



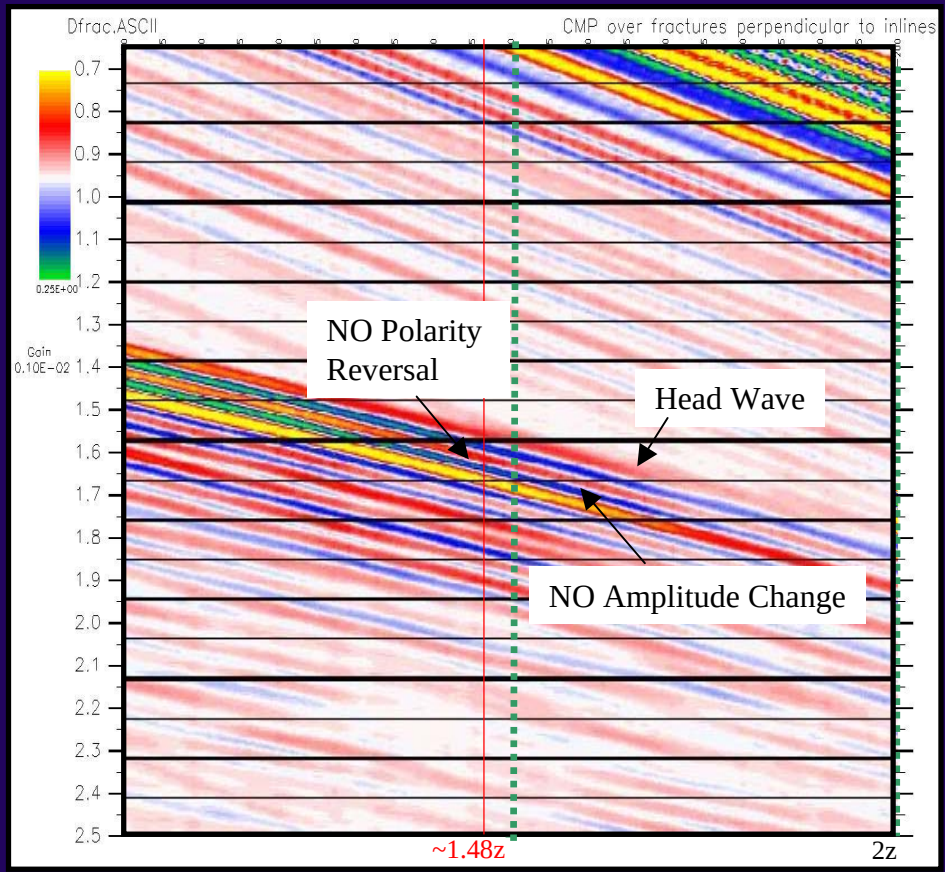
IL36 IL46 IL56 IL66



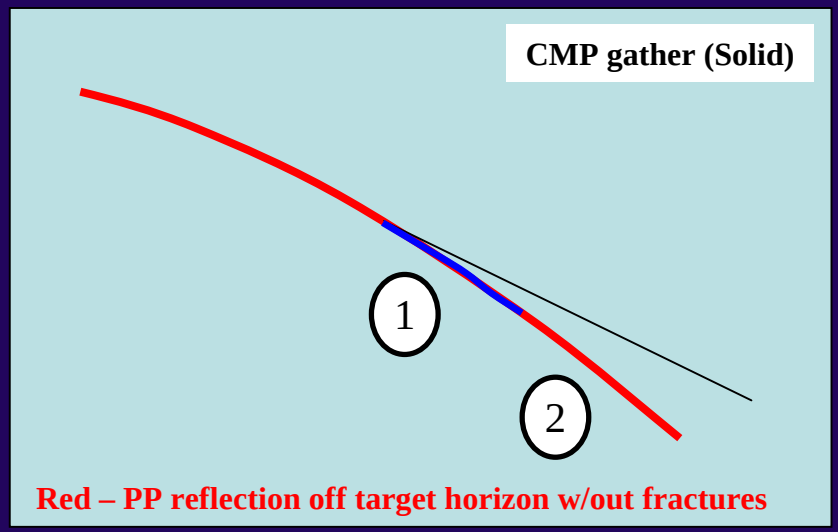
CMP over SOLID

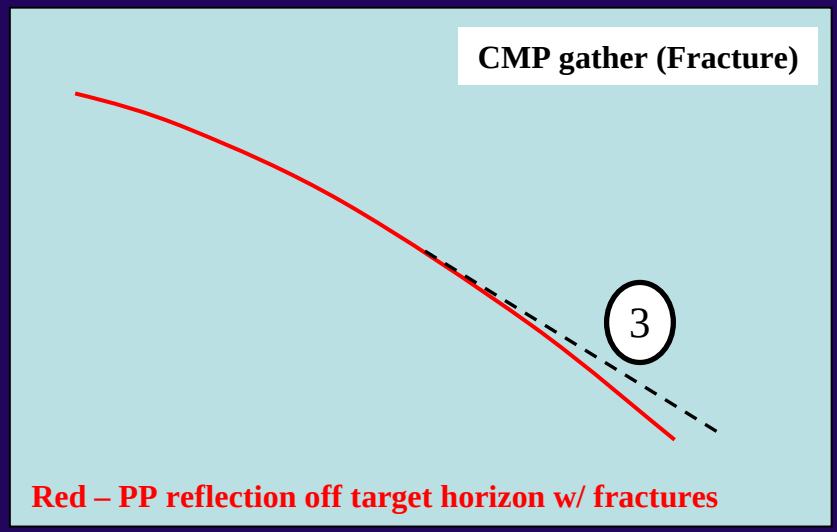


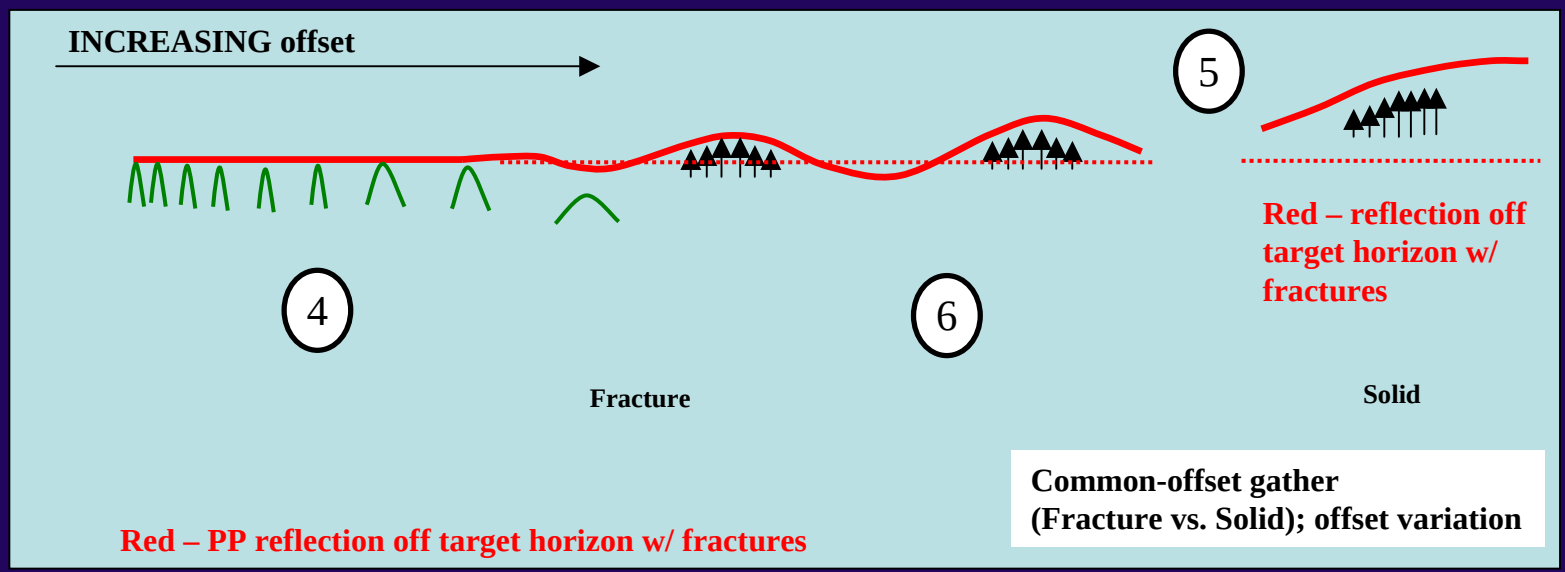
CMP over FRACTURE

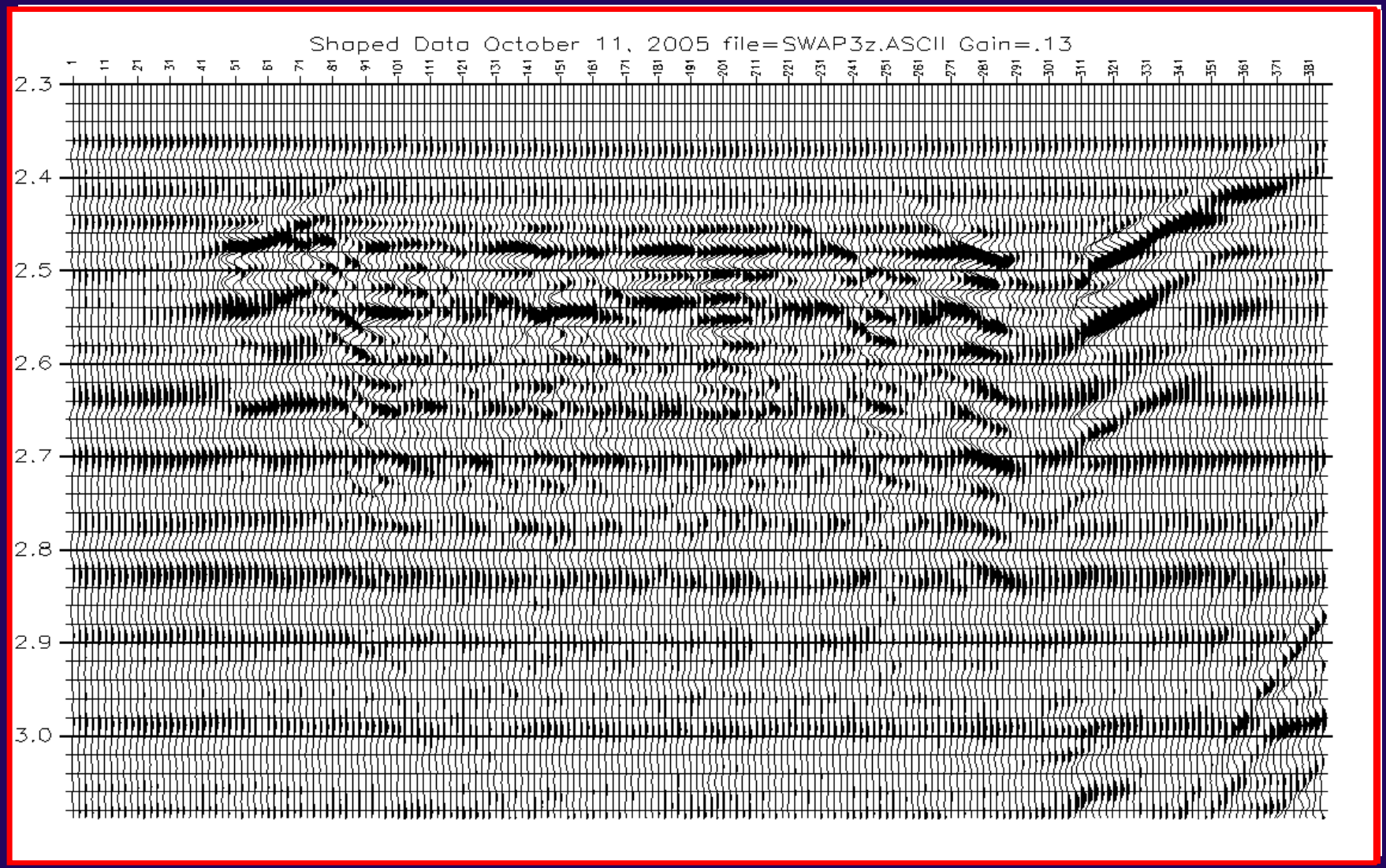


IV. SUMMARY of FINDINGS:





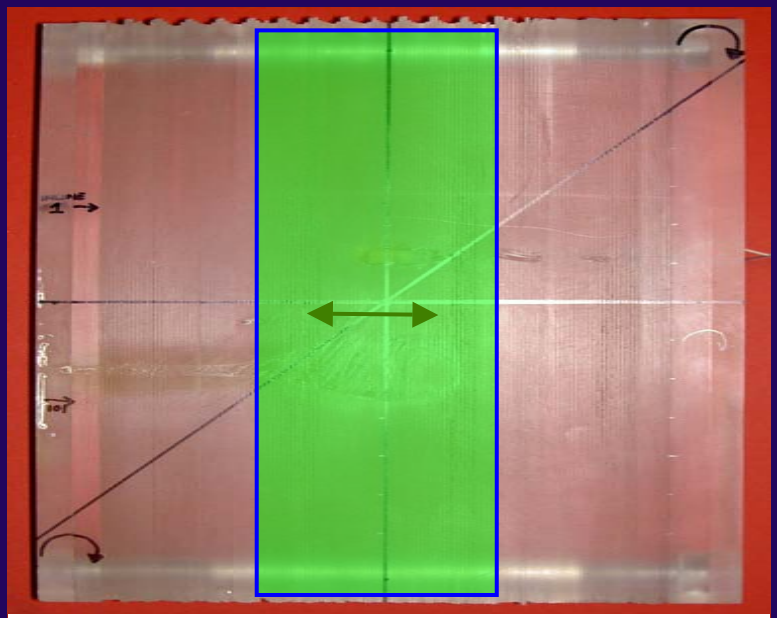



Shaped Data October 11, 2005 file=SWAP3z.ASCII Gain=.13
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0

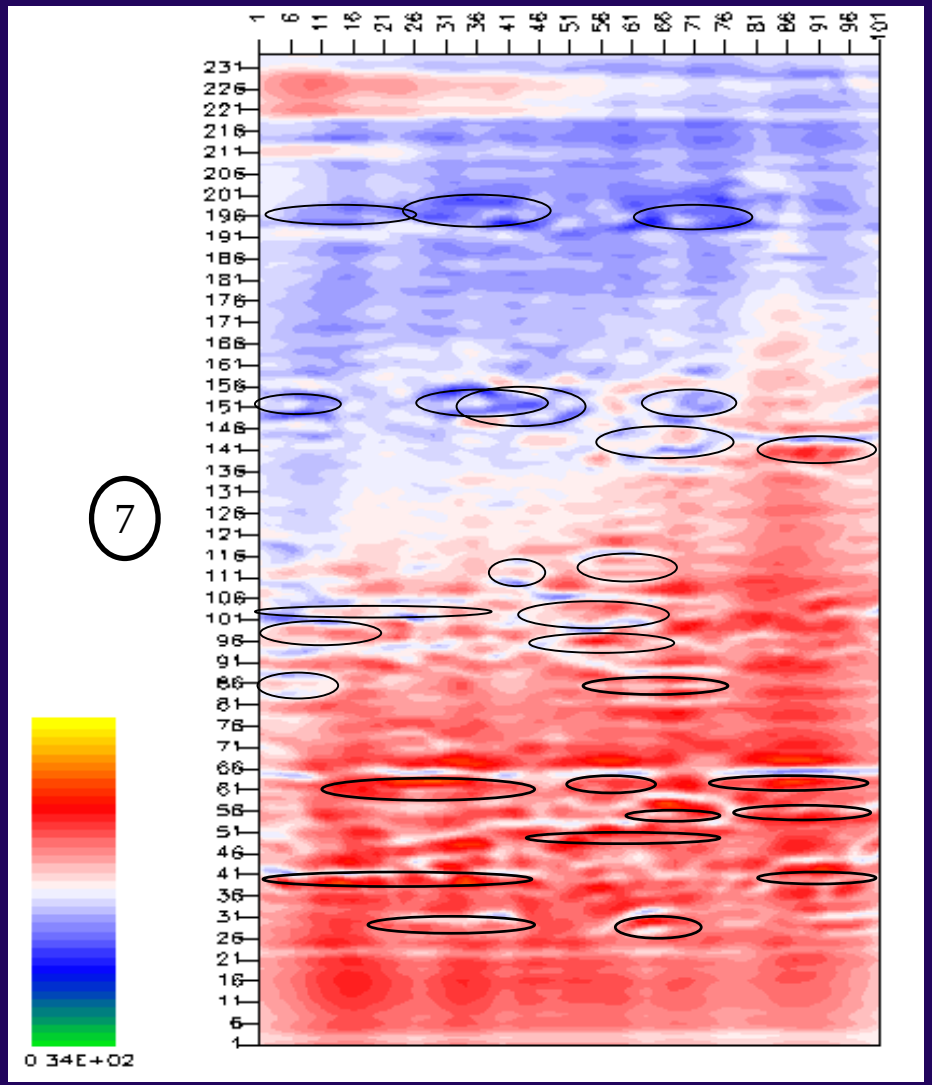
BACK

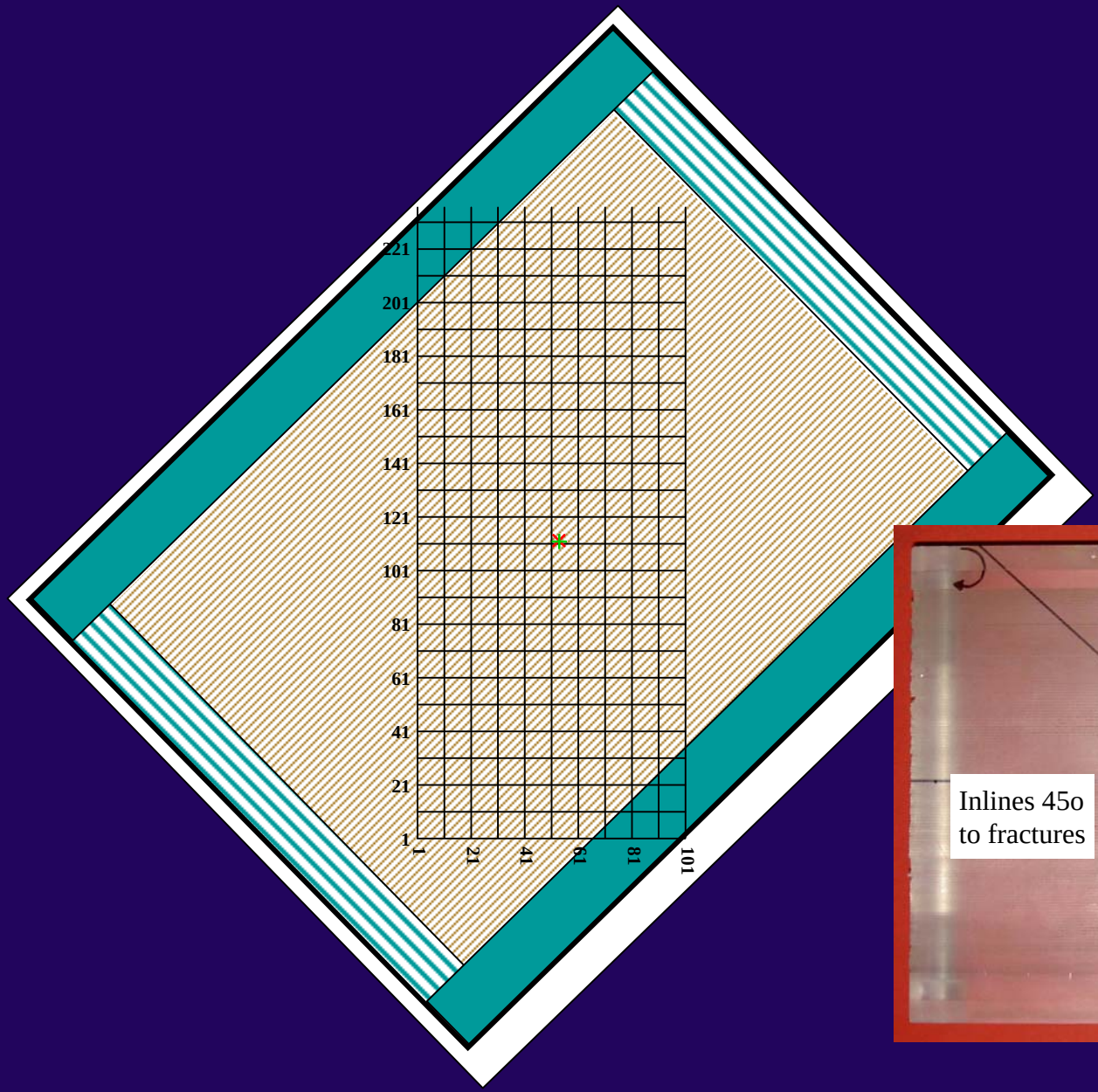
REPLAY

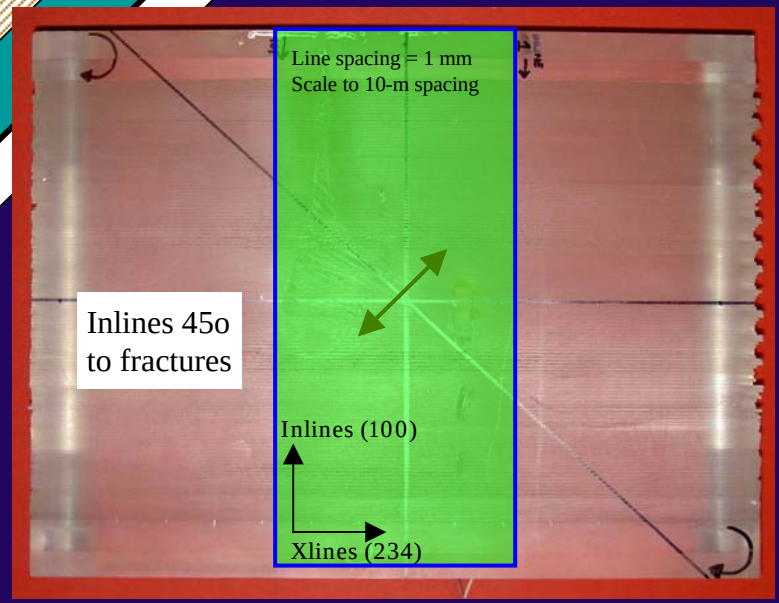
V. FINDINGS

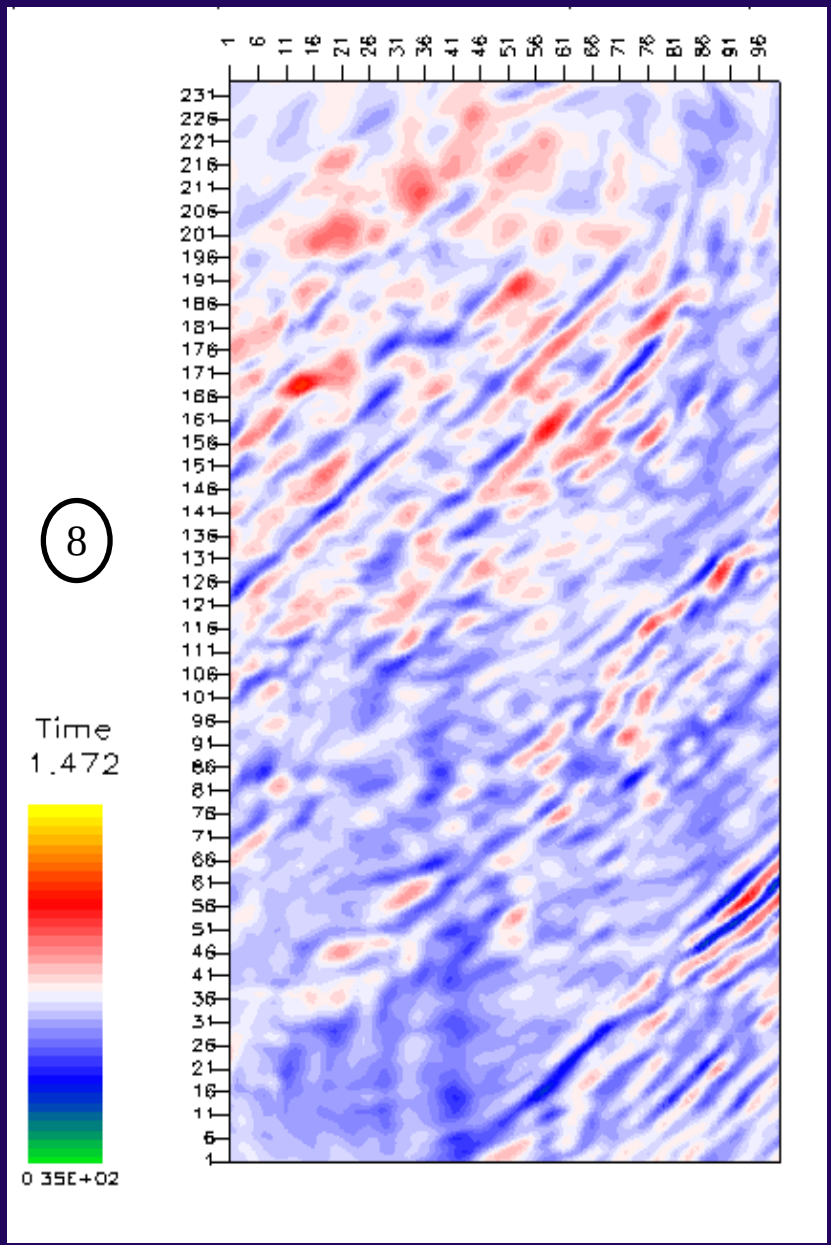


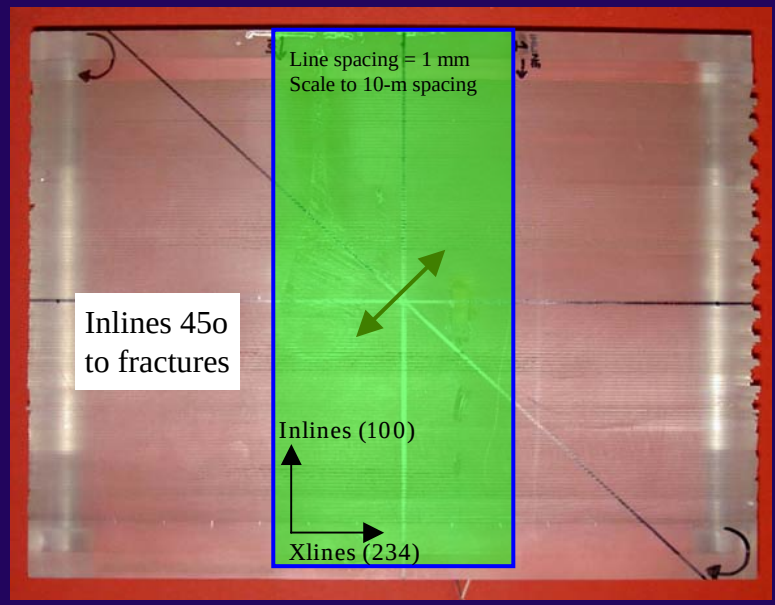
3D Survey over HTI Fracture at Different Azimuths

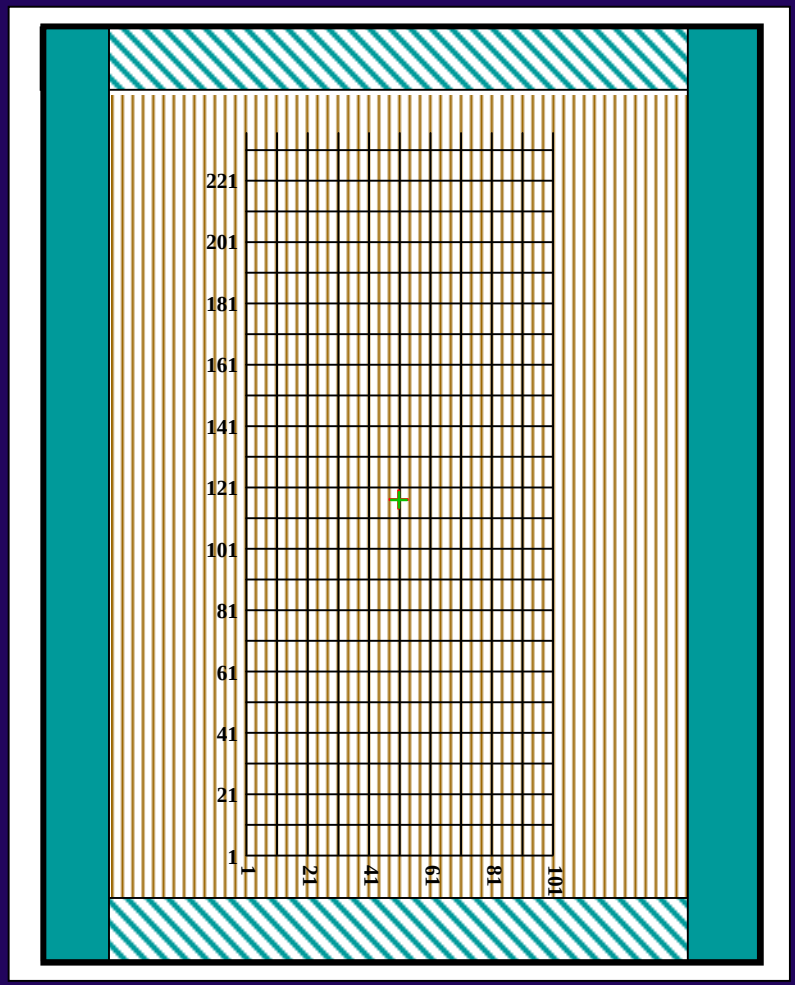


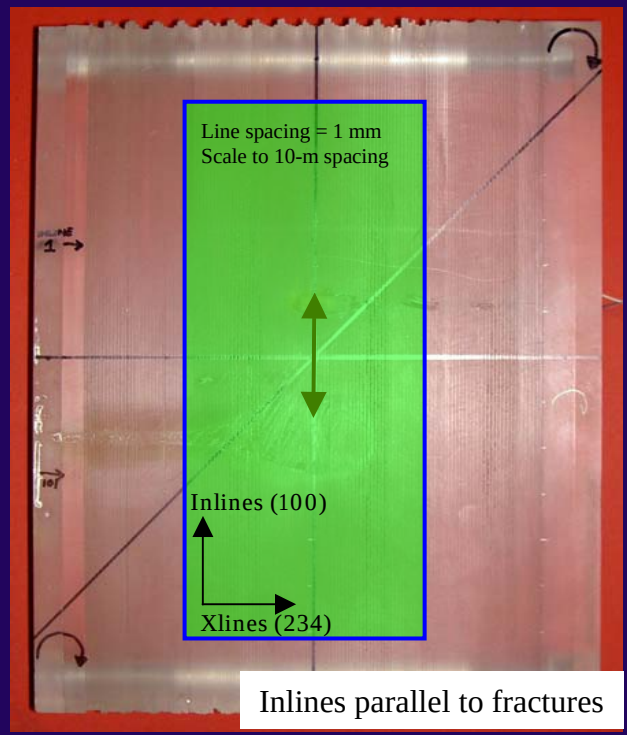

221
201
181
161
141
121
101
81
61
41
21
1
1
21
41
61
81
101


Line spacing = 1 mm
Scale to 10-m spacing
Inlines 45o
to fractures
Inlines (100)
Xlines (234)


8
Time
1.472
0.35E+02


Line spacing = 1 mm
Scale to 10-m spacing
Inlines 45o
to fractures
Inlines (100)
Xlines (234)





Inlines parallel to fractures

BACK

V. CONCLUSIONS

Indicators of fracture density and azimuth:

1. NO polarity reversal at far-offset data (> critical angle)

2. Consistent/uniform reflection amplitude at far-offset data

3. Delay in arrival time or complete absence of head waves

4. Low-frequency scattering like point diffractions at near-offset*
   * for fracture azimuths perpendicular to inlines

V. CONCLUSIONS

Indicators of fracture density and azimuth:

5. Undulating target horizon at far-offsets; depressed reflections where fracture density is high

6. Possibly, converted reverberating wave energy for fracture azimuth parrallel to inlines

7. 3D seismic amplitude anomalies – check with new new attributes

8. Regular spacing between amplitude peaks-troughs in time section

V. Future Work

1. Quantify relationship between seismic indicators vs. fracture density and azimuth

2. Run the same experiments over subtle fracture model

3. Investigate how empirical results bear upon theory of head wave propagation in fractured (HTI) media