

# Full azimuth depth domain processing for seismic detection and characterization of azimuthal anisotropy of rocks

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# Geologic setting and task of the project

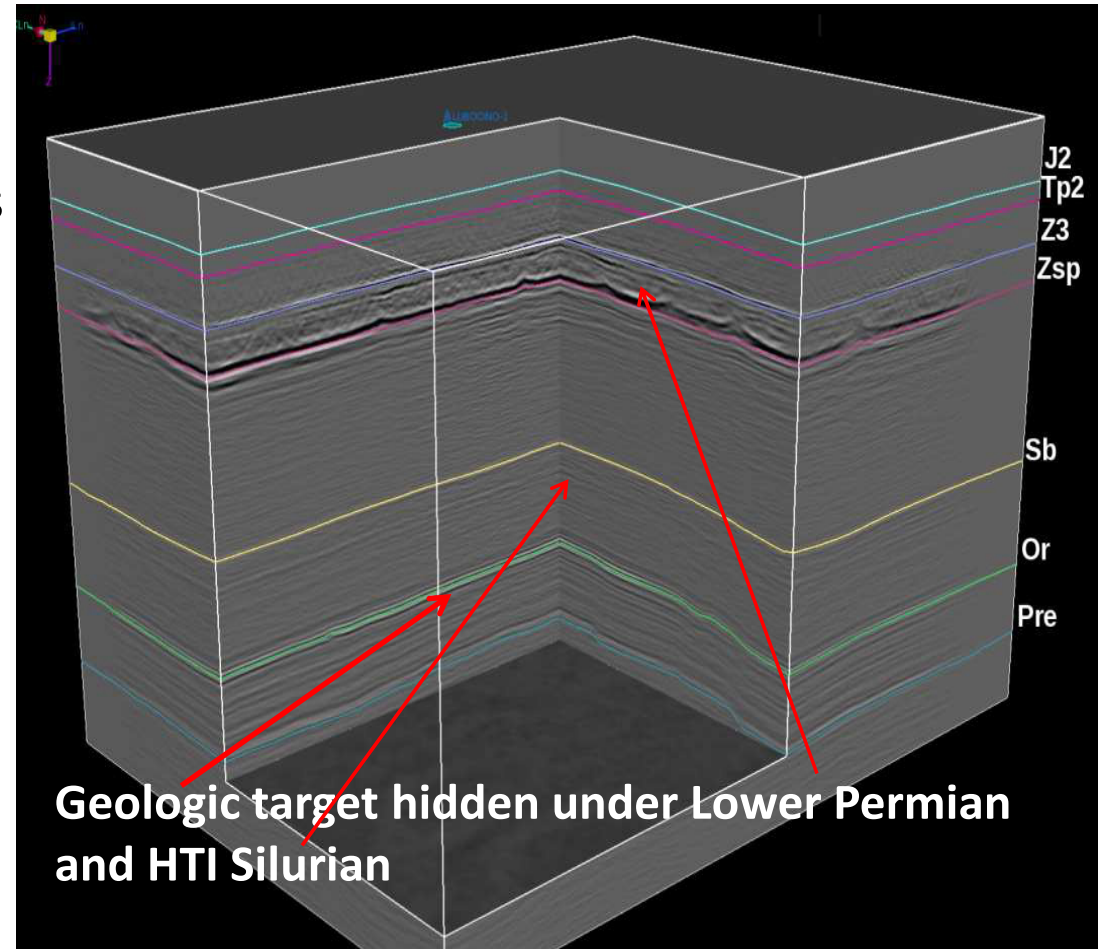
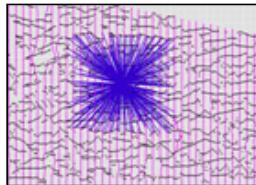
## Location of the FAZ surveys



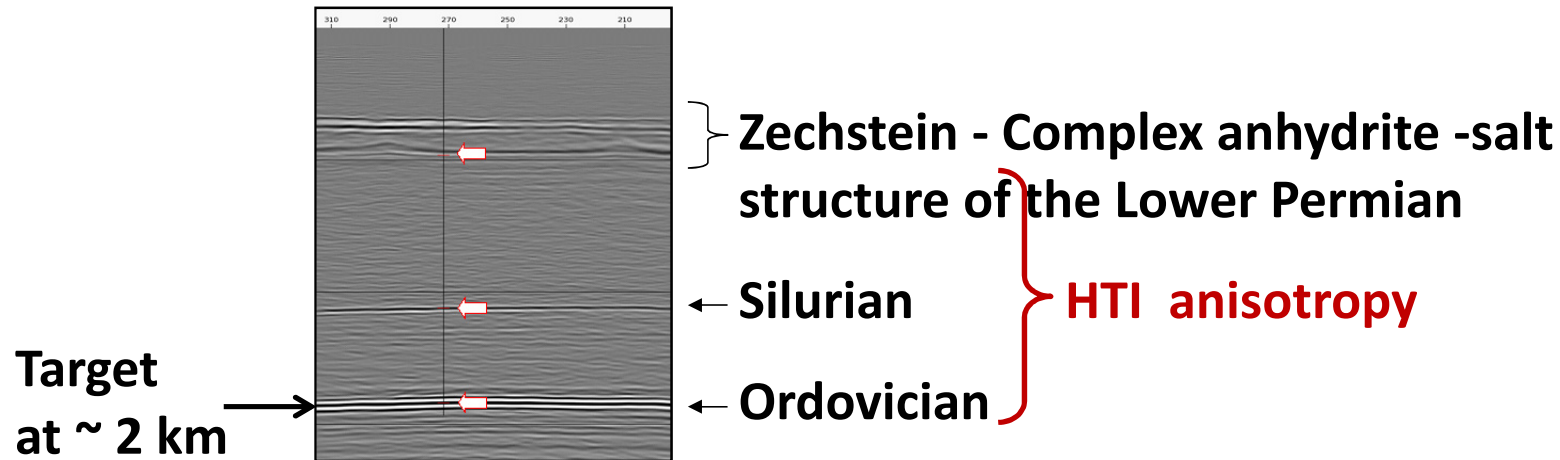
Imaging challenges

## FAZ 3D Acquisition geometry, Poland 2012

$\Delta$  sline: 280 m,  $\Delta$  SP: 40 m  
 $\Delta$  rline: 200 m,  $\Delta$  RP: 40 m  
 recording patch: 6120 m X 5800 m  
 maximum offset: 4285 m  
 bin size: 20 m X 20 m  
 CMP fold: 180  
 CMP binning area: 180 km<sup>2</sup>, imaging area: 90 km<sup>2</sup>

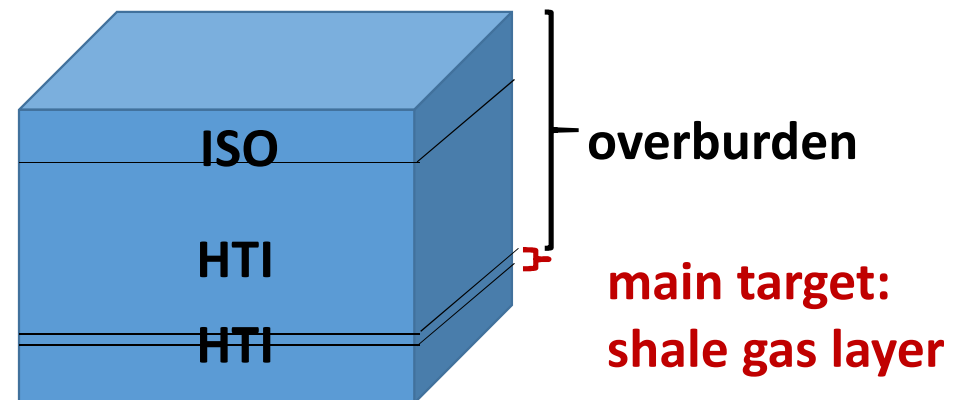
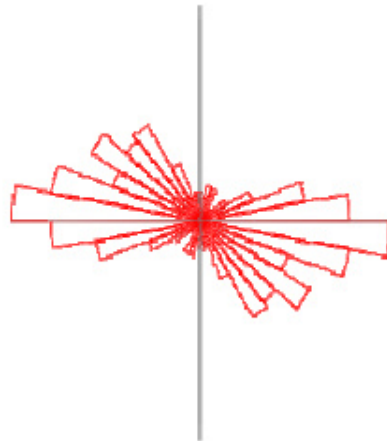


# Geologic setting and task of the project: **initial knowledge**



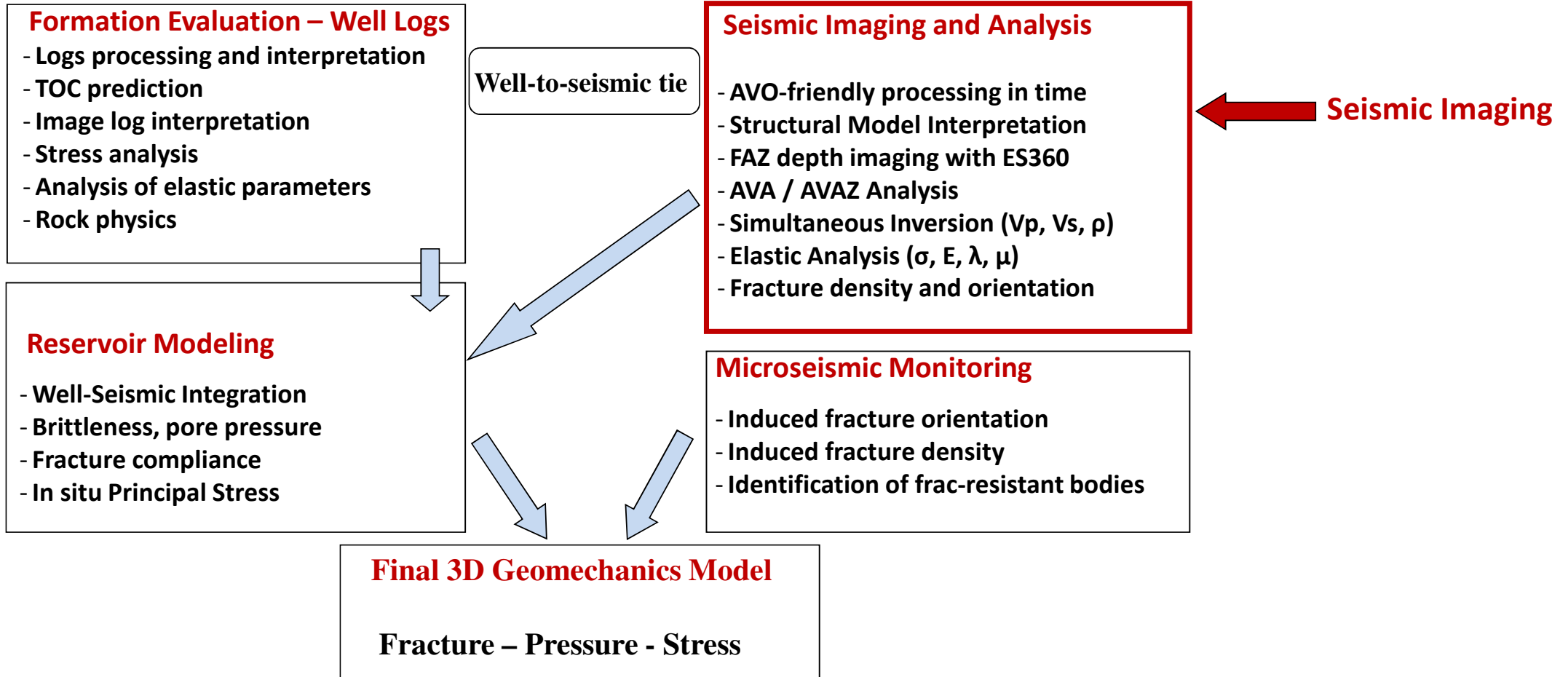
Rose diagram of HTI anisotropy from downhole measurements.

Cumulated for the entire HTI interval



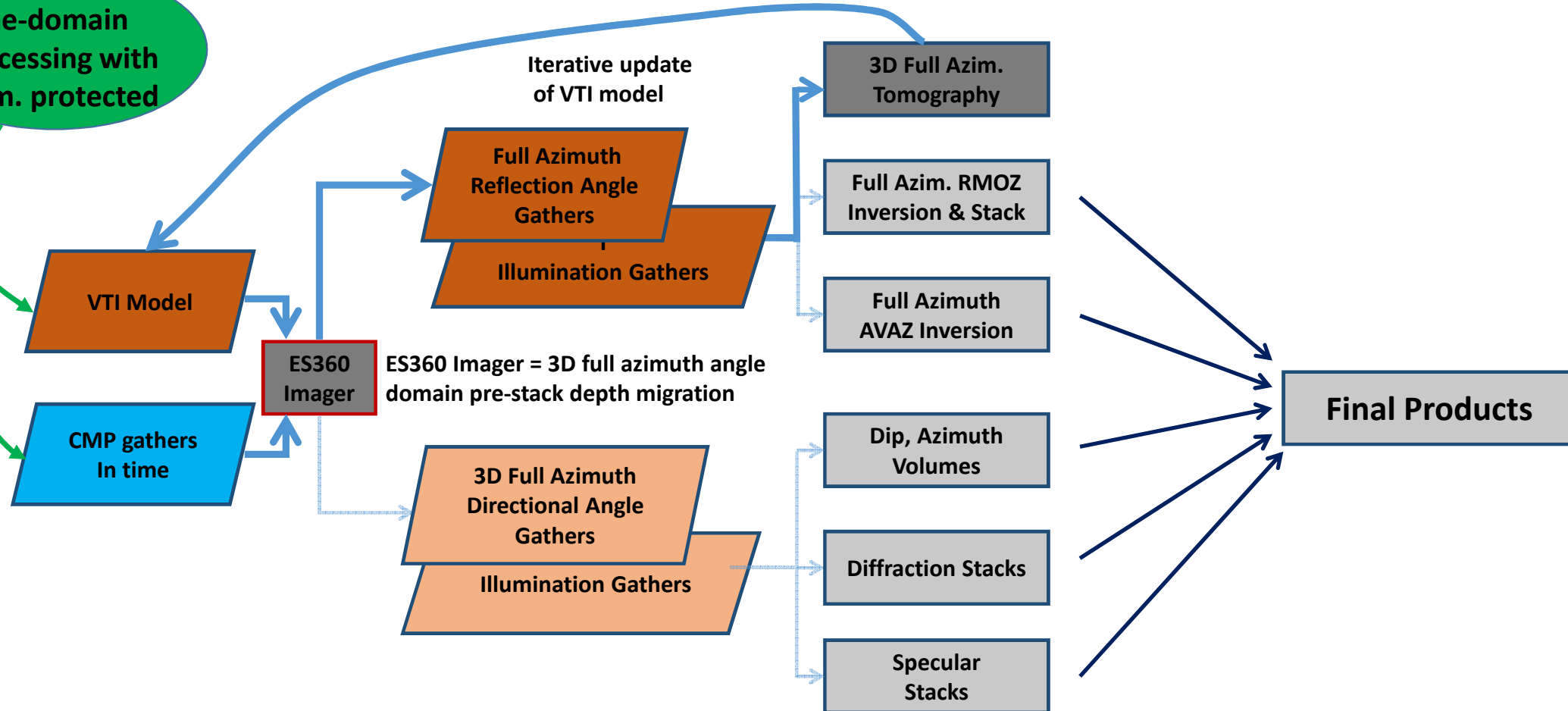


# Processing workshop: general workflow



# Processing workshop: FAZ seismic imaging workflow

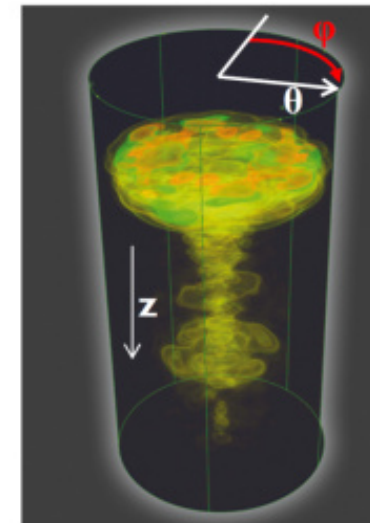
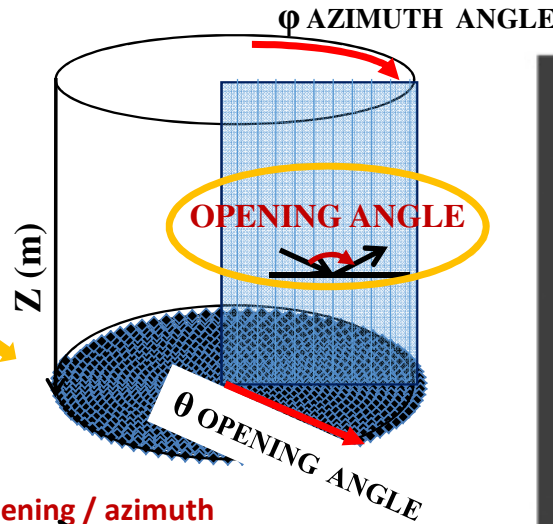
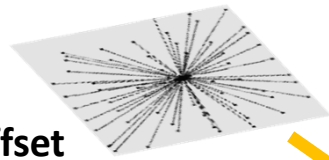
Time-domain  
processing with  
azim. protected



# Processing workshop: details of the Full Azimuth in Angle domain

## Information from 3D gathers

azimuth-offset  
distribution of the input  
CMP gather

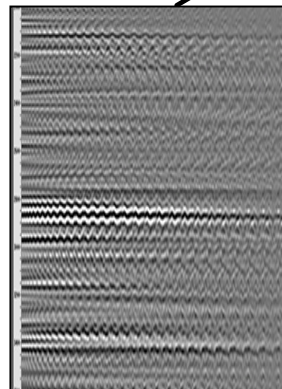
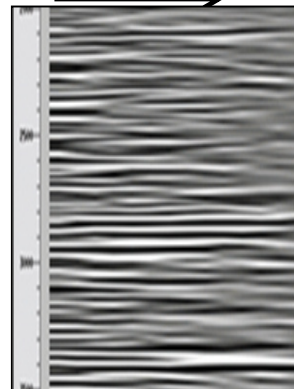
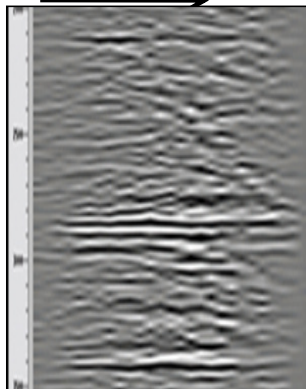


CRP gather in 3D

Offset

Angle (opening)

Angles: opening / azimuth



Kirchhoff (20 traces)

CRAM (20 traces)

ES360 Imager (3000 traces)

## ES360 – FAZ anisotropic seismic in depth-angle:

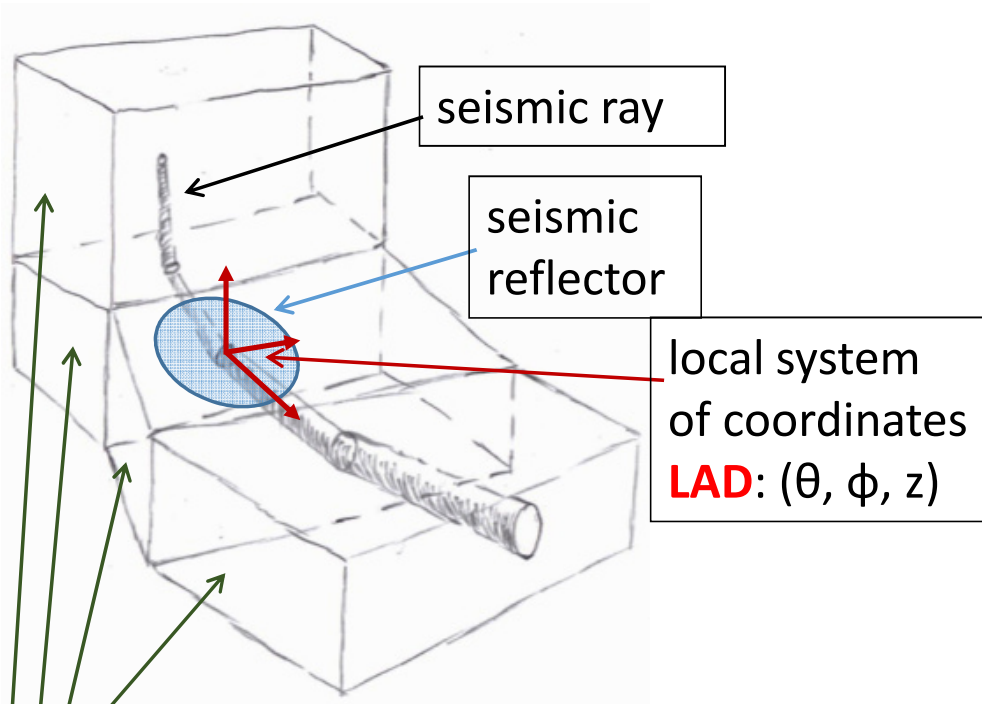
- trace interpolation in angle-depth domain
- 3D analysis of the migrated gathers
- complex-shape events can be flattened

## Processing workshop: details of the **Full Azimuth in Angle domain**

### **ES360: corrections for overburden**

built into raytracing through rock model

1. spatial trace regularization
2. correction for illumination
3. kinematic VTI / HTI flattening of events
4. non-stretch NMO
5. correction for spherical divergence
6. Q-compensation within PreSDM
7. *correction for transmission phenomena*



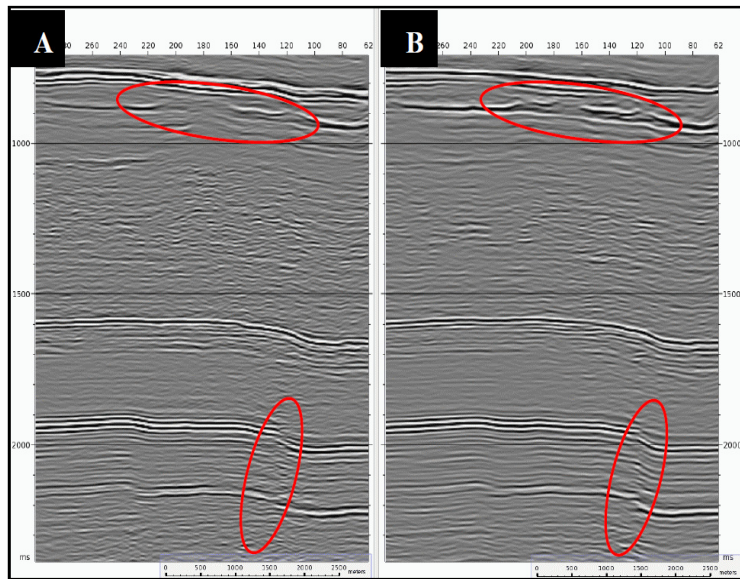
macrovoxels  
of the model

The multiattribute model enables to flatten events, and reconstruct amplitudes related to geology

# Processing workshop: **specific ray tracing** in Angle domain

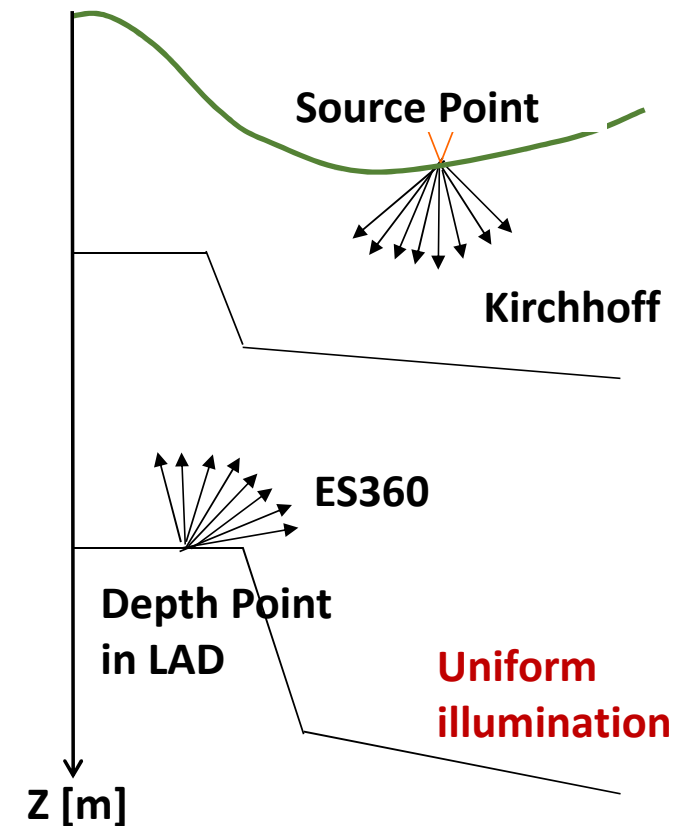
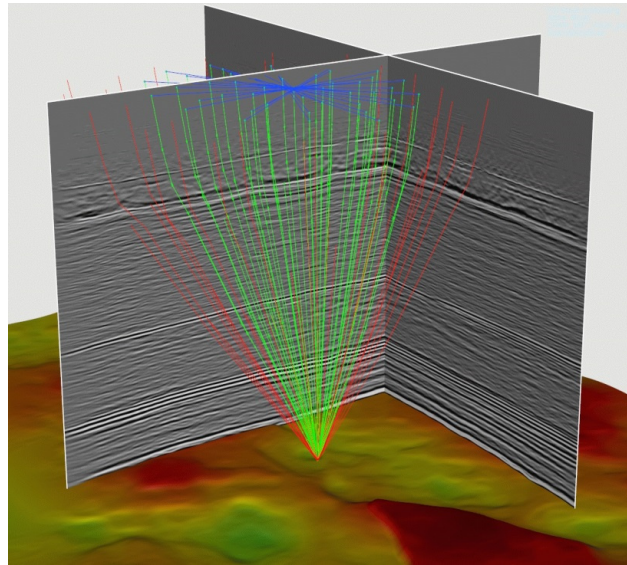
**Kirchhoff:** raytracing for individual offsets

**ES360:** raytracing for individual angle and azimuth



**A – PreSTM**

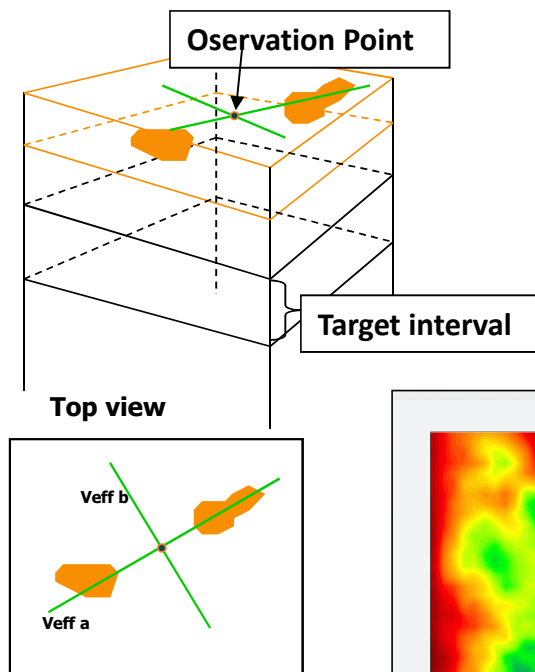
**B – PreSDM**



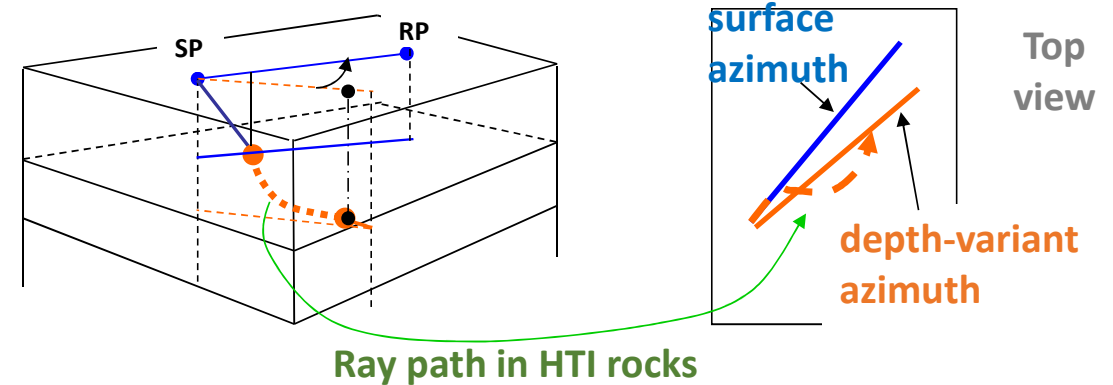


# Processing workshop: Full Azimuth Tomography for model building

## FAZ Tomo separates local bodies from HTI



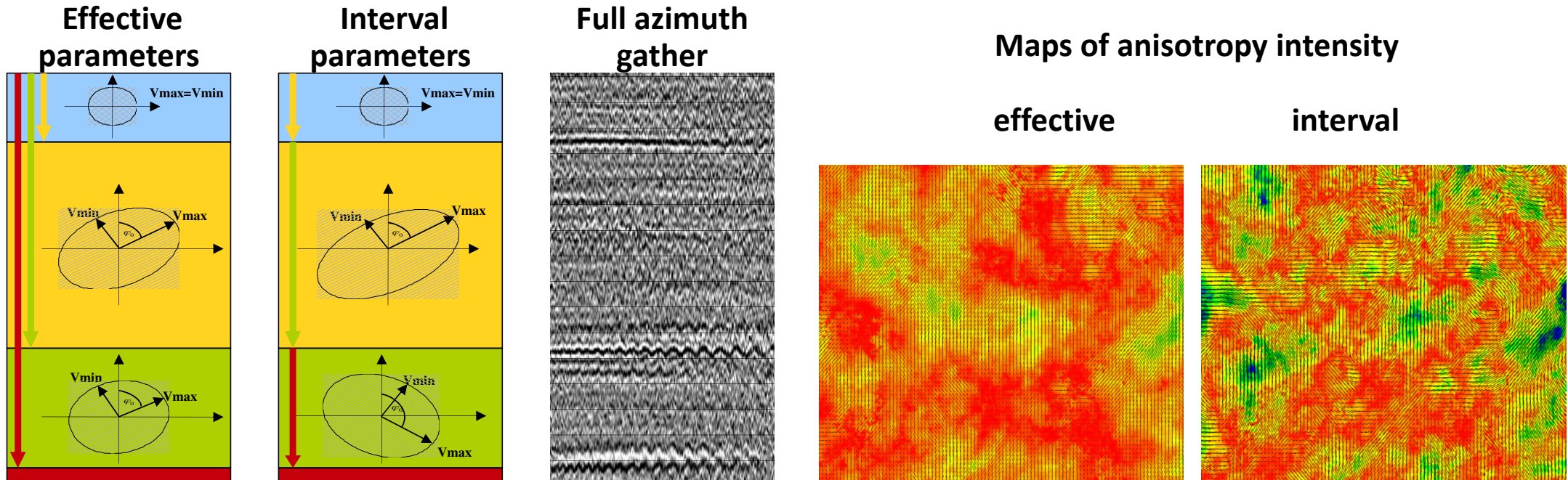
## Surface azimuth vs. Depth-Variant azimuth



To uncover geology-related geomechanical properties of the target interval, the **FAZ** model building is focused on estimation and removal (via ES360 migration) of the **overburden properties**, including isotropic model then VTI and HTI anisotropy.

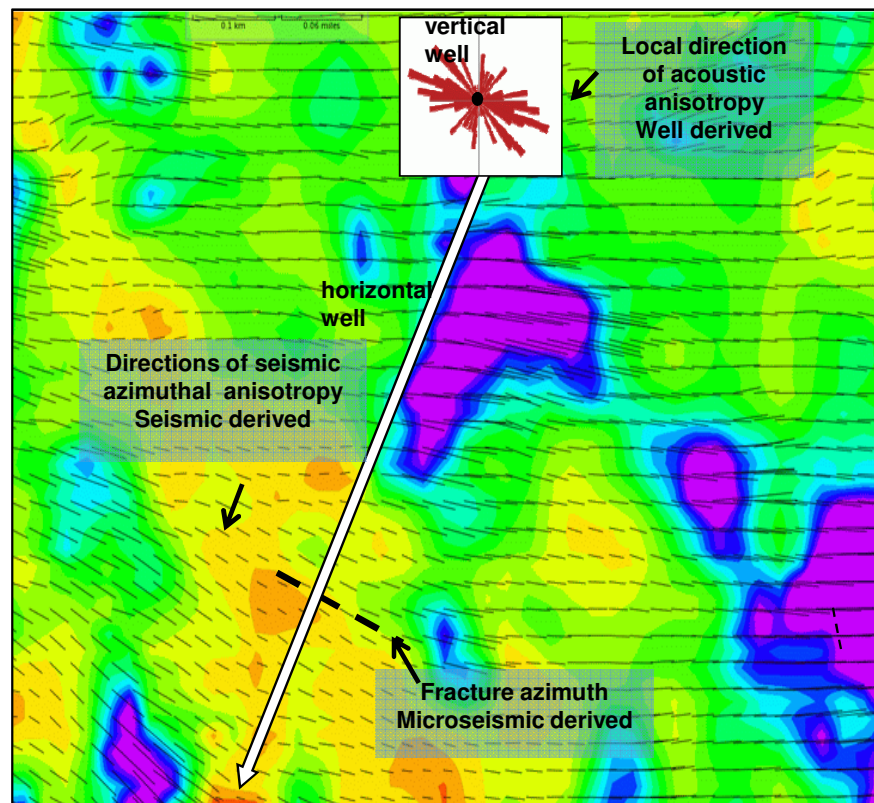


# Processing workshop: effective to interval conversion in LAD

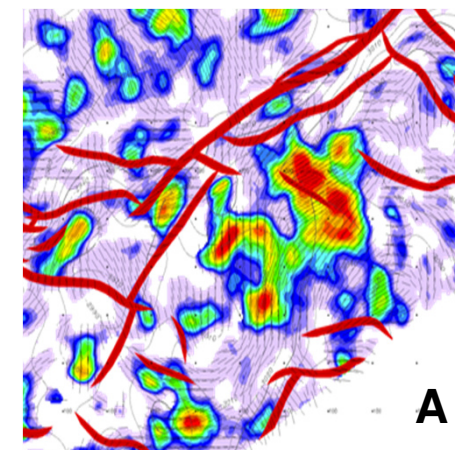
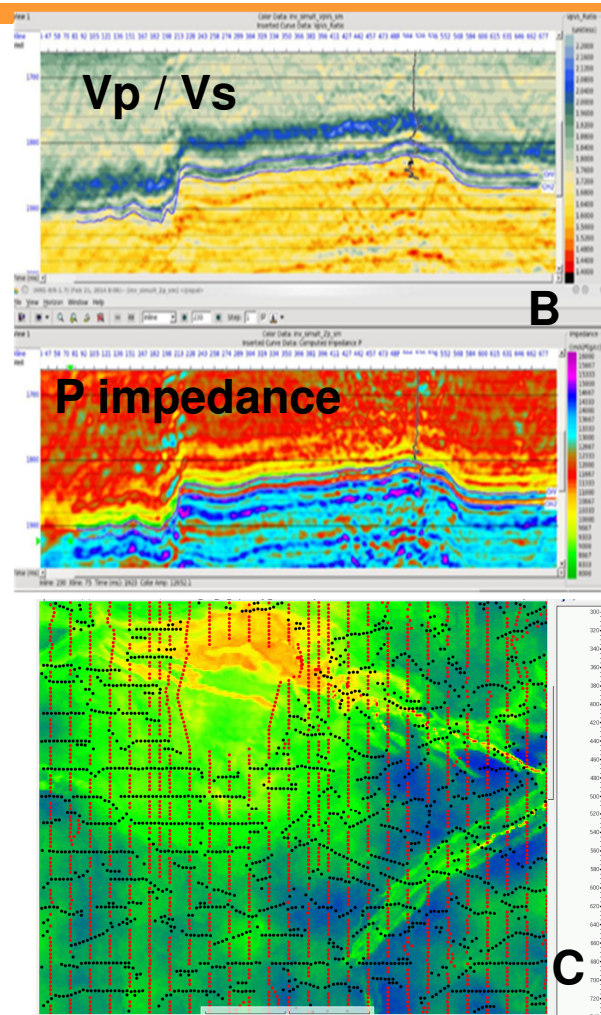


- QC: Event's flattening in migrated gathers
- Residual Moveouts are input to FAZ Tomography

# Results of the project



Composite map of the final results

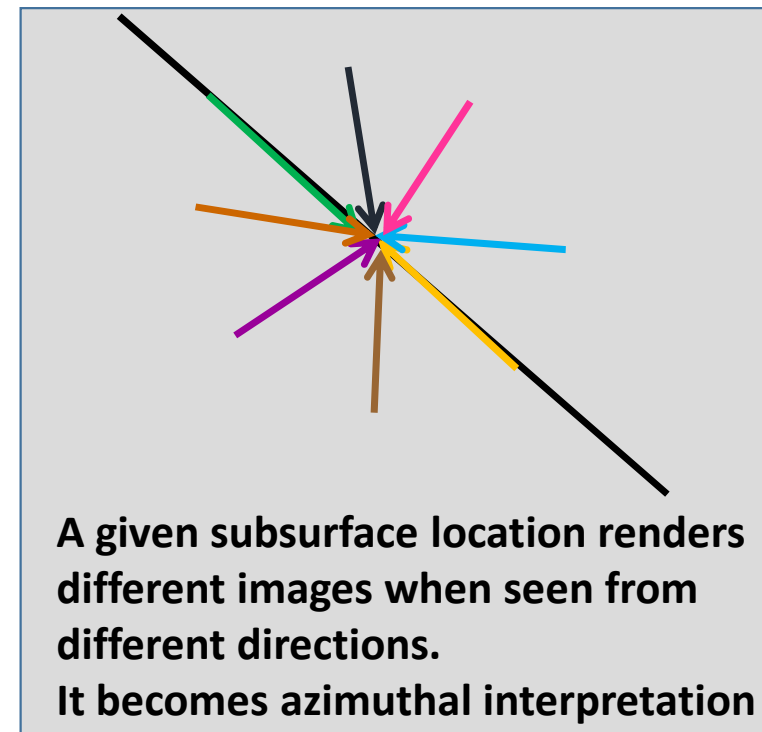
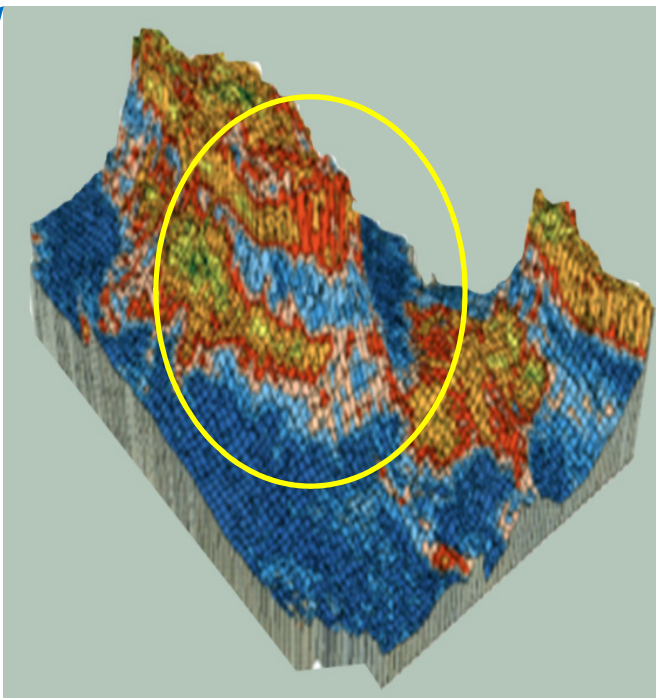
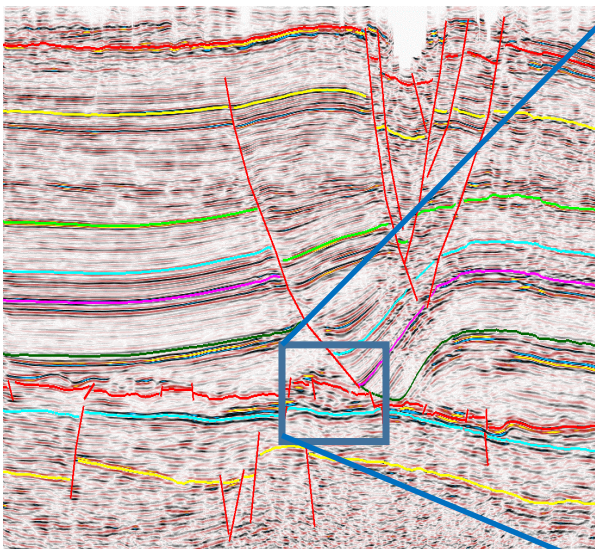


Map of azimuthal anisotropy (A) from simultaneous inversion (B). Sweet spots can be seen. C – illumination map for target horizon, real acquisition geometry. Black are source points, and red marks receivers.



## Further developments: **imaging in overthrust areas**

**Target under complex overburden**

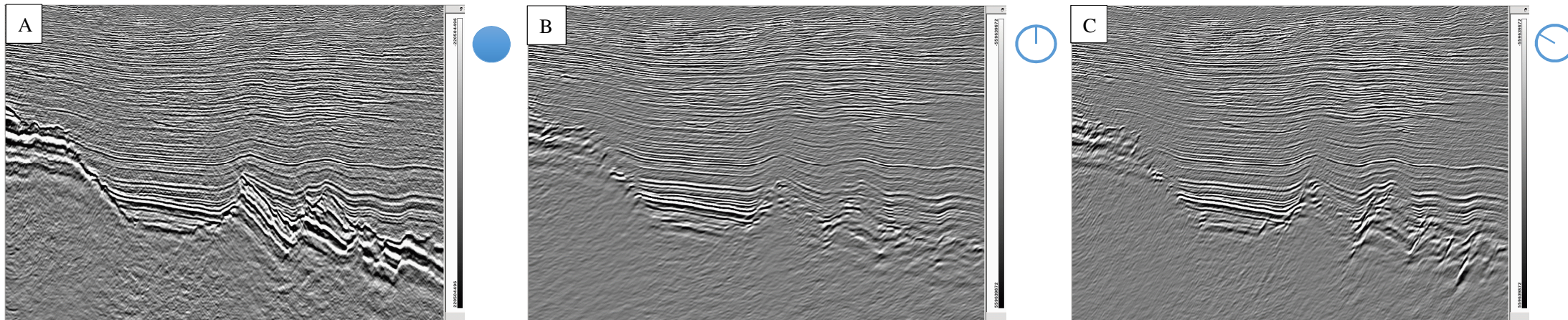


A given subsurface location renders different images when seen from different directions.  
It becomes azimuthal interpretation

## Further developments: **imaging in overthrust areas**

### 1. Dedicated FAZ migration for a given line + **on-the-fly-sectorized** interpretation

Recent practice reveals that mixed azimuthal components of 3D can degrade image of geology



2. Inverse Q built-into ES360
3. Improvements in shallow model building at the initial stage
4. Upgrades in reconstruction of geology-related amplitude.



## Conclusions

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- **characteristics of shale plays vary laterally and with angles – advanced software needed**
- **FAZ seismic predictions are compatible with borehole measurements**
- **estimated relationships between core data, well logs, and full-azimuth seismic provide good input to reservoir modeling**
- **rich-azimuth seismic technology brings added value also to prospection for conventional resources when geology is complicated, e.g. in thrust areas**
- **3D seismic with FAZ technology brought breakthrough in imaging subsurface**



## Acknowledgements

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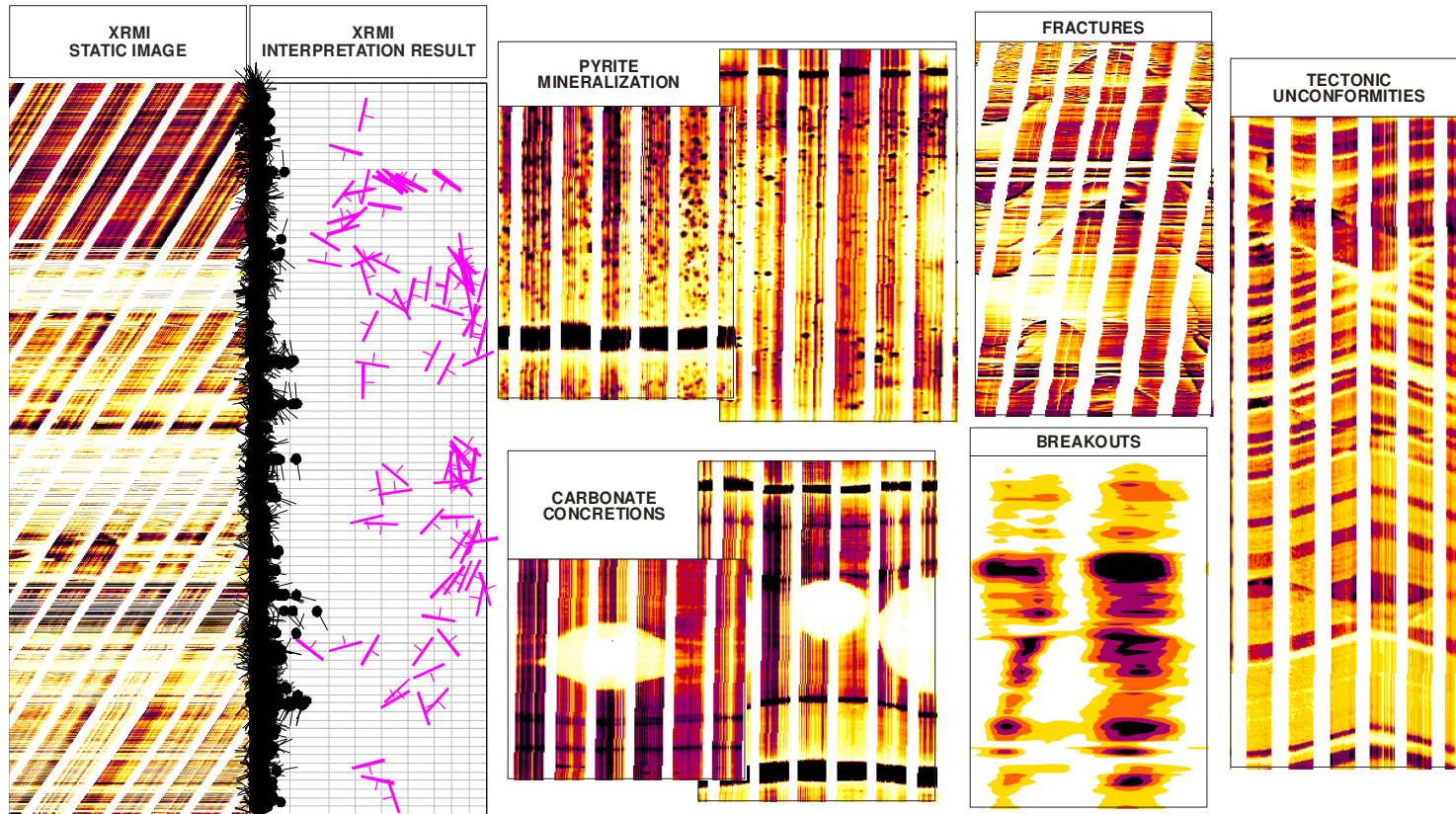
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[www.gtsservices.pl](http://www.gtsservices.pl)



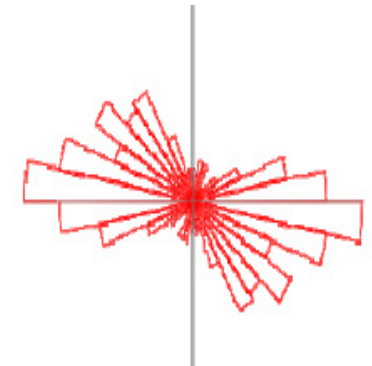


# Formation evaluation



Sample direct images of fractures recorded with XRFI imager

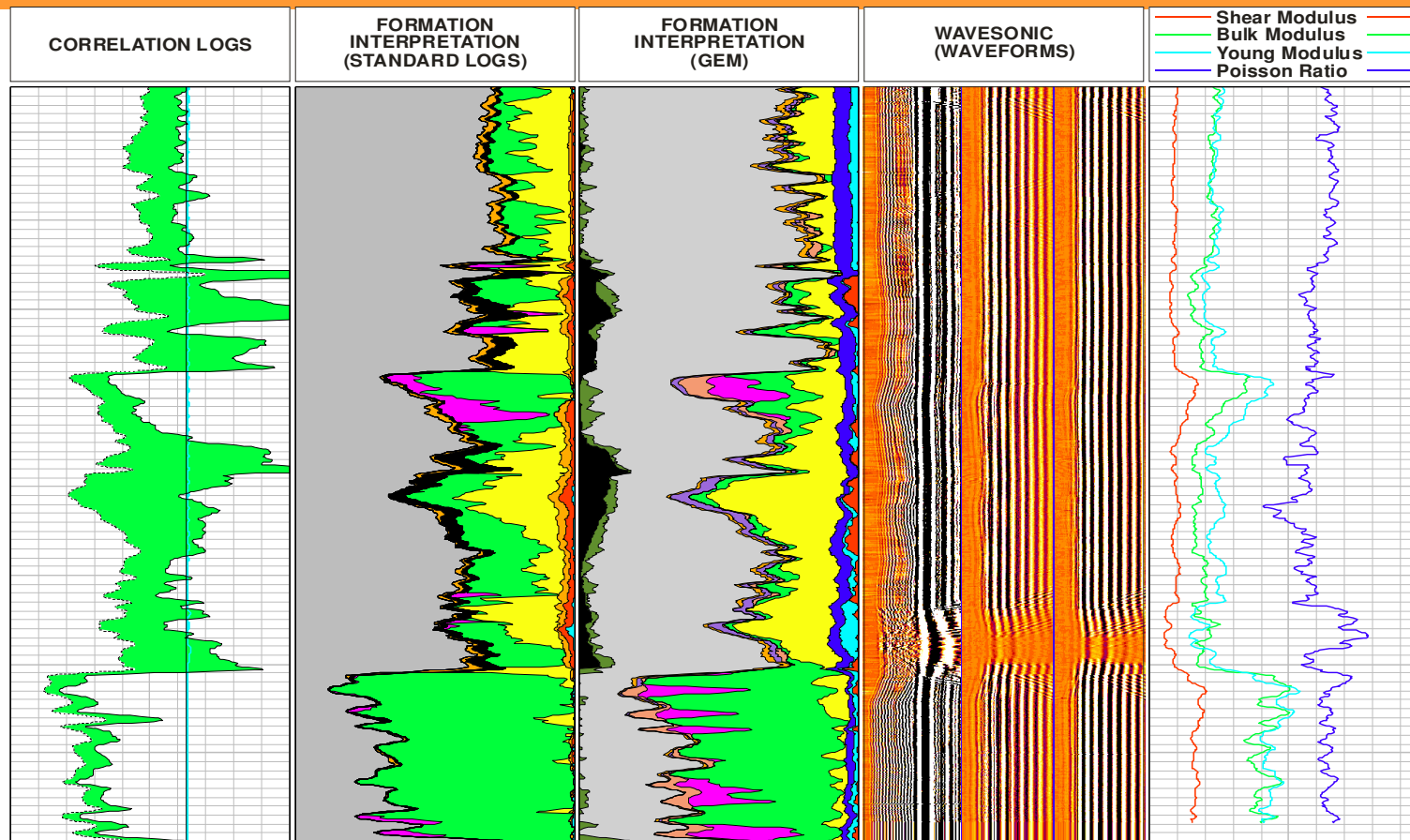
Slice of core with natural fractures



Acoustic anisotropy



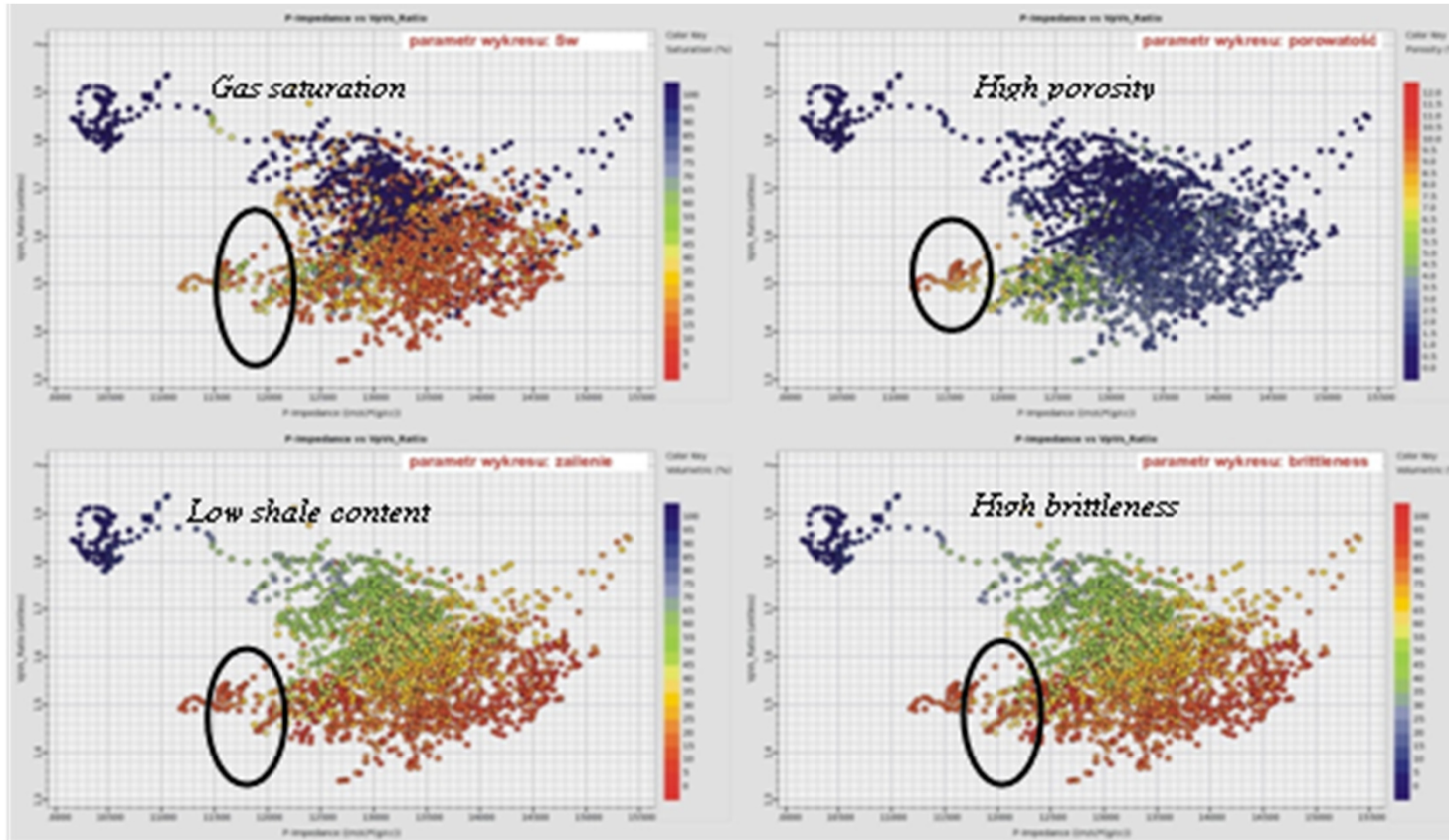
# Formation evaluation



Sample of the final results of litho-facial analysis based on standard GEM tool measurements ( 3 left panels), and from cross-dipole sonic tool (2 right panels)



# Seismic Interpretation



**Cross-plots of seismic-derived geomechanical parameters with well log data provide assessment of elastic properties**