UT-AUSTIN EDGER FORUM

Observation of azimuthal anisotropy on multicomponent Atlantis node seismic data

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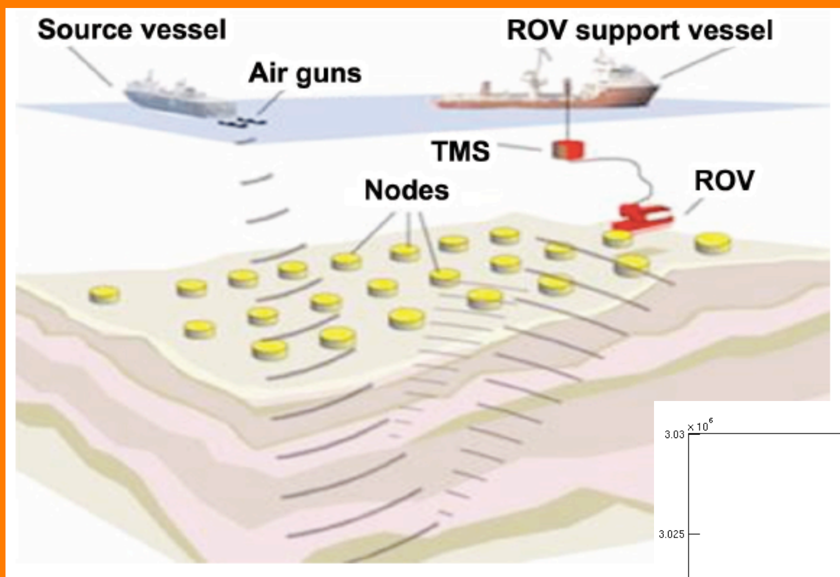
Background and Objective

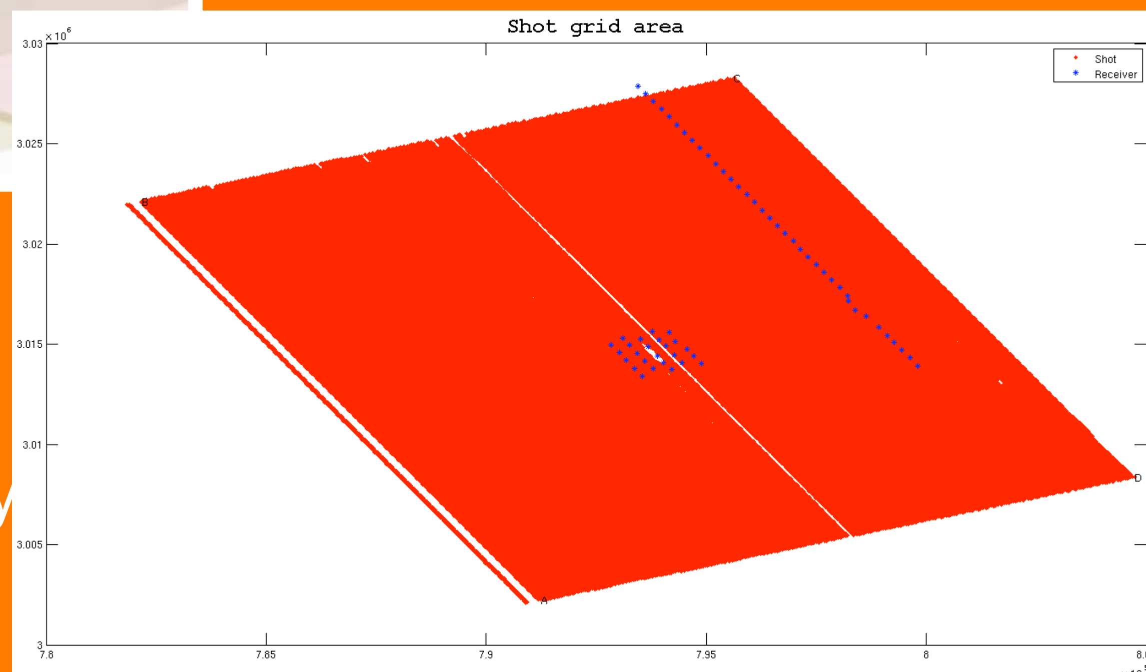
- BP and BHPB collected multicomponent node data from the Atlantis field, GOM.
- Previous forward modeling ignores near surface anisotropy in this field (Regone, 2007). To date no reports are available on anisotropy from this field.
- We investigate the presence of near surface anisotropy using this data set, which may cause an overburden effect in imaging.

Geometry of the ocean bottom node survey

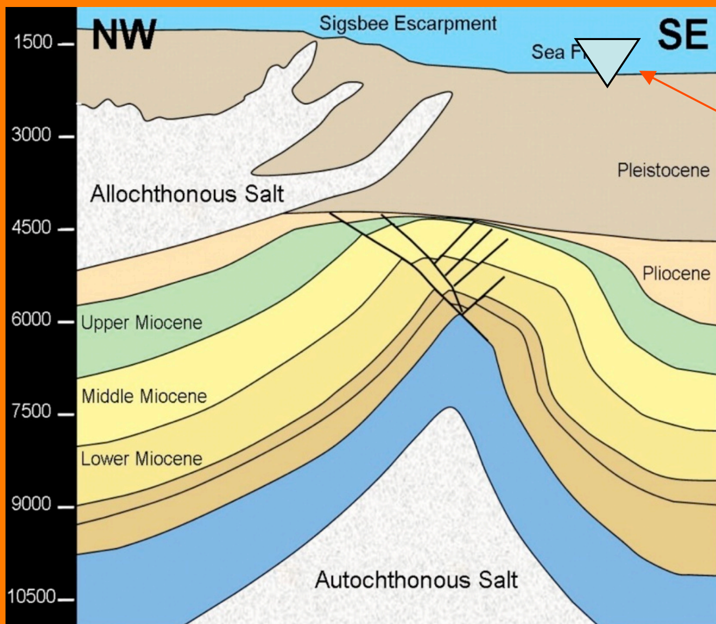


Schematic of the node and shot Positioning showing acquisition setup

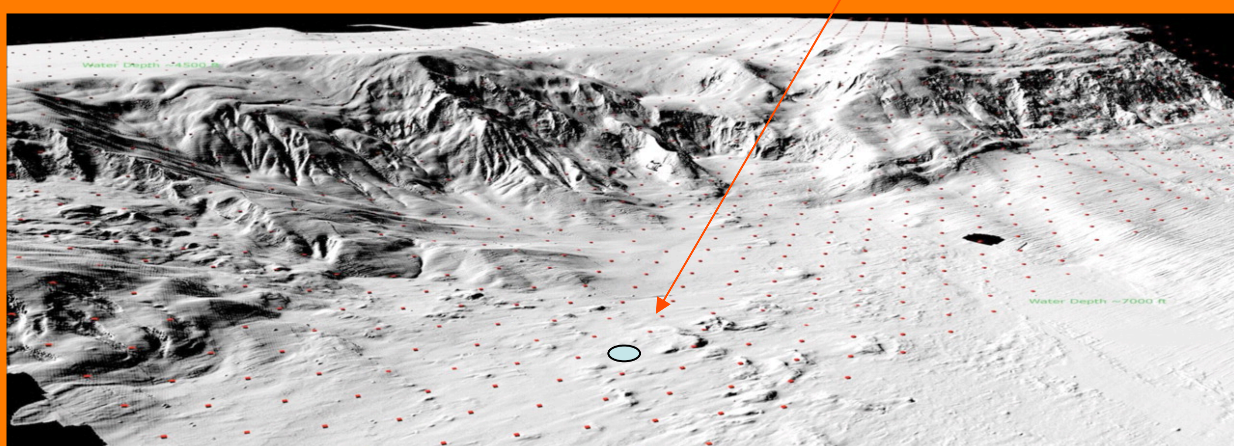
Shot and receiver co-ordinates shown in red and blue respectively



Geology and Bathymetry



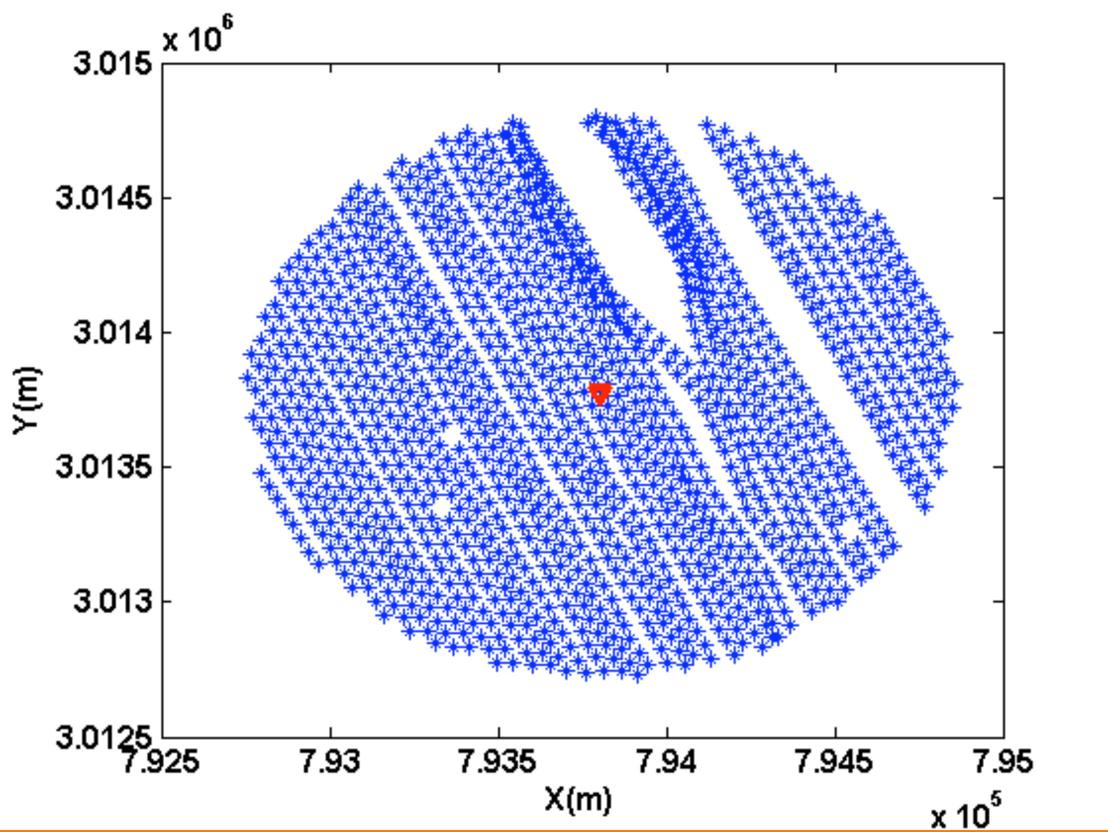
Approximate location of one of the nodes used in this study.



Some Problems

- Limited number of available nodes (25).
- High node spacing (~400 m).
- Unavailability of complete well logs.

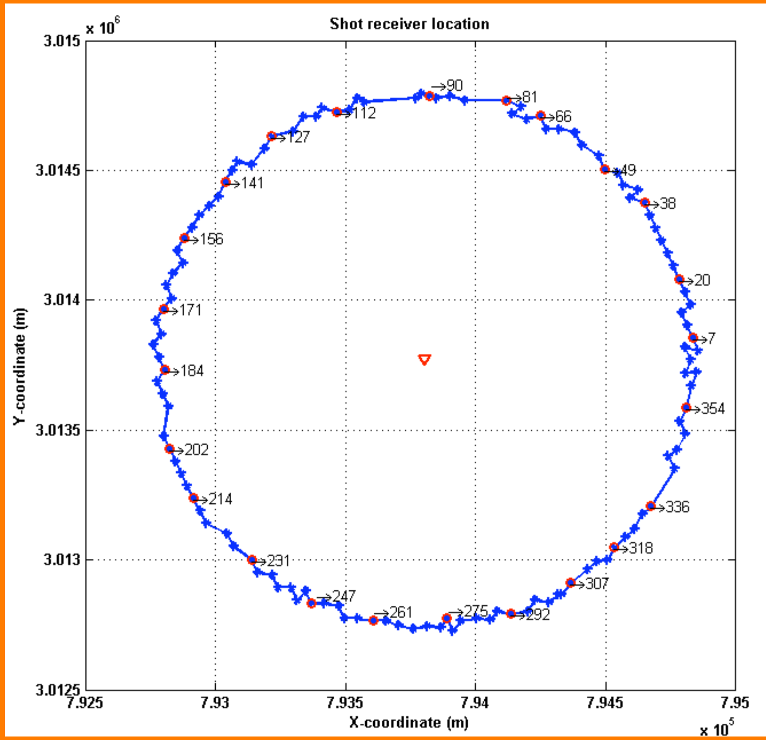
Selected area of interest



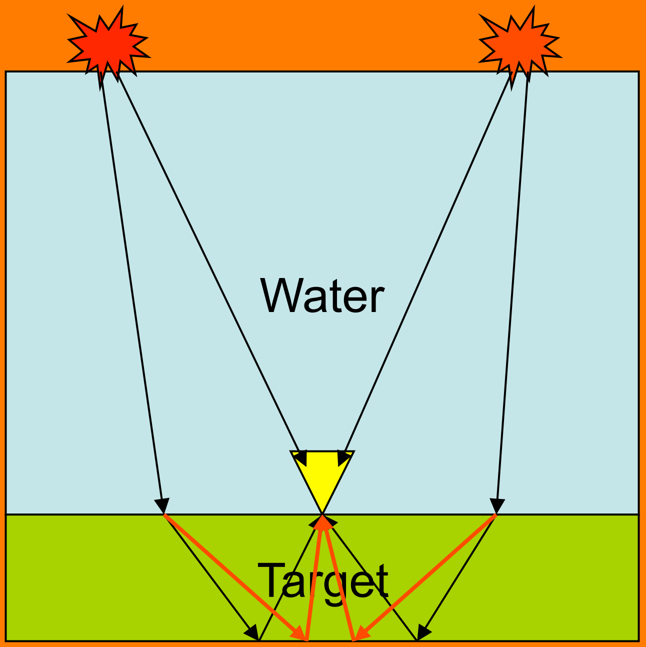
A circle is drawn around a node as an area of interest.

Radius of the circle is 1 km initially.

Derived receiver gather geometry

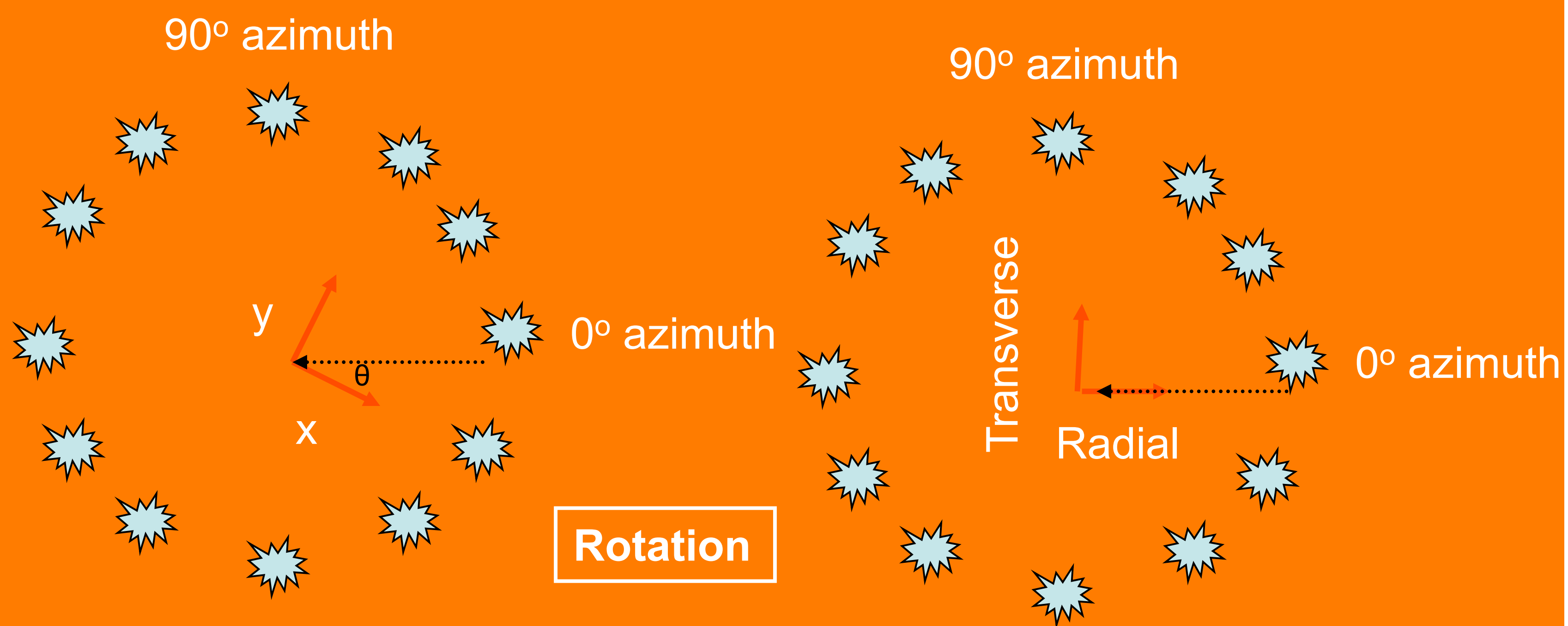


Shots at the circumference of the circle are chosen for preparing the gather.



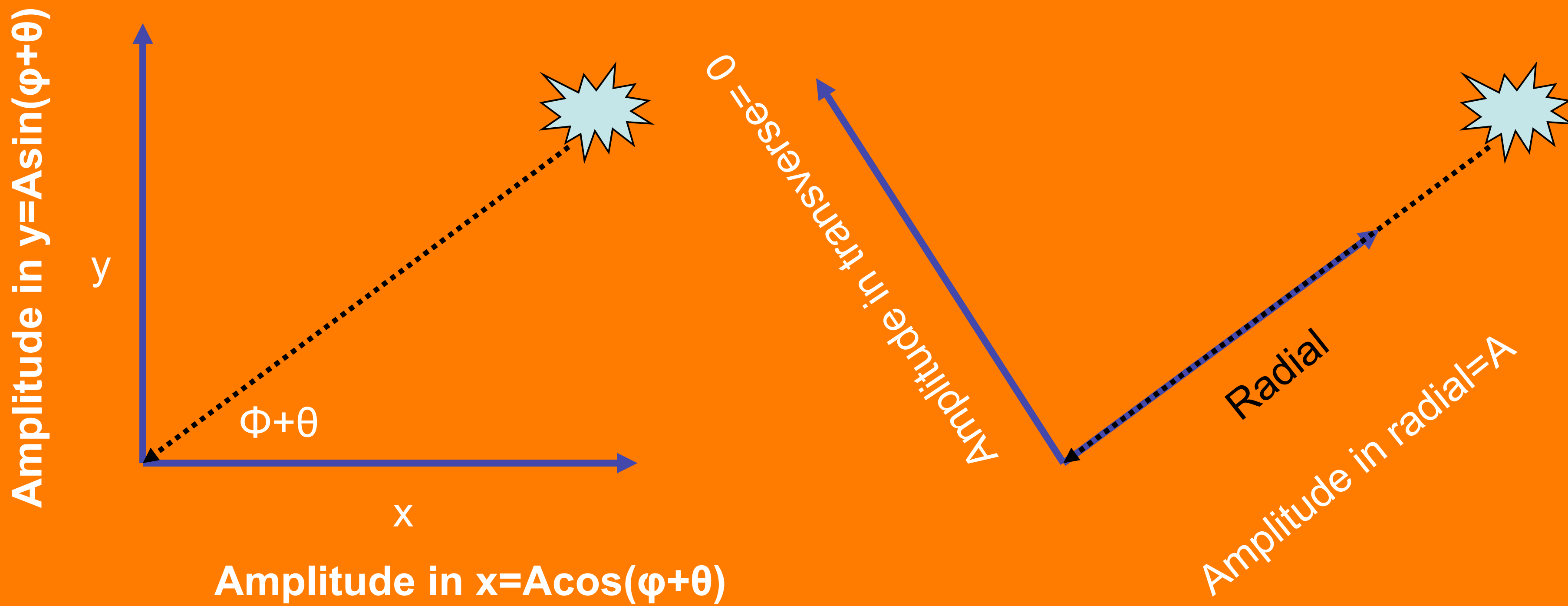
Wave Path in this geometry

Rotation of the data



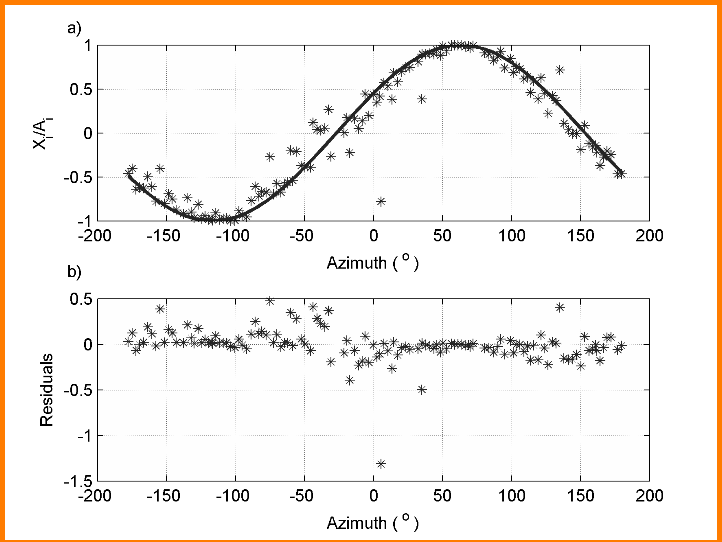
Therefore to make X and Y component Radial and transverse, we need (φ+θ) degree rotation of them.

Amplitude analysis



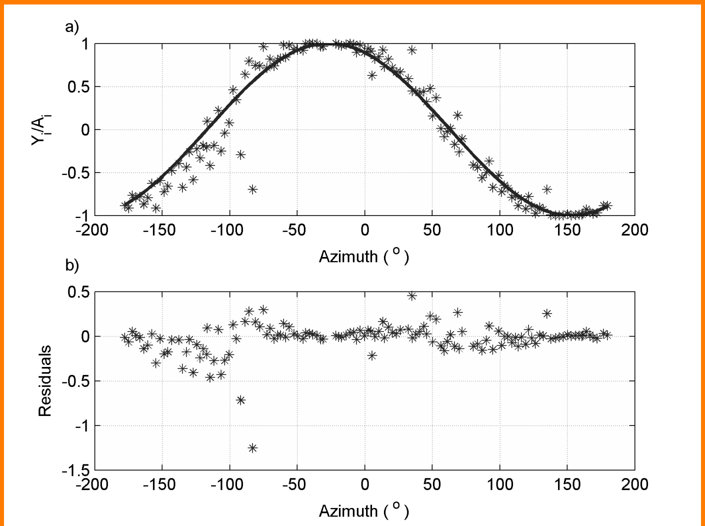
Orientation Analysis (vector fidelity)

X component analysis



$$\cos(\varphi_i + \theta) = \frac{X_i}{A_i},$$

Y component analysis

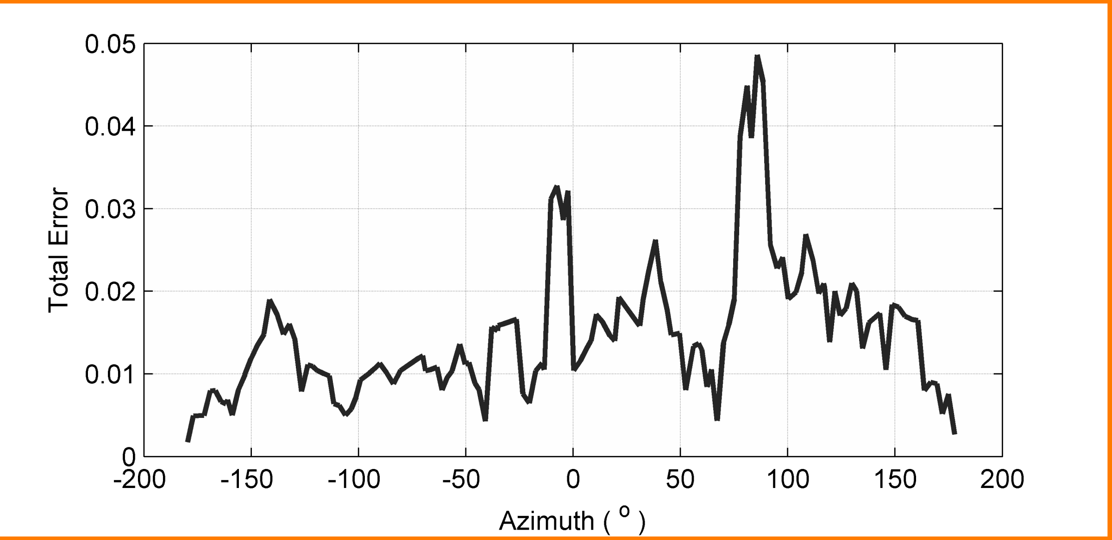


$$\sin(\varphi_i + \theta) = \frac{Y_i}{A_i}.$$

Where $A_i = \sqrt{X_i^2 + Y_i^2}$

We get θ=South 27º East

Total Residuals after rotation



Absolute value of the residuals.

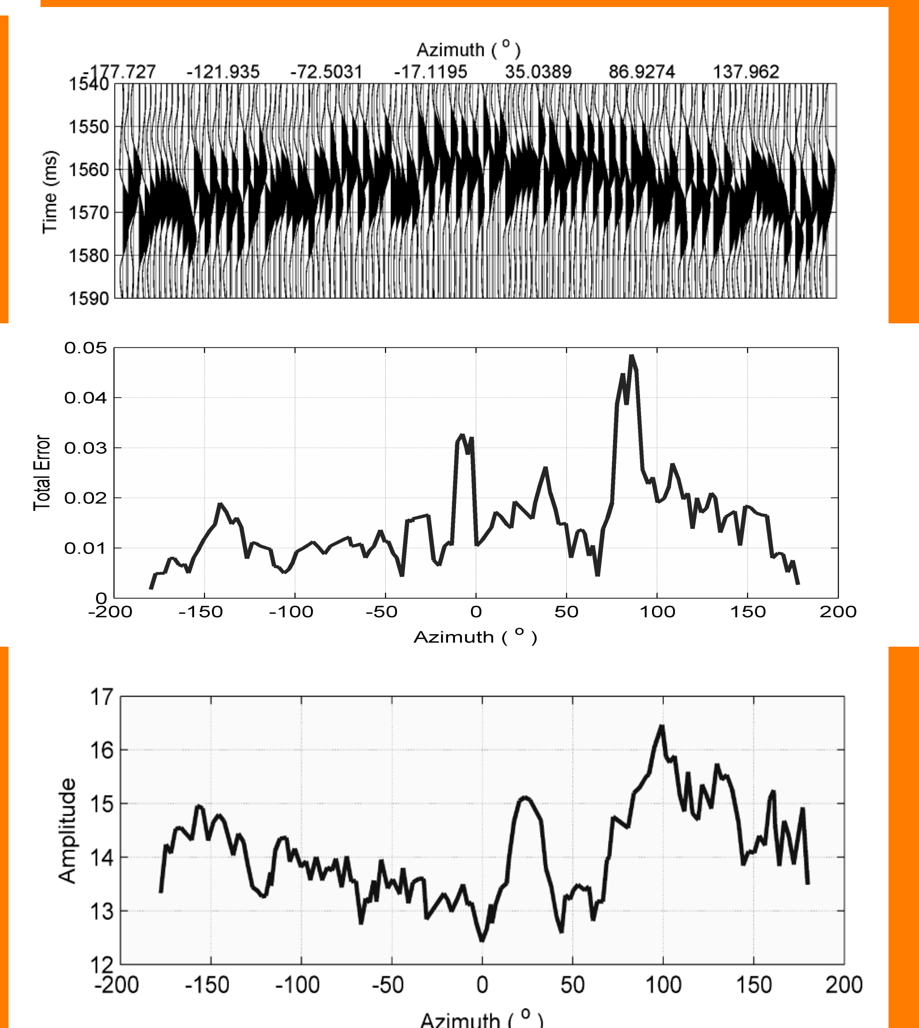
This indicates that the rotation is not perfect.

Azimuthal Gather-Direct wave

Radial

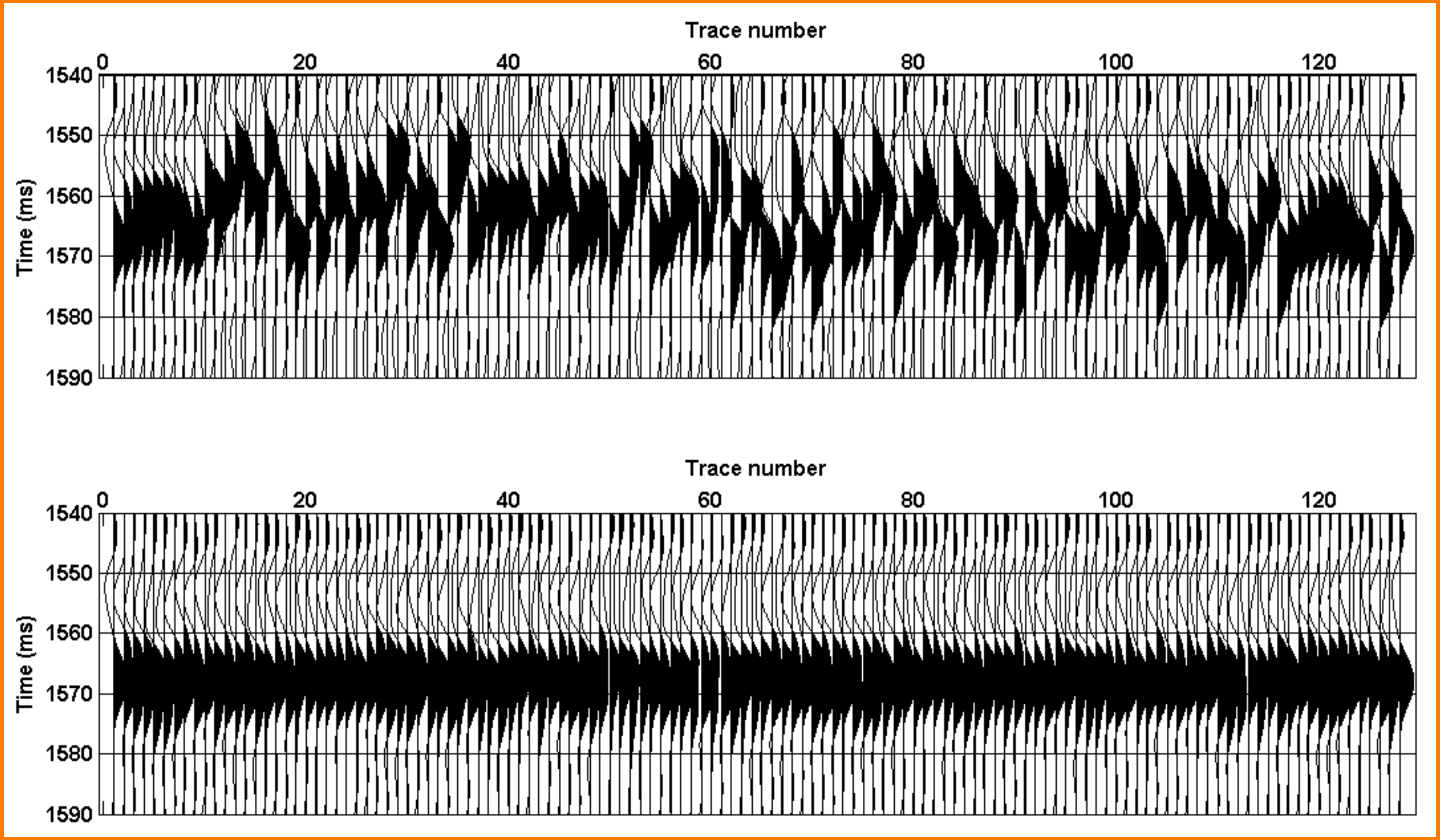
Transverse

Amplitude
with azimuth

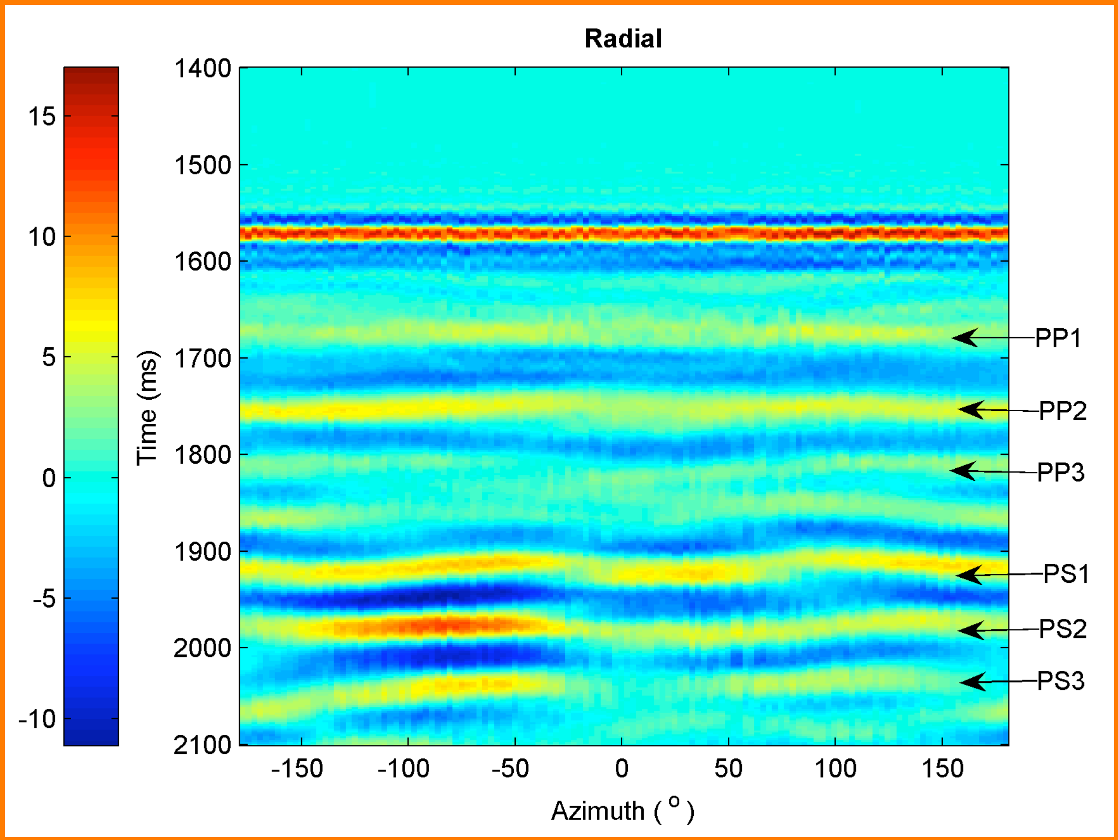


Note the bias in the amplitude distribution, which may correlate with the rotational error (previous slide)

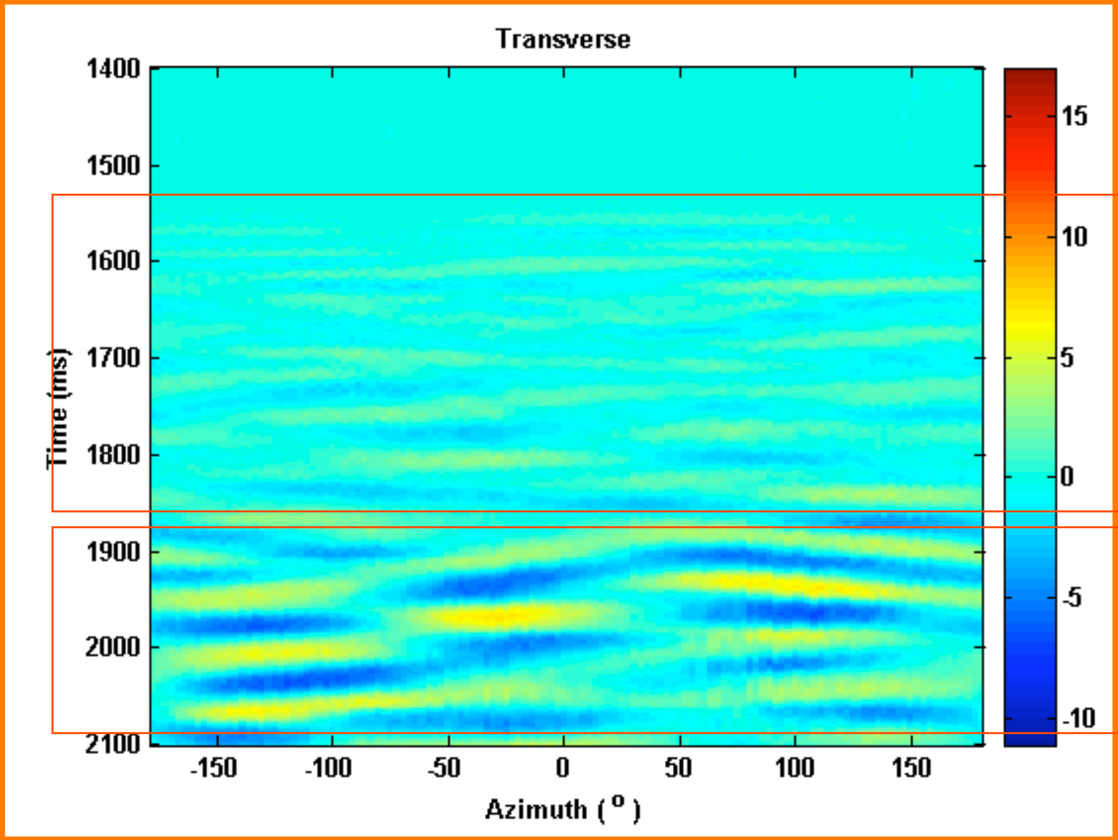
Trim-statics



Observation



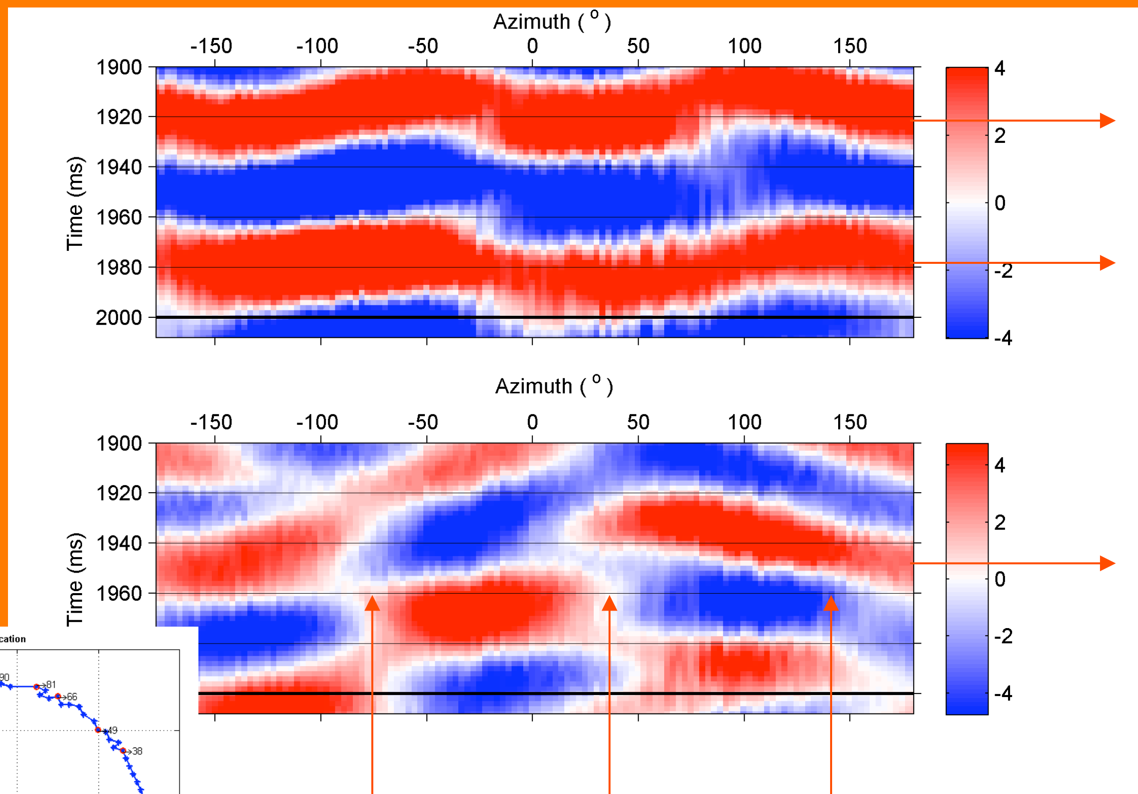
Transverses Component



~Zero P-wave energy

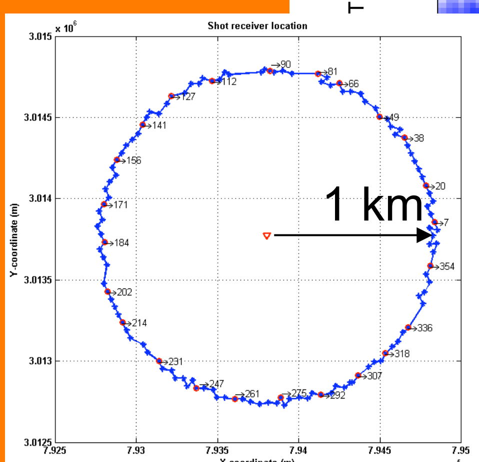
Polarity flips

Zoomed view



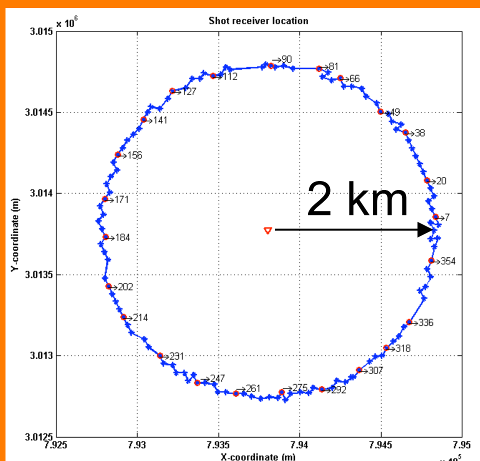
Periodic variation of the S-wave traveltime in the radial component

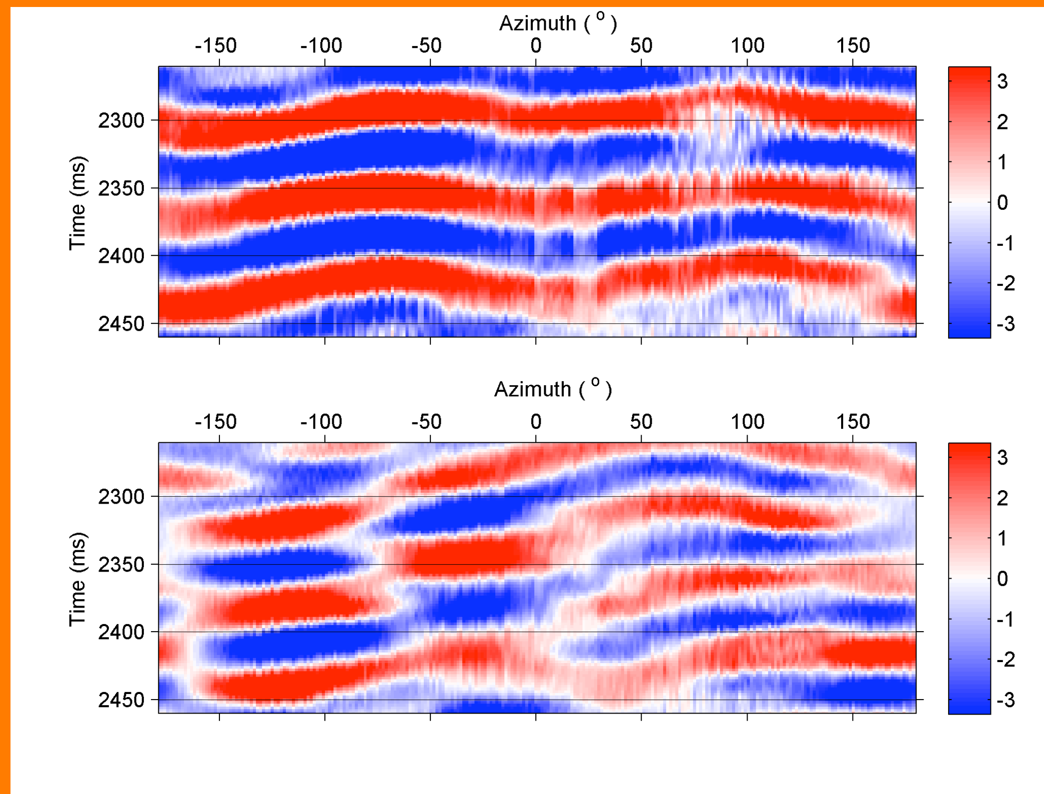
Polarity flip in transverse



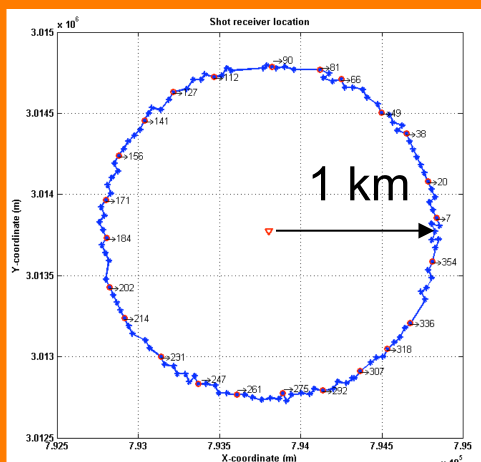
Energy null and polarity flips

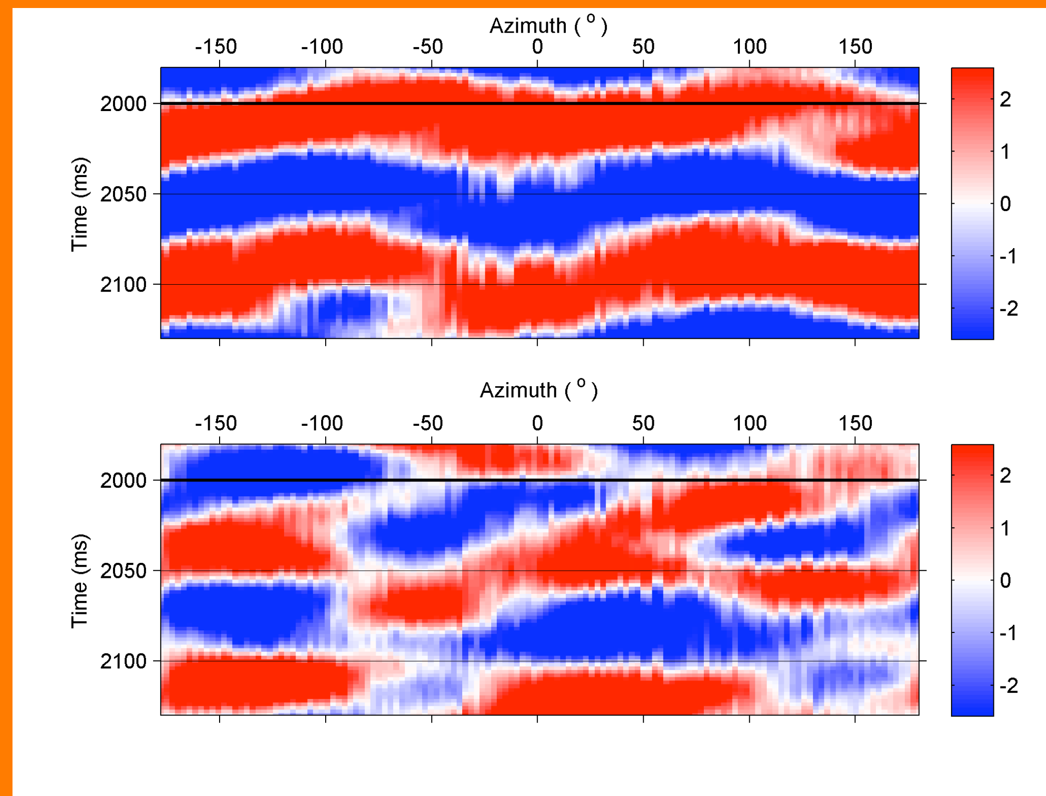
Bigger search radius (2 km)





Observation from another node

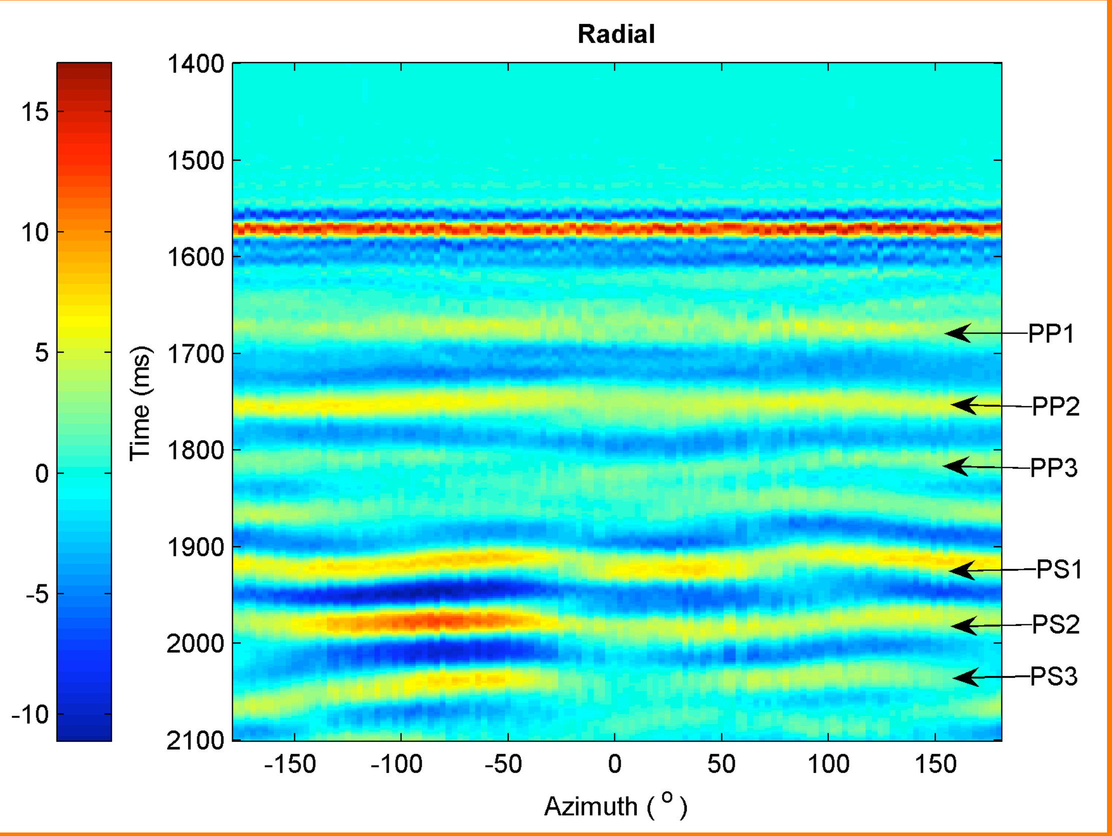




Layer parameter estimation

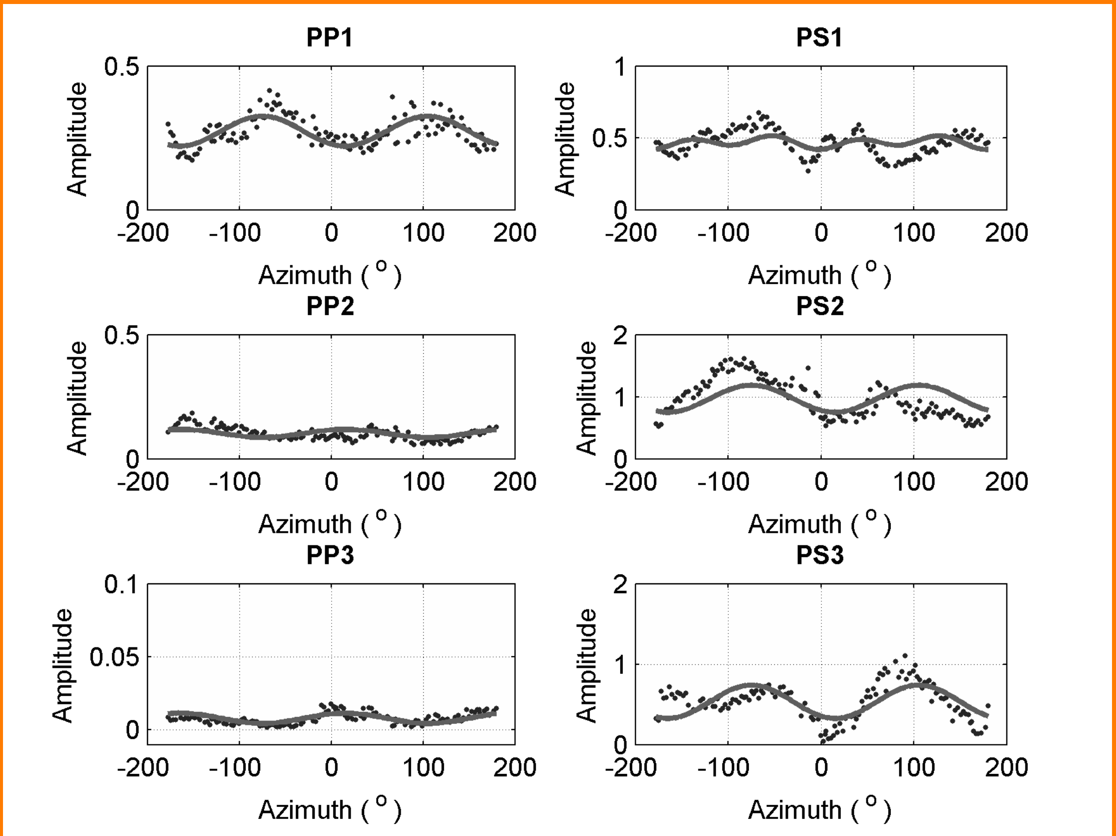
- We observed traveltime and amplitude variation due to anisotropy from the radial component in first few layers.
- Amplitude analysis (AVAZ) is performed to estimate the layer properties of those layers.
- To get interval properties, amplitude responses are corrected for overburden effect using an algorithm developed by Li (1997).

Observation in radial components



Studied layers are marked with arrows. Note the typical traveltime and amplitude variations in those layers due to anisotropy.

Amplitude variation of each event after layer stripping



Amplitude patters are fitted with a A+ Bcos2(φ-$φ_{SYM}$) function

Observation and assumptions

- We find a constant φ_{SYM} value.

- Most of the amplitude plots can be modeled with [A+ Bcos2(φ-φ_{SYM})] function.

- Therefore we believe the medium is showing HTI symmetry.

- HTI symmetry may be due to alignment of the microcracks or grain boundaries.

- Microcraks and grain boundaries are water filled.

Calculations

- For water filled microcraks or grain boundaries (or fractures):

$$B_{PP} = g\Delta T$$

$$B_{PS} = \frac{\sqrt{g}}{1+\sqrt{g}}\Delta T$$

Modified from Bakulin et al, 2000

Here g is $(V_S/V_P)^2$ and ΔT is the tangential weaknesses.

We obtain B_{PP} and B_{SS} values by curve fitting.

Therefore solving the above equations we can obtain g and ΔT

We can also show for water filled system:

$$\Delta T = \frac{-\delta^{(V)}}{2g}$$

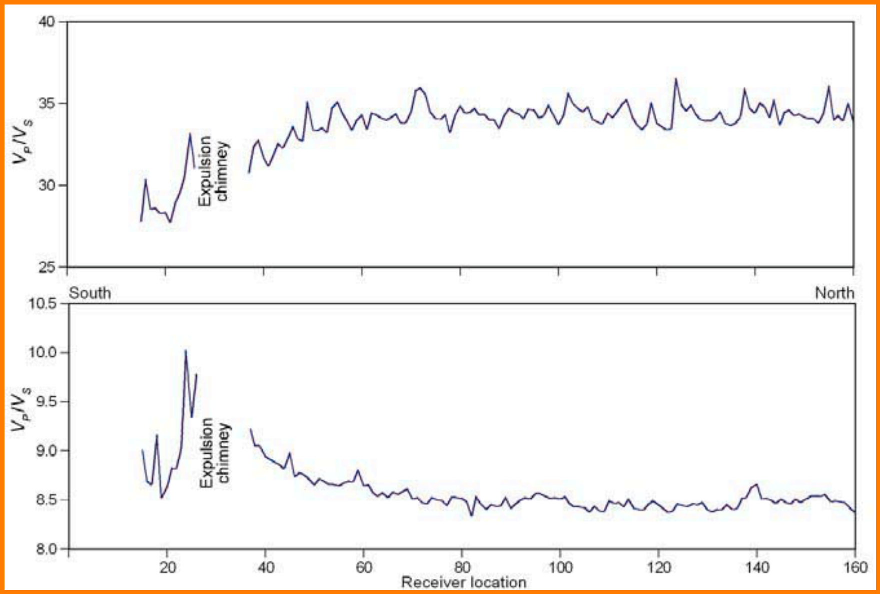
Therefore we can also find δ^V

Results from one node

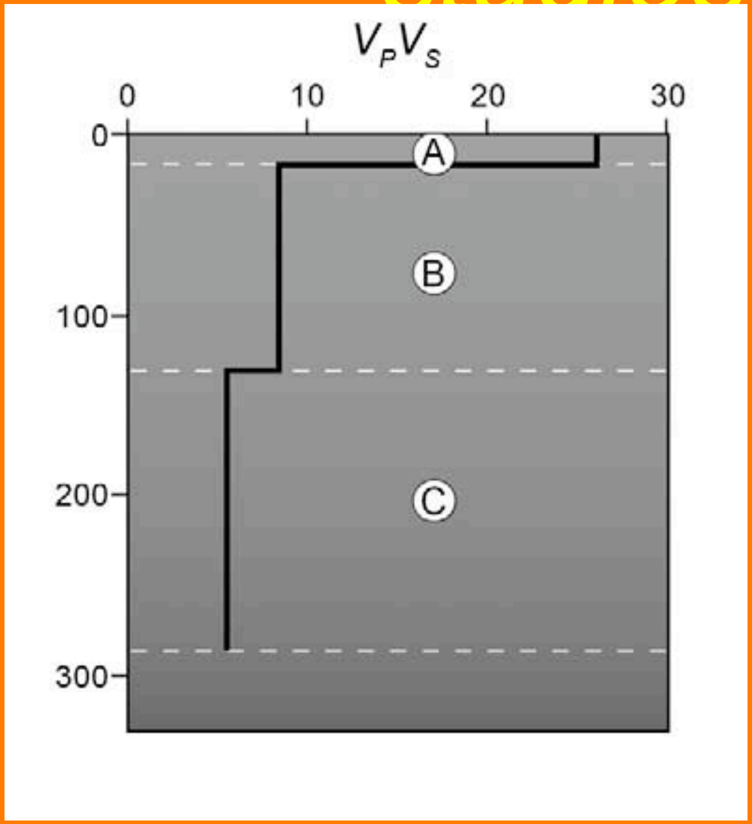
Properties	**Layer 1**	**Layer 2**	**Layer 3**
B (PP)	**-0.041**	**0.016**	**0.004**
B (PS)	**-0.082**	**0.210**	**0.101**
$\delta^{(v)}$	**0.080**	**-0.032**	**0.008**
V_P/V_S	**2.770**	**12.140**	**12.400**

Symmetry axis(φ_{SYM})= East 15º North.
Azimuth of the X axis of the receiver (θ)=South 27º East

Results from other studies



Backus et al. 2006



Hardage et al. 2007

No data is available on anisotropy analysis.

Conclusions

- Atlantis data shows the presence of azimuthal anisotropy which can be modeled using an HTI model.
- Anisotropic signatures are present in the form of S-wave splitting, P and S wave traveltime and AVO anomaly.
- Layer stripping is applied to study interval parameters.
- A nearly constant value for the strike symmetry axis is obtained from the analysis of the amplitude variation of both P and S-wave (East 15º North).
- High value of Vp/Vs is observed. Similar high values are observed by others.
- Small Vp/Vs value in the top layer could be due to wrong picking of the event.
- Moderate anisotropic parameters are obtained.

Future works for the UT students

- Traveltime anisotropy analysis is not performed.
- Even though overburden effect is taken care of to estimate the anisotropic parameters, used method is not robust.
- No physical model is generated using well log data to correlate the events.
- There are several other nodes left to perform anisotropy analysis.
- Our work identified presence of seismic anisotropy, but estimation of anisotropic parameters is not final.
- Cause of anisotropy (which may be stress induced) is not yet constrained.

Acknowledgements

- BP Houston and BHP Billiton
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