

# Role of Anisotropic Methods in Characterization of Tight Gas Sands

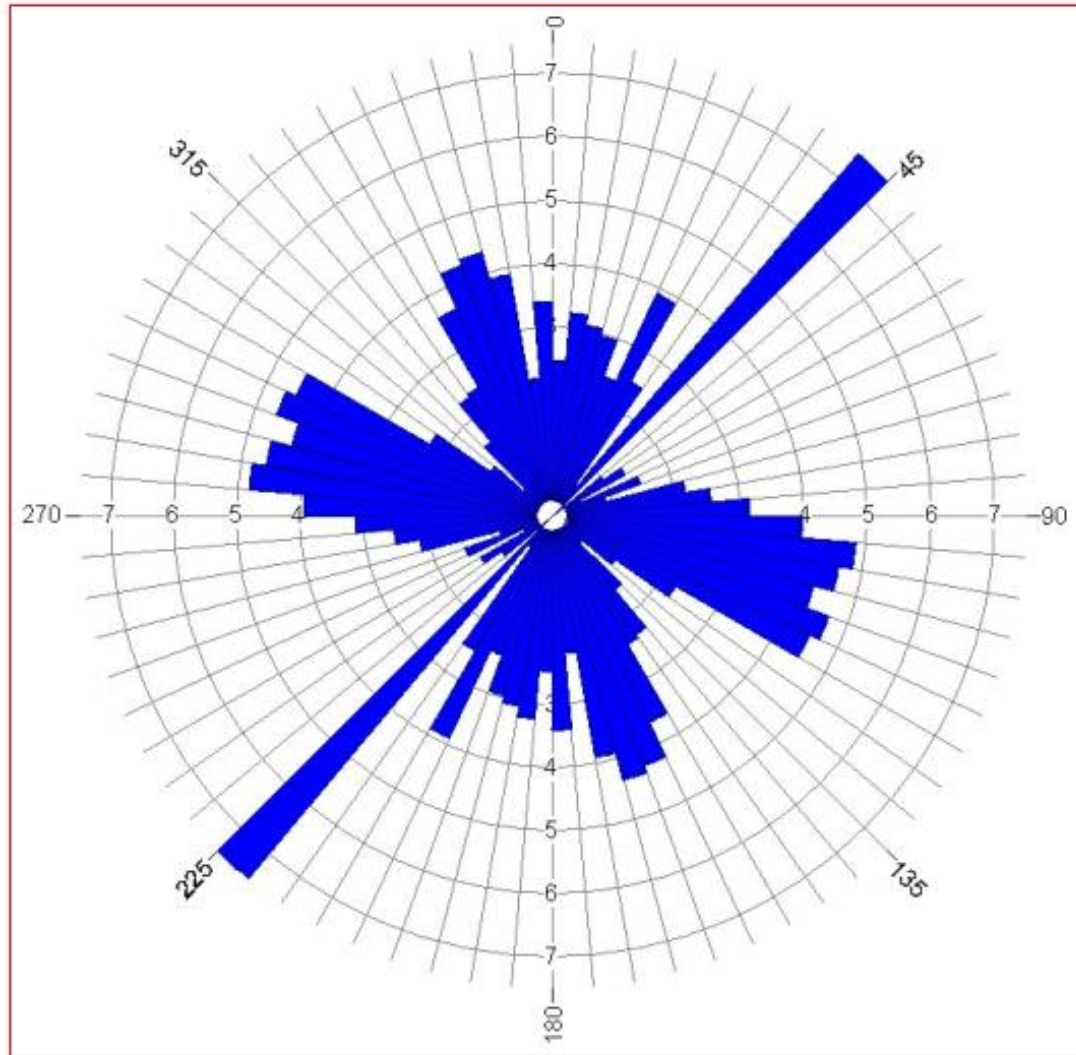
*Ilya Tsvankin*

*Center for Wave Phenomena*

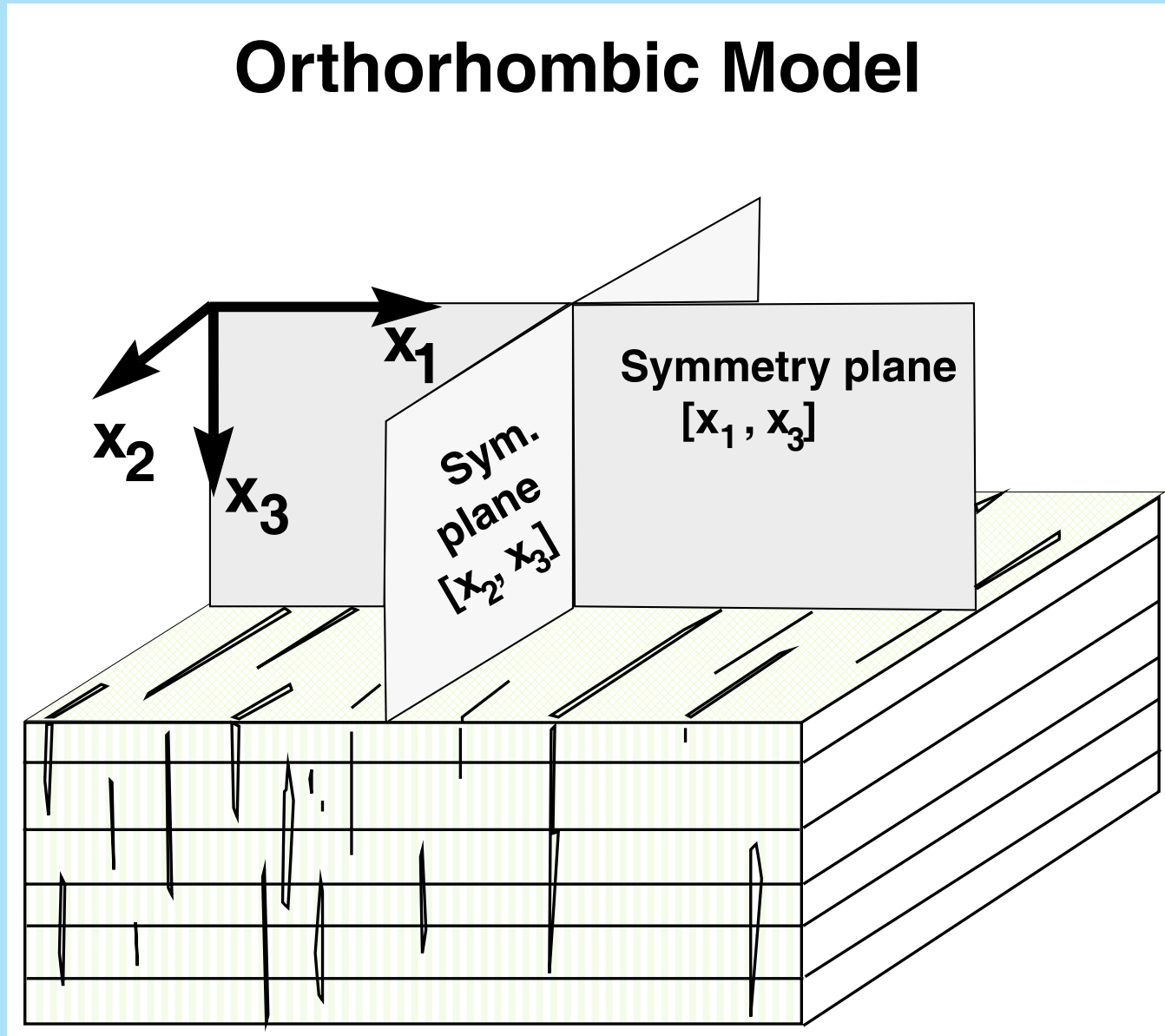
*Colorado School of Mines*

RPSEA meeting, April 6, 2010

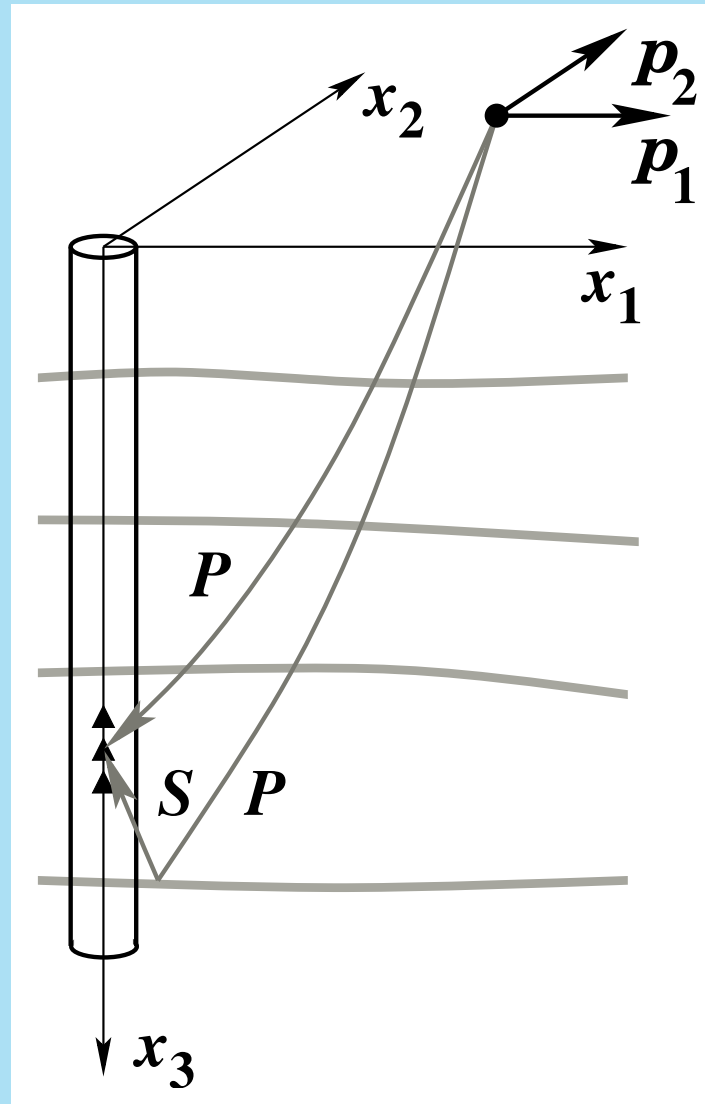
# Fractures $\Rightarrow$ Pathways for Fluid Flow (fracture azimuths from well logs)



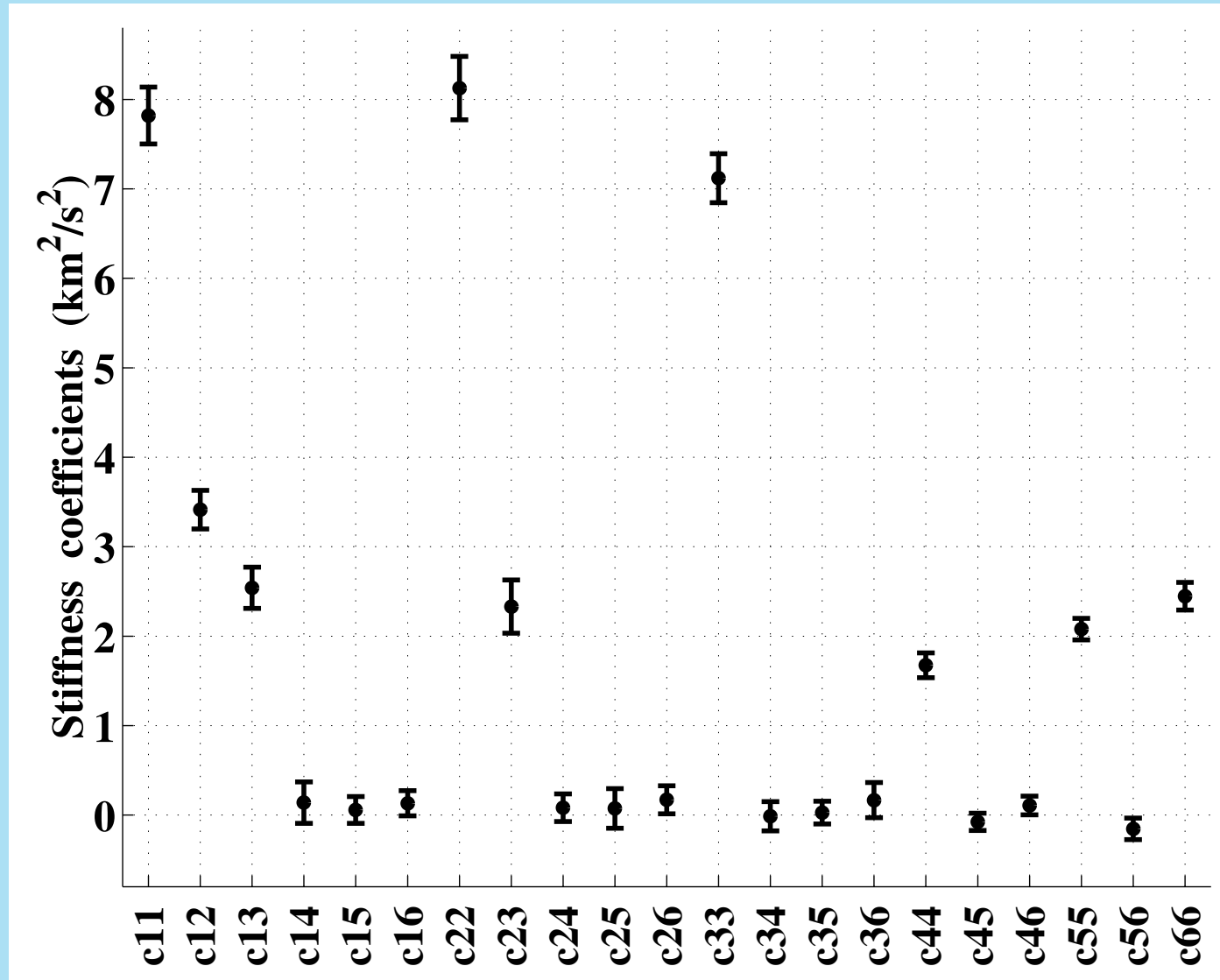
# Aligned Fractures Create Anisotropy



# Multicomponent, Multi-azimuth, Walkaway Vertical Seismic Profiling (VSP)



# Orthorhombic Model at Vacuum Field (Dewangan & Grechka, 2003)



# Reflection Data Signatures in Fracture Characterization

- splitting of SS- or PS-waves  
(time delays, amplitudes)
- wide-azimuth, long-offset  
reflection traveltimes
- azimuthal prestack amplitude  
(AVO) variation
- azimuthally varying attenuation

# Reasons for Azimuthal Variation

- dipping or curved interfaces
- lateral velocity variation
- *azimuthal anisotropy* due to
  - fractures & stress
  - host rock

# Azimuthal AVO Analysis

- high vertical resolution
- sensitive to anisotropy

## But

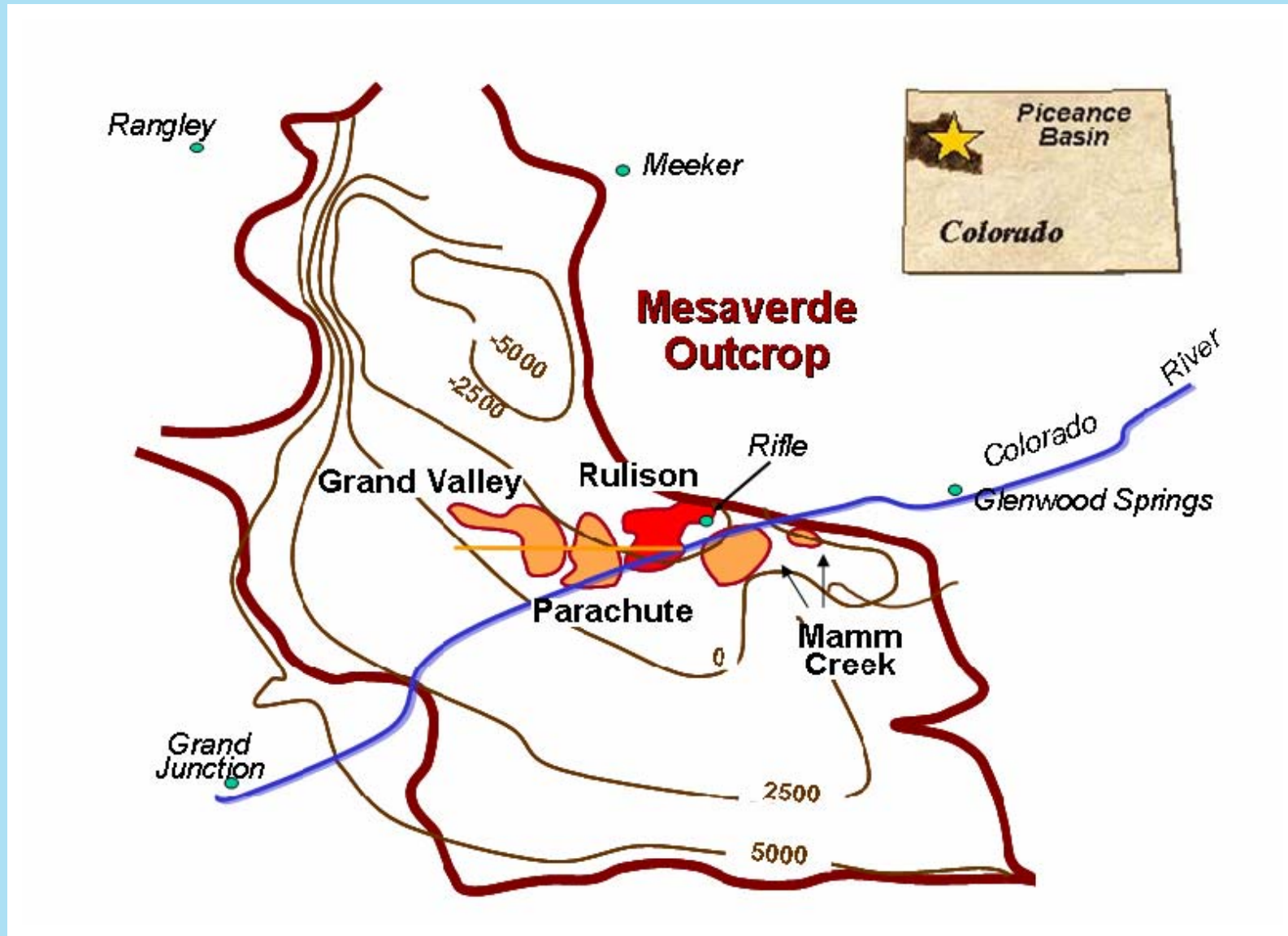
- low signal/noise, especially for S-waves
- gives only jumps in properties
- overburden distortions

# Processing/Inversion Methodology for Wide-Azimuth Data

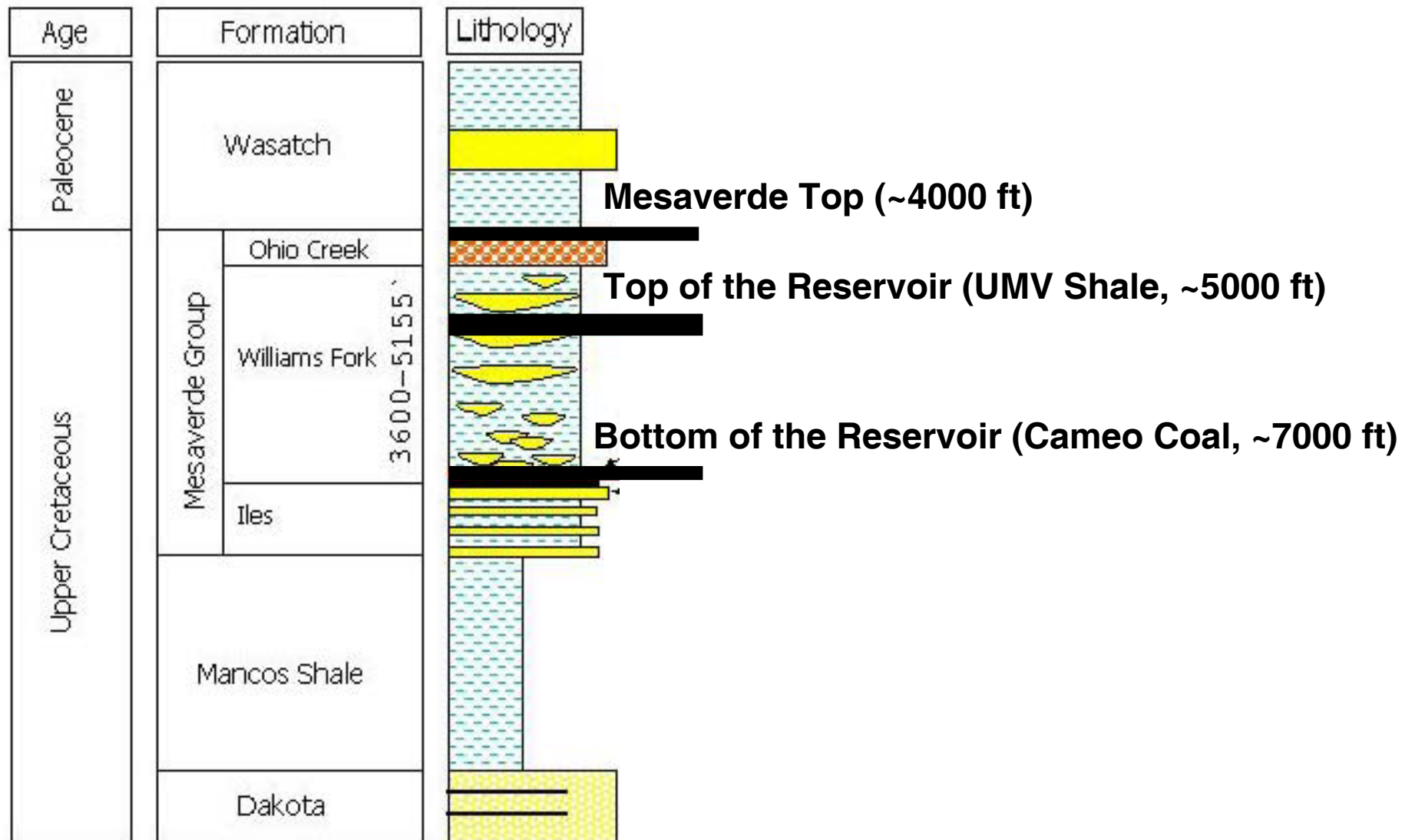
- 3D “global” nonhyperbolic moveout inversion
- estimation of NMO ellipses
- picking of amplitudes
- moveout-based anisotropic spreading correction (MASC)
- azimuthal AVO analysis

# Rulison Field, Colorado

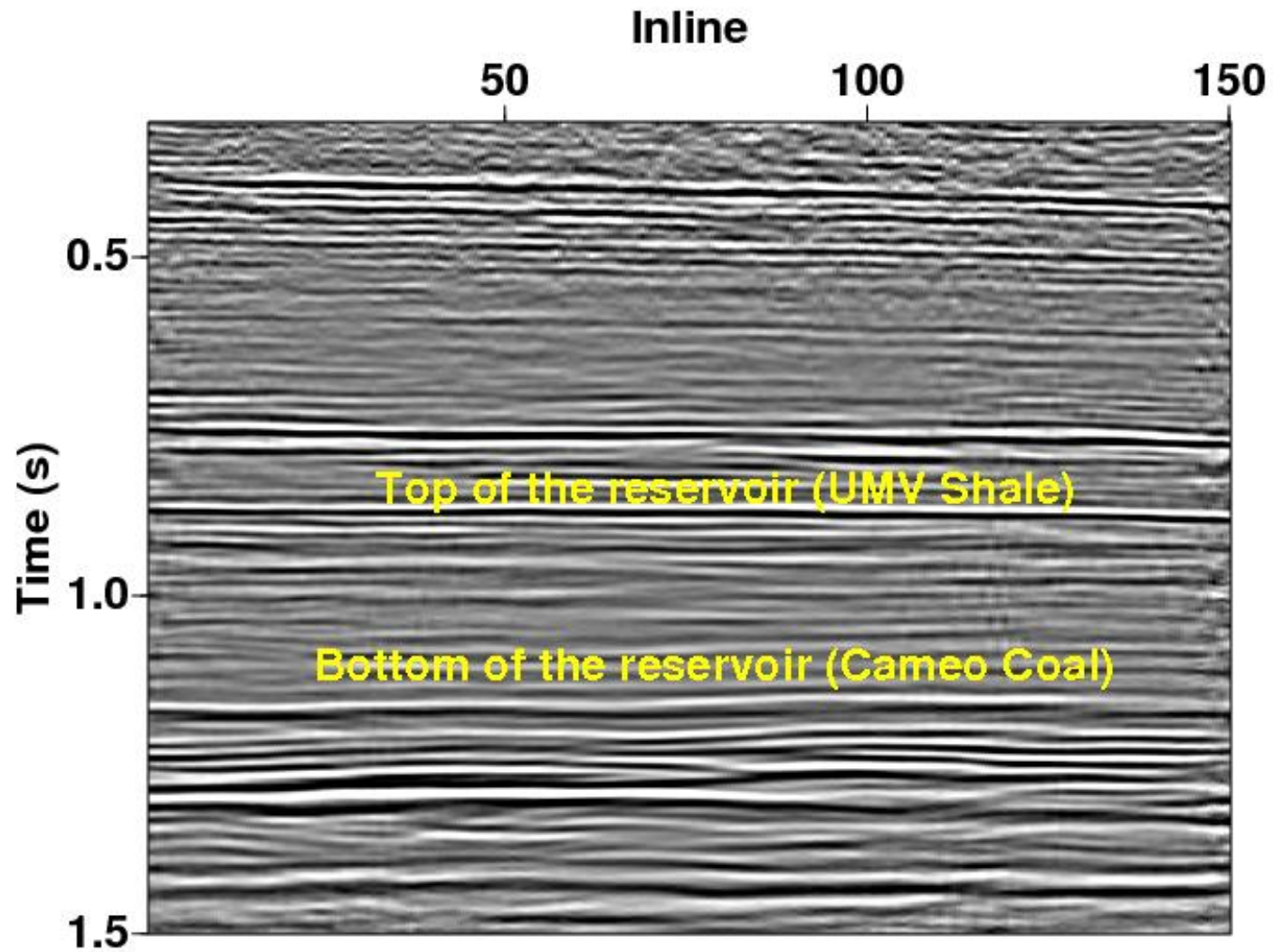
(data courtesy of RCP)



# Stratigraphic Column



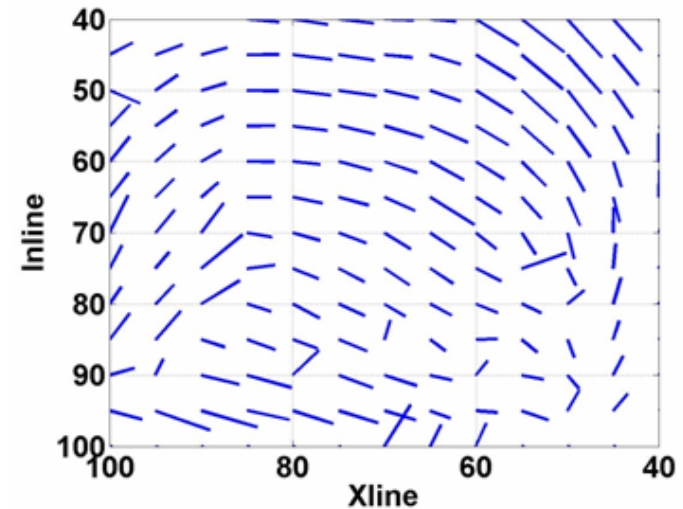
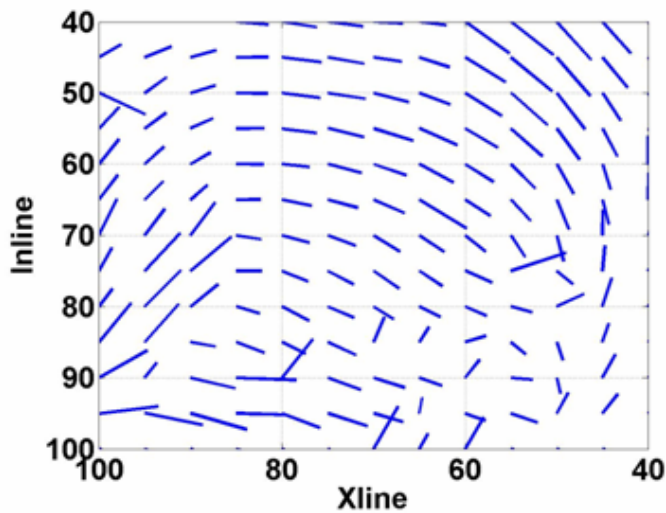
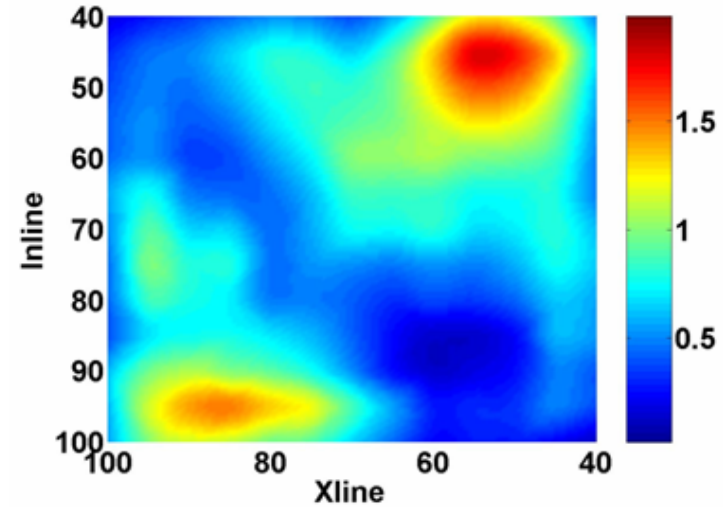
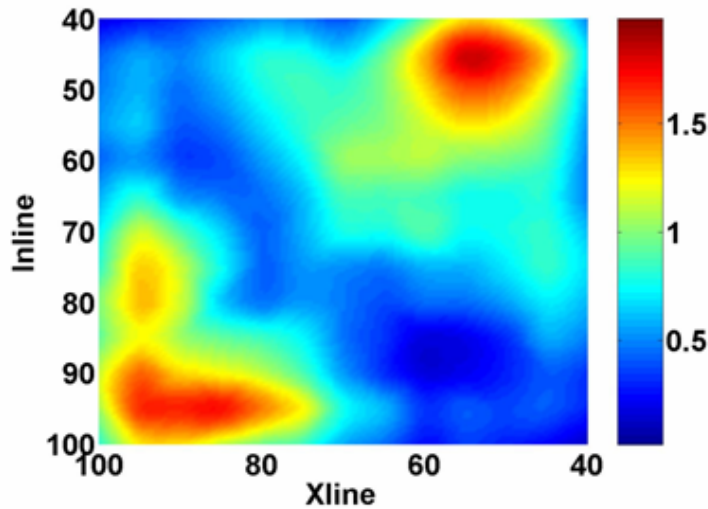
# Migrated Section



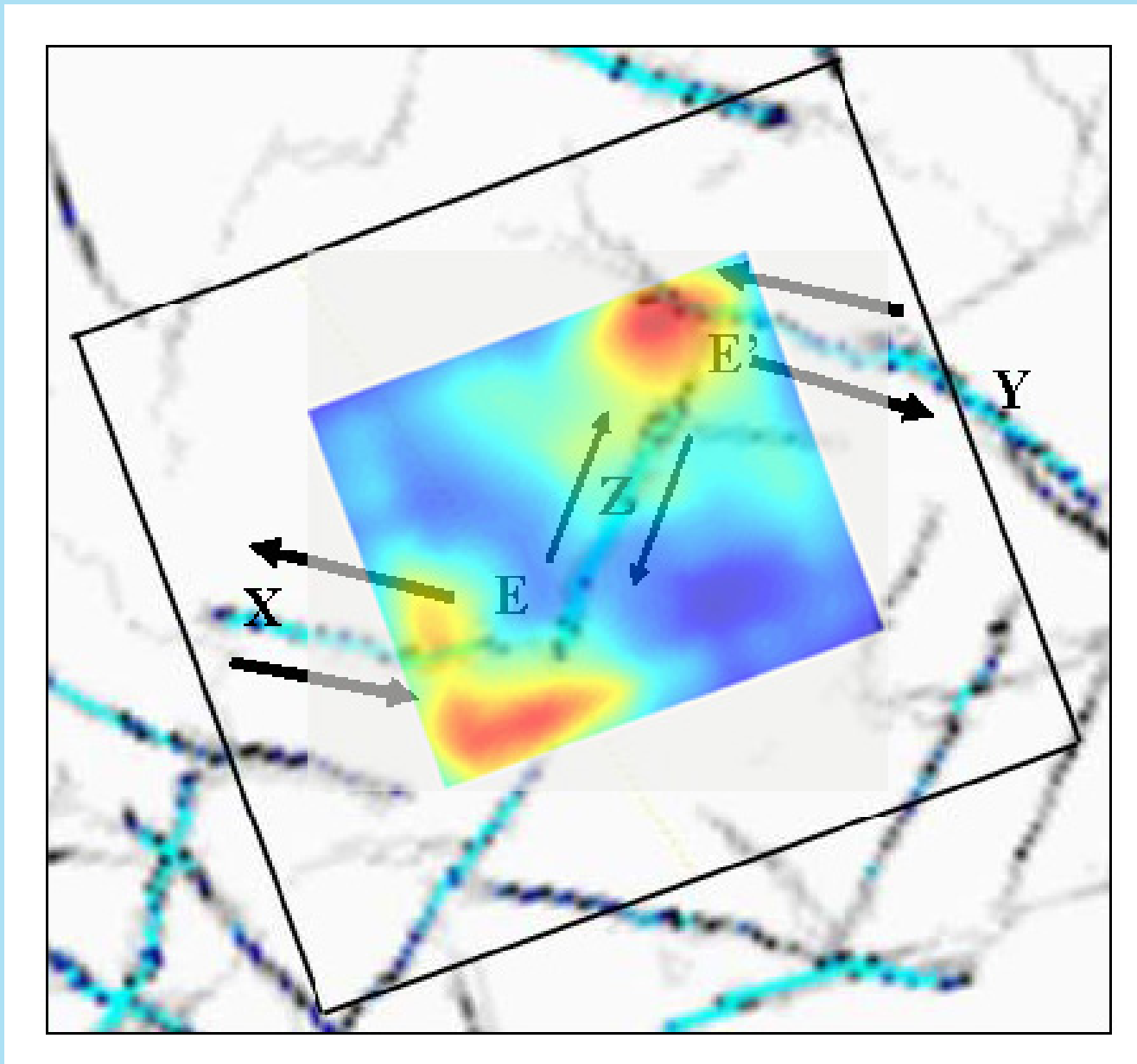
# Azimuthal AVO for Reservoir Bottom

## MASC

## Conventional



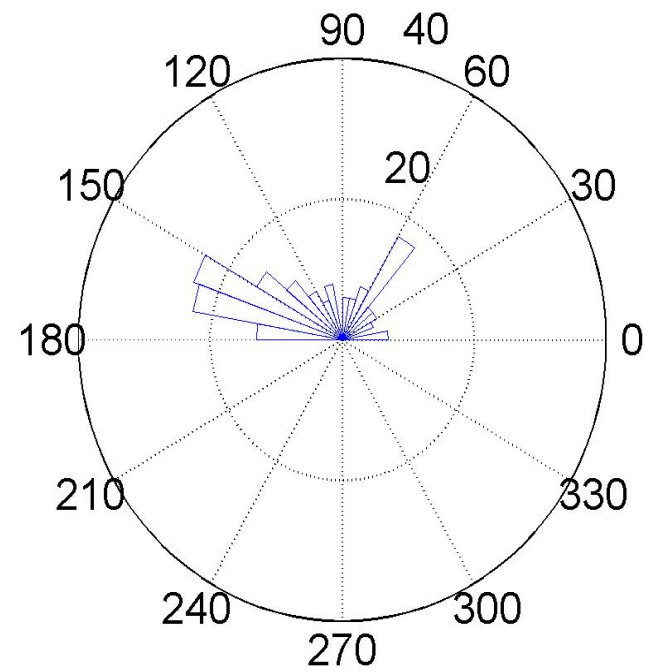
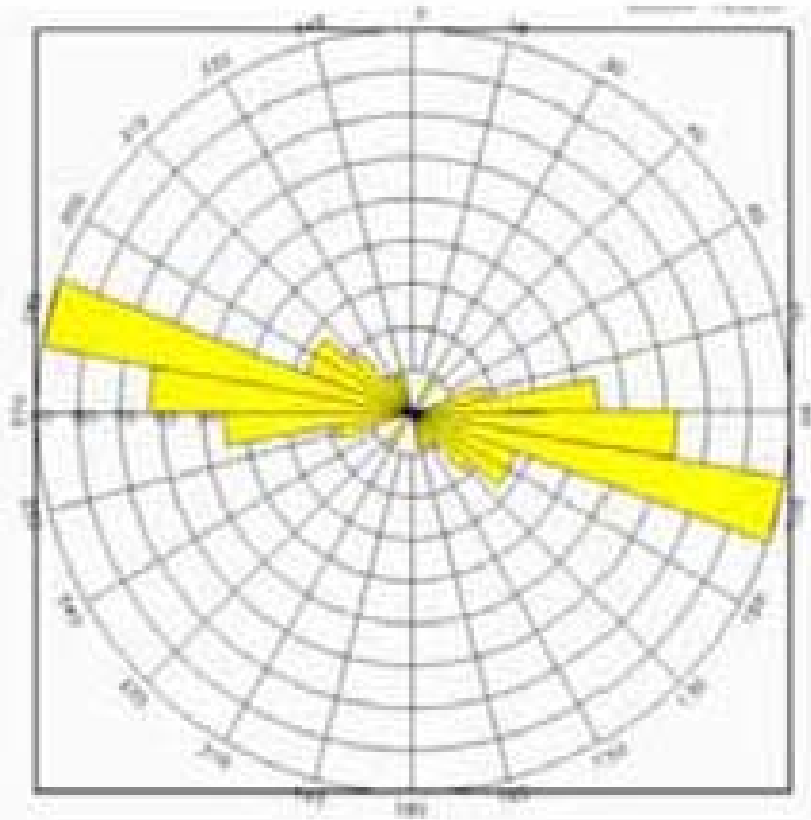
# Comparison with Wrenching Faults



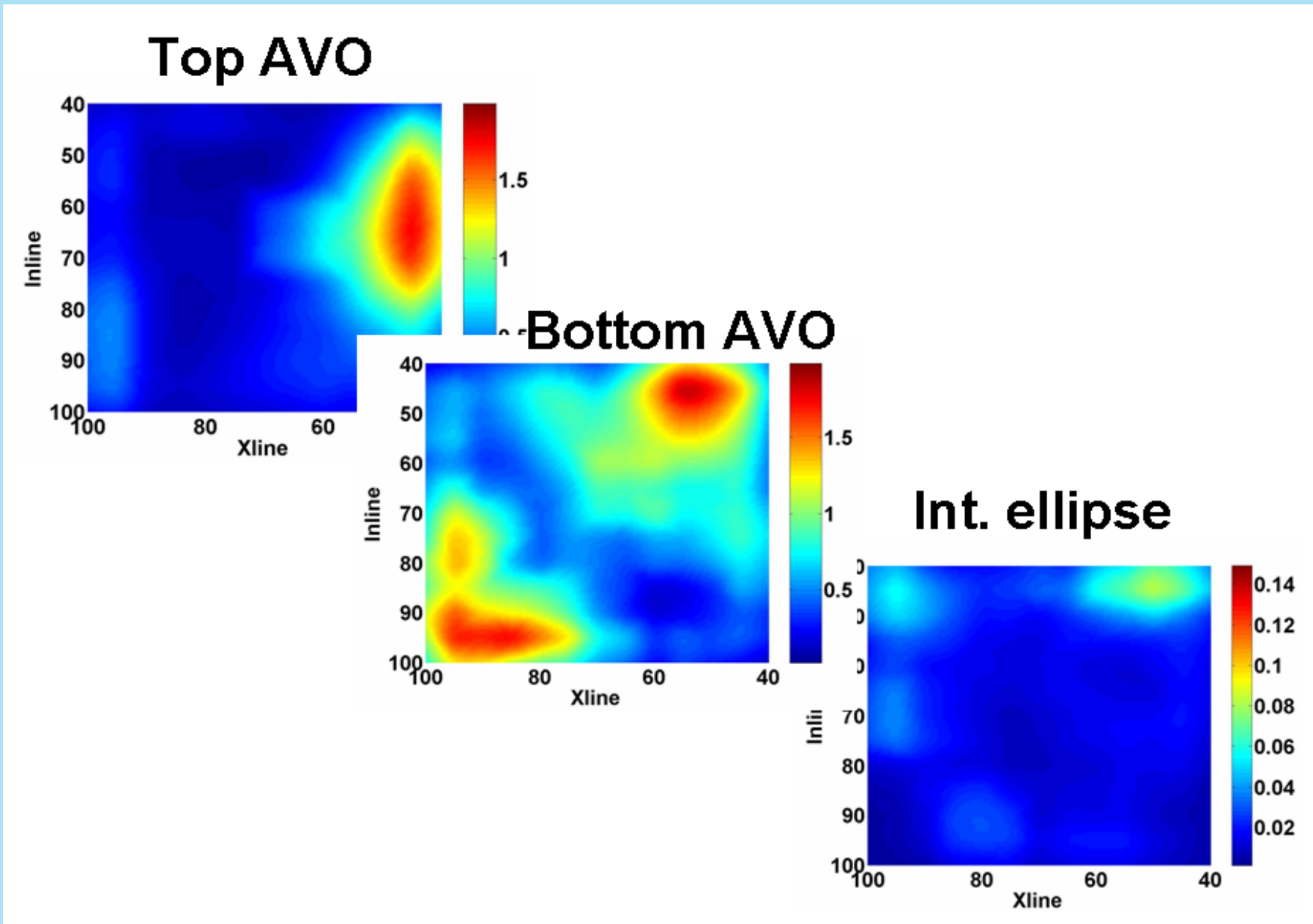
# Comparison with FMI Logs

Logs

AVO



# Comparison of AVO and NMO Ellipses



# Rulison Case Study (P-wave)

- *AVO* ellipse most sensitive
- amplitude anomalies correlate with geology
- *AVO* inversion ambiguous:
  - poor *AVO* – *NMO* correlation
  - multiple fracture sets?
  - fractures above and/or below?
  - fracture infill?

# Road to the Future: Multicomponent Seismic Inversion Combined with

- multiazimuth, walkaway VSP
- passive seismics
- well logs (DSI, FMI, saturation)
- core measurements
- geology

# Acknowledgments

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