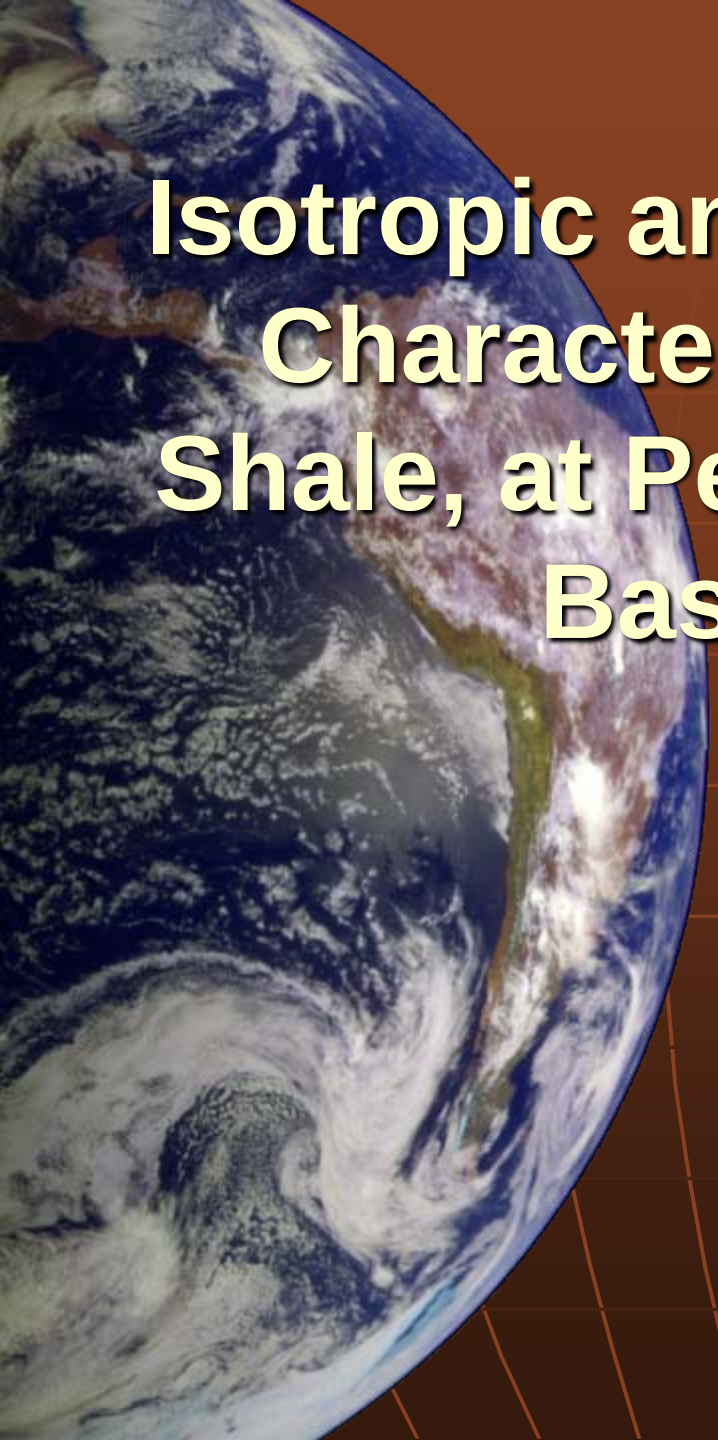

Isotropic and Anisotropic Seismic Characterization of Woodford Shale, at Pecos County, Delaware Basin, West Texas

Na Shan

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Outline

- Overview and Well log Observation
- VTI Model
- HTI Model
- Orthorhombic Model
- Sensitivity of seismic model
- Conclusion

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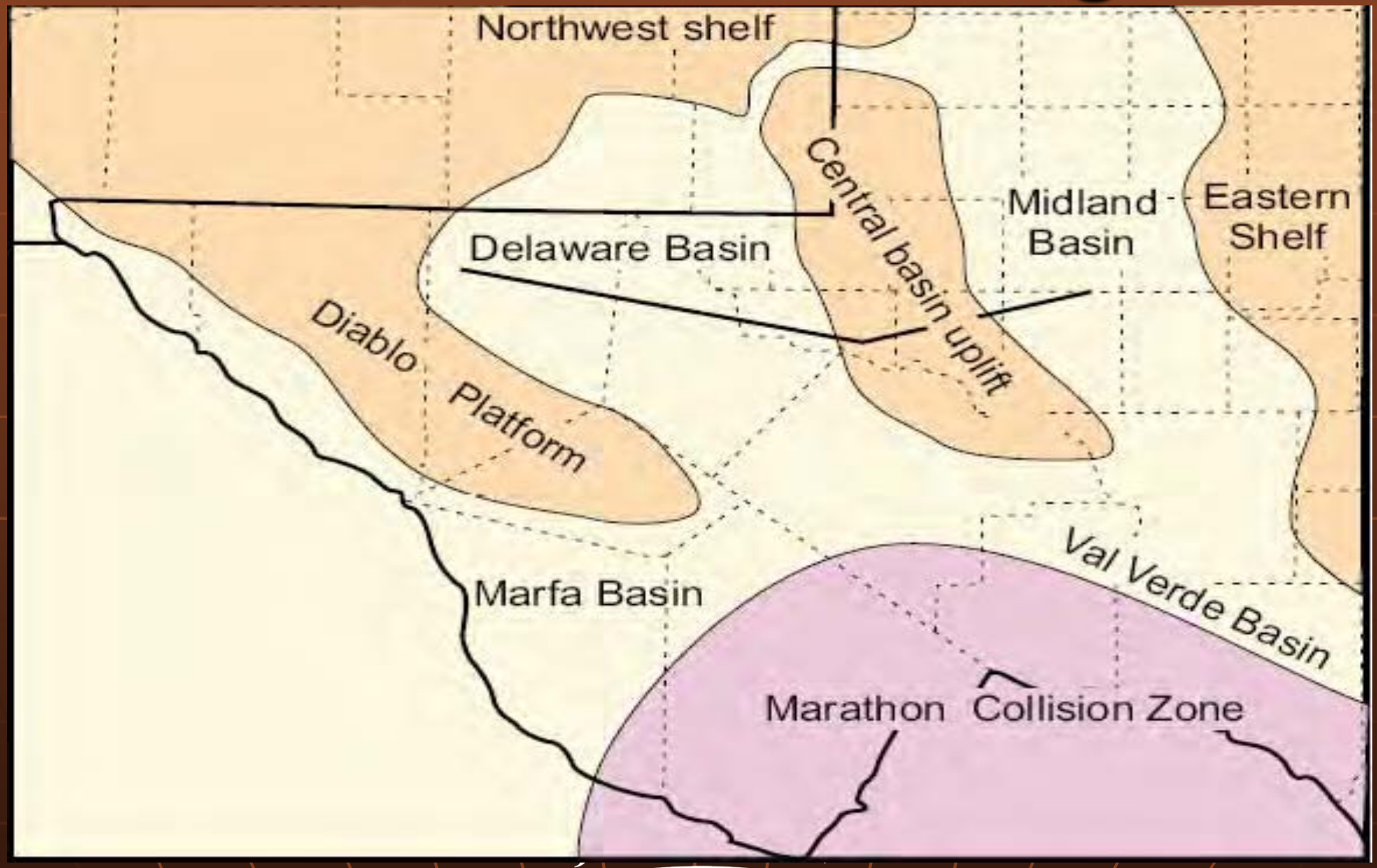
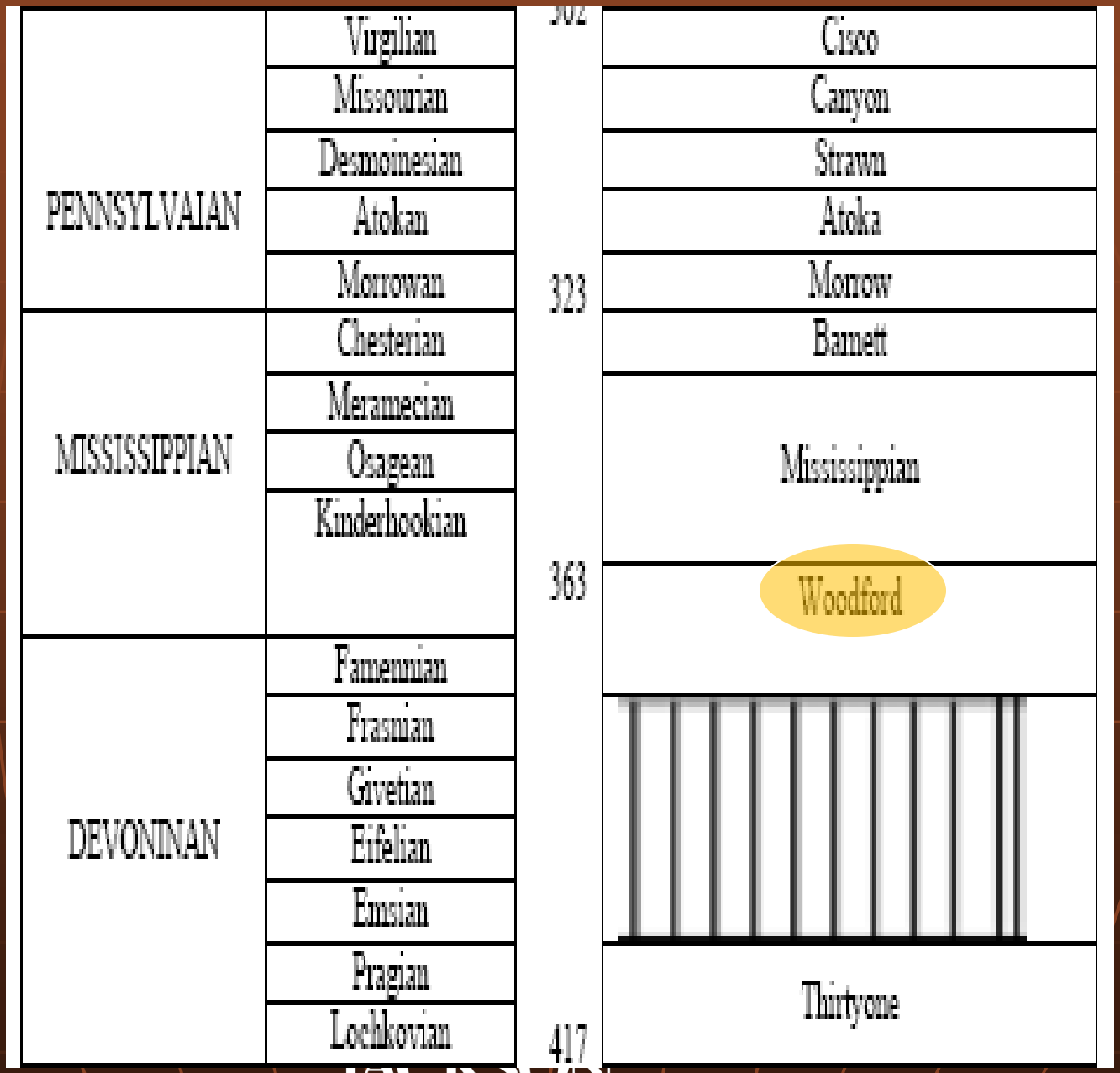
West Texas Setting



Modified by Walaa Ali, M from King, 1942. Steve Ruppel.

Delaware Basin Stratigraphy

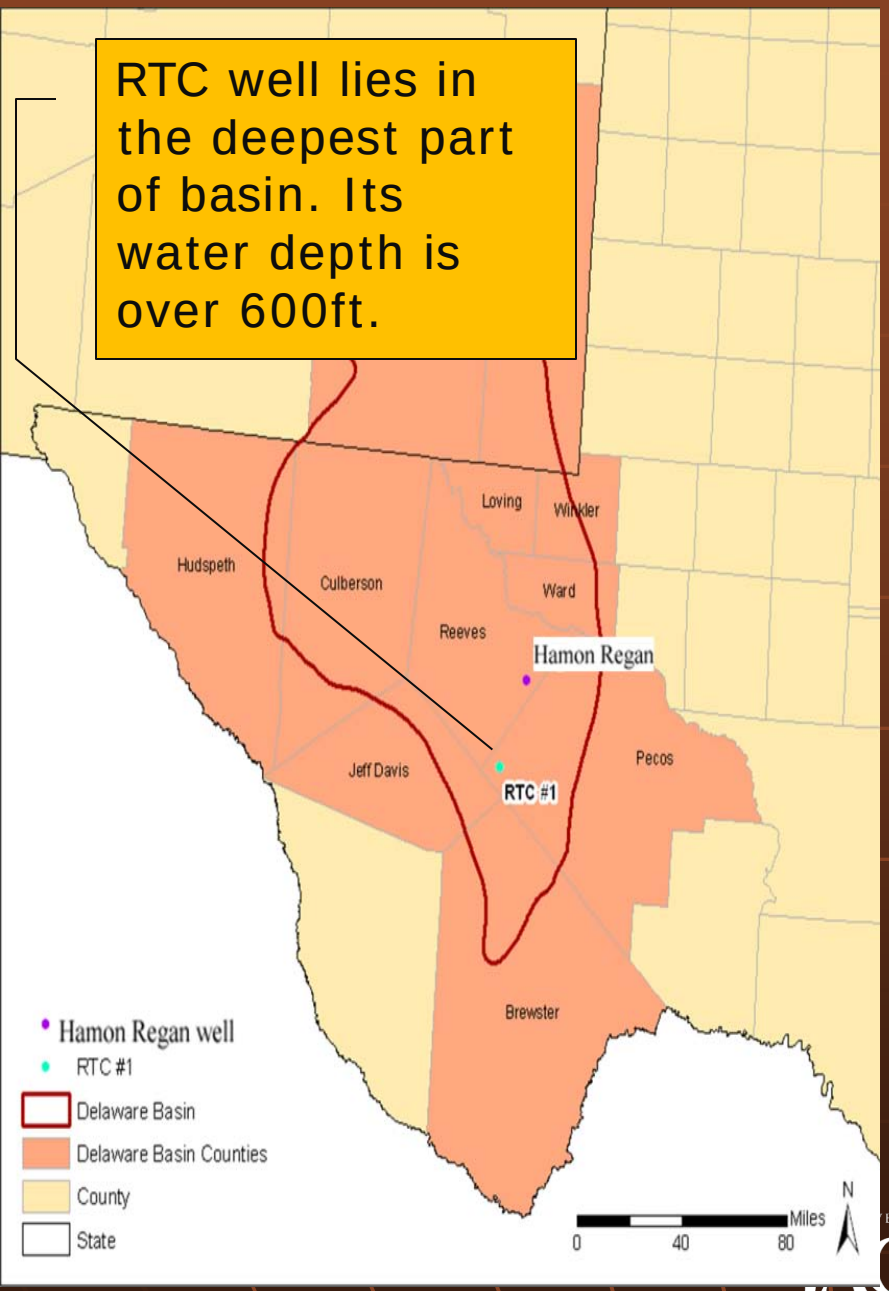


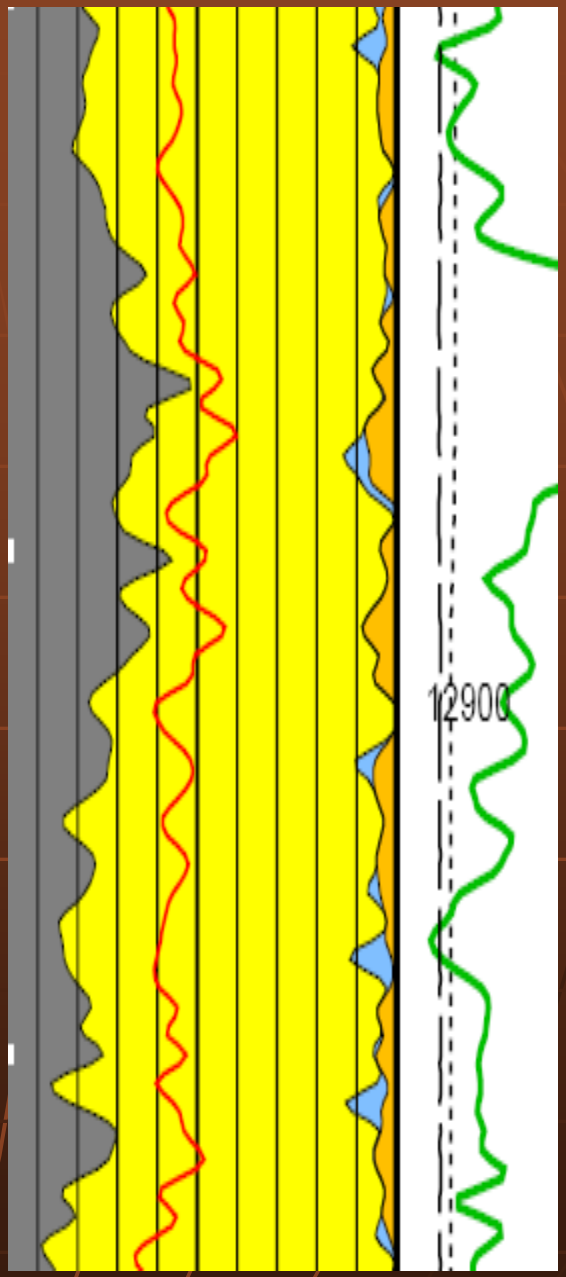
Walaa Ali, 2009; Dutton 2005

Woodford Formation

- High organic matter (high GR), brownish-black fissile shale
- Thickness varies from 96- 460ft (30 m to 200 m), in the Delaware Basin
- In West Texas and southeastern New Mexico, it contains about 80 x 10^9 bbl of oil (240 x 10^12 ft3 of natural gas equivalent)
- Production usually contains viable lithofacies like chert, sandstone, dolostone and siltstone where are highly fractured.

RTC well lies in the deepest part of basin. Its water depth is over 600ft.





Modified by Walaa Ali

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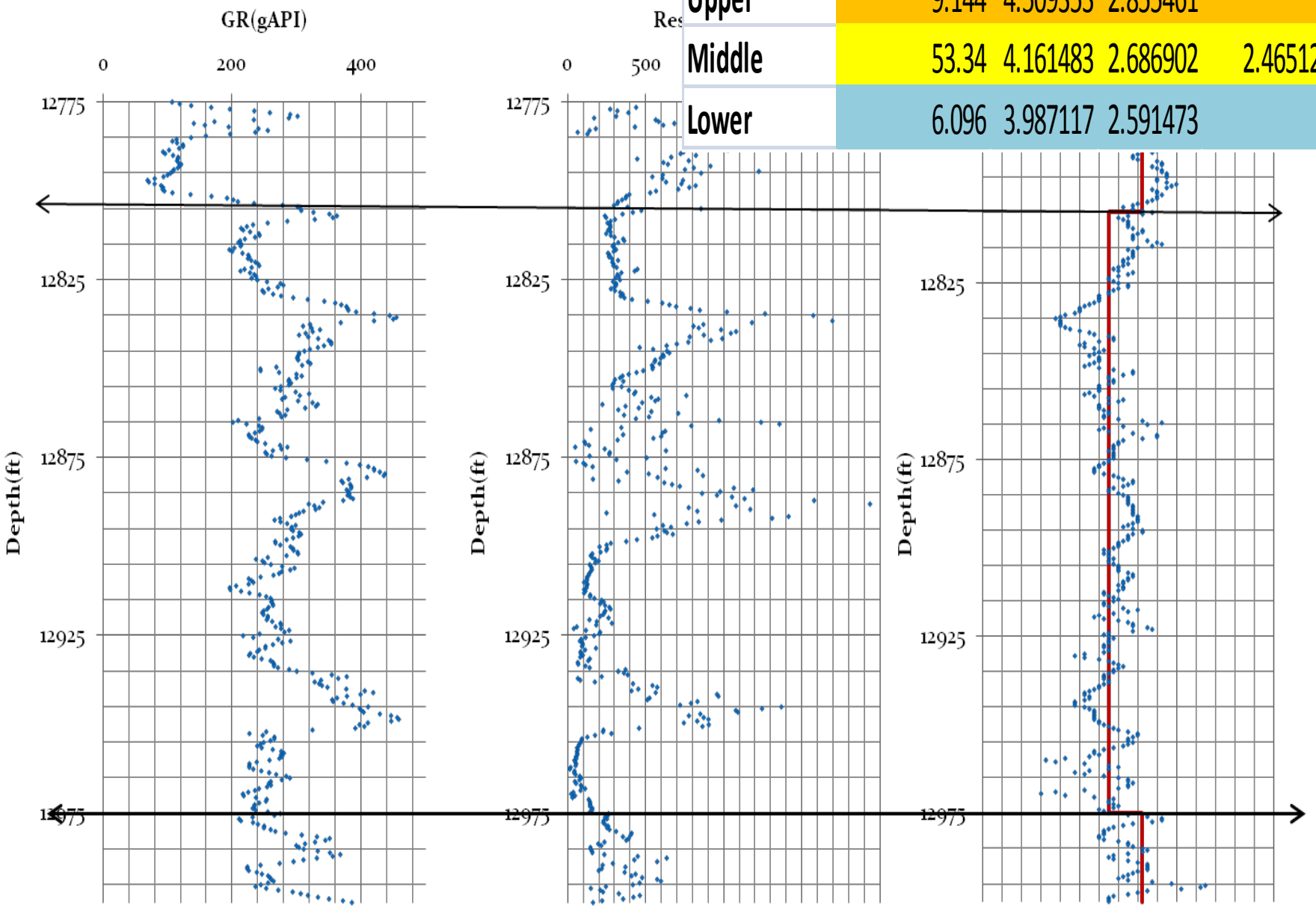
Woodford	Thickness(m)	Vp(km/s)	Vs(km/s)	Density(g/cm3)
Upper	9.144	4.509353	2.855461	2.53
Middle	53.34	4.161483	2.686902	2.465128412
Lower	6.096	3.987117	2.591473	2.53



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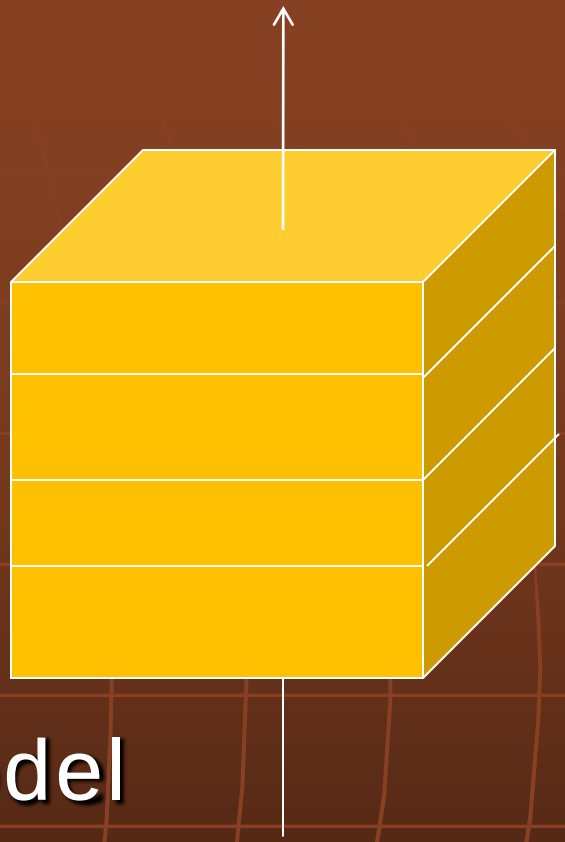
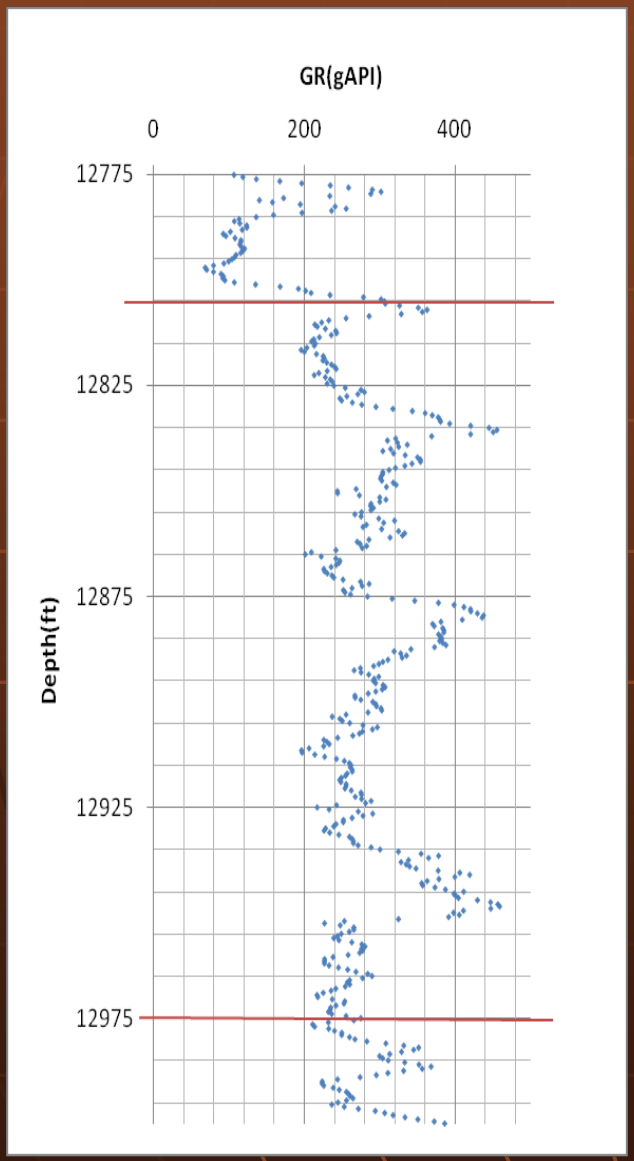
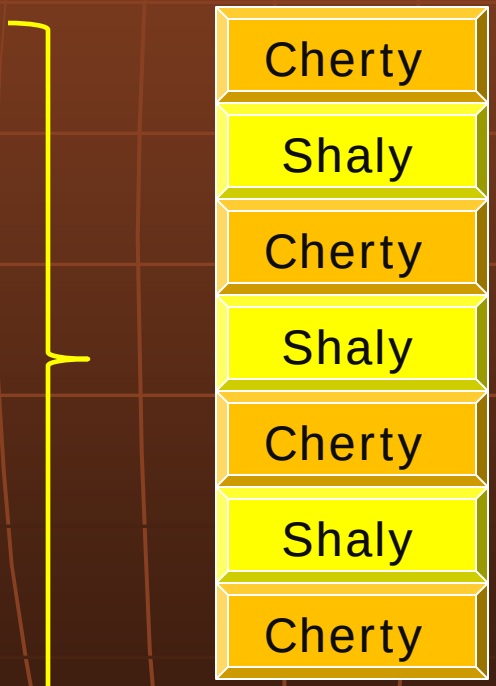
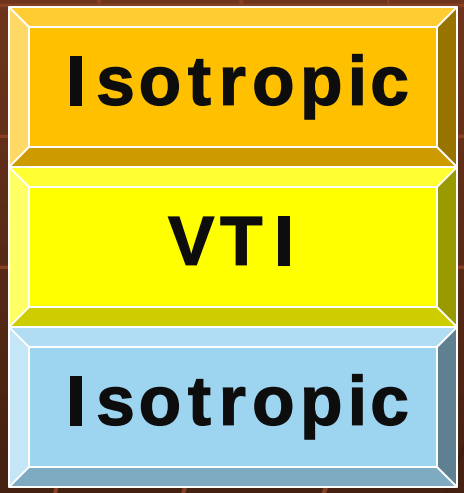


VTI-Middle Layer



Vertical Impulsive Source
Generate PP, PS and SS wave
Z Component (Vertical), X Component (Radial)





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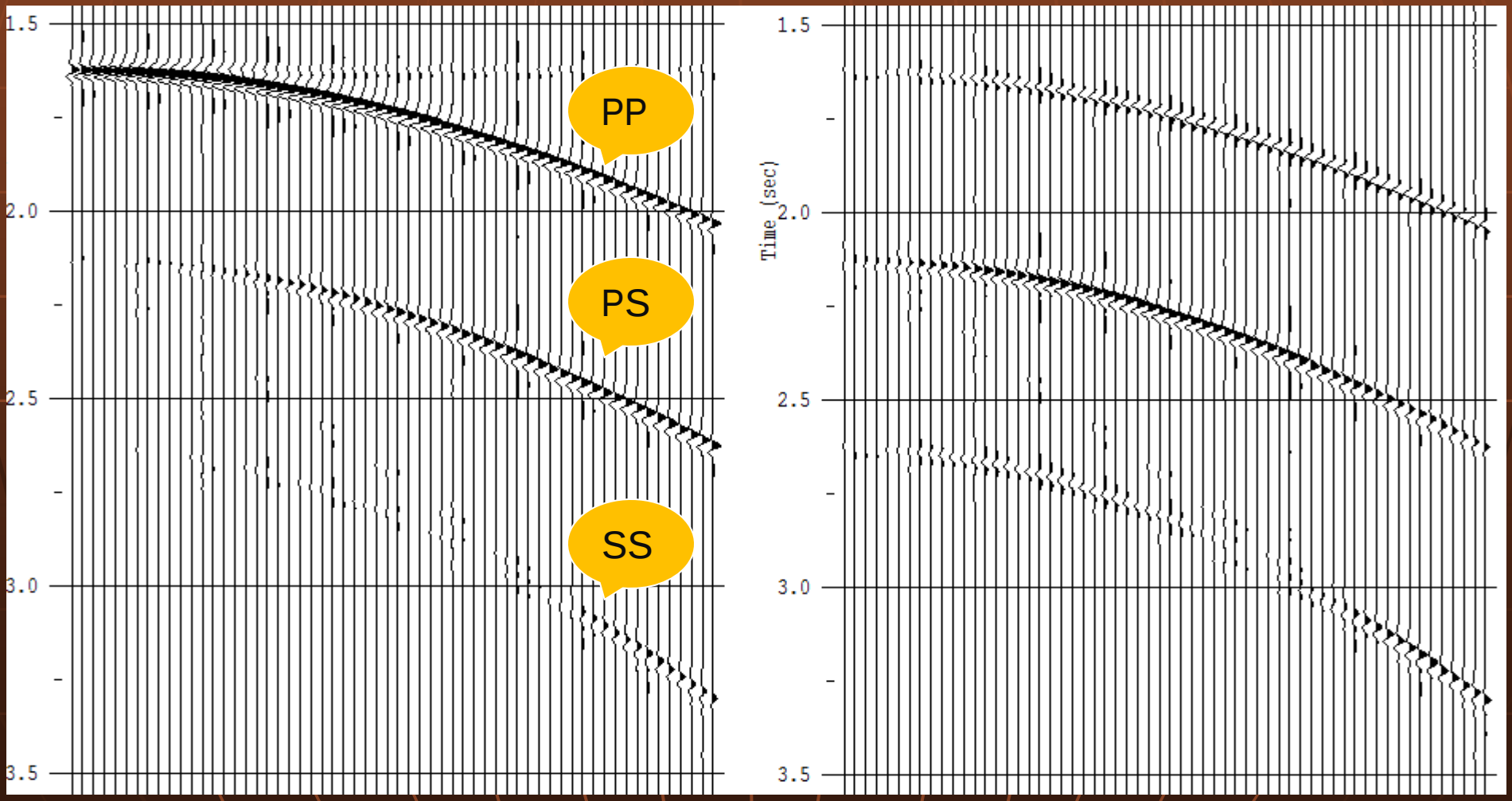
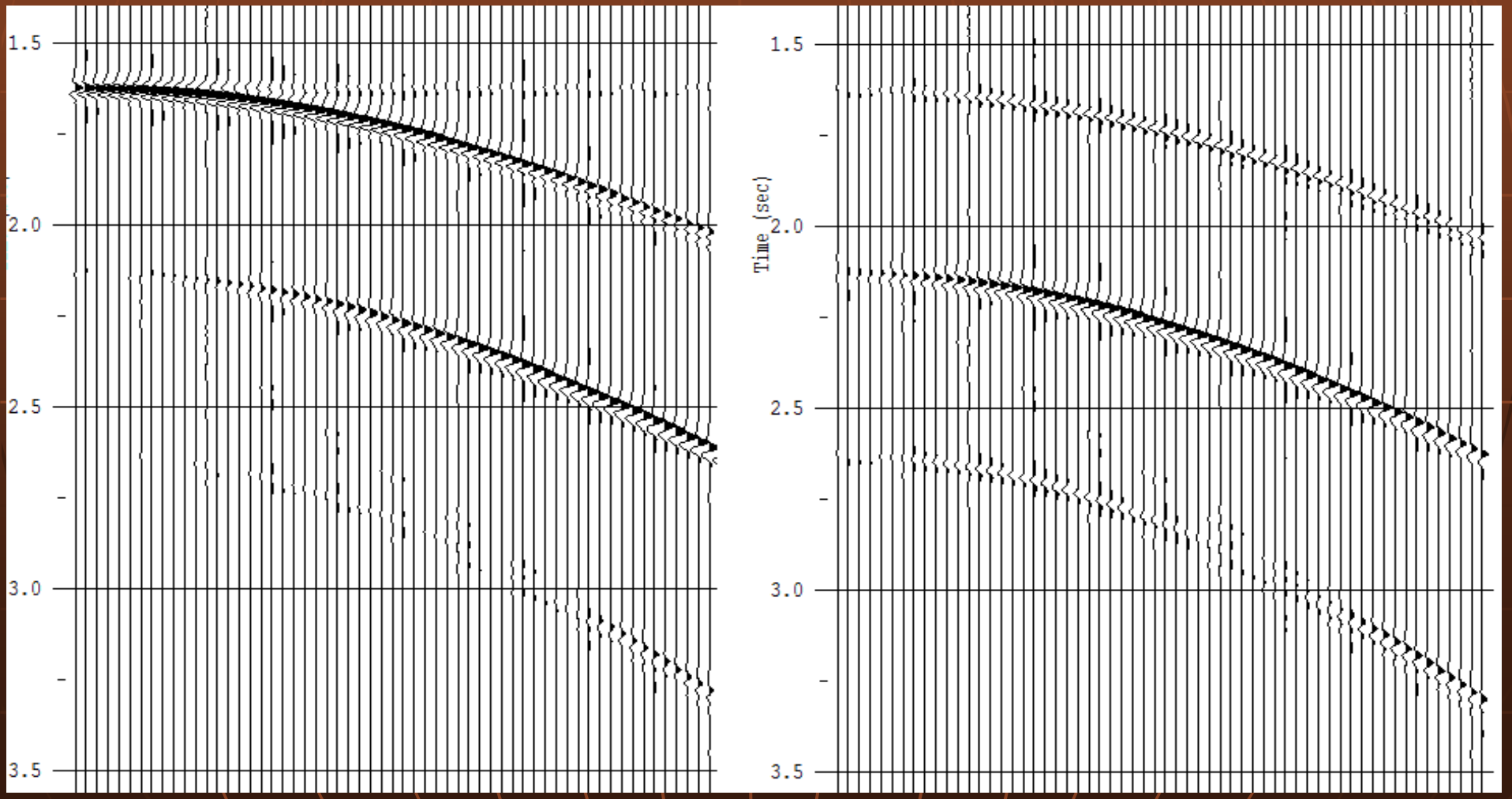
Isotropic
Z Component

Isotropic
X Component



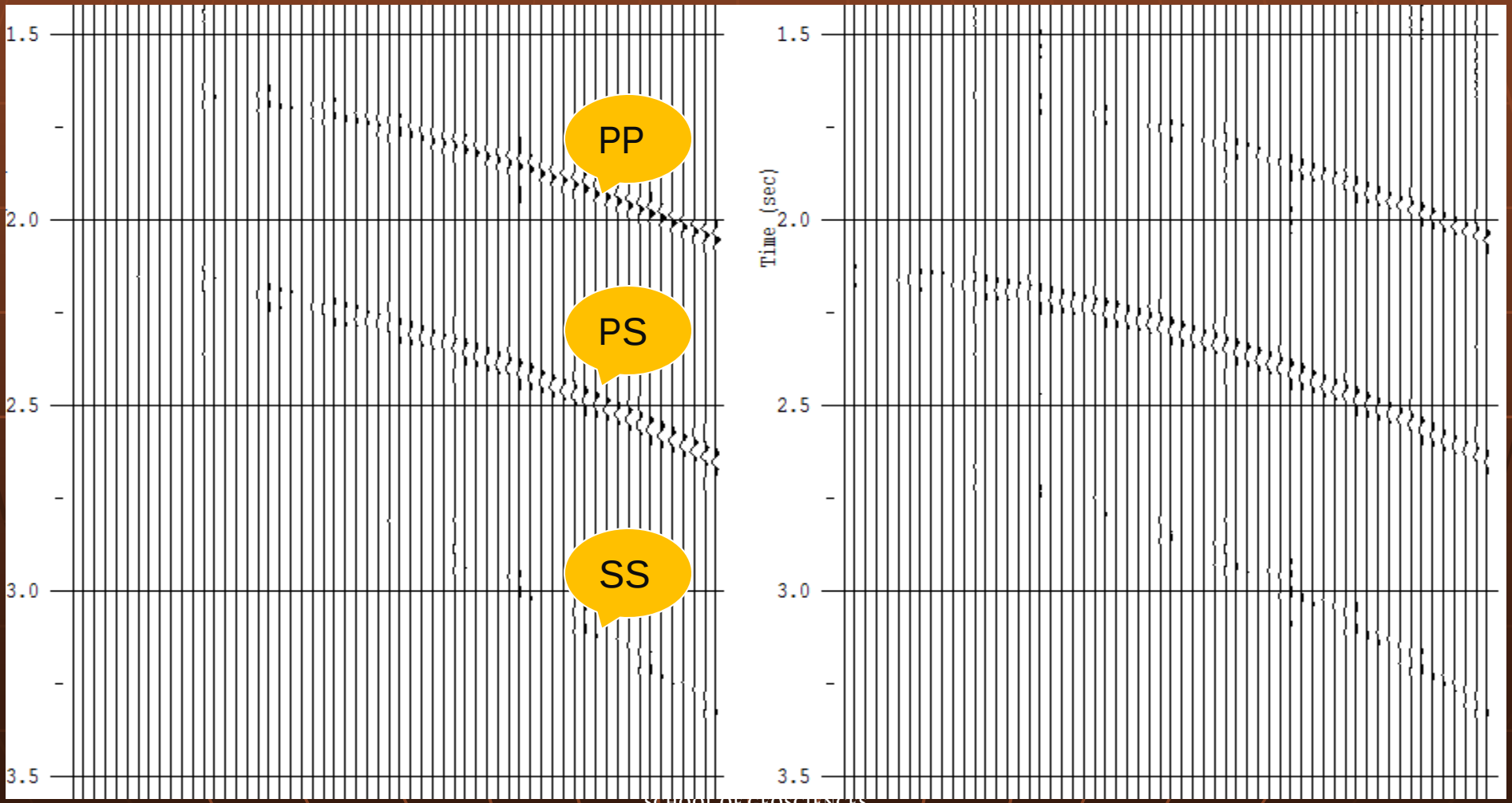
VTI
Z Component

VTI
X Component



VTI-Isotropic
Z Component

VTI-Isotropic
X Component



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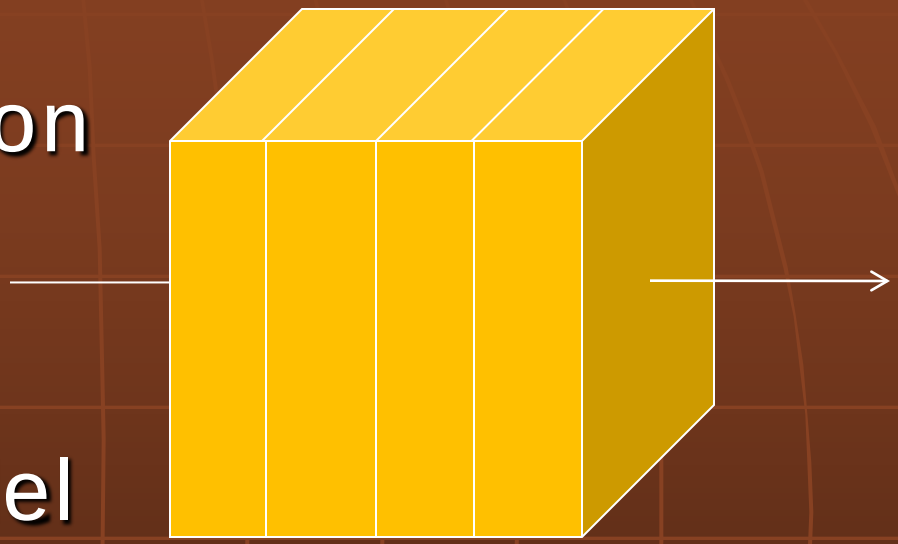
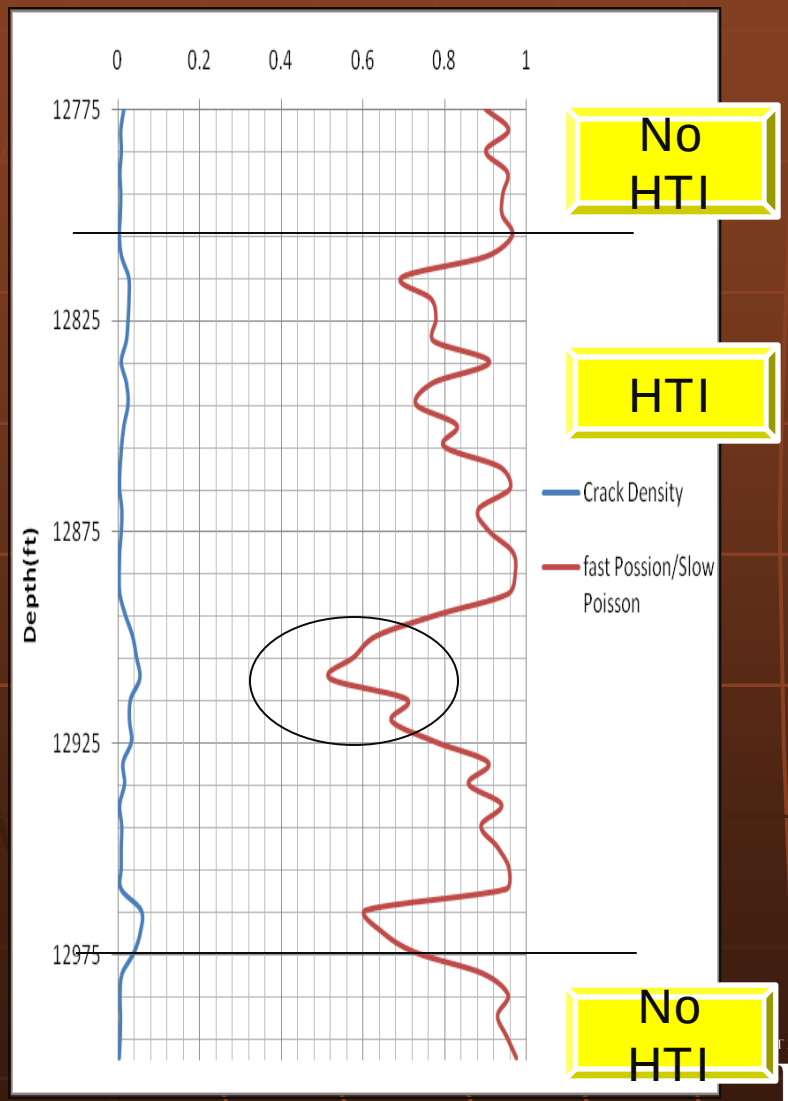
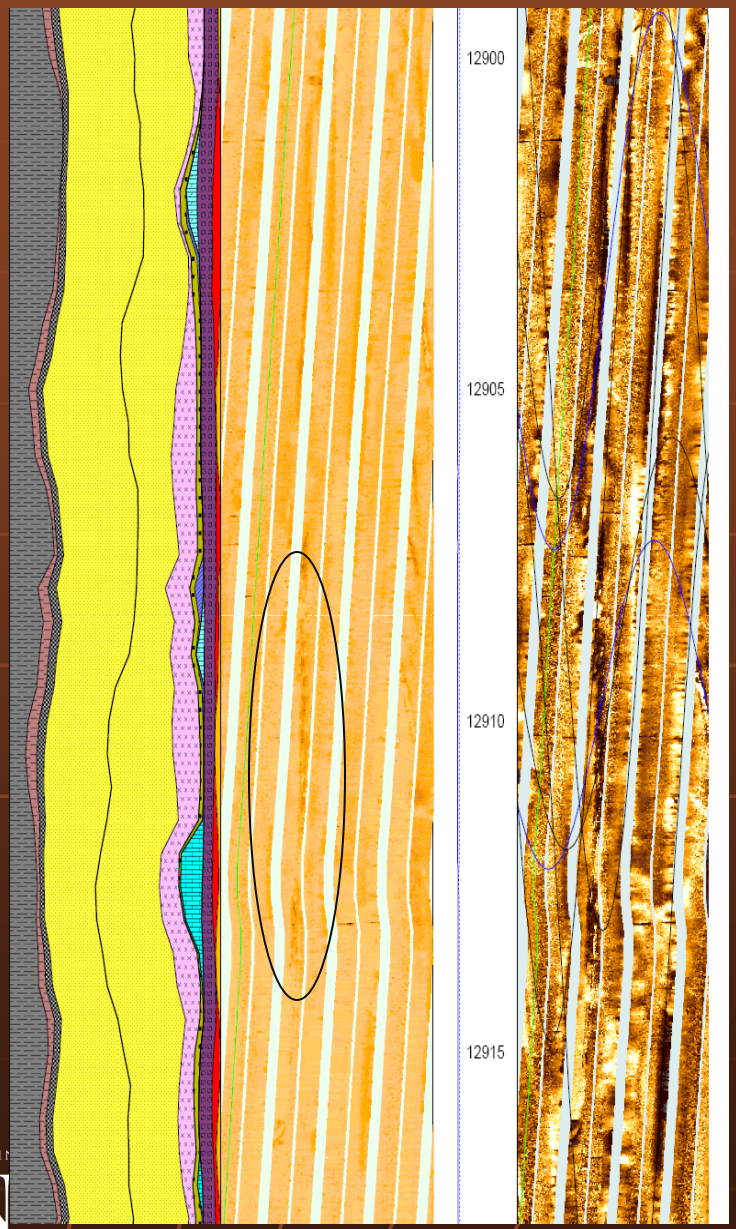


HTI Model





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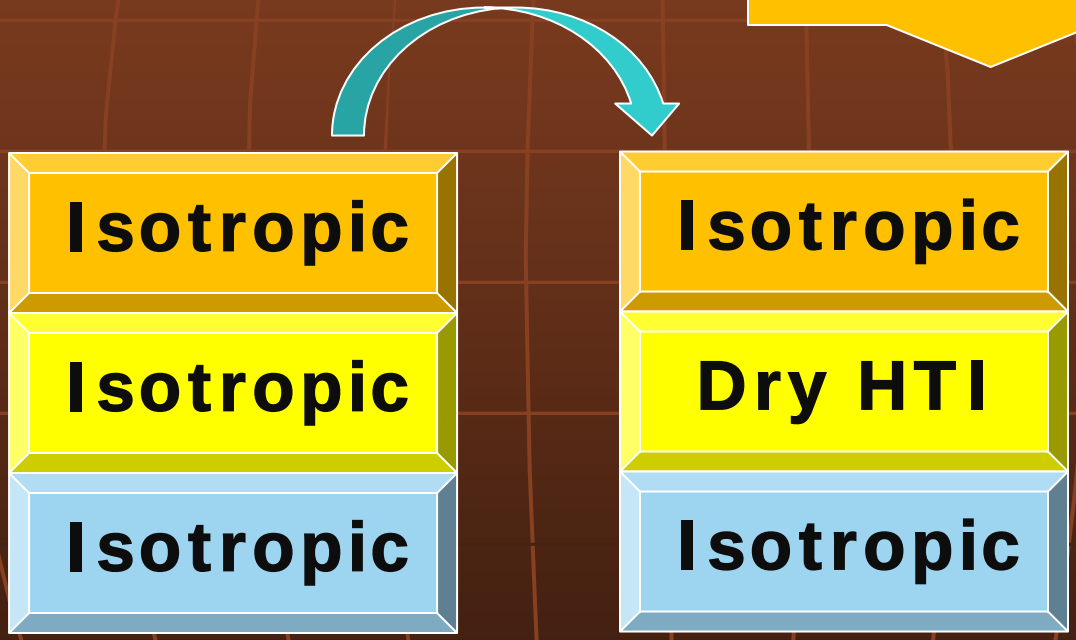
HTI Model

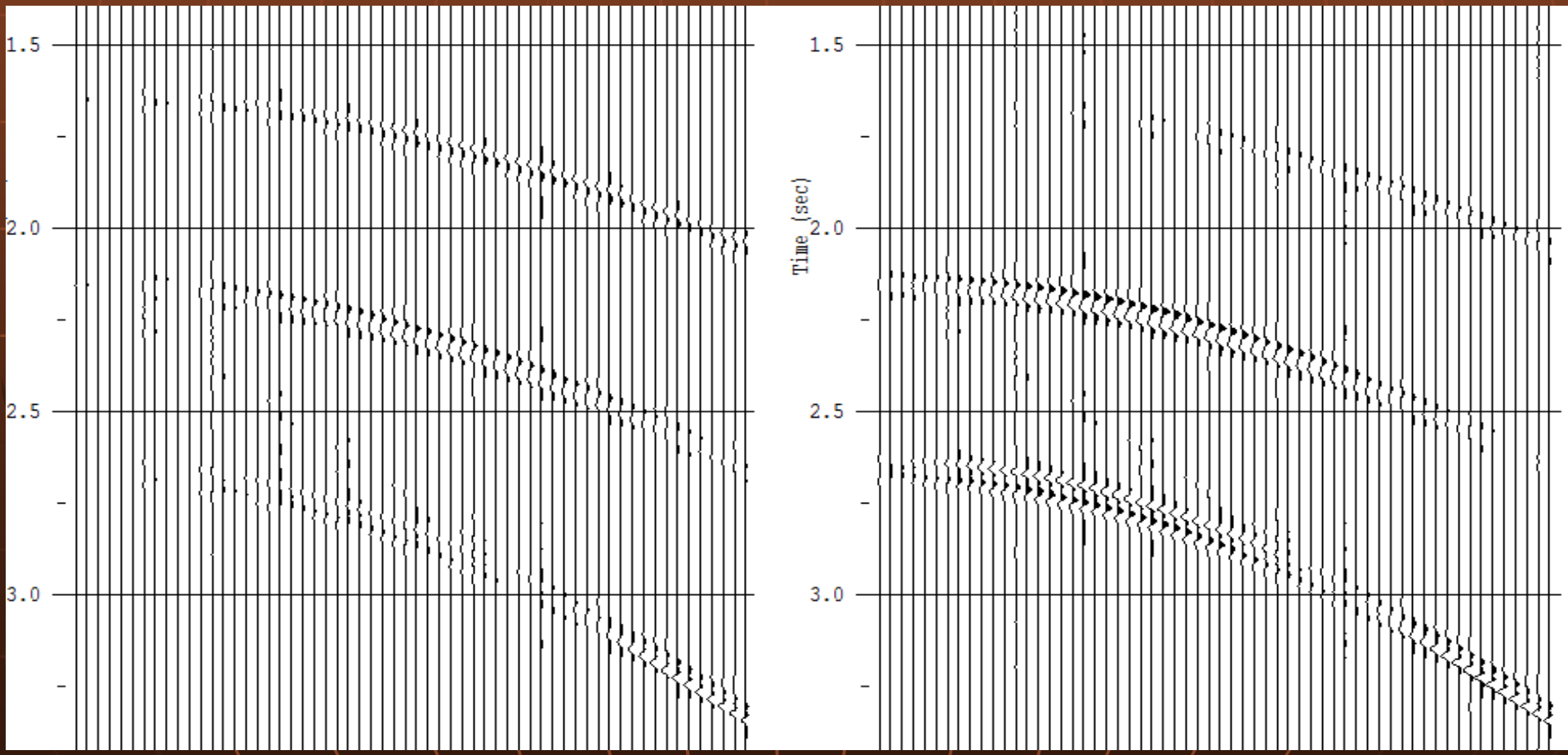
Assumptions
Hudson (Bakulin) Model
Isolated Penny Shaped Cracks
Dry Cracks Only
Crack Density: 0.08 (<0.1)



Difference

HTI-Isotropic θ=0
Z Component

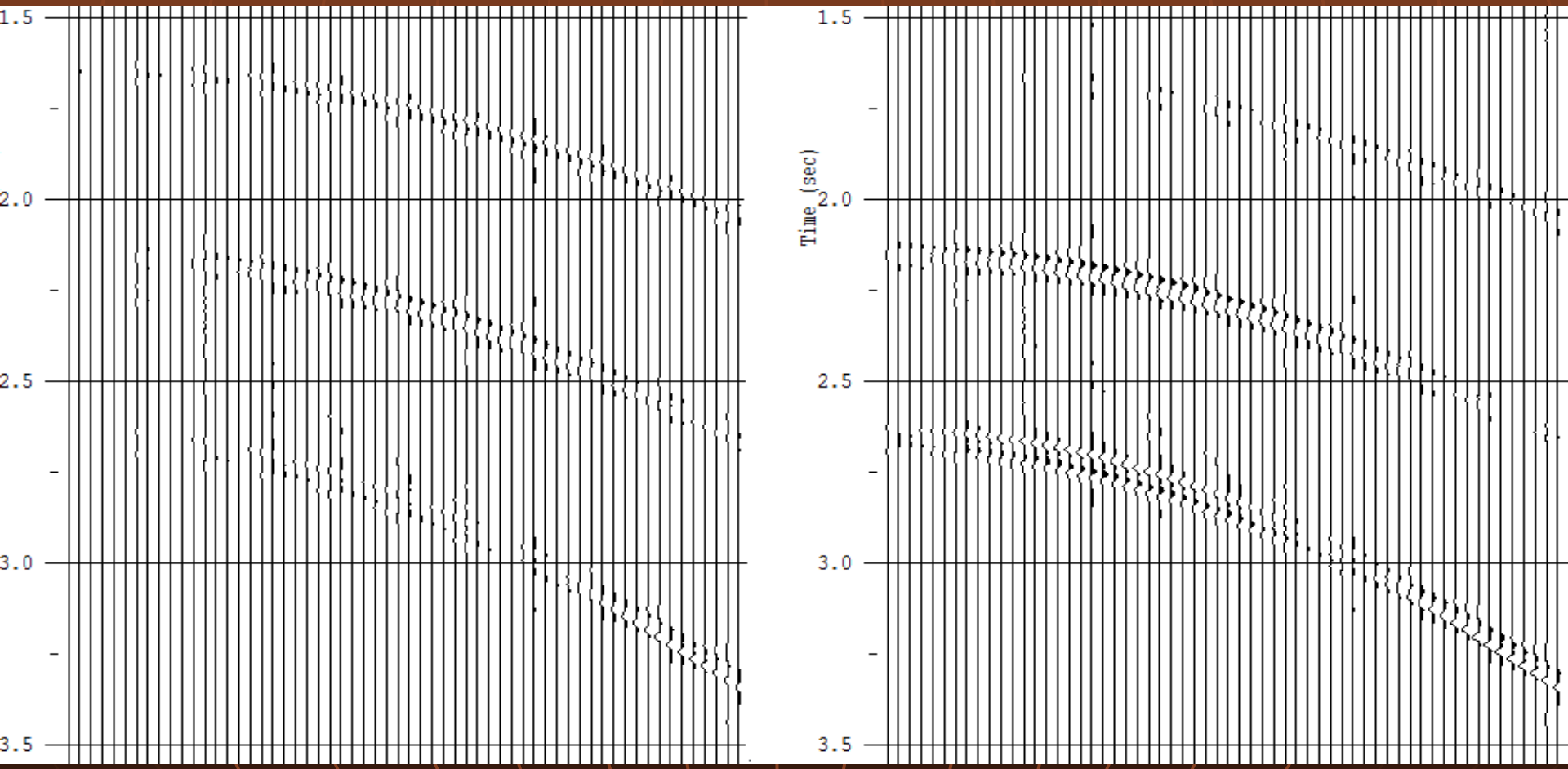
HTI-Isotropic θ=0
X Component



Difference

HTI-Isotropic θ=30
Z Component

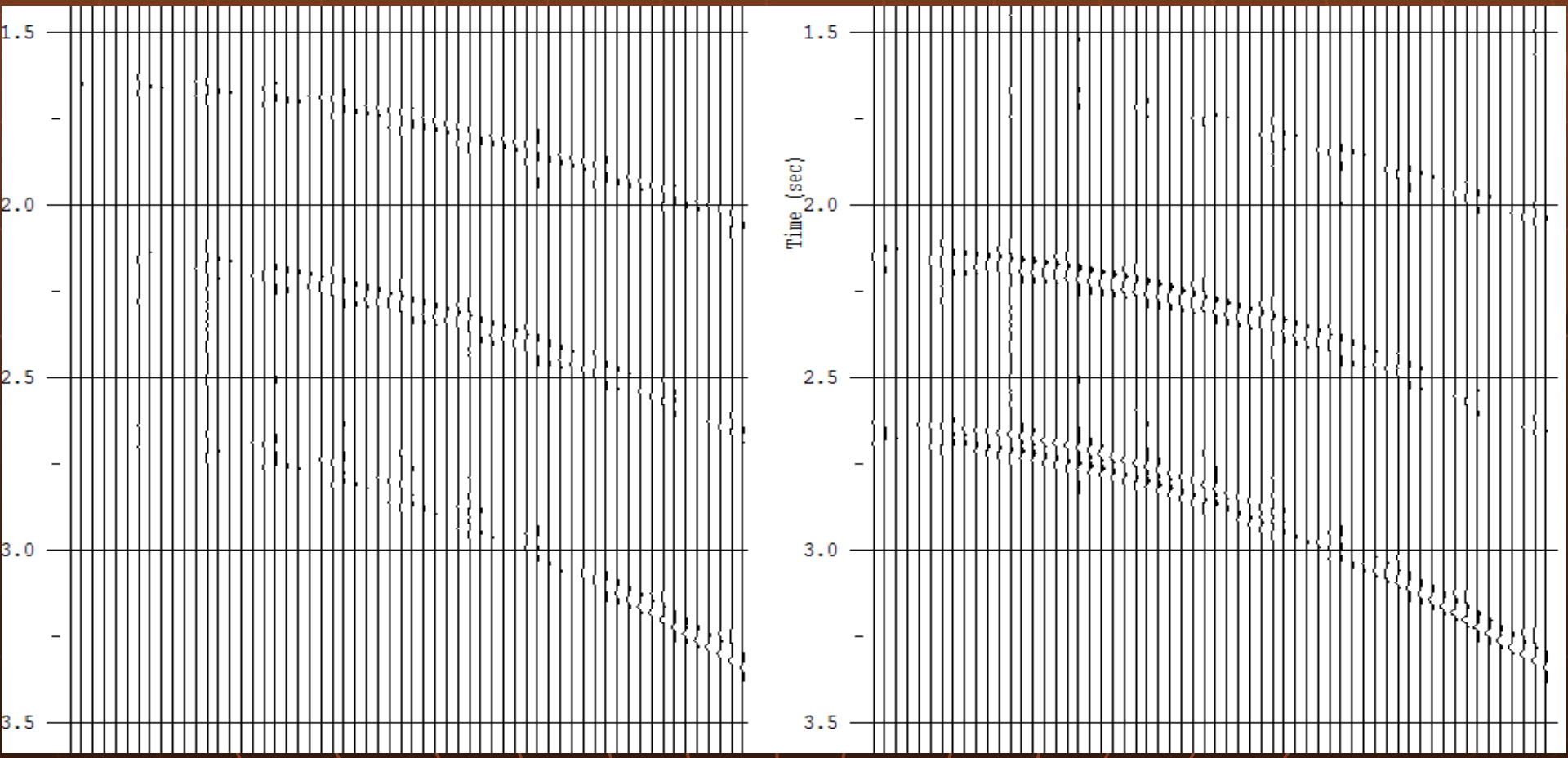
HTI-Isotropic θ=30
X Component



Difference

HTI-Isotropic θ=45
Z Component

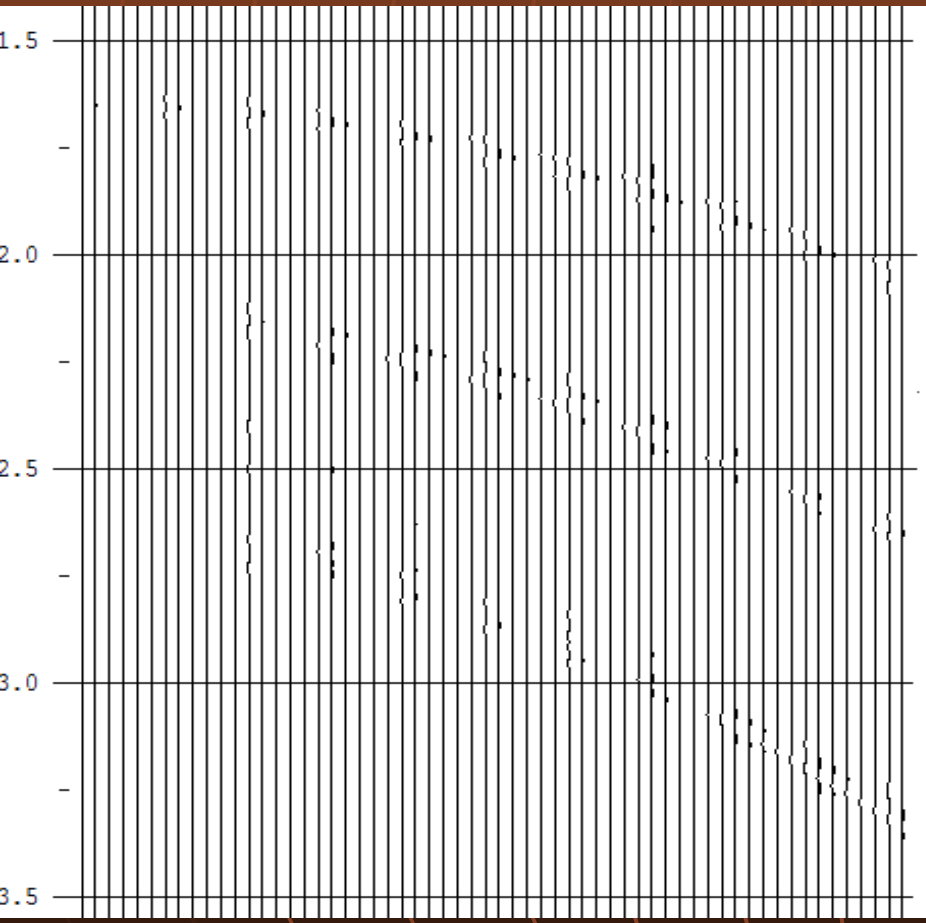
HTI-Isotropic θ=45
X Component

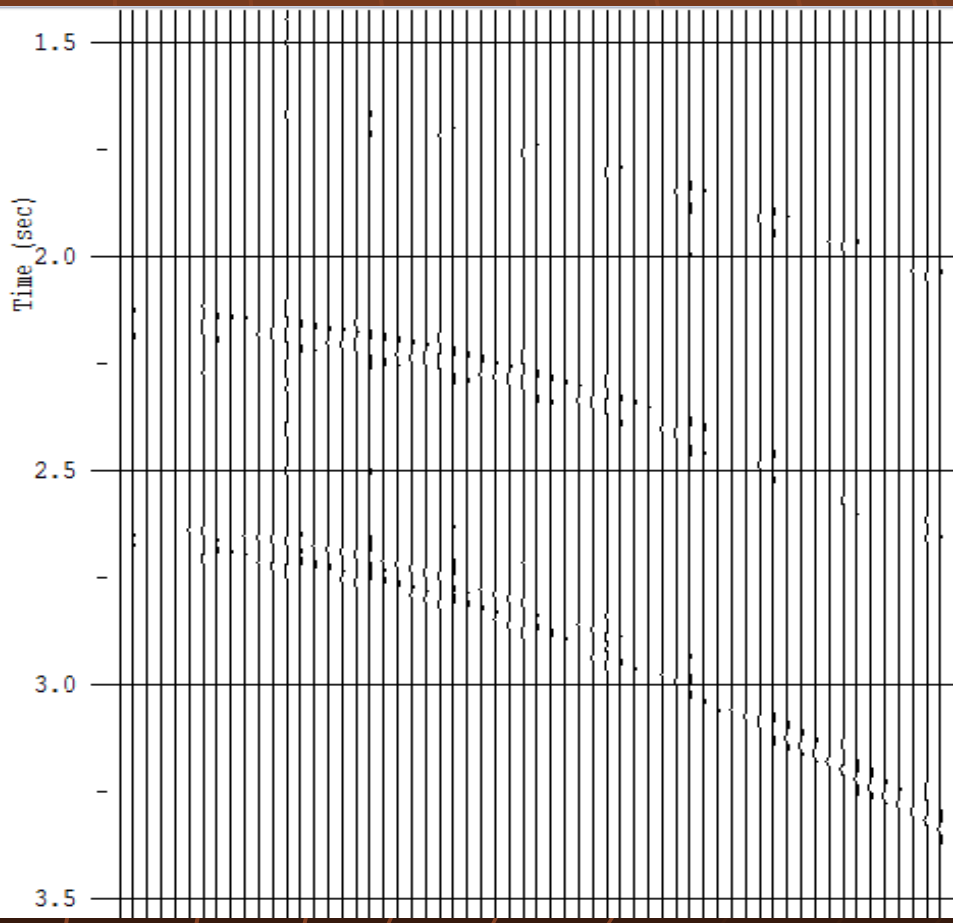


Difference

HTI-Isotropic θ=60
Z Component

HTI-Isotropic θ=60
X Component

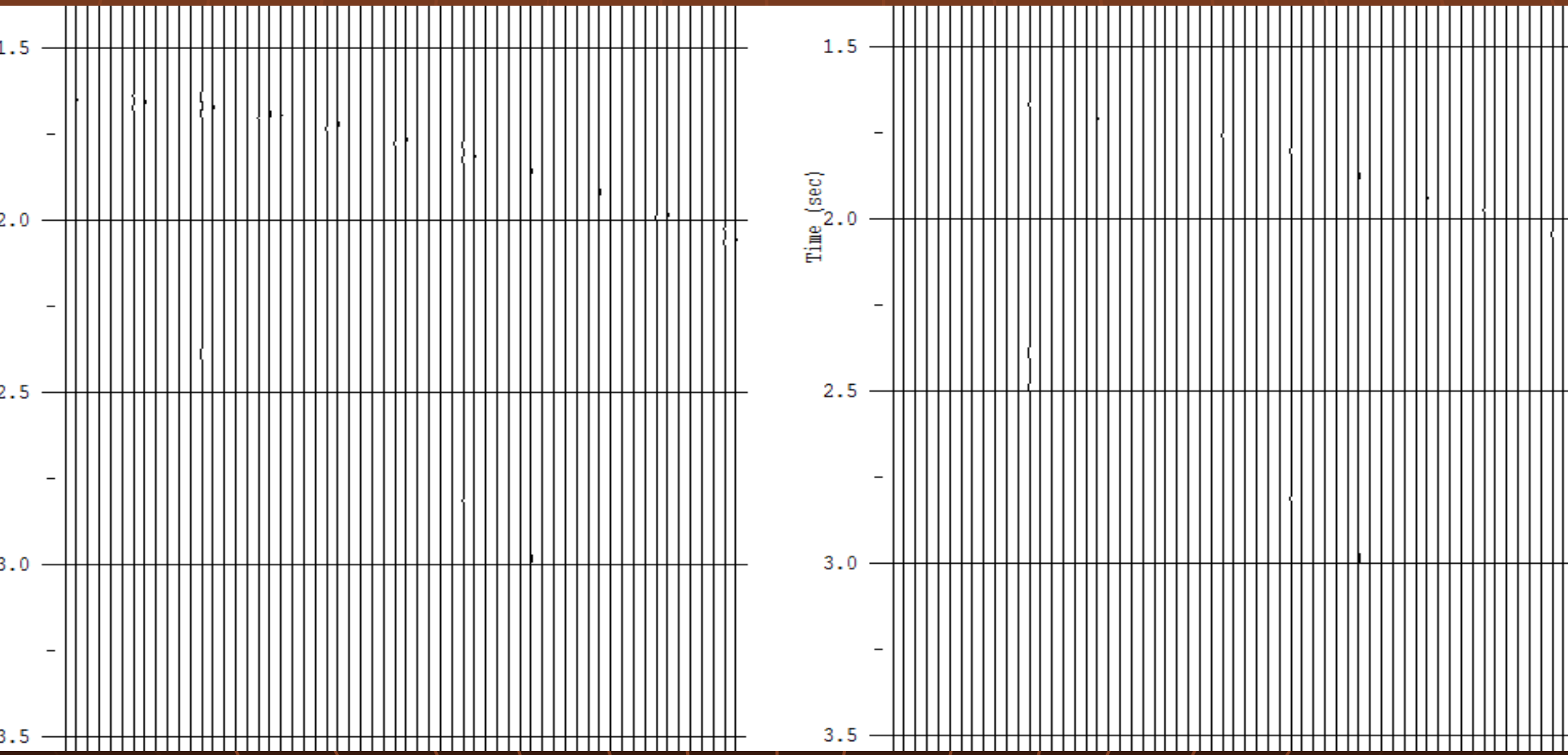




Difference

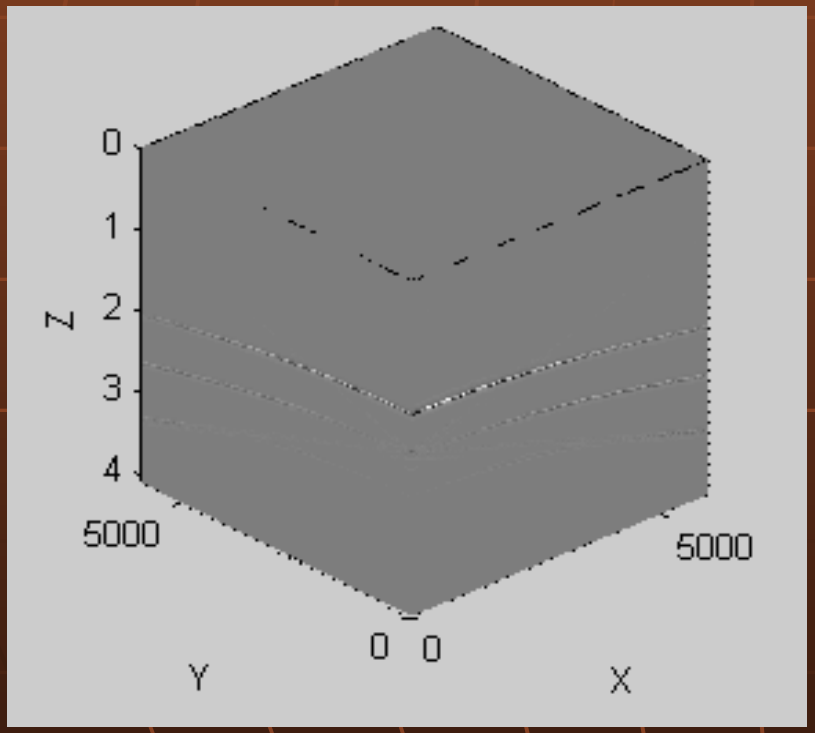
HTI-Isotropic θ=90
Z Component

HTI-Isotropic θ=90
X Component

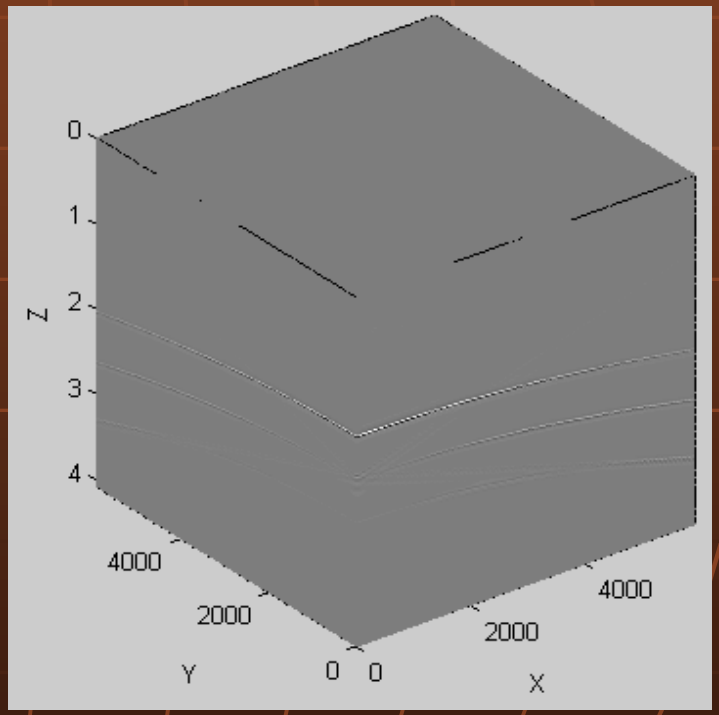


Shot at (0,0) 2D grid of receivers in XY Plane

Isotropic
Z Component



HTI(Dry)
Z Component



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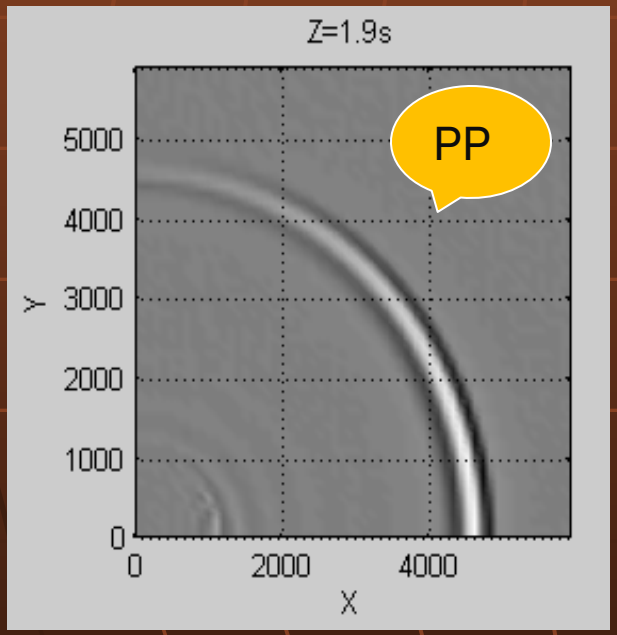
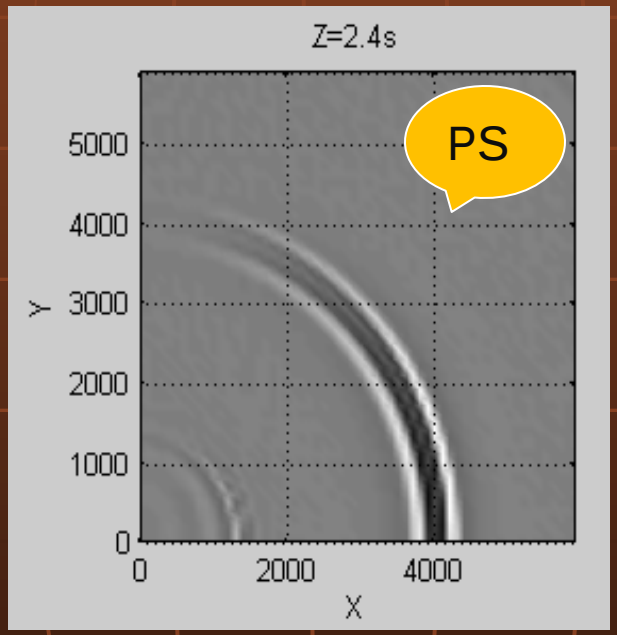
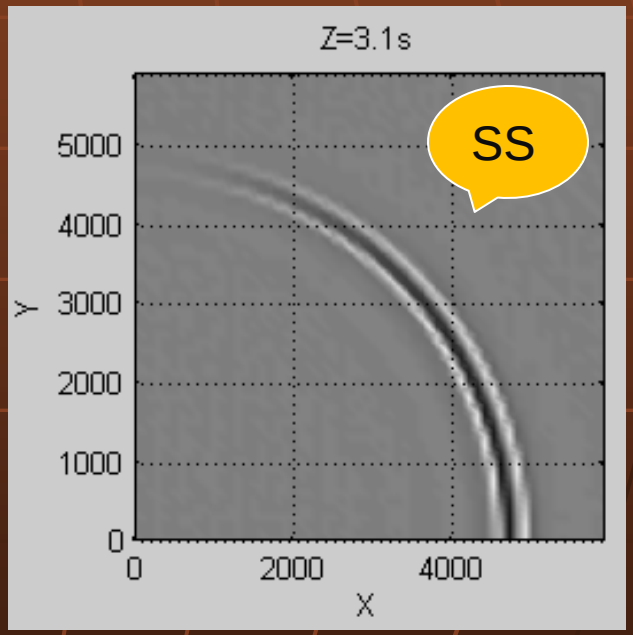
HTI(Dry)-Isotropic
Z Component

The largest difference lies at X direction.







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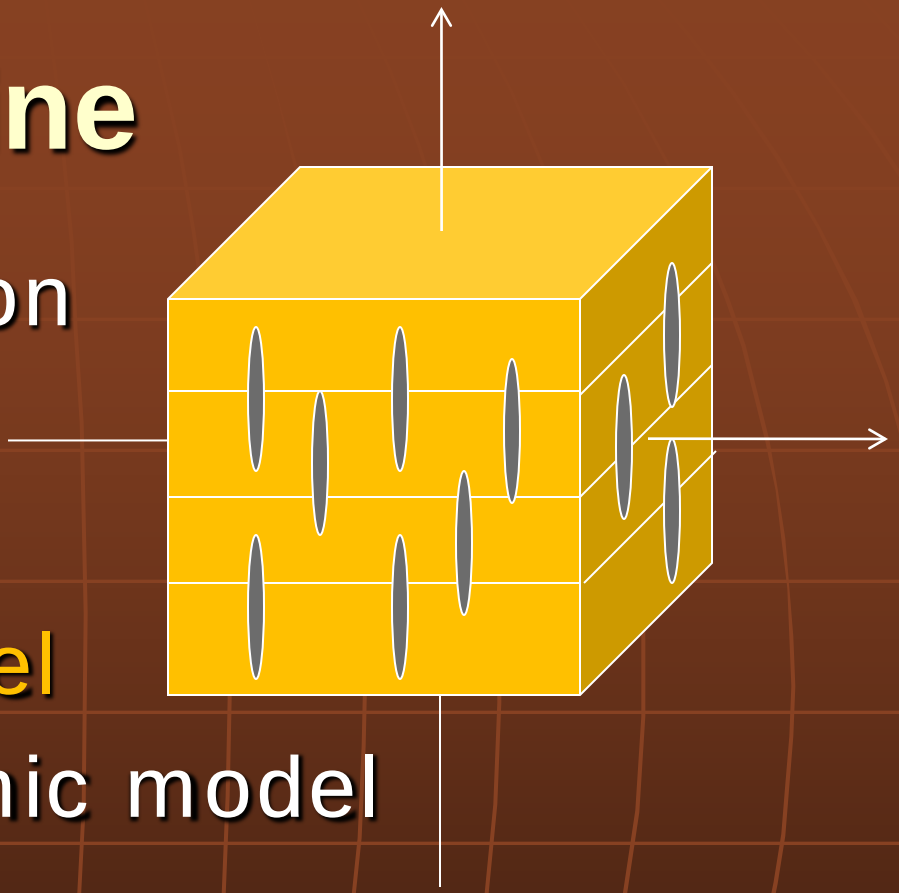
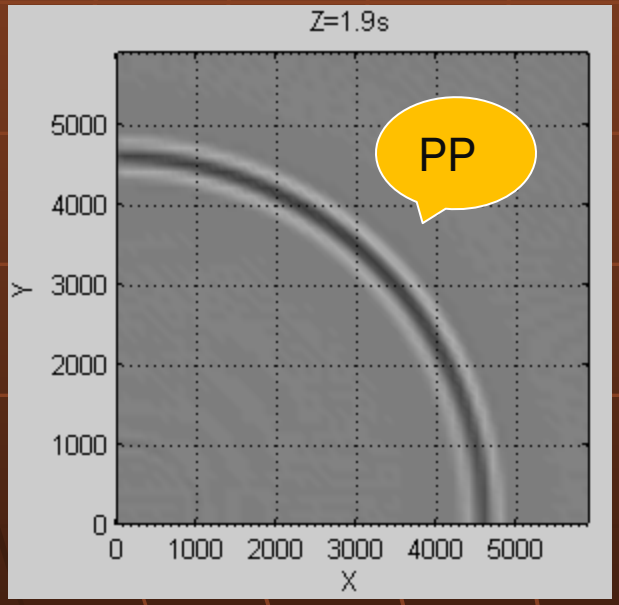
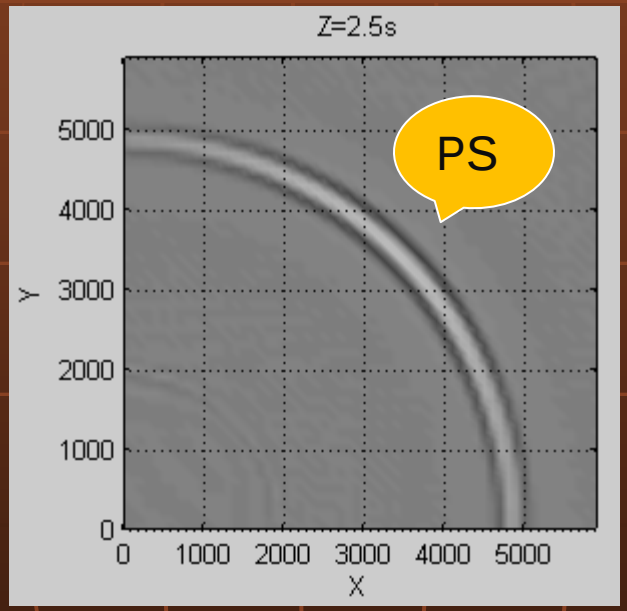
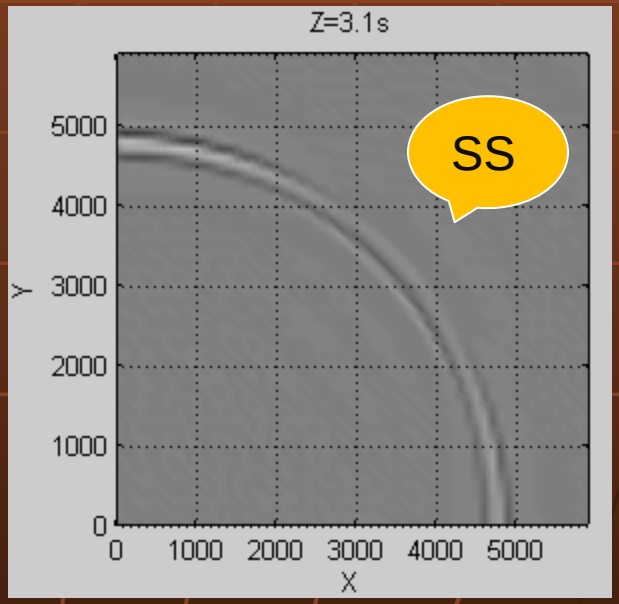


Orthorhombic - Isotropic
Z Component

Can't find a certain azimuth of largest amplitude difference







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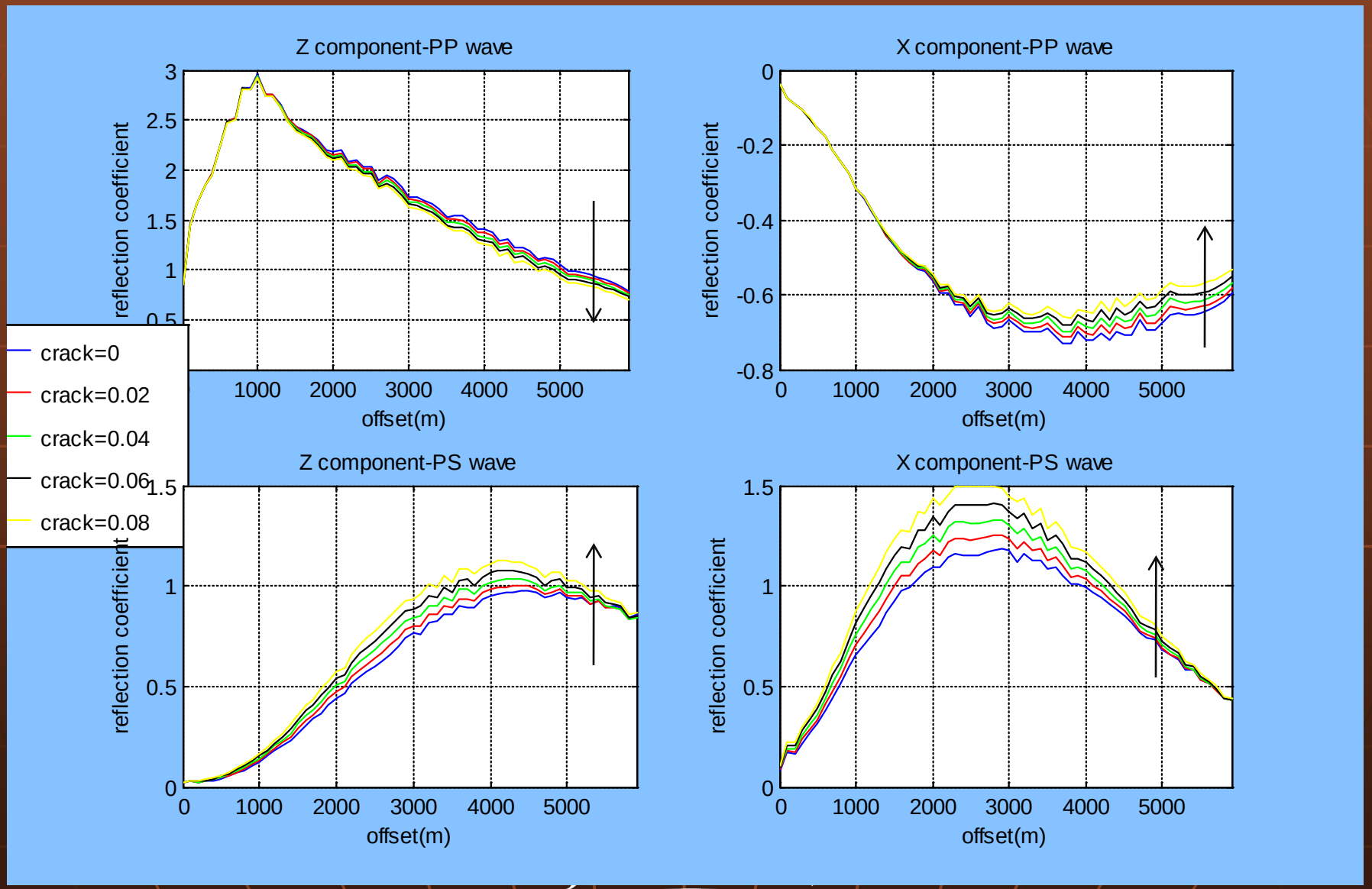
HTI-Crack Density



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Conclusions

- VTI: obvious seismic difference for PP and PS at middle to far offset compared to Isotropic model.
- HTI: obvious amplitude change with azimuth. The largest difference lies in X direction for Z component, compared to isotropic model.
- Orthorhombic: obvious amplitude change with azimuth, but cannot find a certain azimuth to characterize the largest difference for Z component

Conclusions

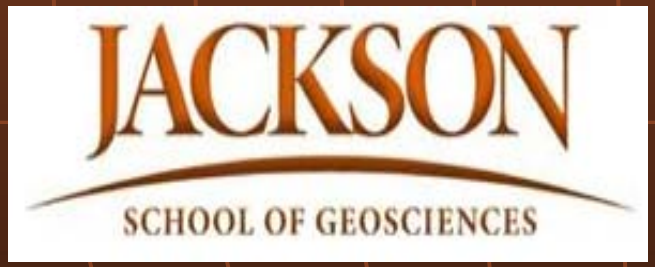
Sensitivity

- HTI: crack density might be a sensitive parameter and the most sensitive AVO changes are the PP reflection at far offset of X component and PS reflection at middle offset of X component.

Future Work

- Test the sensitivity of VTI model
- Test the sensitivity of model of different gas saturations
- Hopefully, I could get more logs and seismic to correlate them and go on with anisotropy analysis

Acknowledgement



Robert Tatham
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Steve Ruppel
Walaa Ali
Tom Hess
Samik Sil
Yi Tao

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Thank You

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