



INVERSION OF SEISMIC DATA FOR ASSESSING FLUID REPLACEMENT IN THE NISKU FORMATION

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OBJECTIVE

- Evaluate the seismic response of the Nisku Formation in terms of its impedance variations with the surrounding formations
 - Compare the effect of using a dataset processed with two different approaches in an inversion study.
 - Monitor the effect of injecting CO2 in the Nisku Formation in terms of impedance changes using time-lapse numerical data

INTRODUCTION

- ~70 km west of Edmonton
- WASP



INTRODUCTION

Project Pioneer:

- Capture 1 MT/yr of CO2 at Keephills 3
- Use for EOR
- Inject into the Devonian saline aquifer, Nisku Formation
- Data provided by, CNRL, TransAlta & Schlumberger



Project Pioneer was cancelled in 2012

PROCESSING OVERVIEW

Seismic data processed ^{Time} (ms) under two approaches:

Conventional sequence from previous processing (surface wave attenuation & spiking deconvolution)

 ~9-14 Hz around the target zone





Special sequence (radial filter & Gabor decon)

- Better attenuation of low-freq. noise
- Signal ~5-9 Hz

WELL LOG ANALYSIS

| Properties | Nisku | Calmar |
|--------------|--------|--------|
| ф | 7.4 % | 1.8 % |
| Permeability | 315 md | 0.83 |







- Horizon: 2nd White Speckled Shale
- Frequency cut-off: ~8-13 Hz





Initial Model case b):

- Horizon: 2nd White Speckled Shale
- Frequency cut-off: ~6-10 Hz

Inversion analysis case a): Inversion analysis case b):

Analysis window: 800 – 1500 ms indicated by yellow bars



Inversion case a):

- More continuous layers without much lateral variation
- Lower Zp values in 1500 the Nisku Fm.





Inversion case b):

- Thicker layers with some lateral variation
- Higher resolution in the Colorado Group

0.0



Zp (e06)



position

Inversion case b):

- More low-frequency content present in the seismic data
- Same vertical position

2D geological model created based on well log information and parameters from the Highvale line



| | B (1 | | | | |
|-------|---------------|-------------|-------------|-------------|-----------------------|
| Block | Depth (Km) | Vp (m/s) | Vs (m/s) | ρ (g/cc) | Formation |
| 1 | 0.0 | 1900 | 1590 | 2.3 | Shallow surface |
| 2 | 0.1 | 1920 | 1600 | 2.3 | Shallow - Lea Park |
| 3 | 0.773 | 3000 | 1610 | 2.35 | Lea Park |
| 4 | 1.27 | 3300 | 1620 | 2.5 | Viking |
| 5 | 1.533 | 3700 | 2000 | 2.68 | Banff |
| 6 | 1.605 | 5410 | 3029 | 2.61 | Exshaw |
| 7 | 1.613 | 3795 | 2195 | 2.74 | Wabamun |
| 8 | 1.764 | 6000 | 3300 | 2.67 | Graminia |
| 9 | 1.769 | 5889 | 3328 | 2.78 | Blueridge |
| 10 | 1.787 | 5890 | 3350 | 2.77 | Calmar |
| 11 | 1.793 | 5500 | 3150 | 2.8 | Nisku |
| 12 | 1.897 | 6200 | 3300 | 2.77 | Ireton |
| 13 | 2.0 | 5000 | 2660 | 2.8 | Duvernay/Leduc |
| 14 | 2.14 | 4000 | 2100 | 2.77 | Basal Cooking Lake |

| PARAMETERS | HIGHVALE | | |
|--------------------|--------------------|--|--|
| Source type | Dynamite (1Kg/18m) | | |
| Source interval | 80 m | | |
| Receiver interval | 20 m | | |
| Sample rate | 2 ms | | |
| Record length | 3 sec. | | |
| Number of channels | 201 | | |
| Lines length | 17.38 Km | | |

- CO2 volume estimation based on the static approach (Frailey, 2009)
- A disk was used to estimate the CO2 volume and radius of extension (Vera, 2012)



 Gassmann fluid substitution was used to calculate the changes in Vp, Vs and density (Alshuhail, 2011).







• Edges and top of the plume is clearly identifiable with a plume width of 500 m.

2D SEISMIC MODELLING Inversion analysis – Baseline stack



- Synthetic P-impedance log created from the geologic model
- Wavelet extracted from wellseismic tie process
- Correlation > 99%







- **Monitor Inversion:** Exact impedance
 - values as the P-
 - impedance log except in the
 - ^{8.6} injection zone and below it.





- P-impedance decreased ~7%
- Shape of the plume is even more clear than before. Top, base and sides are easily identifiable with a plume width of 500 m.
- Fewer artifacts are still seen at the edges of the plume and below it.





CONCLUSIONS

Seismic processing:

- New processing recovered low-frequency signal useful in inversion studies.
- Seismic Inversion:
 - Broadband result was obtained with new processing
 - More lateral variation related with low-frequency signal
 - Previous processing showed a cleaner and more continuous section.

2D seismic modelling:

- Time delay (1.81 ms), amplitude change (~30%) and Impedance change (-7%) in the post-injection seismic section.
- The shape of the CO2 plume is more easily identifiable by impedance changes (width = 500 m).

ACKNOWLEDGEMENTS

- TransAlta Corporation, CNRL and Schlumberger
- Helen Isaac, Dave Henley, Raul Cova and Bob Loblaw
- Shahin Moradi
- Brian Russell
- ProMAX, NORSAR-2D and Hampson-Russell Software
- Carbon Management Canada (CMC) and CREWES sponsors and members.