



# 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

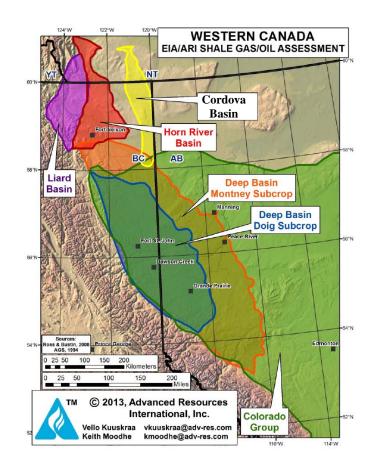
### Introduction

- 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



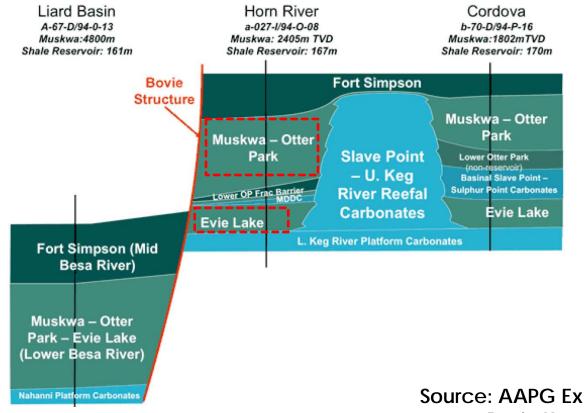
### Horn River Basin

- Location: Northeast BC & Southwest NT
- Area: 18,000 km<sup>2</sup>
   Producing well: 200 (Feb 2014)
- OGIP: 500 Tcf
   Compare to: Cordova: 200 Tcf; Montney: 2000 Tcf





### Stratigraphy



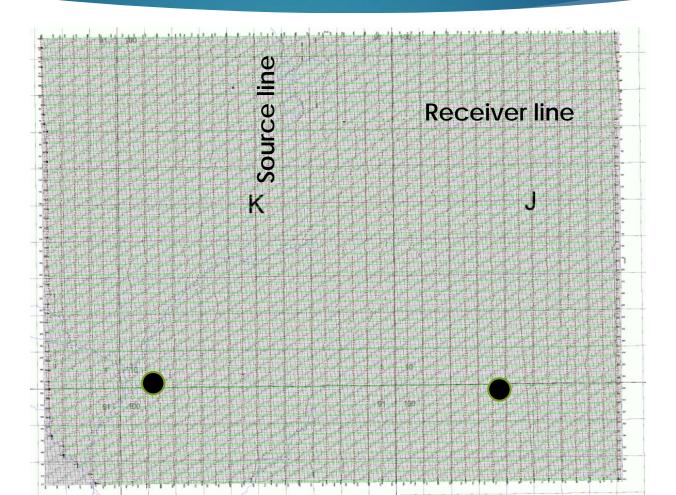
Source: AAPG Explorer, Horn River Basin Keeping Canada Hot



### 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



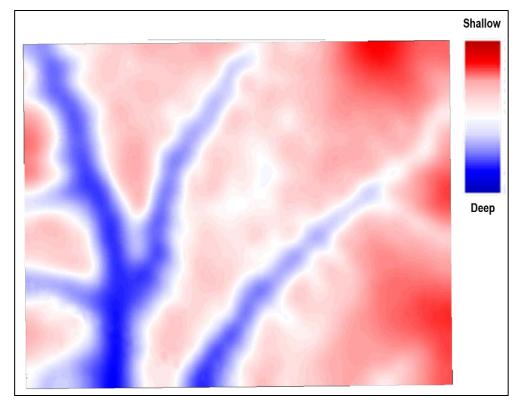


### Data processing

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



### Near-surface: 2<sup>nd</sup> refractor

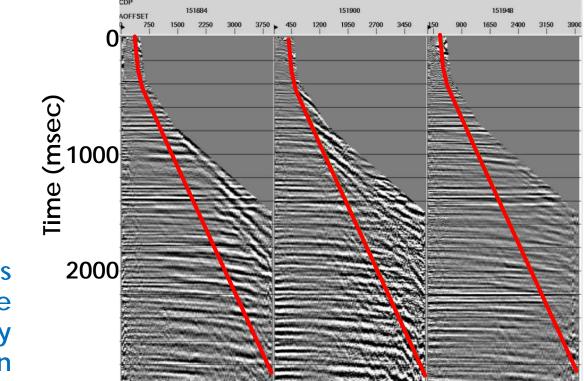


2<sup>nd</sup> refractor elevations:

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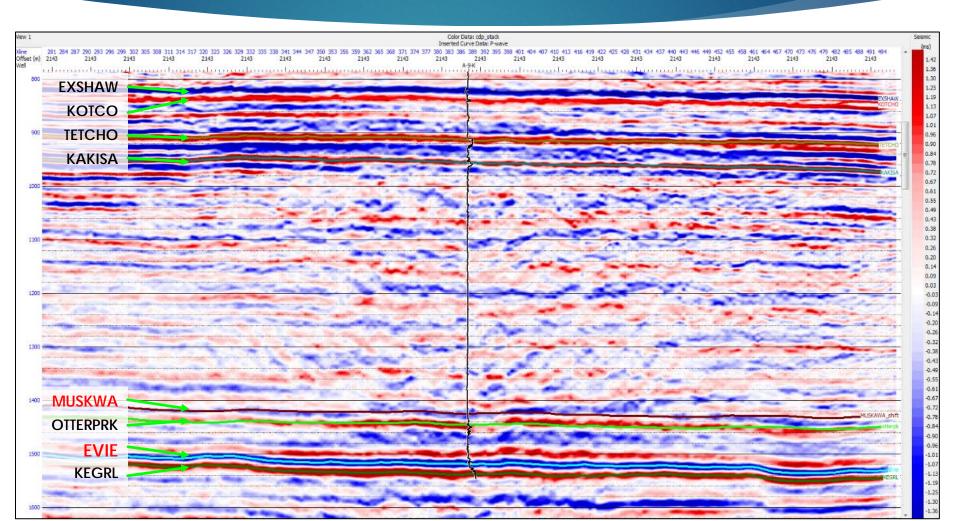
### **PSTM Gathers**



PSTM image gathers with an outer mute function indicated by green

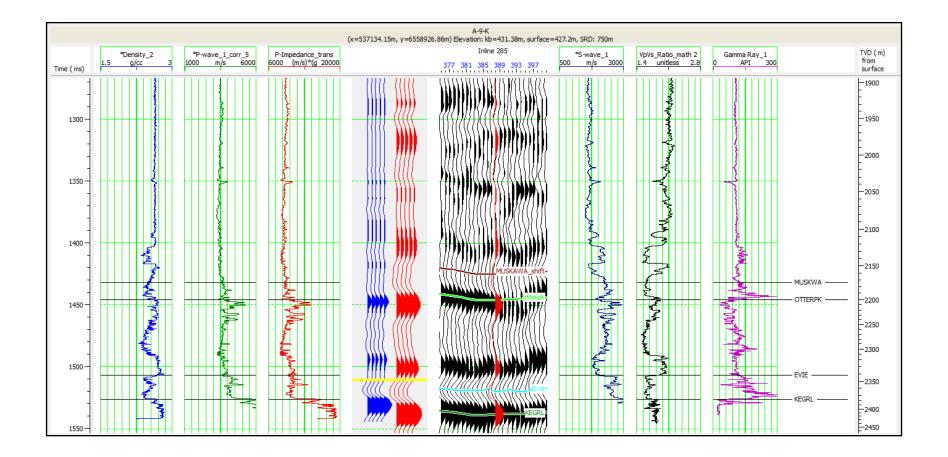


### PSTM Stack & Picked Horizons



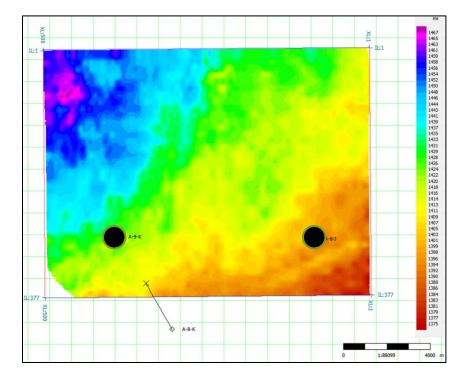
**CREWES** 

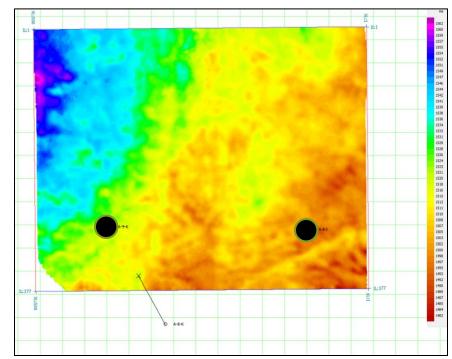
### Well Log Correlation





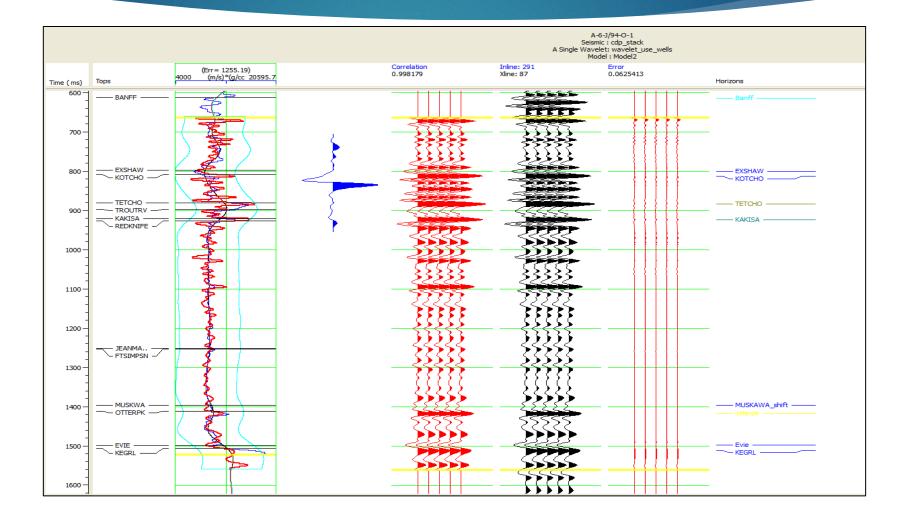
## Target horizons: Muskwa (left) & Evie (right)





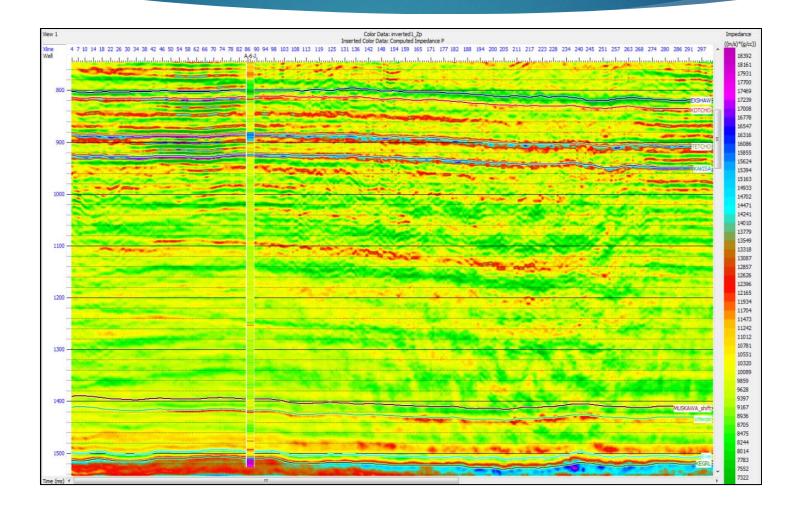


### Post-stack Inversion



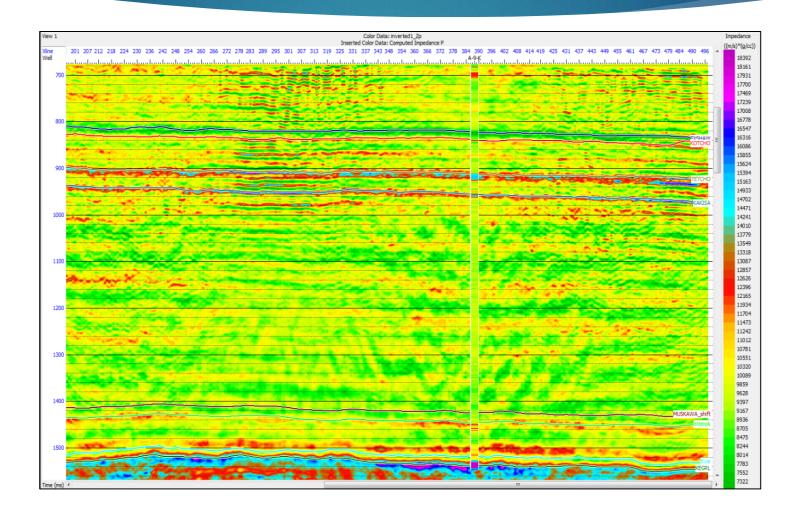


### Impedance



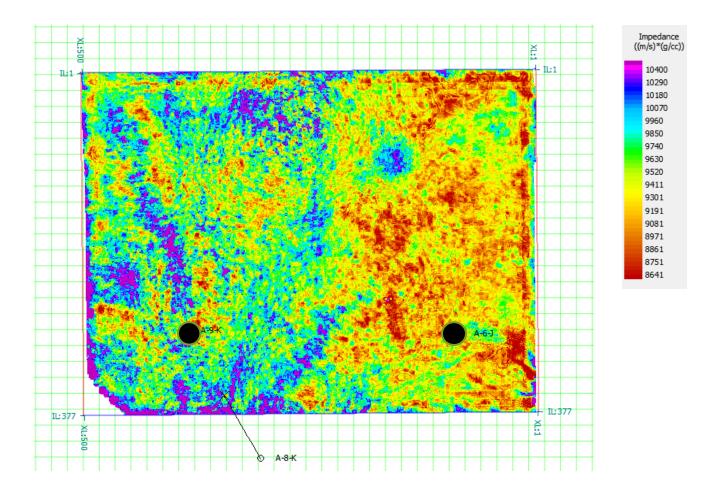


### Impedance





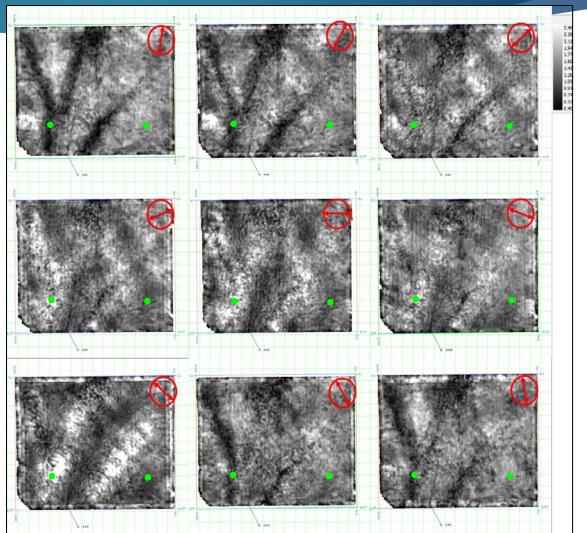
### Impedance: Evie Map





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

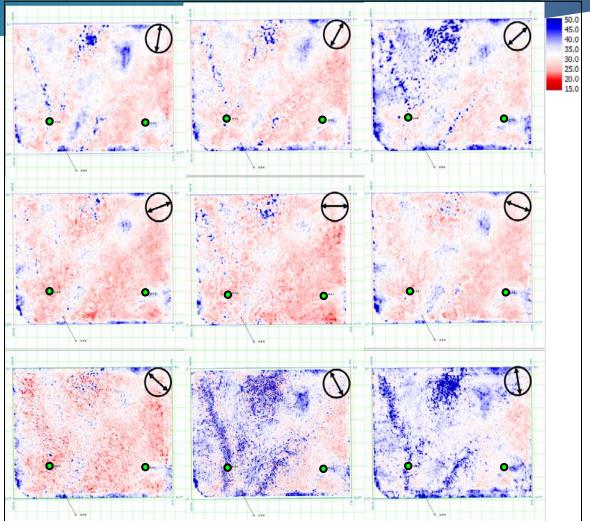
**Red arrows indicate** azimuths. Black indicate lower amplitude values, or in another word lower impedance contrast. Therefore, it indicates the direction of fracture strike. Major directions are 0o (i.e. Well A-9) and 900 (i.e. Well A-6).



### **CREWES**

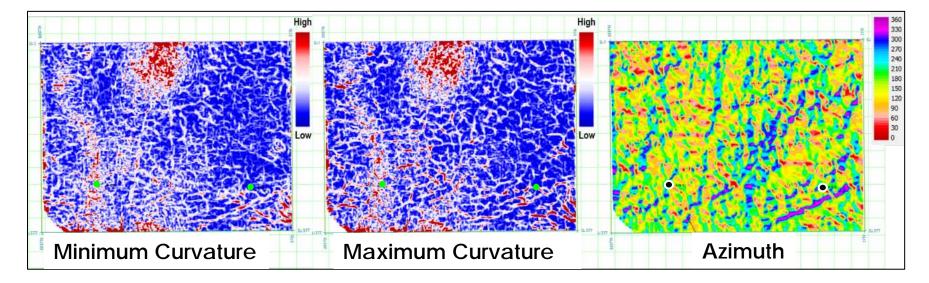
### Instantaneous frequency at the Evie

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





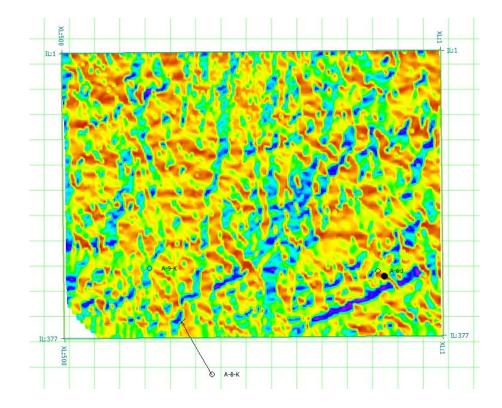
### Curvature at the Evie



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

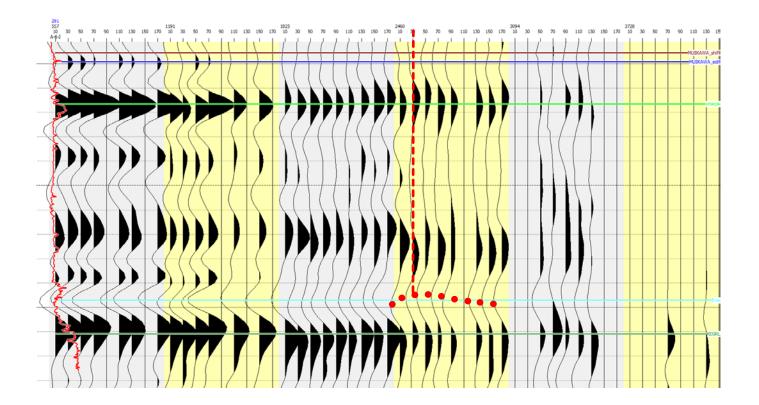


### Curvature azimuth ~ 33





### **COCA** Gathers



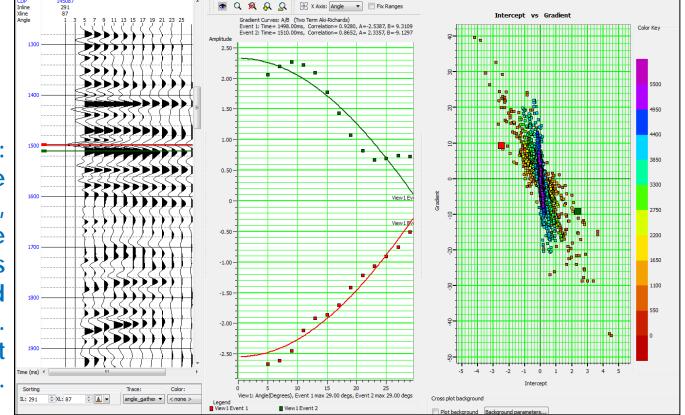
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### AVO vs AVAZ (Ruger's)

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

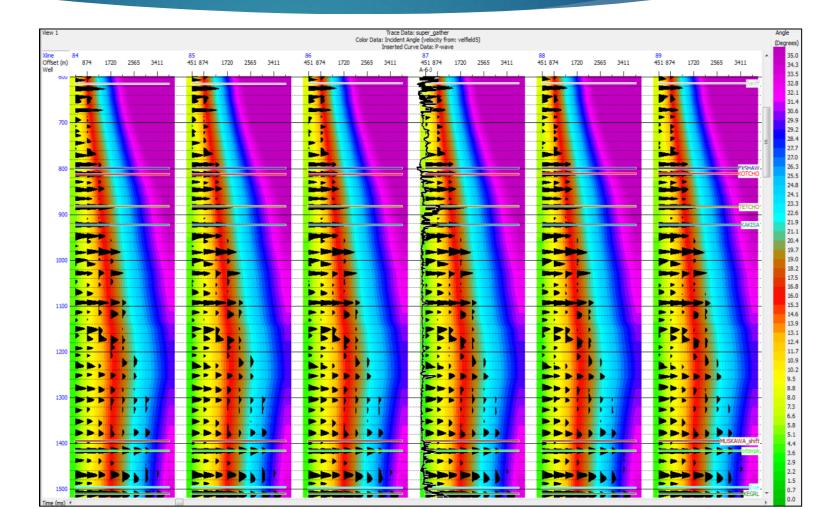


### AVO Analysis: Synthetic



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

### Super gathers

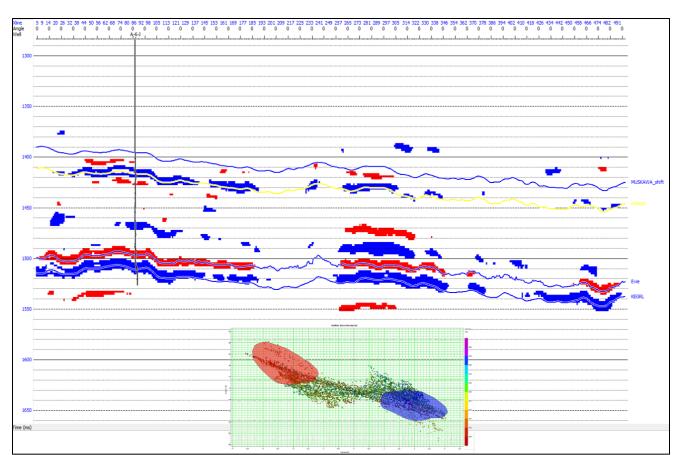




## Angle gathers & Amplitude vs Angle

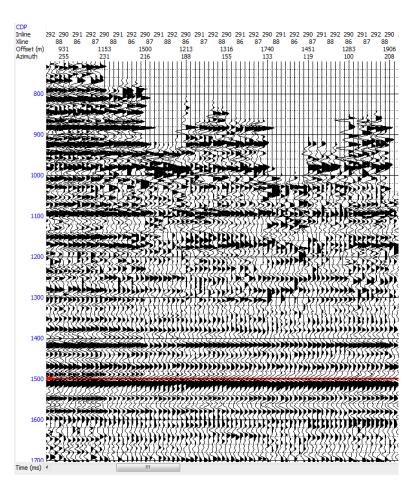
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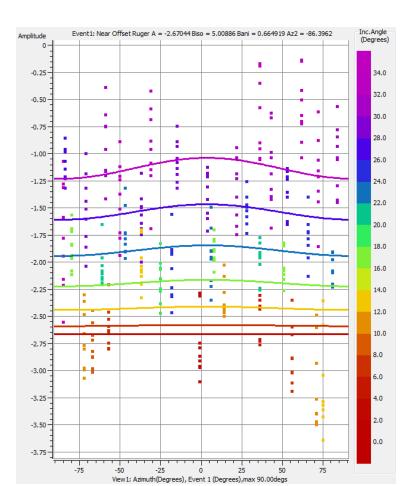




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class IV reservoir. Red is top & blue is bottom of the reservoir. AVAZ











# 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

- CREWES sponsors for their support
- NSERC for the grant CRDPJ 379744-08
- Seitel and Arcis for permission to use the data and publish the results
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- Dr. Don Lawton, Dr. Faranak Mahmoudian, Nassir Saied, Jesse Kolb, Dr. Helen Isaac, and Dr. Pat Daley
- Saudi Aramco for PhD sponsorship of the first author



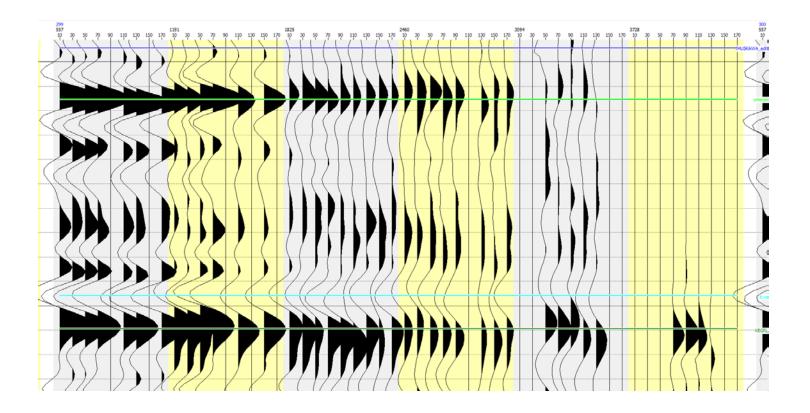




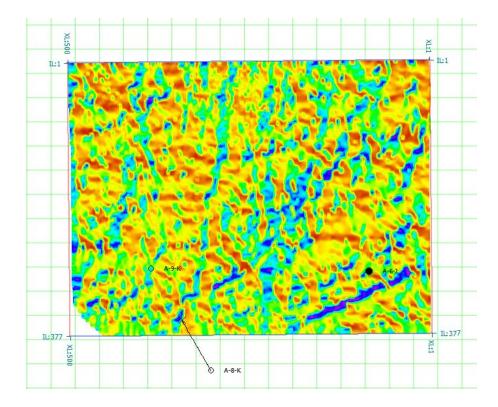
# Thank you





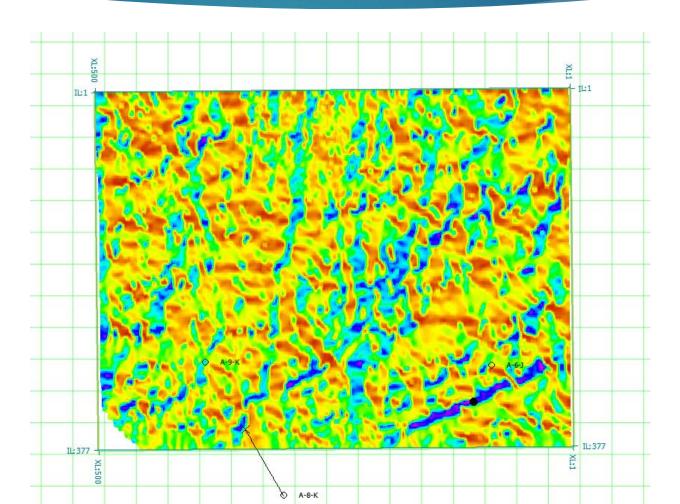
















### **COCA** Gather

