

Fluid substitution analysis for the monitoring test center and an overview of the Shell QUEST project

By: Shahin Moradi

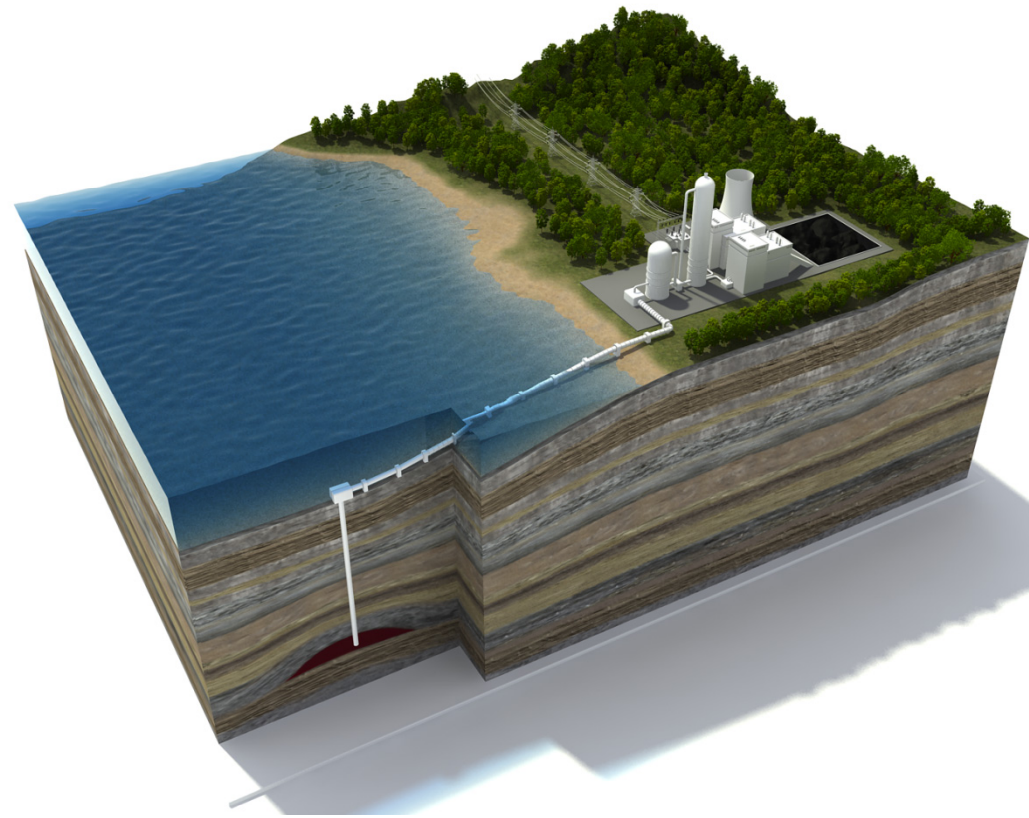
Supervisor: Dr Don Lawton

OUTLINE

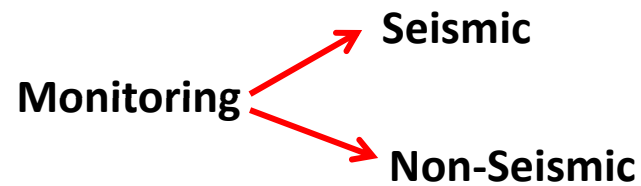
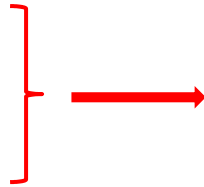
- Introduction
- Objective
- Area of study
- Data
- Theory
- Results
- QUEST project
- Conclusions

Introduction

- **Carbone Capture and Storage(CCS):**
 1. **Capture CO2**
 2. **Transport**
 3. **Injection**



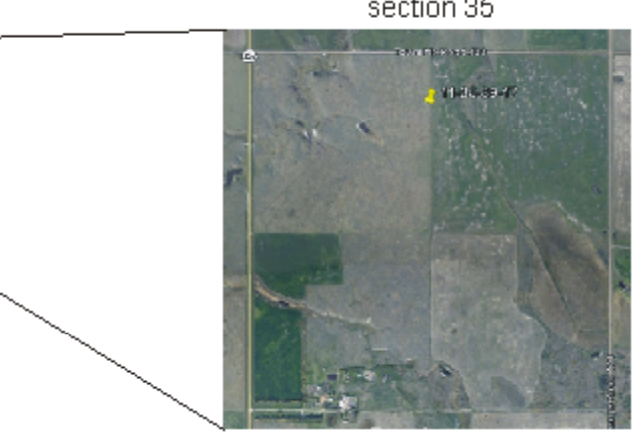
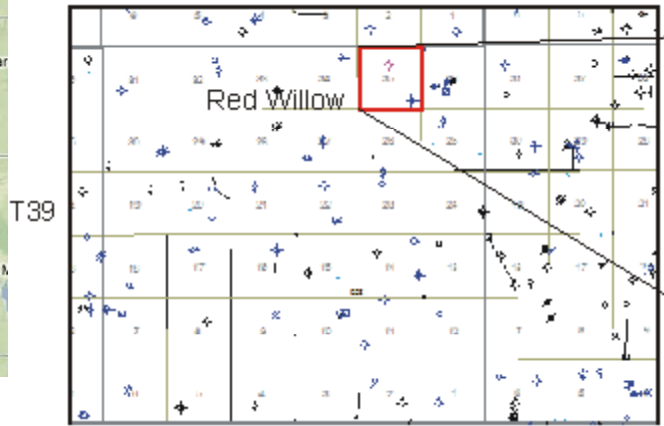
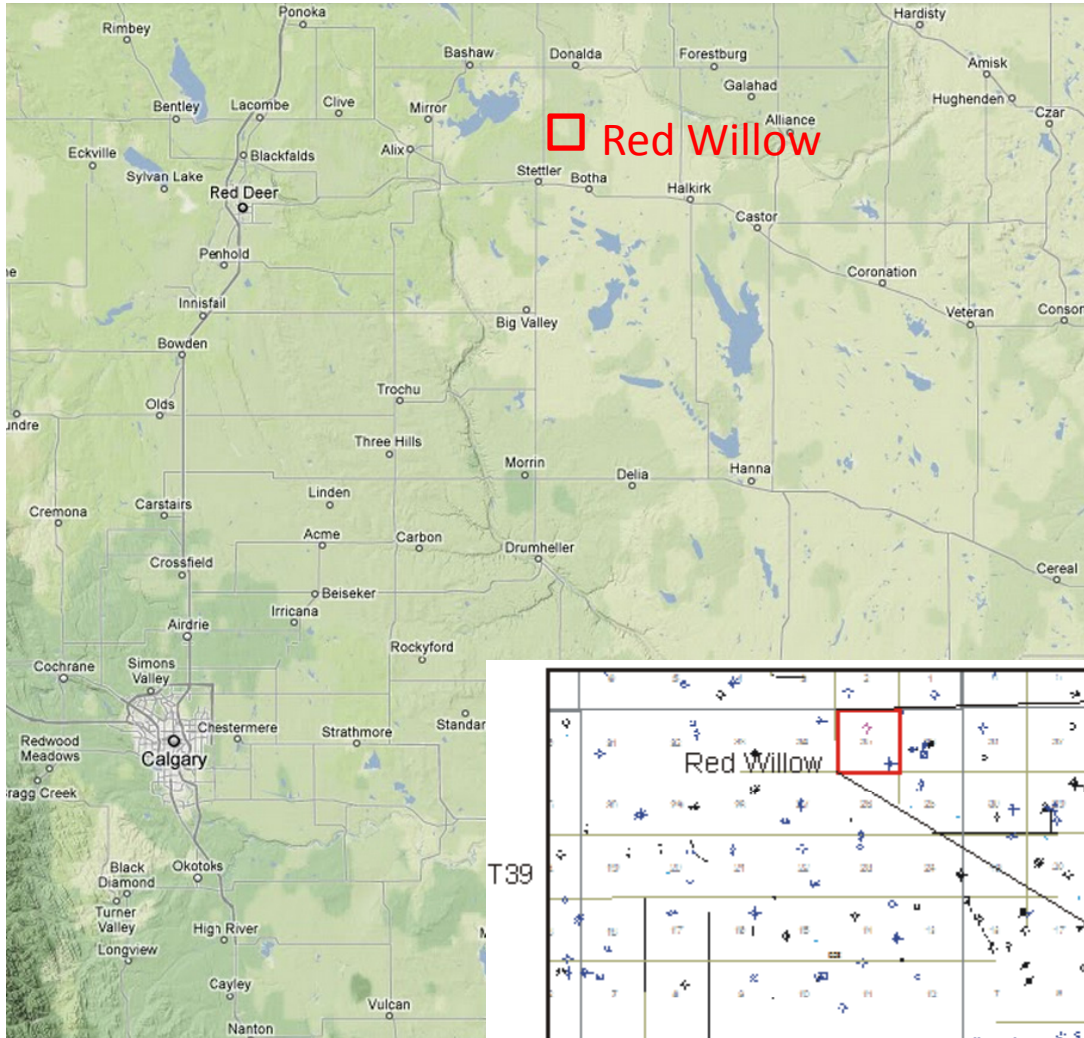
- Pre- injection
- Injection
- Post -injection



OBJECTIVE

- Investigate the detectability of CO₂ in Basal Belly River Sandstone in Red willow area (Alberta).

Study Area



Regional Stratigraphic Nomenclature

Stratigraphic Nomenclature			Major Energy Resources	Hydrostratigraphy	
Period	Group	Formation			
Quaternary	Pre and glacial drift				
Tertiary	Paskapoo			Scollard - Paskapoo aquifer	
	Edmonton	Scollard		post-Colorado aquifer-aquitard system	Battle aquitard
		Battle			Horseshoe Canyon aquifer
		Whitemud			Bearpaw aquitard
		Horseshoe Canyon			Belly River aquifer system
		Bearpaw			Lea Park aquitard
		Belly River			Milk River aquifer
	Colorado	Lea Park	Milk River		Colorado aquitard system
		Cardium			
		Second White Spackled Sandstone			
		Viking			
		Mannville	Clearwater		Upper Mannville aquifer
					Clearwater aquitard
	Jurassic	U			Lower Mannville aquifer
M				Jurassic aquitard	
L				Mississippian - Jurassic aquifer system	
Triassic					
Permian					
Pennsylvanian	Stoddart				
	Rundle				
	Banff				
	Exshaw			Exshaw - Banff aquitard	
	Wabamun				
Devonian	Upper	Winterburn		Upper Devonian aquifer system	
		Woodbend	Ireton		Ireton aquitard
			Leduc		
			Grosmont		
			Conking Lake		
	Middle	Beaverhill Lake			Middle - Upper Devonian aquifer system
		Elk Point	Upper	Prairie Evaporite	Prairie aquiclude - aquitard system
				Winnipegosis	Winnipegosis aquifer
			Lower	Cold Lake	
		Lower		Lotsberg	
	Not deposited				
Silurian					
Ordovician					
Cambrian	U			Cambrian aquitard system	
	M	Basal Sandstone		Basal aquifer	
	L	Not deposited			
Precambrian				aquiclude	



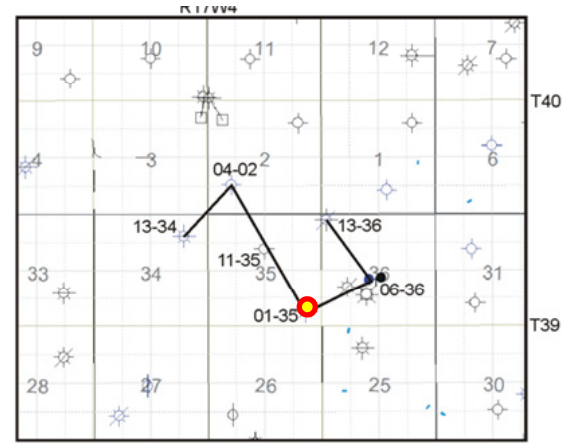
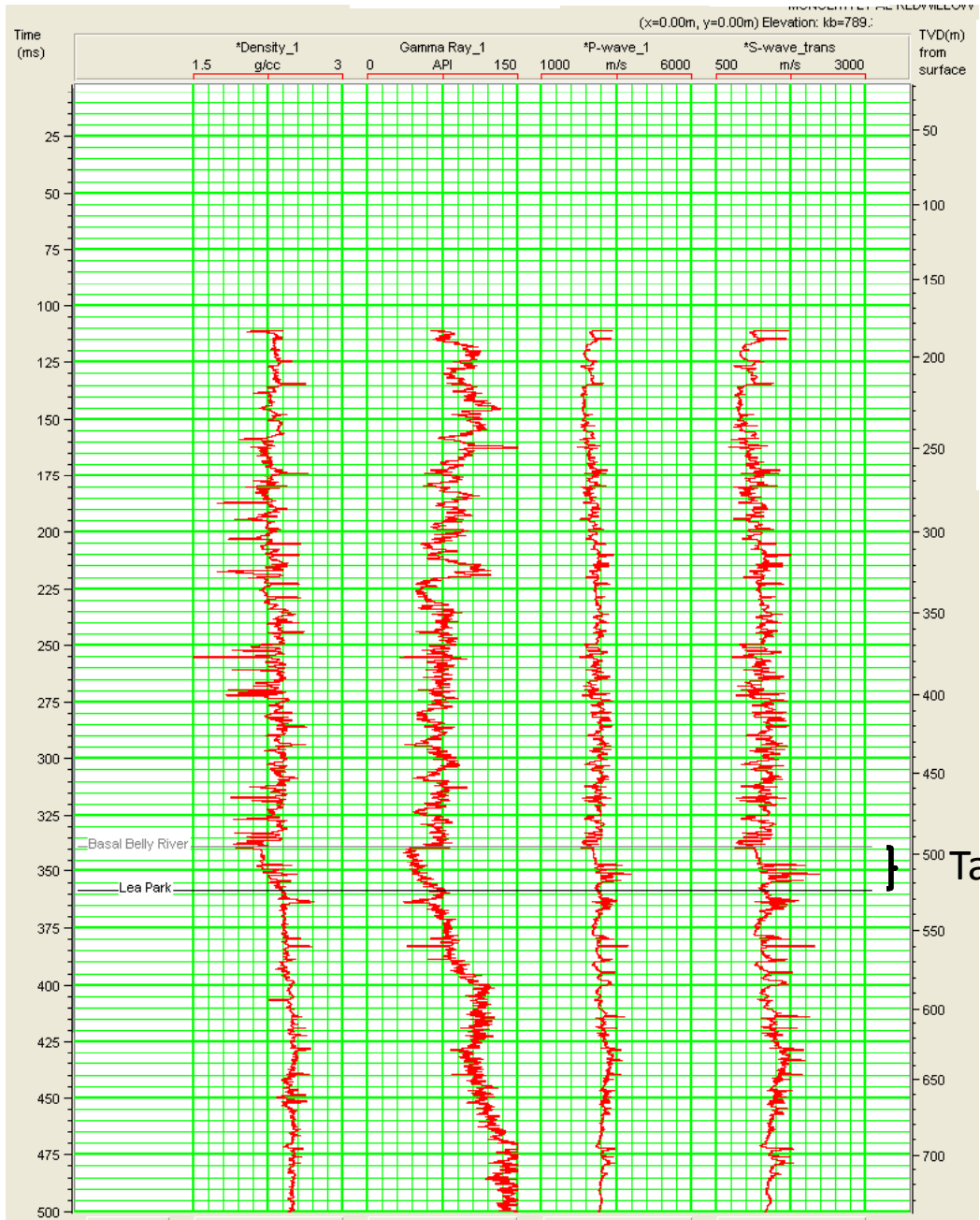
Legend

- Gas
- Oil
- Heavy Oil and Oil Sands
- Coal
- Salt
- Aquifer
- Sandstone
- Shale
- Mixed Heterolithics

Modified after Bachu et al. 2000.

Data:

Density Gamma-Ray P-wave velocity S-wave Velocity



Gamma ray and sonic logs

Target

Theory

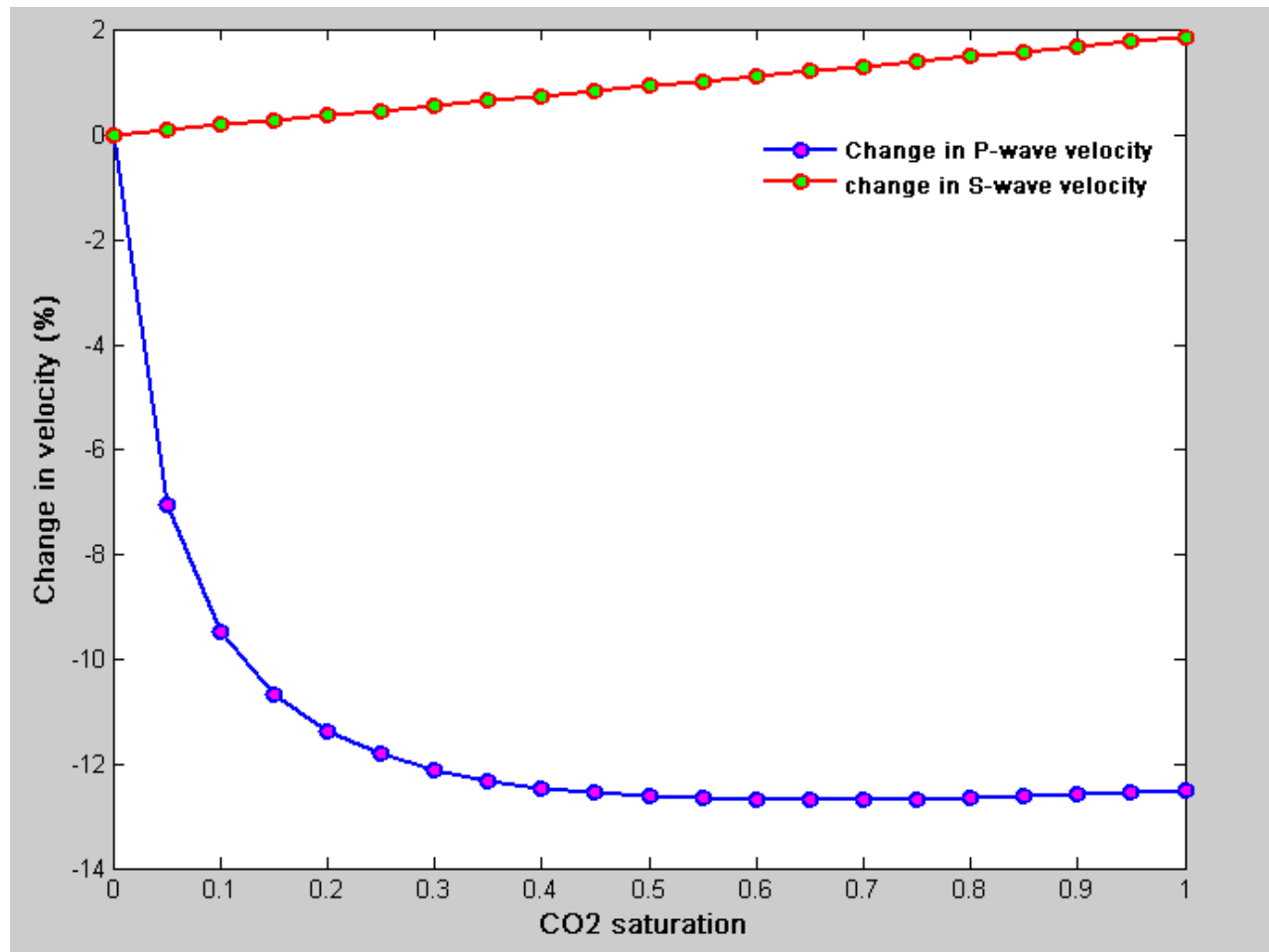
Injection affects the physical properties of the rock such as Bulk modulus and density(Gassman, 1951):

$$K_{\text{new saturated}} = K_{\text{dry frame}} + \frac{\left(1 - \frac{K_{\text{Dry frame}}}{K_{\text{mineral}}}\right)}{\left(\frac{\phi}{K_{\text{new fluid}}} + \frac{(1-\phi)}{K_{\text{mineral}}} - \frac{K_{\text{Dry frame}}}{(K_{\text{mineral}})^2}\right)}$$

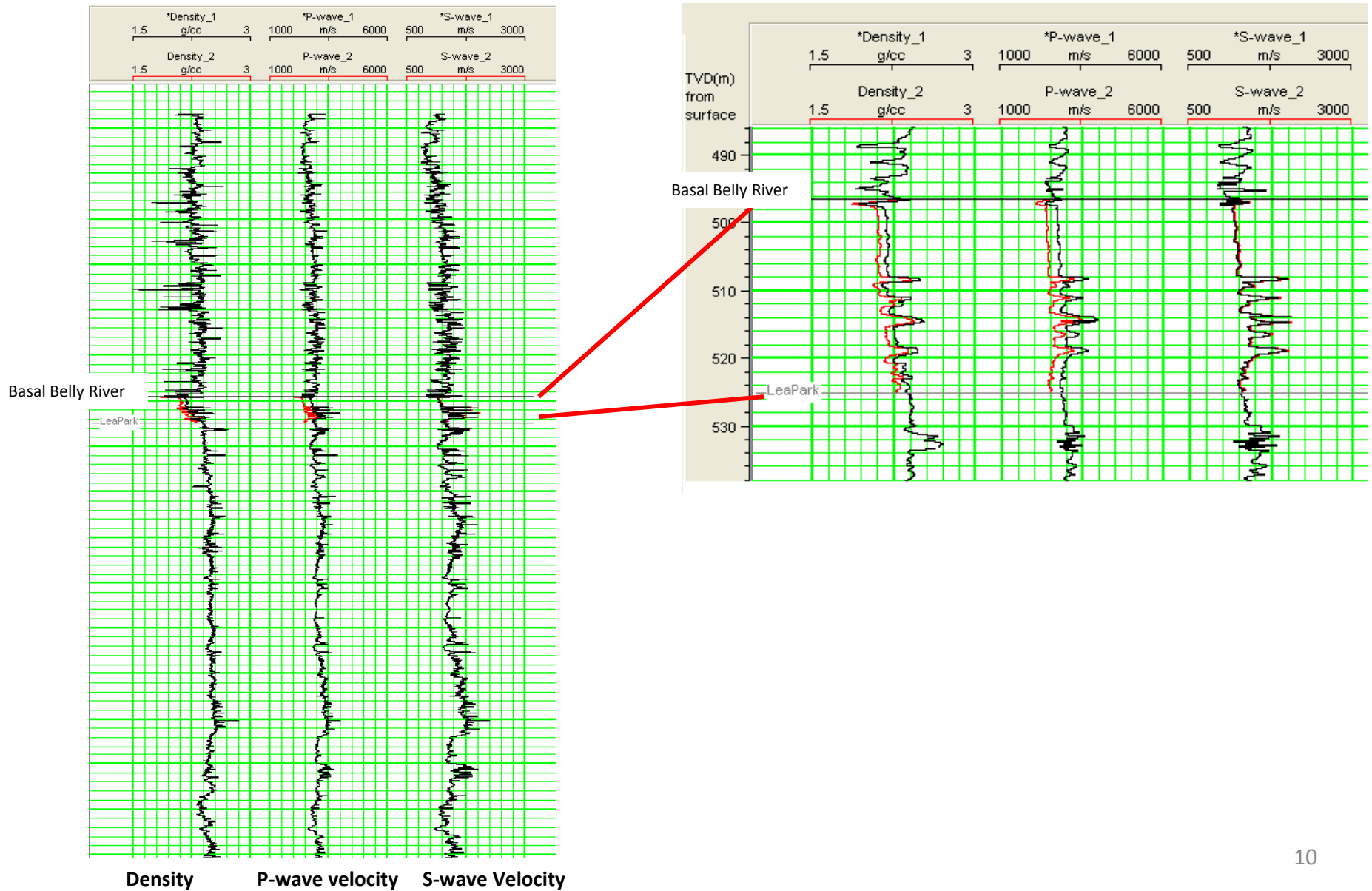
K: Bulk modulus

ϕ : Porosity

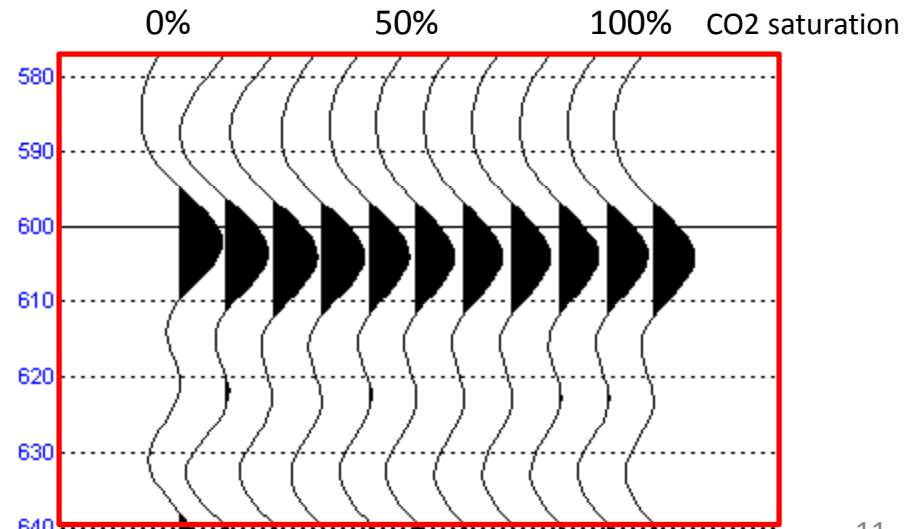
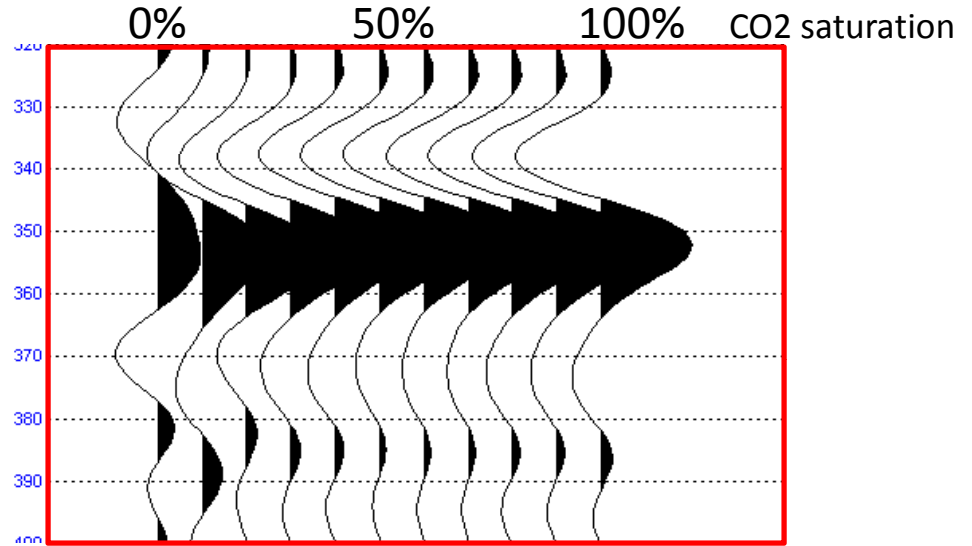
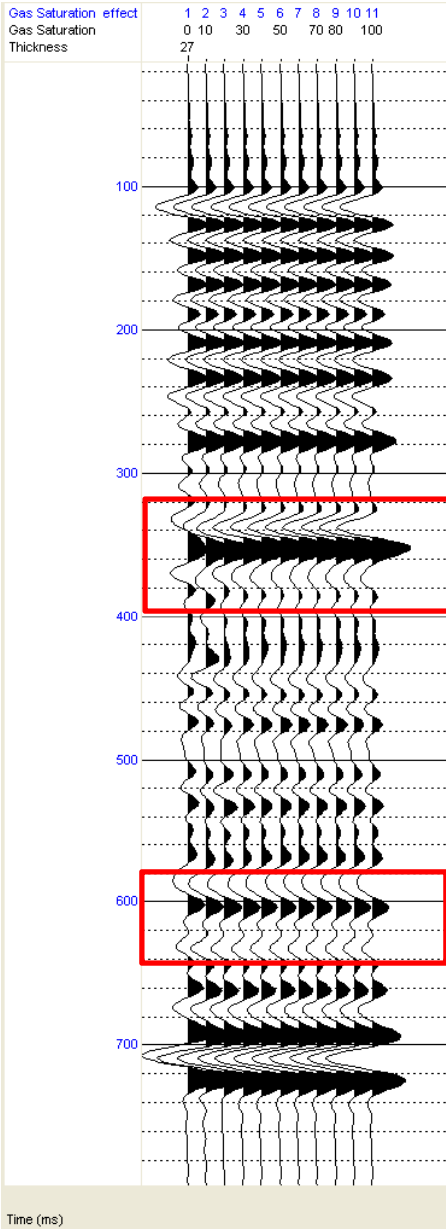
Effect of gas saturation in velocity



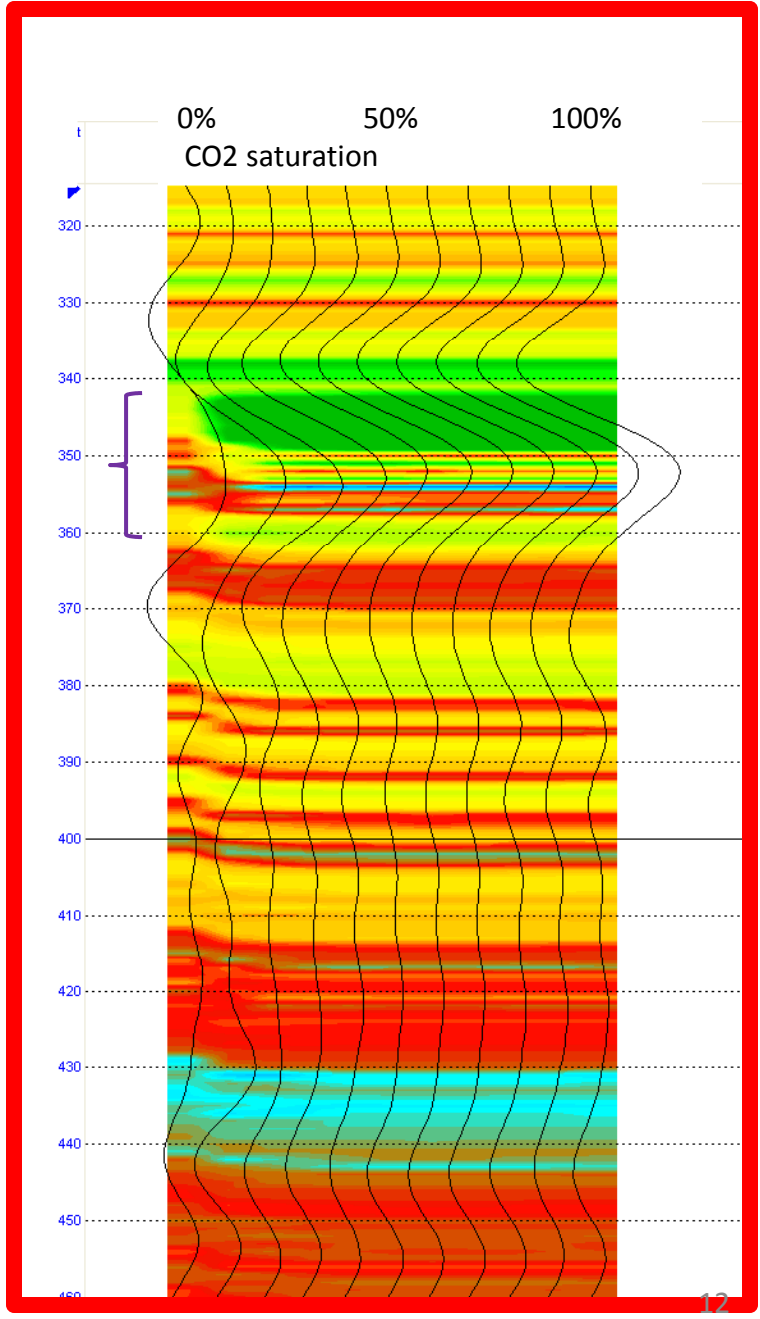
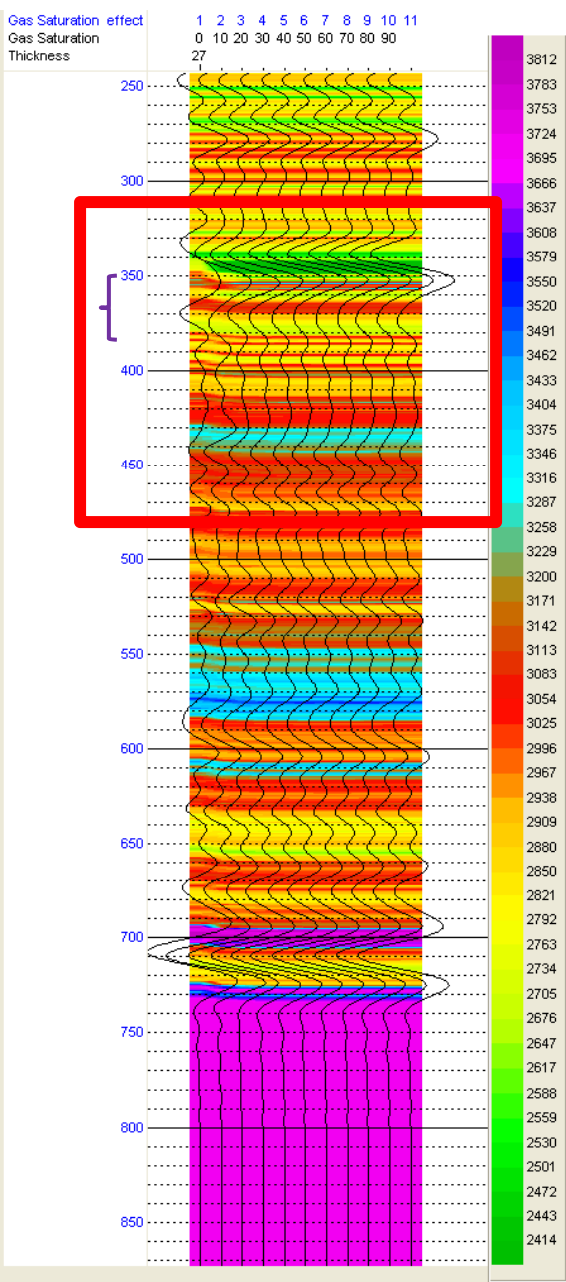
Fluid substitution results



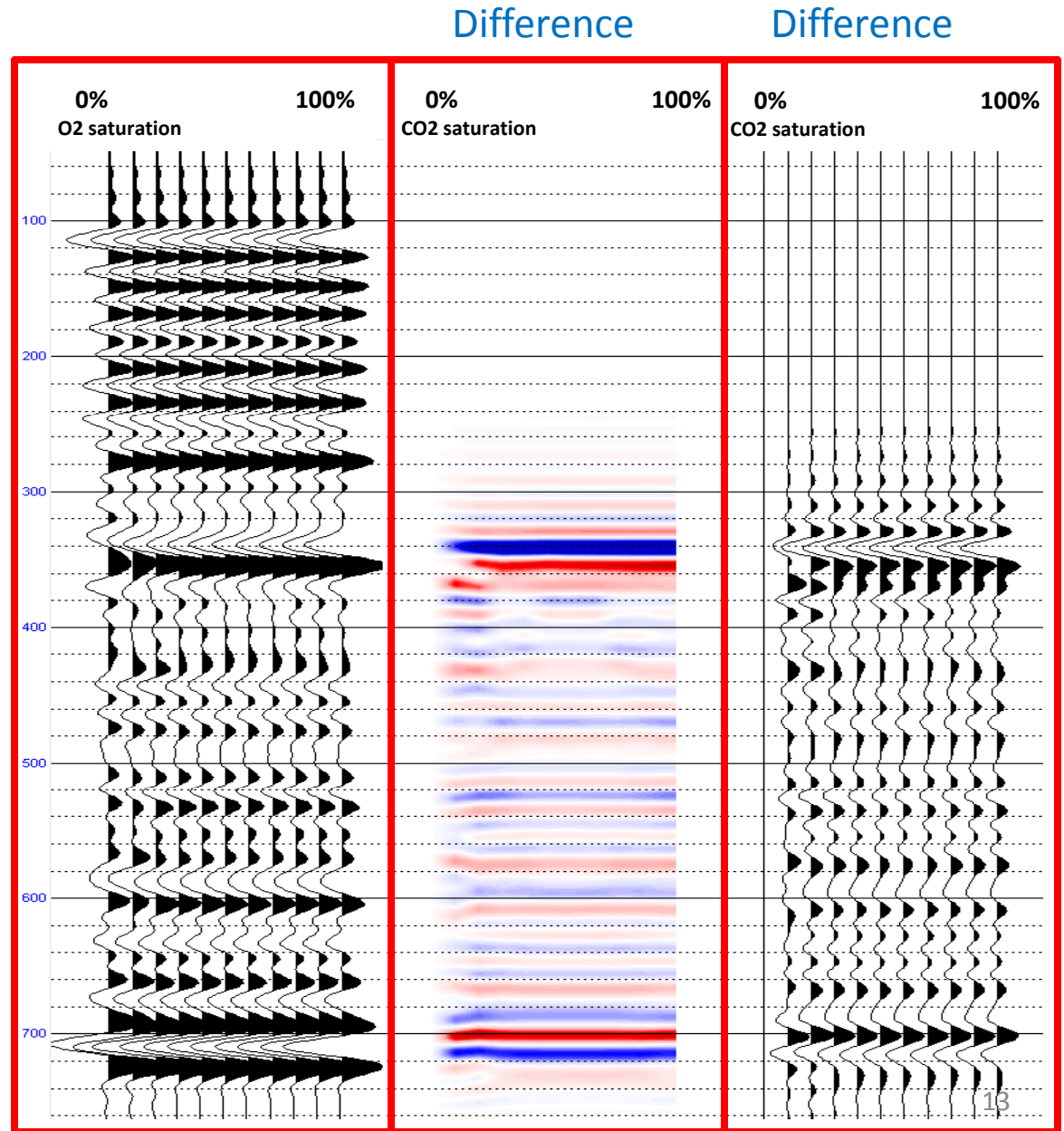
Synthetic Seismograms and CO2 saturation



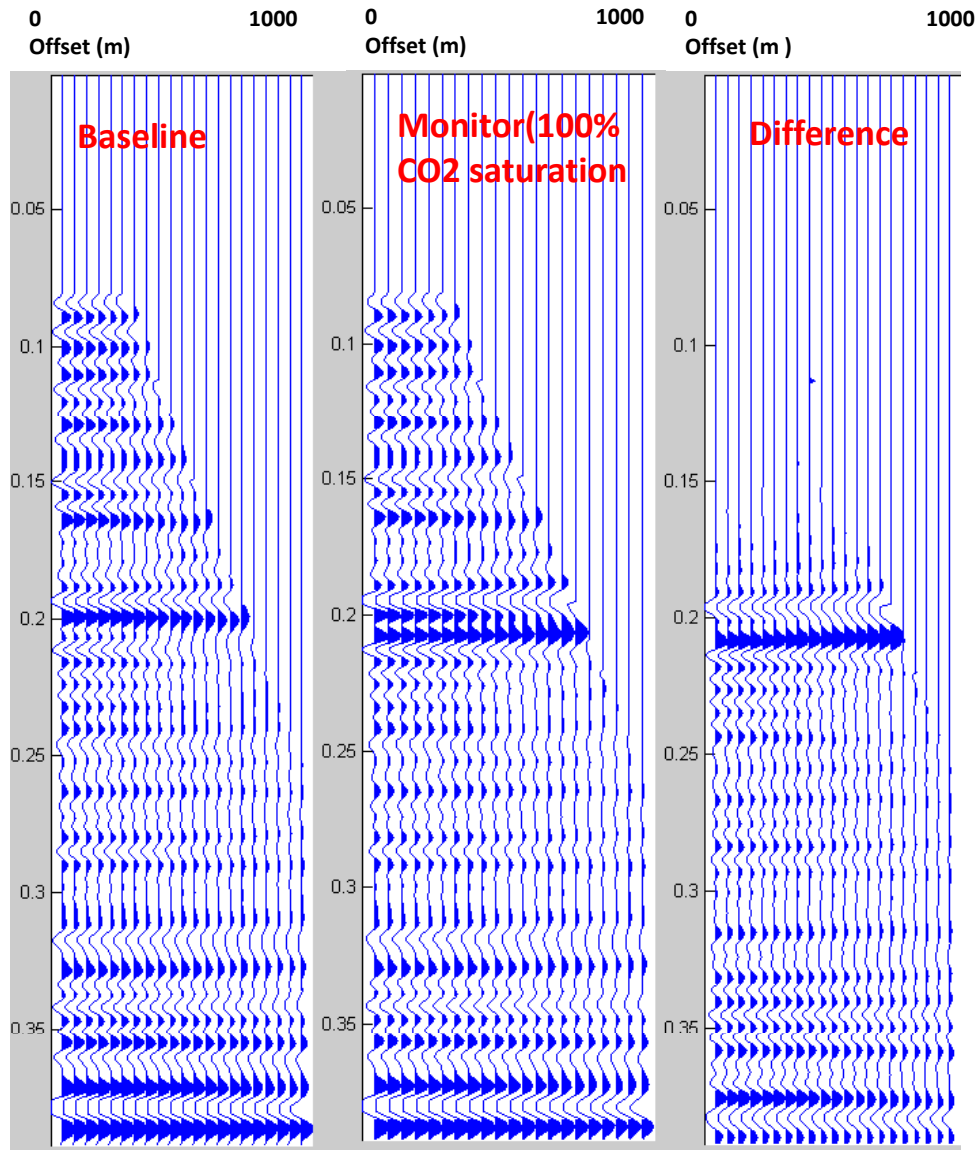
P-wave Velocity Change



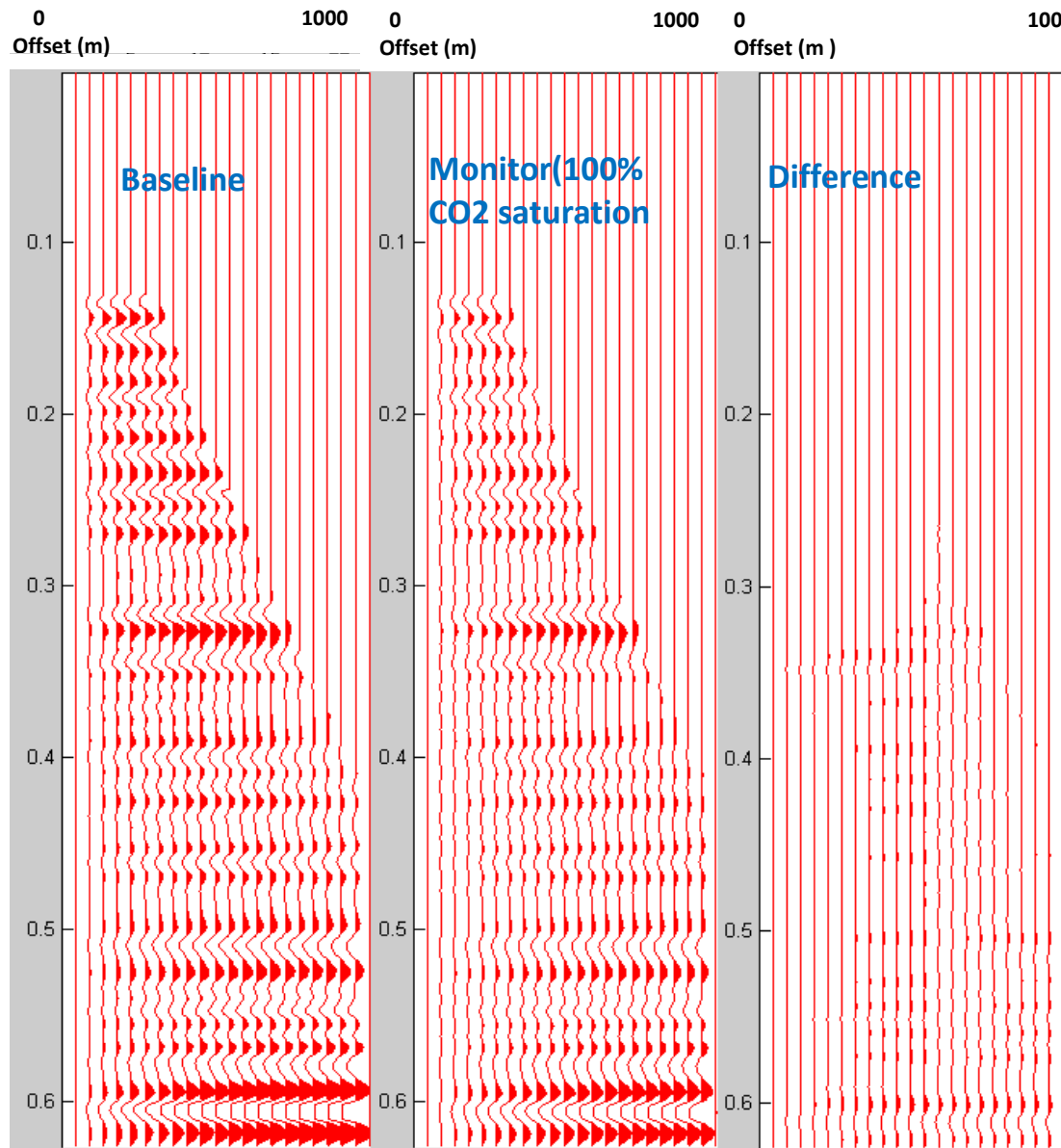
Detectability



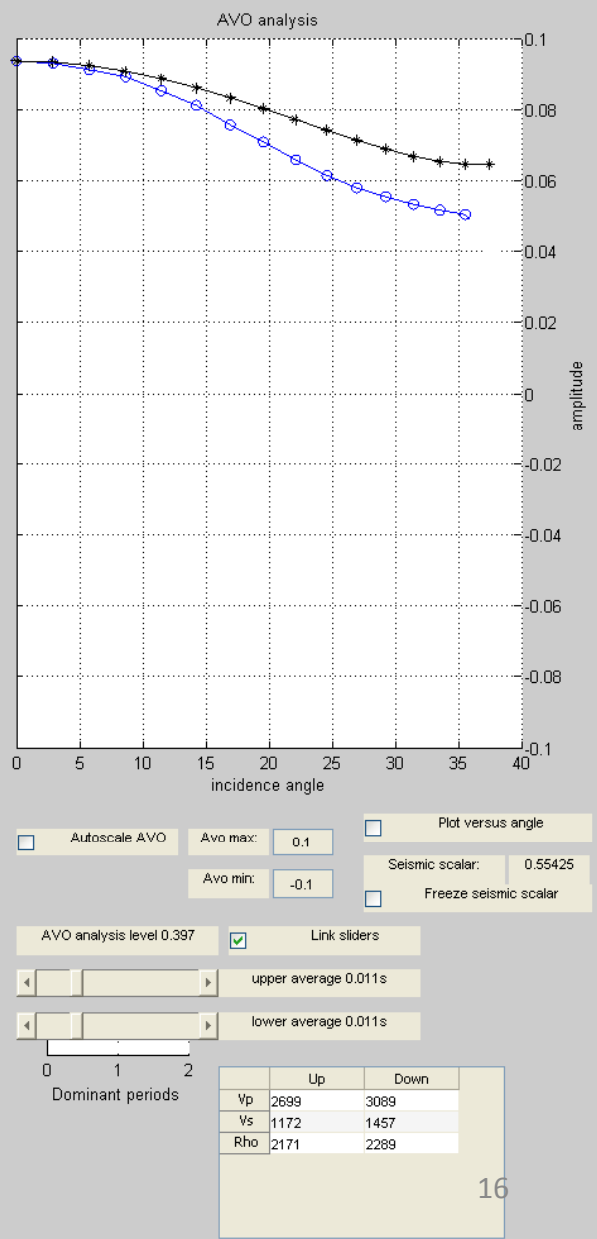
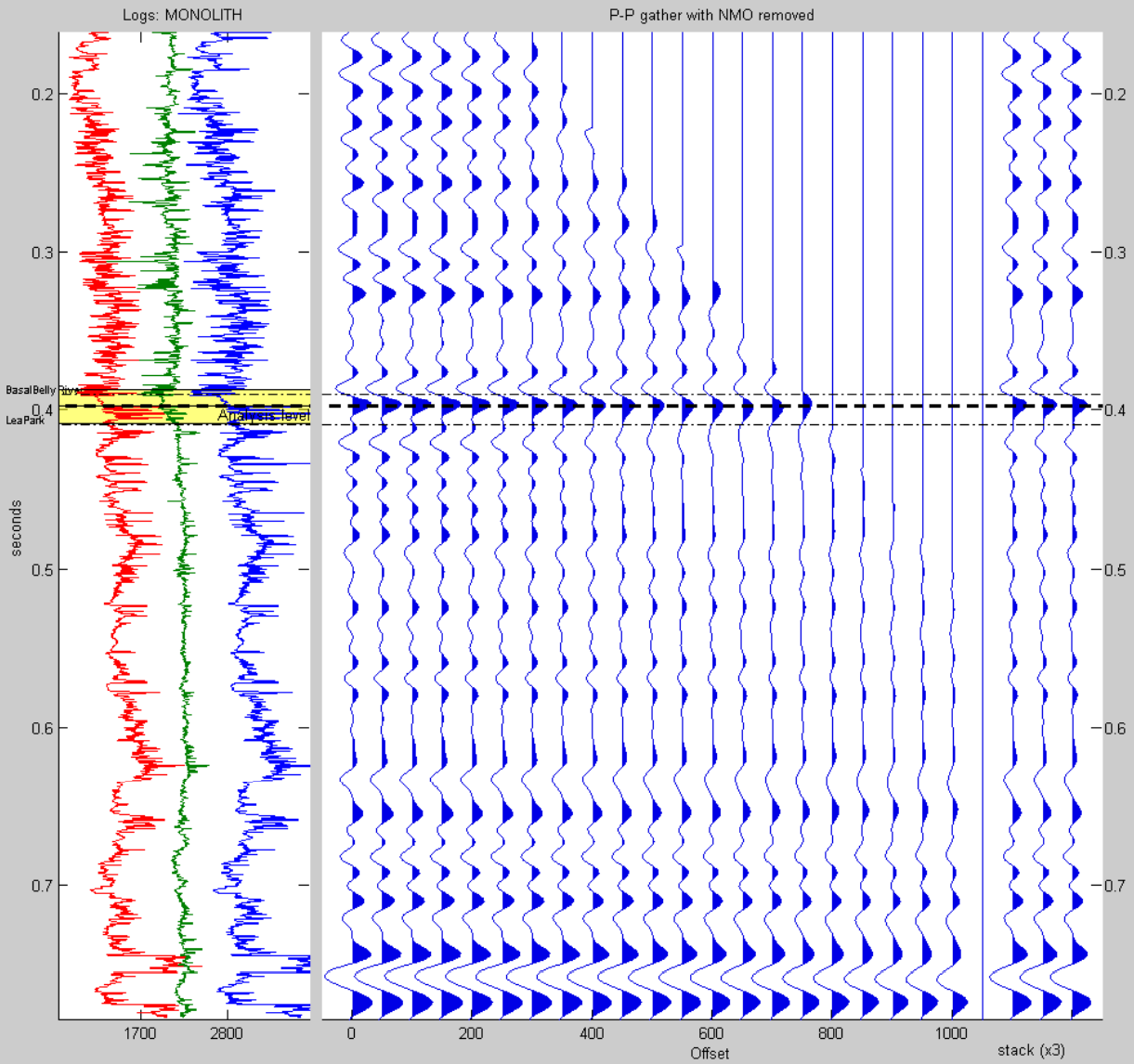
P-P Synthetics:



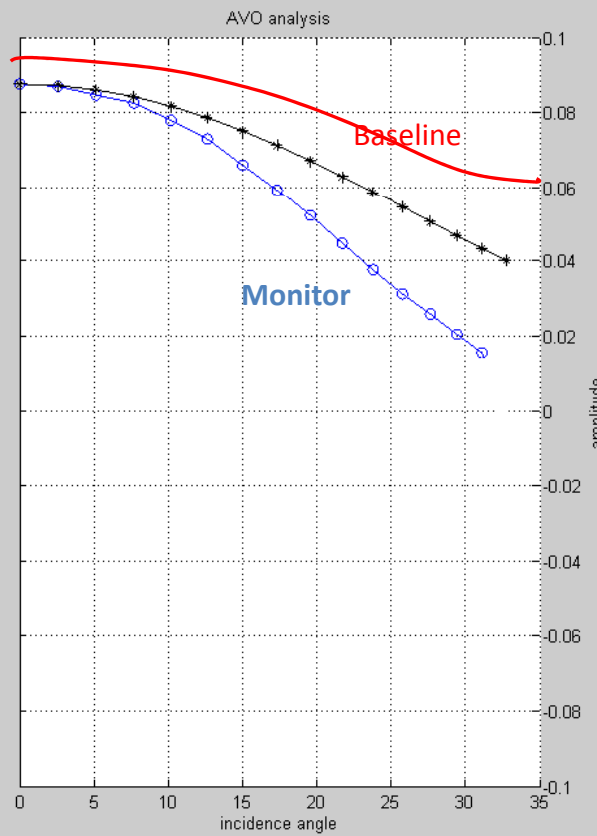
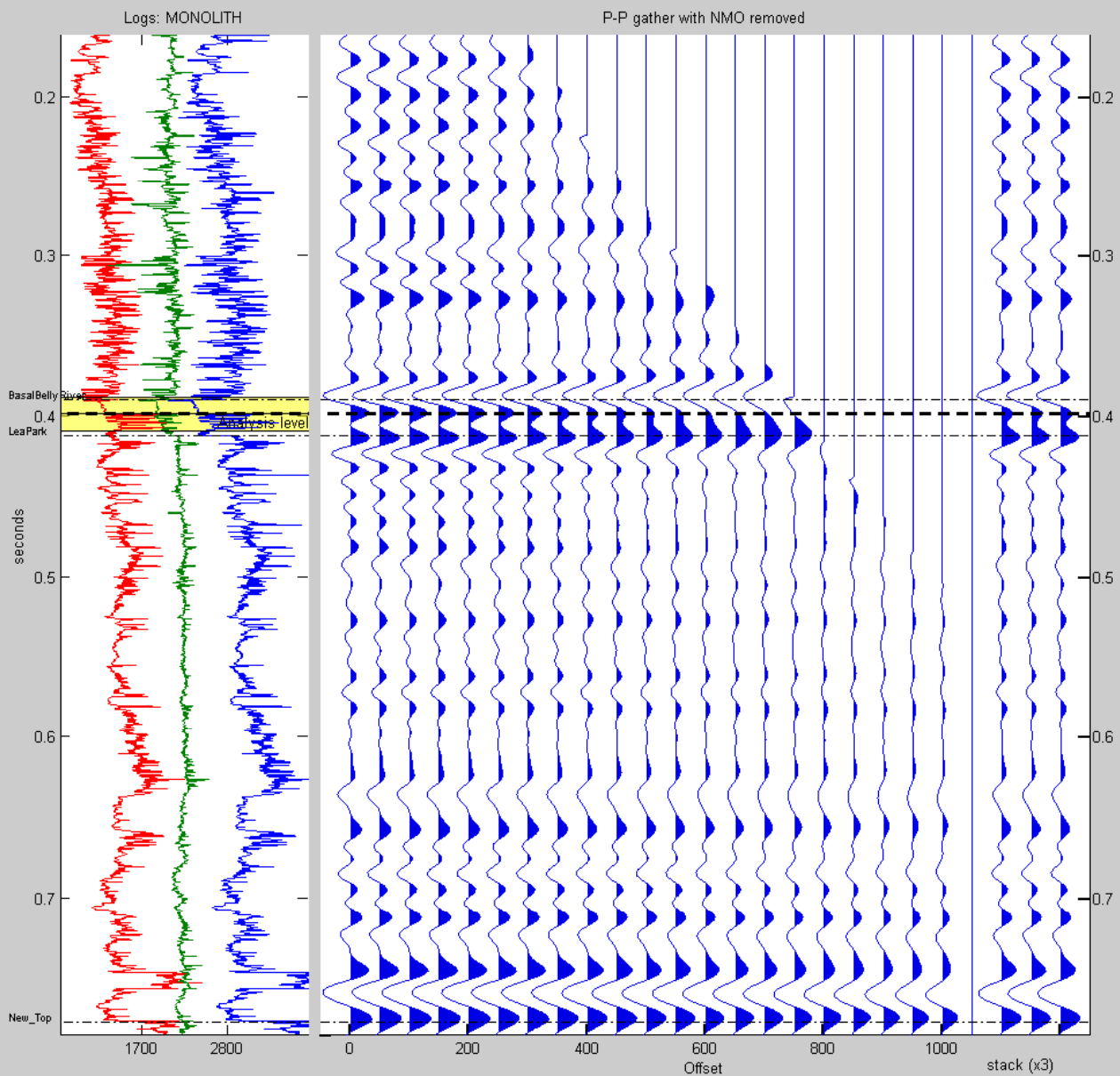
P-S Synthetics:



AVO : P-P Synthetic(Baseline)



AVO : P-P Synthetic(100% CO2 saturation)



AVO analysis controls:

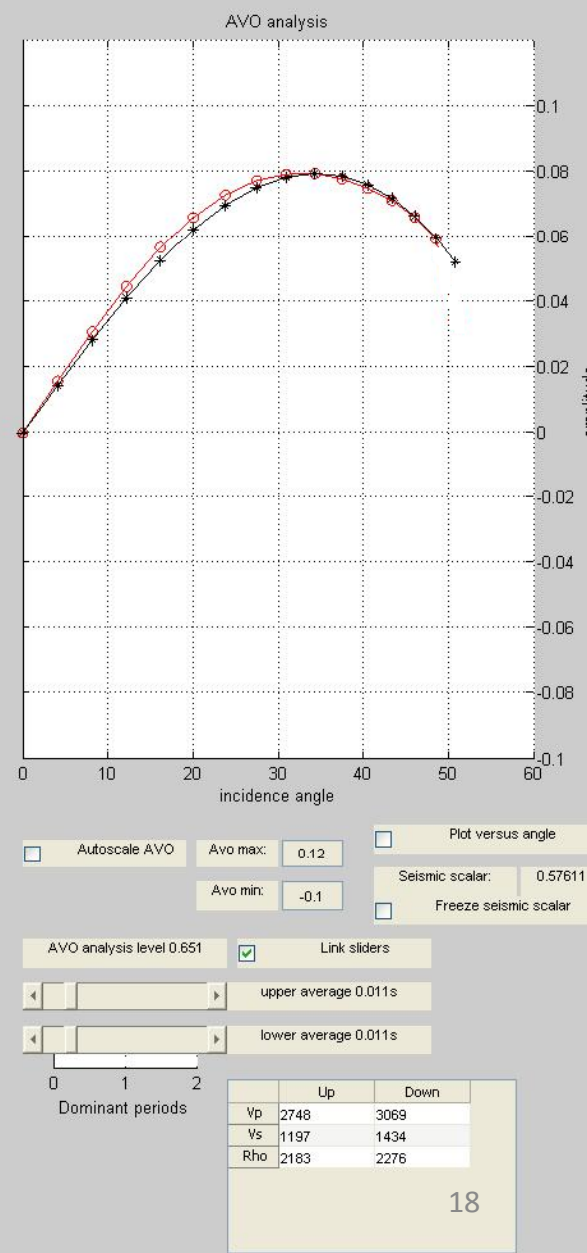
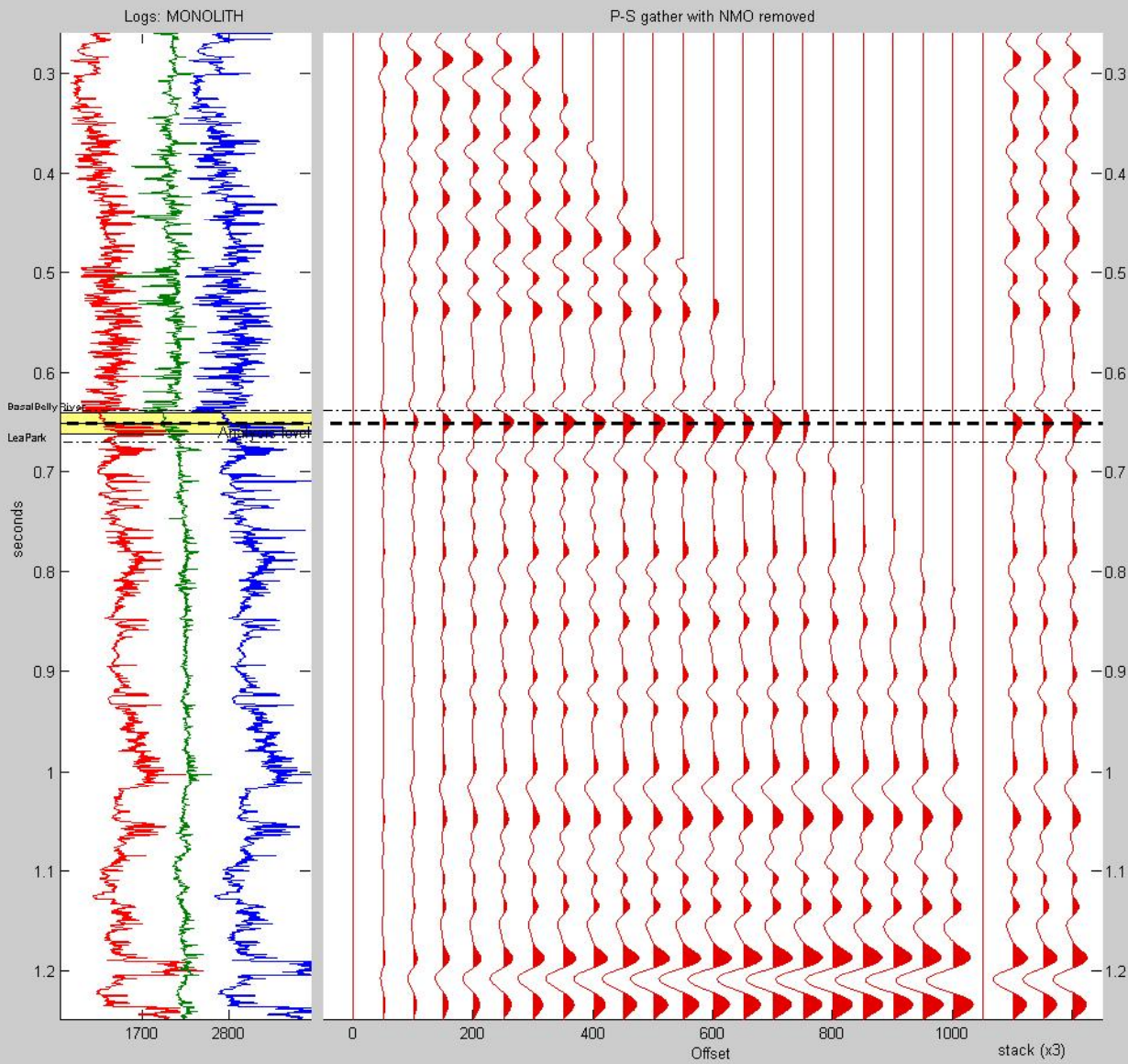
- Autoscale AVO
- Avo max: 0.1
- Plot versus angle
- Avo min: -0.1
- Seismic scalar: 0.63868
- Freeze seismic scalar
- AVO analysis level 0.399 Link sliders
- upper average 0.011s
- lower average 0.011s

Dominant periods: 0 1 2

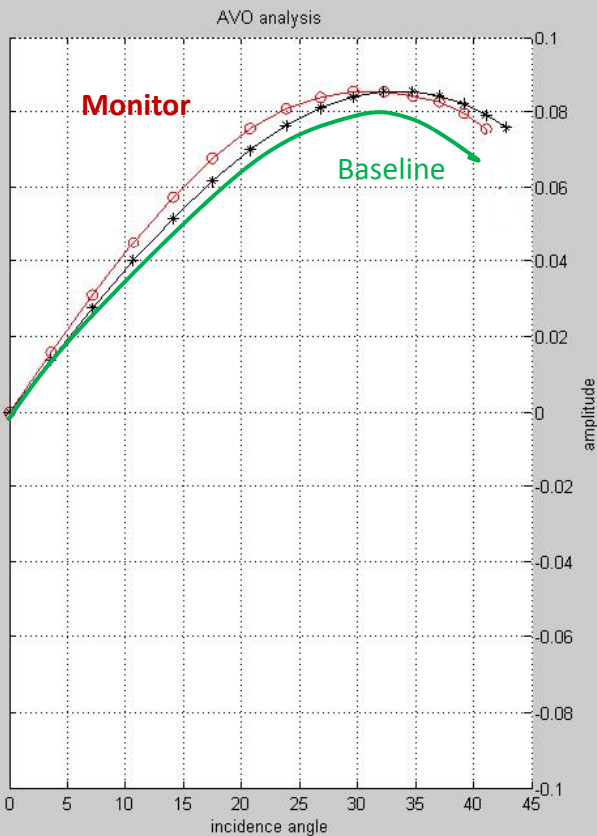
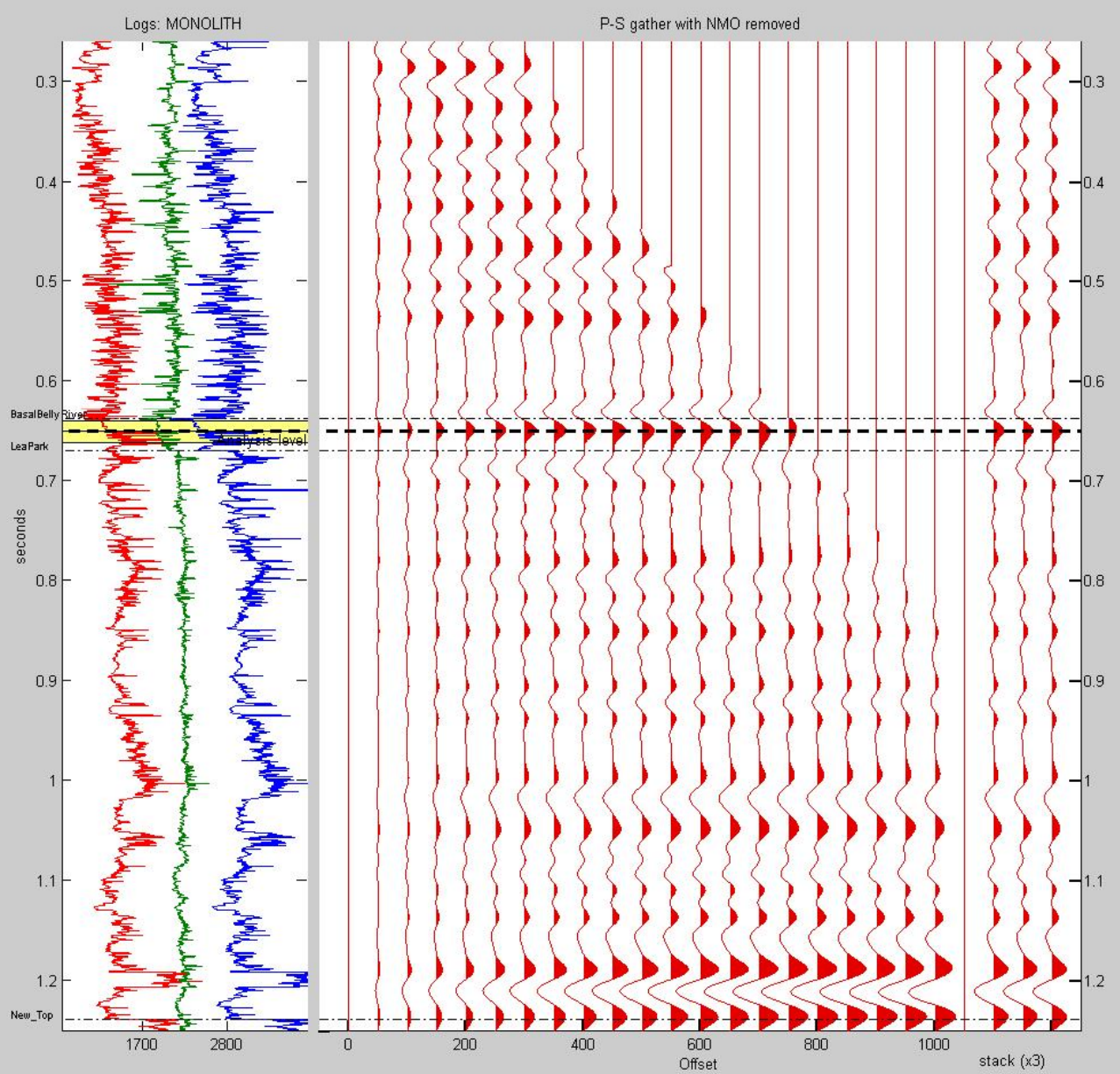
	Up	Down
Vp	2389	2712
Vs	1204	1488
Rho	2102	2207

17

AVO : P-S Synthetic(Baseline)



AVO : P-S Synthetic(100% CO2 saturation)

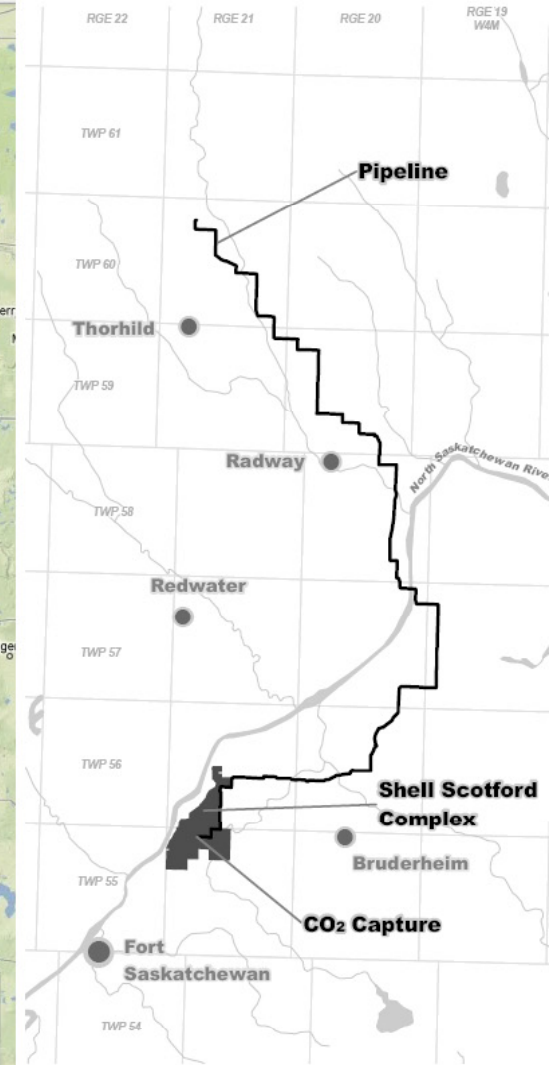
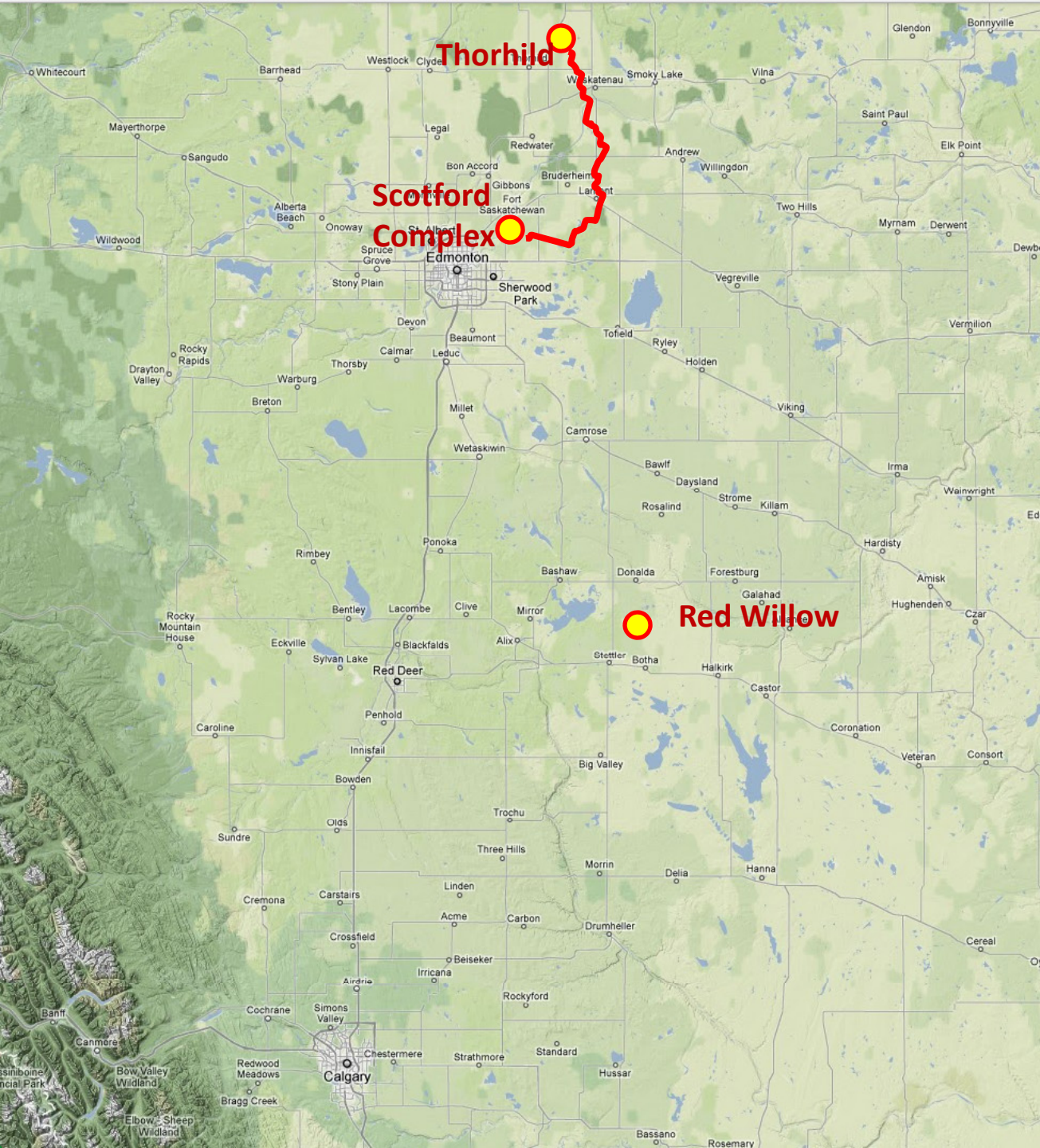


Autoscale AVO Avo max: 0.1 Plot versus angle
 Avo min: -0.1 Seismic scalar: 0.88178
 Freeze seismic scalar
 AVO analysis level 0.651 Link sliders
 upper average 0.011s
 lower average 0.011s
 1 2 Dominant periods

	Up	Down	
Vp	2404	2675	19
Vs	1218	1453	
Rho	2107	2193	

QUEST project





Joint among:
 Shell Canada Energy (60%),
 Chevron Canada Limited
 (20%)
 Marathon Oil Canada
 Corporation (20%)

Regional Stratigraphic Nomenclature

Stratigraphic Nomenclature			Major Energy Resources	Hydrostratigraphy				
Period	Group	Formation						
Quaternary	Pre and glacial drift							
Tertiary	Edmonton	Paskapoo		Scollard - Paskapoo aquifer				
		Scollard		Battle aquitard				
		Battle		Horseshoe Canyon aquifer				
		Whitemud		Bearpaw aquitard				
		Horseshoe Canyon		Belly River aquifer system				
		Bearpaw		Lea Park aquitard				
		Belly River		Milk River aquifer				
		Lea Park	Milk River					
		Cretaceous	Upper	Cardium		Colorado aquitard system		
				Second White Speckled Sandstone				
				Viking				
				Mannville	Clearwater			
				Lower				Upper Mannville aquifer
								Clearwater aquitard
Jurassic	U			Lower Mannville aquifer				
				Jurassic aquitard				
				Mississippian - Jurassic aquifer system				
M								
Triassic								
Permian								
Pennsylvanian								
Mississippian		Stoddart		Exshaw - Banff aquitard				
		Rundle						
		Banff						
		Exshaw						
		Upper	Wabamun			Upper Devonian aquifer system		
			Winterburn					
			Woodbend		Ireton, Grosmont, Leduc, Cooking Lake			
			Beaverhill Lake					
		Middle	Elk Point		Upper	Prairie Evaporite	Prairie aquiclude - aquitard system	
						Winnipegosis		Winnipegosis aquifer
Lower	Cold Lake							
	Lotsberg							
	Not deposited							
Lower					Elk Point aquiclude system			
Silurian								
Ordovician								
Cambrian	U			Cambrian aquitard system				
M	Deadwood		Basal Sandstone					
	Earlie							
L	Basal SST							
Precambrian				aquiclude				

Legend

- Gas
- Oil
- Heavy Oil and Oil Sands
- Coal
- Salt
- Aquifer
- Sandstone
- Shale
- Mixed Heterolithics

Quest Stratigraphic Nomenclature

Period	Formation	Quest Nomenclature
Devonian	Lower	Upper Lotsberg Salt
		Devonian Mudstones
		Lower Lotsberg Salt
		Basal Red Beds
Silurian		Absent
Ordovician		Absent
Cambrian	U	Upper Marine Silts (UMS)
		Middle Cambrian Shale (MCS)
	M	Lower Marine Sands (LMS)
		Basal SST
L		Not Deposited
Recambrian		Cratonic Basement

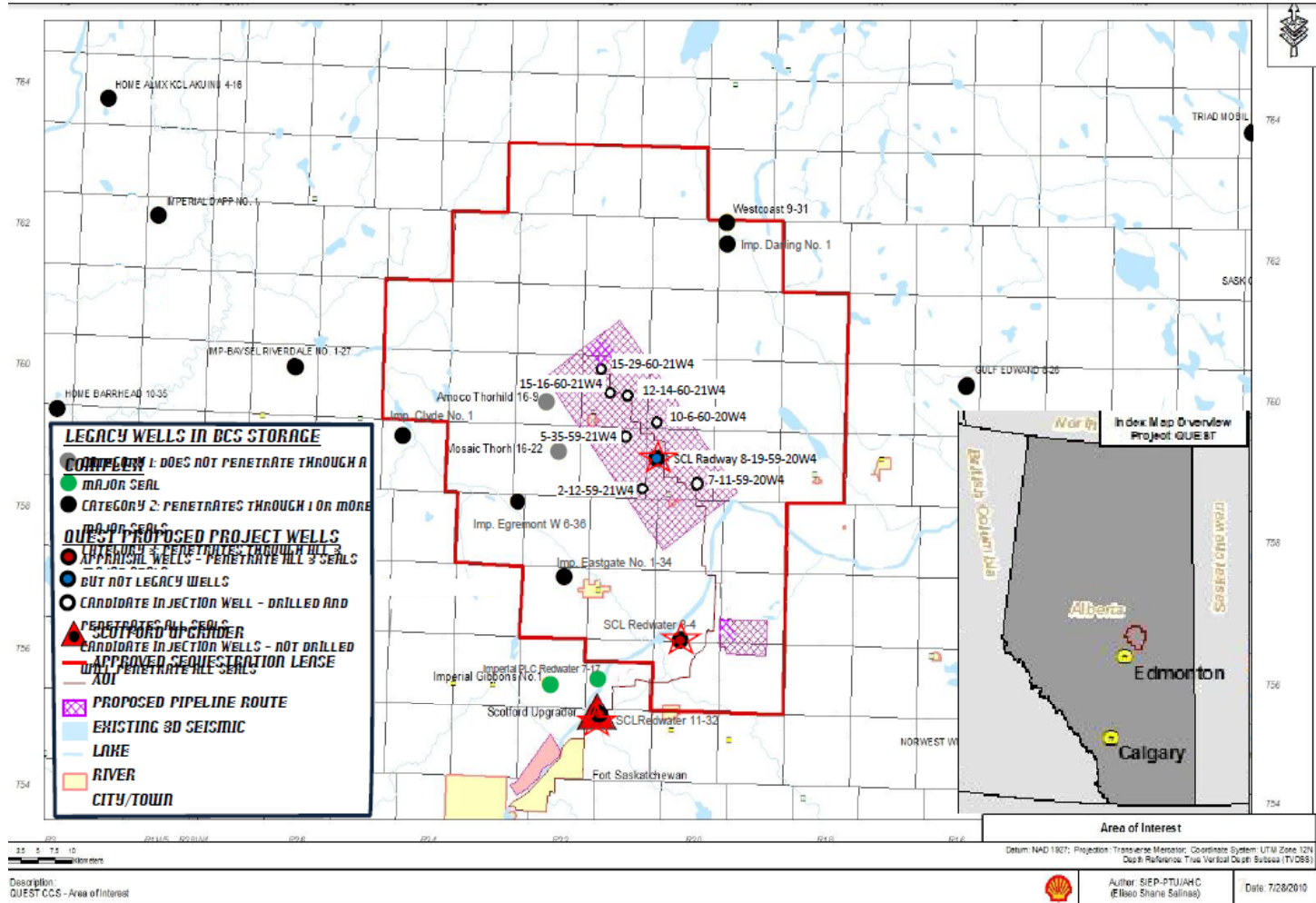
Red Willow ←

Quest ←

BCS Storage Complex

Modified after Bachu et al. 2000.

Baseline Data



Conclusion

- Surface seismic data is able to detect the CO₂ plum in Basal Belly River sands.
- P-S converted wave dose not show a significant change by increasing CO₂ saturation.
- AVO could be investigated for detectability analysis.

Acknowledgment

Thanks to:

Dr. Don Lawton

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AND

Thanks!