



South Komie 3D Seismic Analysis of Fractured Reservoirs

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CREWES

Motivation

Information related to *fracture intensity and orientation* is vital for the development of unconventional reservoirs



Outline

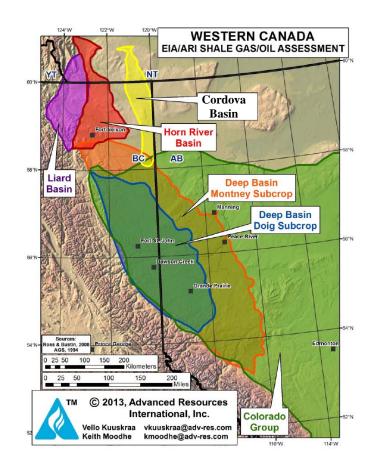
Introduction

- Horn-River Basin
- Data acquisition & processing
- South Komie 3D data analysis
 - Post stack inversion
 - Post-stack attributes
 - Pre-stack COCA
 - Pre-stack AVO and AVAZ
- Conclusions



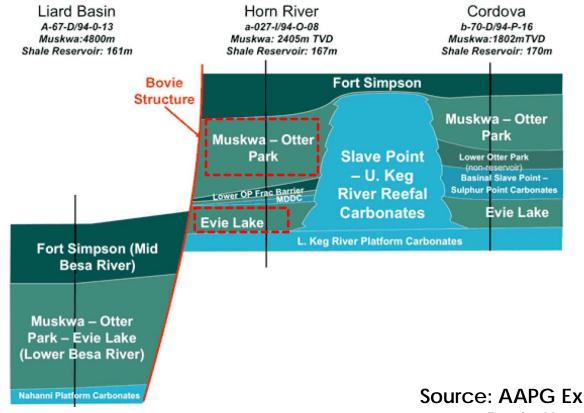
Horn River Basin

- Location: Northeast BC & Southwest NT
- Area: 18,000 km²
 Producing well: 200 (Feb 2014)
- OGIP: 500 Tcf
 Compare to: Cordova: 200 Tcf; Montney: 2000 Tcf





Stratigraphy



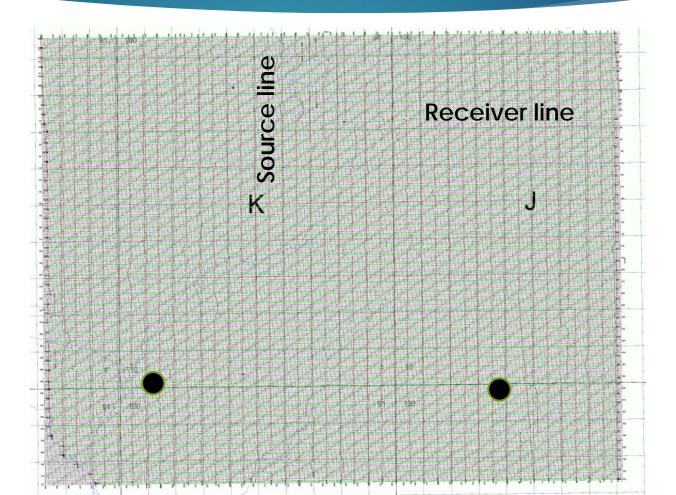
Source: AAPG Explorer, Horn River Basin Keeping Canada Hot



Data Acquisition

- Acquisition data: 12-29 March 2009
- Source: Dynamite (single hole)2 kg at 15 m depth
- Receiver: single 3-C
- Sample interval: 2 ms
- Source interval: 60 m Receiver interval: 60 m
- Source Line orientation: N-S
- Source Line spacing: 360 m
- Receiver line orientation: E-W
- Receiver line spacing: 240 m

Base Map



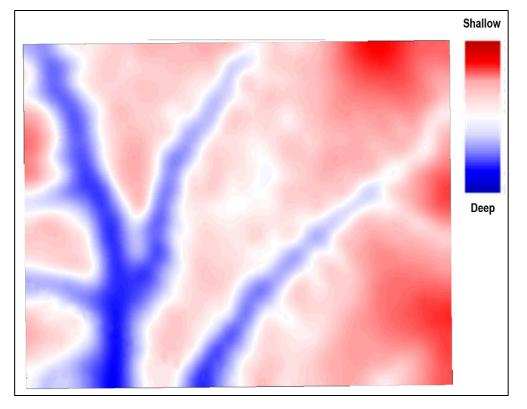


Data processing

Geometry **Amplitude recovery** Other statics Linear-noise attenuation Surface-consistent Decon Noise suppression **3D COV Binning Migration Velocity Analysis**



Near-surface: 2nd refractor

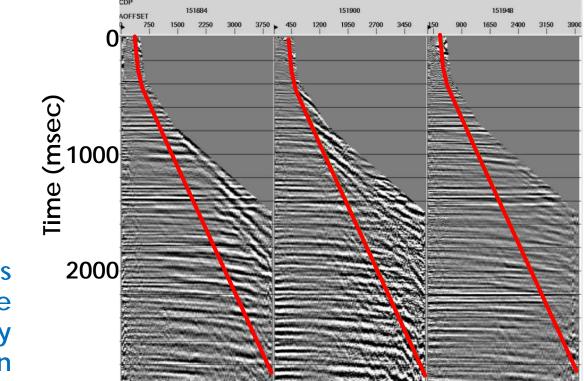


2nd refractor elevations:

A significant channel system within the near surface is observed.

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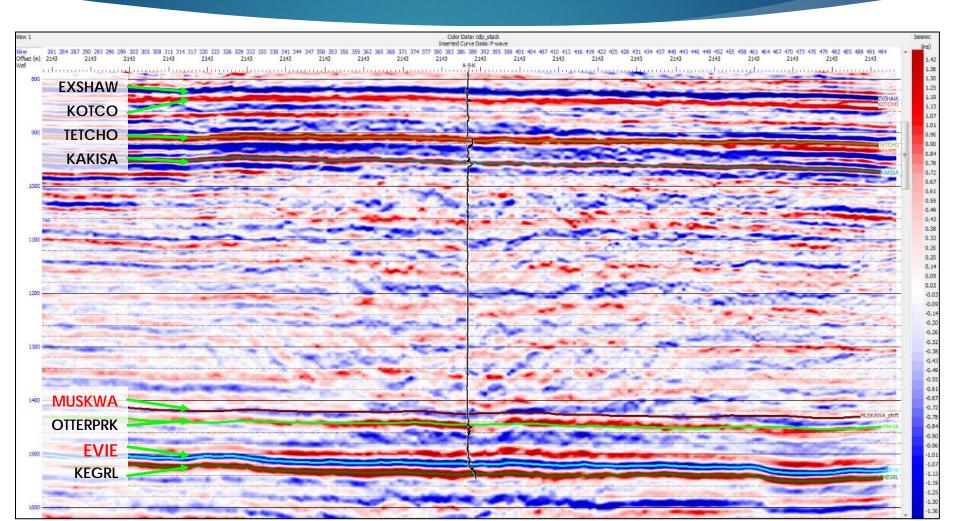
PSTM Gathers



PSTM image gathers with an outer mute function indicated by green

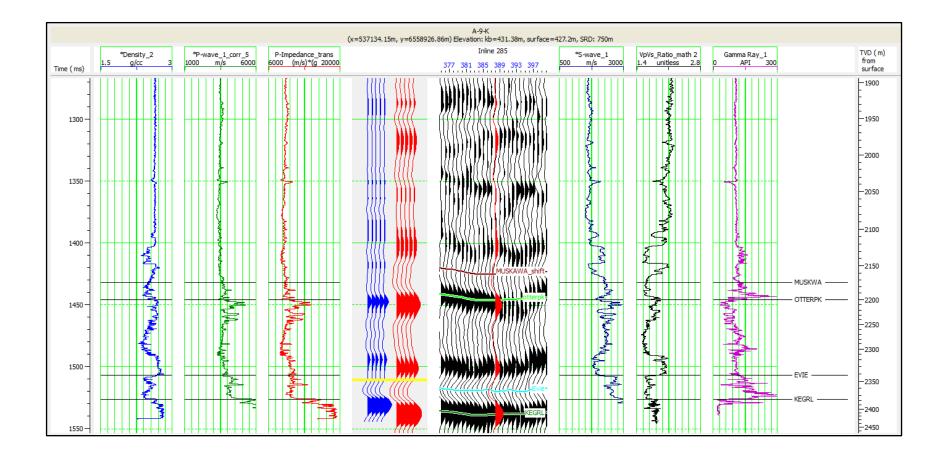


PSTM Stack & Picked Horizons



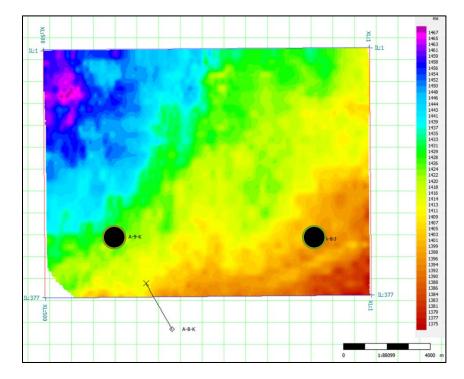
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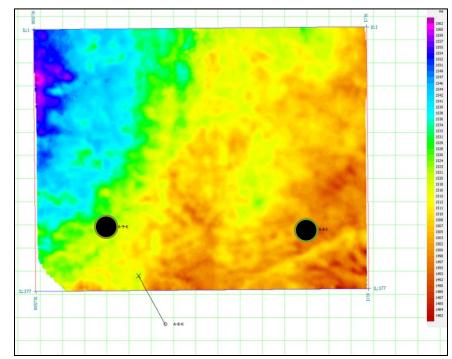
Well Log Correlation





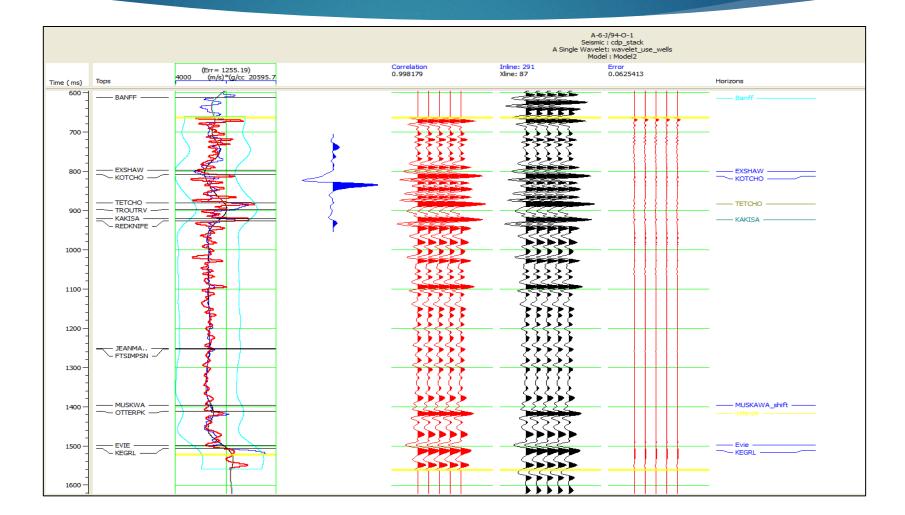
Target horizons: Muskwa (left) & Evie (right)





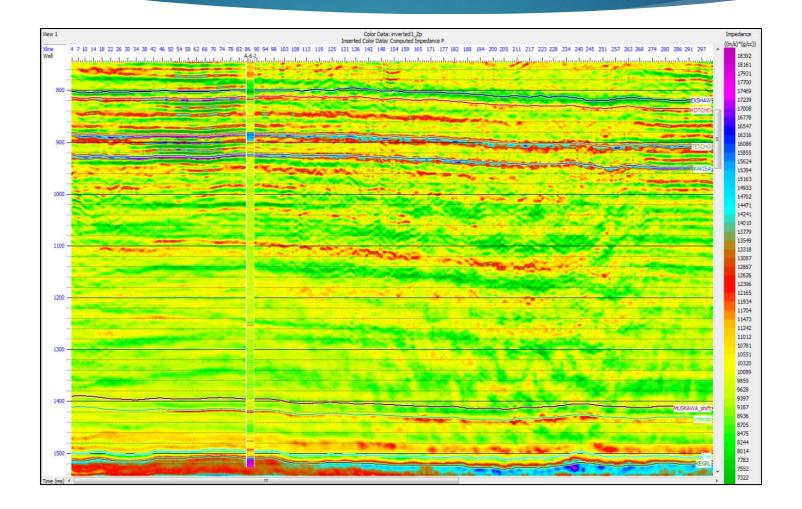


Post-stack Inversion



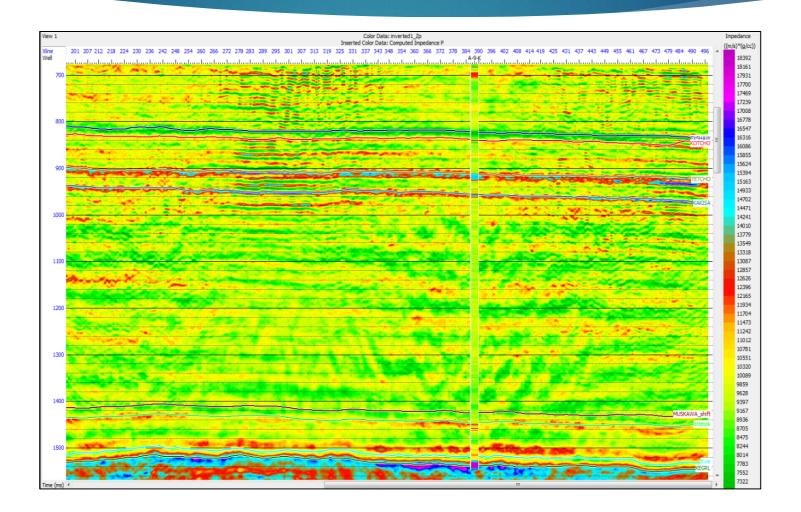


Impedance



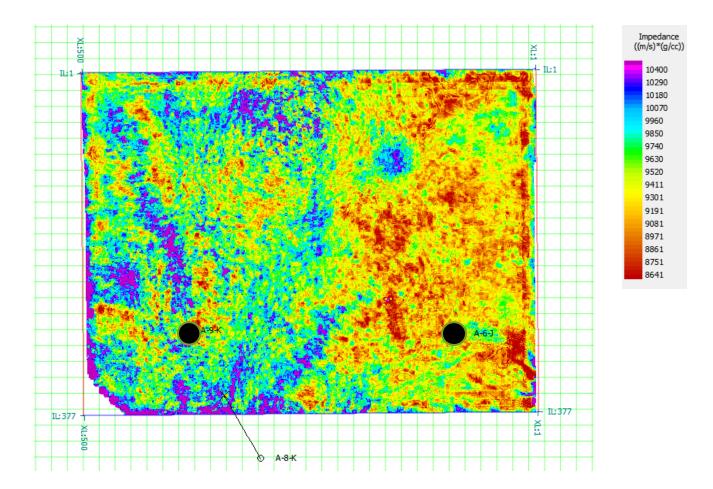


Impedance





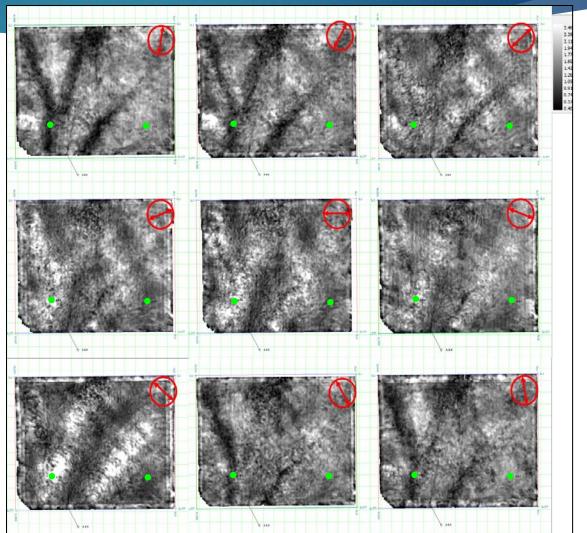
Impedance: Evie Map





RMS amplitude at the Evie, sectored by S-R azimuth

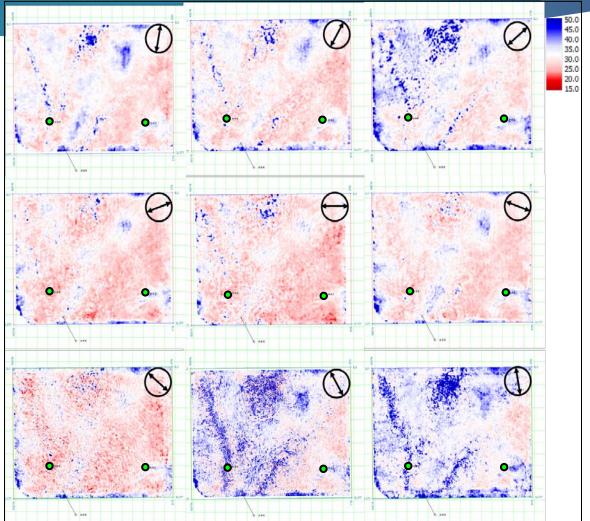
Red arrows indicate azimuths. Black indicate lower amplitude values, or in another word lower impedance contrast. Therefore, it indicates the direction of fracture strike. Major directions are 0o (i.e. Well A-9) and 900 (i.e. Well A-6).



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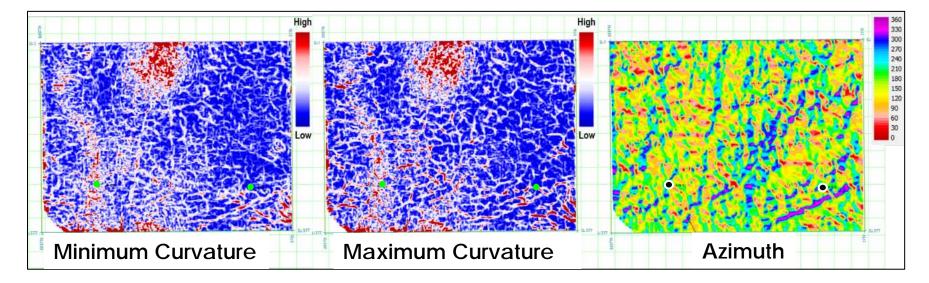
Instantaneous frequency at the Evie

Black Arrows indicate azimuth. Lower instantaneous frequencies see more fractures. Therefore, higher values indicate the fracture strike. Major direction are 90°





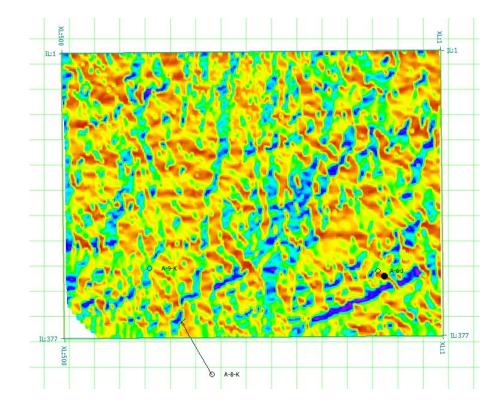
Curvature at the Evie



High curvature values indicate fractured zones. Azimuth map indicates that the major trends are about 0° and 40°.

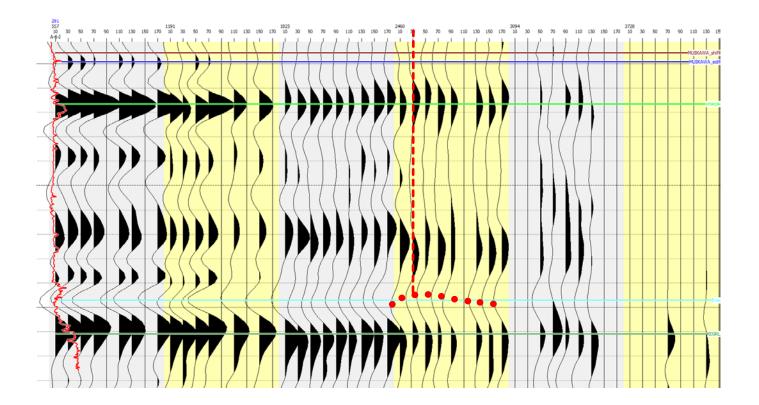


Curvature azimuth ~ 33





COCA Gathers



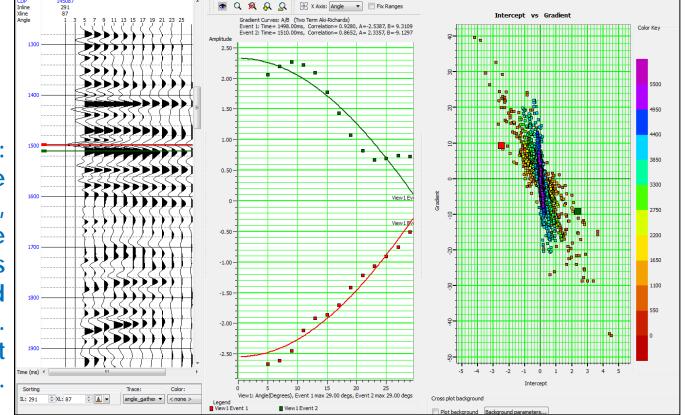
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AVO vs AVAZ (Ruger's)

 $Rpp(\theta)$ $Rpp(\Theta, \emptyset)$ $= A_{iso} + B_{iso}sin^2\Theta + C_{iso}tan^2\Theta sin^2\Theta$ $= A_{iso} + Bsin^2\Theta + Ctan^2\Theta sin^2\Theta$ $A_{iso} = \frac{1}{2} \left[\frac{\Delta V p}{V p} + \frac{\Delta \rho}{\rho} \right]$ $B = B_{iso} + B_{ani}$ $B_{iso} = \frac{1}{2} \frac{\Delta V p}{V p} - 4 \left[\frac{V s}{V p} \right]^2 \frac{\Delta V s}{V s} - 2 \left[\frac{V s}{V p} \right]^2 \frac{\Delta \rho}{\rho}$ $B_{ani} = \frac{1}{2} \left[\Delta \delta^{\nu} - 8 \frac{Vs}{Vn} \Delta \gamma^{\nu} \right]$ $C_{iso} = \frac{1}{2} \frac{\Delta V p}{V p}$ $C = C_{iso} + \frac{1}{2} [\Delta \delta^{\nu} sin^2 \phi + \Delta \epsilon^{\nu} cos^2 \phi] cos^2 \phi$

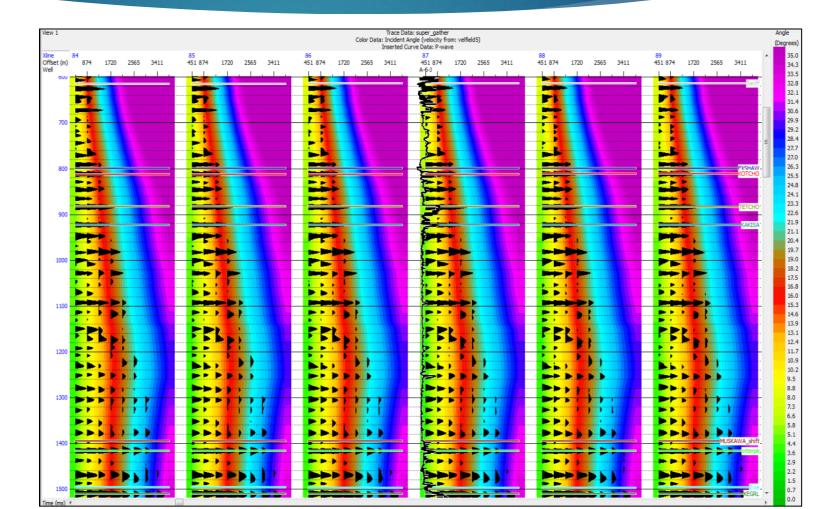


AVO Analysis: Synthetic



AVO modelling: synthetic angle gather (left), amplitude curves (middle), and intercept vs. gradient plot (right).

Super gathers



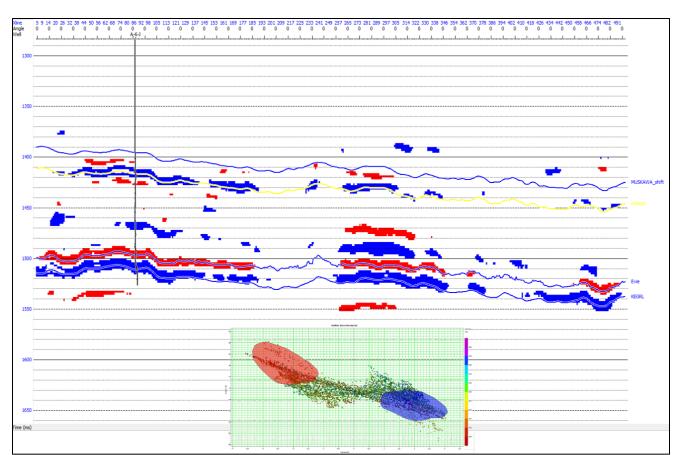


Angle gathers & Amplitude vs Angle

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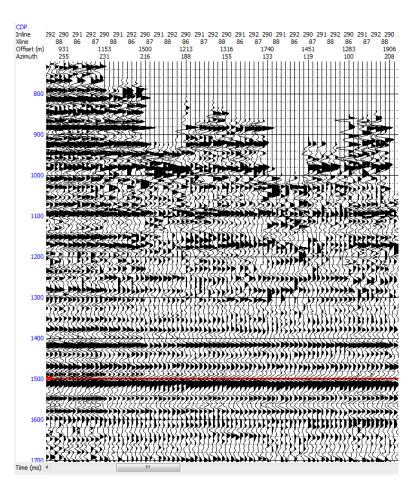
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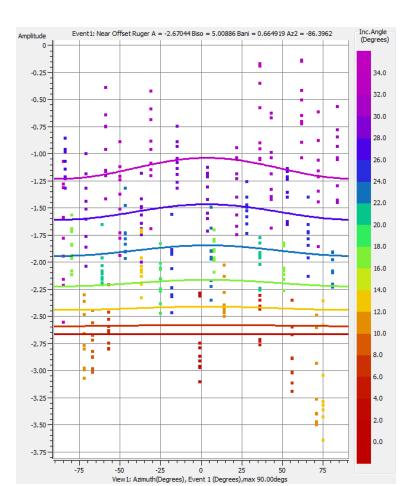




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class IV reservoir. Red is top & blue is bottom of the reservoir. AVAZ











CONCLUSIONS



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Conclusions

- Post-stack P-impedance inversion is utilized to indicate sweet spots
- post-stack amplitude, instantaneous frequency, and curvature attributes are utilized for identifying fracture direction and intensity
- Pre-stack AVO show class IV AVO for some of Evie
- Pre-stack AVAZ is utilized to invert for A, Biso, Bani, Symmetry Angle



Acknowledgments

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- NSERC for the grant CRDPJ 379744-08
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- Saudi Aramco for PhD sponsorship of the first author



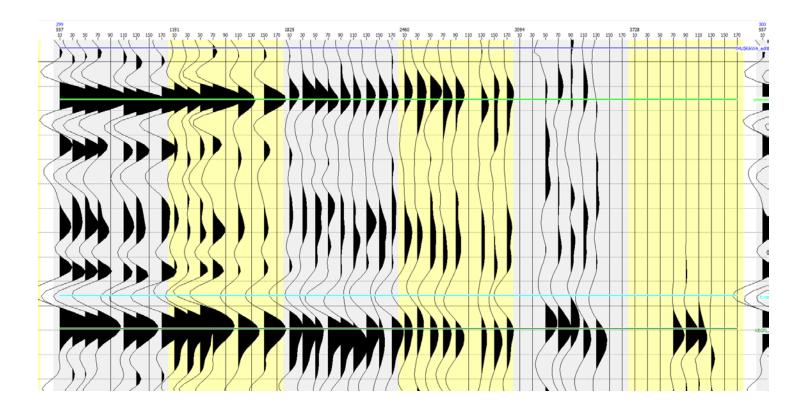




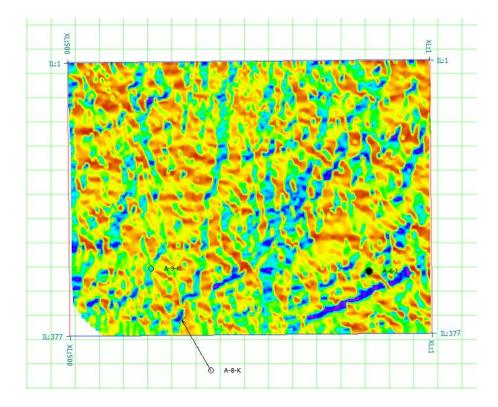
Thank you





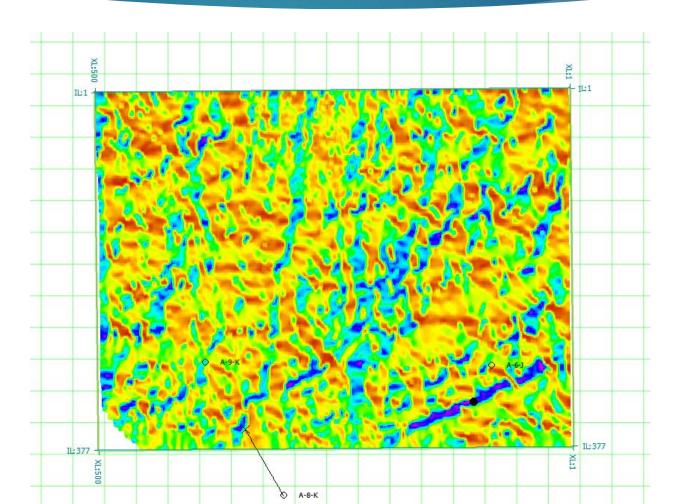
















COCA Gather

