Multicomponent interpretation: examples from the Marcellus Shale and Athabasca oil sands

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Project objectives

- Marcellus project
 - General interpretation of PP, PS1 and PS2 seismic volumes
 - Interval V_p/V_s map analysis
 - Anisotropic analysis utilizing PS1 and PS2 volumes
 - Identification of potential hydrocarbon and hydraulic fracturing sweet spots
- Oil sands project
 - General interpretation of PP stack including impedance inversion
 - Shear log estimation and analysis
 - Begin processing of PS data
 - Ultimate goal is to characterize and understand the reservoir, caprock, and near surface intervals





Marcellus geological setting

- Middle Devonian deposition
- Relatively deep marine, anoxic
 - Dominantly black shale
- Erosive clastic genetic origin
 - Appalachian orogeny
- 1% 11% TOC range



(modified from Marcellus Center for Outreach and Research)

North America Devonian Paleogeography



(modified from Blakey 2011)

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Marcellus seismic data

- •~24 km²
- 2 ms sampling
- 34 m line and trace spacing
 - Inlines and xlines oriented parallel and perpendicular to Appalachian Mtns
- Freq. ranges:
 - PP: 5-50 Hz, PS1: 10-40 Hz, PS2: 10-35 Hz





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The Bradford County 3D 3C seismic dataset



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PP – PS1 registration

- Linear stretch/squeeze
 - Vp/Vs is near 2
- Polarity and phase appears fairly consistent between PP and PS1
- PS1 highlights faults better than PP





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Lower Marcellus PS1 RMS amplitude Low 1 km

High





Interval V_p/V_s

Marcellus-Onondaga interval V_p/V_c Tully-Marcellus interval V_p/V_s 1.40 1.05 1.60 1.60 1 km 1 km 2.20 1.80





PS1 to PS2 traveltime anomalies







Marcellus project conclusions

- The Appalachian Basin in the project area is a wedge shape thickening towards the orogeny (southeast)
- The target interval, the Marcellus Shale, is mildly dipping with complex, but well-imaged fault structure
- Interval V_p/V_s maps are highly variable in the Marcellus Fm, and may indicate sweet spots conducive to hydraulic fracturing
- High V_p/V_s values tend to correlate with anisotropic zones and along faults







Athabasca project geological setting





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North America Cretaceous Paleogeography



(modified from Blakey 2011)



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3D 3C seismic data and well log data





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Impedance inversion



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Impedance inversion



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R_{deep}

Castagna's derived shear sonic log

Vp vs. Vs crossplot Color Key Depth (m) P-wave (m/s)

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PS data processing progress





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Oil sands project summary

- Regional seismic interpretation completed on cretaceous clastics
 - Well data integration
 - Pervasive seismic reflection horizon picking
- Post stack PP impedance inversion
 - Based on both constant and variable input models
 - High interval RMS impedance correlates with increased sand content
- Shear log estimation for wells without dipole sonic logs
- PS seismic data processing underway







Going forward

- Marcellus project
 - Well control is the most important factor deciding future work
 - Understanding production trends based on geological data
 - Proper PP-PS1 and PP-PS2 registration with variable V_p/V_s values
 - Post-stack and pre-stack individual and joint inversion could be a useful tool for understanding unconventional reservoir properties
- Oil sands project
 - Joint processing of PP seismic data with converted wave seismic data
 - Joint inversion and pre-stack inversion of fully processing PP, PS1 and PS2 seismic data
 - Focus analysis on more specific intervals and geographical locations







Acknowledgements

- Canadian Natural Resources Limited and Geokinetics for providing data
- CREWES industrial sponsors
- Natural Sciences and Engineering Research Council through grant CRDPJ 461179-13



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VISTA[®] 2D/3D SEISMIC DATA PROCESSING



Hidden and removed slides





Converted waves



- Asymmetric ray paths
 - Common conversion versus midpoint
- Travel time difference in PP and PS
 - Shear velocities vs p velocities
- Applications of converted wave seismic:
 - Constraining interpretation
 - Imaging through variable fluids
 - Interfaces with low p-impedance contrasts
 - Near-surface imaging
 - Lithological classification and geomechanics





Upper Marcellus PP RMS amplitude

Lower Marcellus PP RMS amplitude







Upper Marcellus PS1 RMS amplitude

Lower Marcellus PS1 RMS amplitude





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Interval V_p/V_s

Tully-Marcellus interval V_p/V_s ratio

Marcellus-Onondaga interval V_p/V_s ratio





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PS1 to PS2 traveltime anomalies

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3D 3C seismic data and well log data





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