

Importance and Limitations of using Seismic Reflection Data to Understand the Risk of Induced Seismicity and Reservoir Capacity in a CCS Project

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Stroud¹, Robert A. Bauer¹, John McBride ²

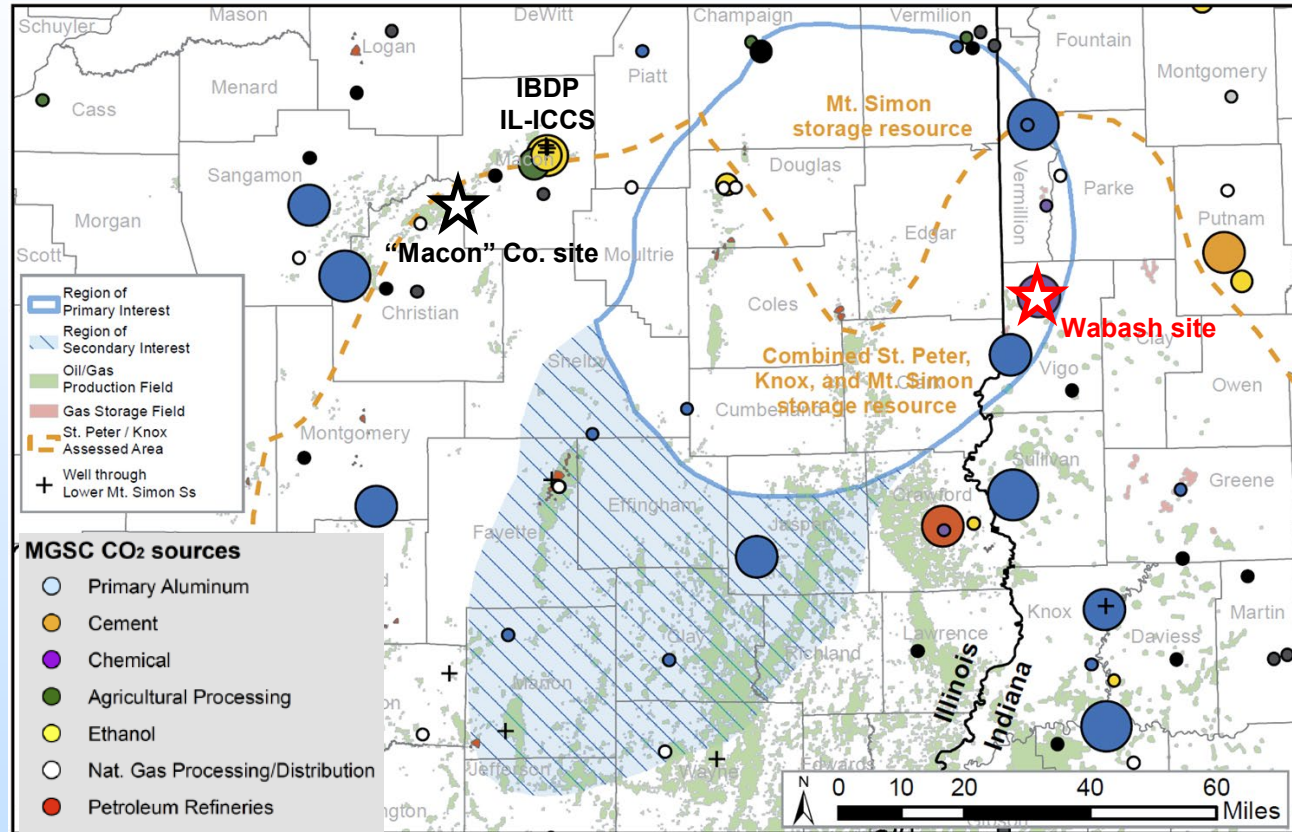
¹ Illinois State Geological Survey

² Brigham Young University

Acknowledgments

- We thank Mitchel Barklage and Wade Zaluski for their significant contributions.
- Landmark Graphics software via their University Donation Program and cost share for Petrel* E&P software platform donation from Schlumberger Carbon Services. IHS for their use of Petra and Kingdom via their University Grant Program.
- IBDP DE-FC26-05NT42588
- Wabash CarbonSAFE DE-FE0031626
- CarbonSAFE Illinois East Basin DE-FE0029445
- CarbonSAFE Illinois Macon DE-FE0029381

Overview

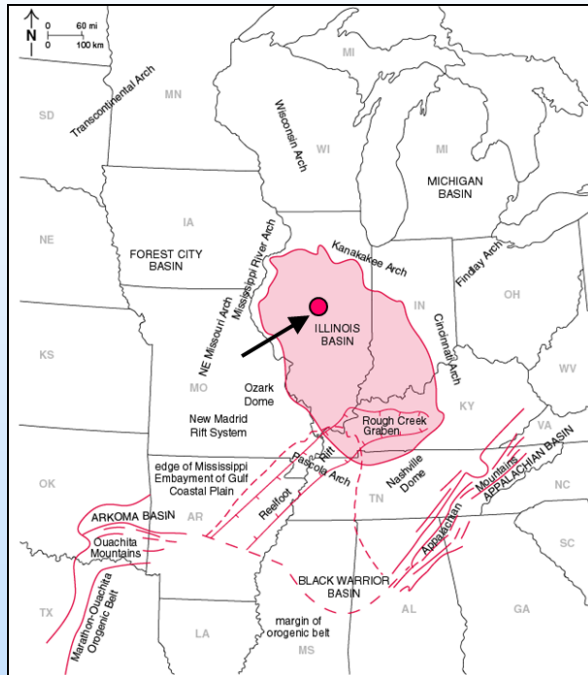


- Regional assessment of CO₂ sources and storage reservoirs/seals
- Building on regional partnership work...
 - Stacked saline options
 - EOR potential
- Primary/secondary areas of geological interest

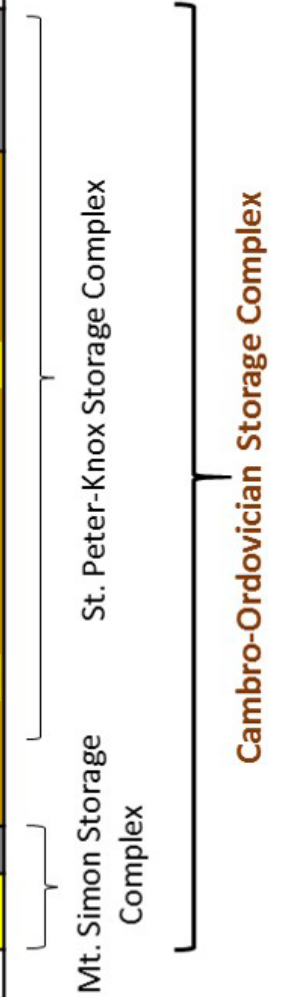
East sub-Basin Pre-Feasibility
 Project Number: DE-FE0029445

Wabash CarbonSAFE
 Project Number: DE-FE0031626

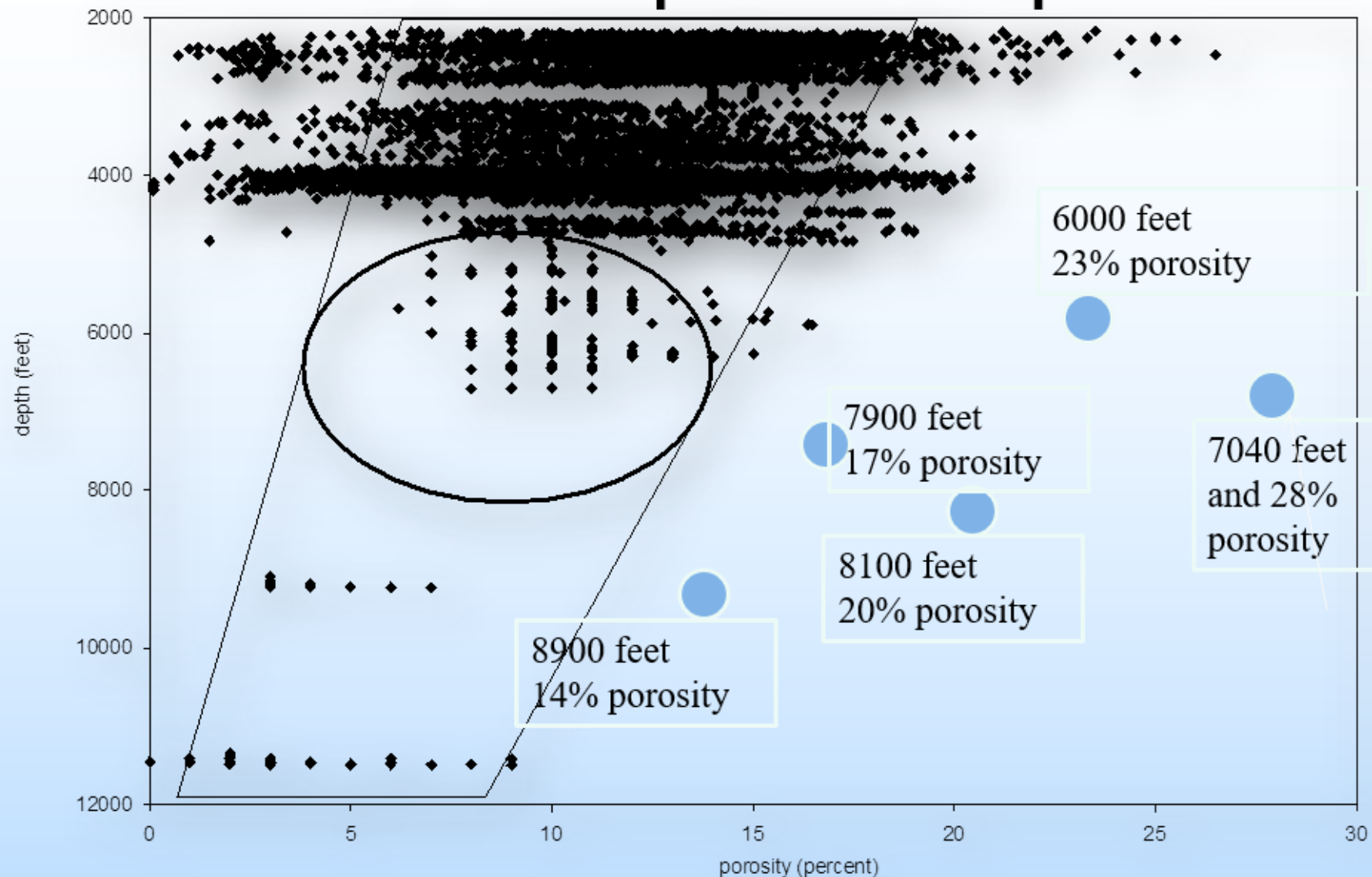
CO₂ Storage Complexes



SYSTEM	GROUP	FORMATION	Storage Elements	
Ordovician	Maquoketa	Brainard	Secondary Seal	
		Ft. Atkinson		
		Scales		
	Galena	Kimmswick		
		Decorah		
	Plateville			
	Ansell	Joachim	Potential target	
		St. Peter		
	Cambrian	Knox	Shakoppee	Secondary Seal/Reservoir
			New Richmond	
Oneota				
Gunter				
Eminence			Potential target	
Potosi				
Franconia			Primary Seal	
Ironton-Galesville				
Eau Claire				
Mt. Simon				
Precambrian				



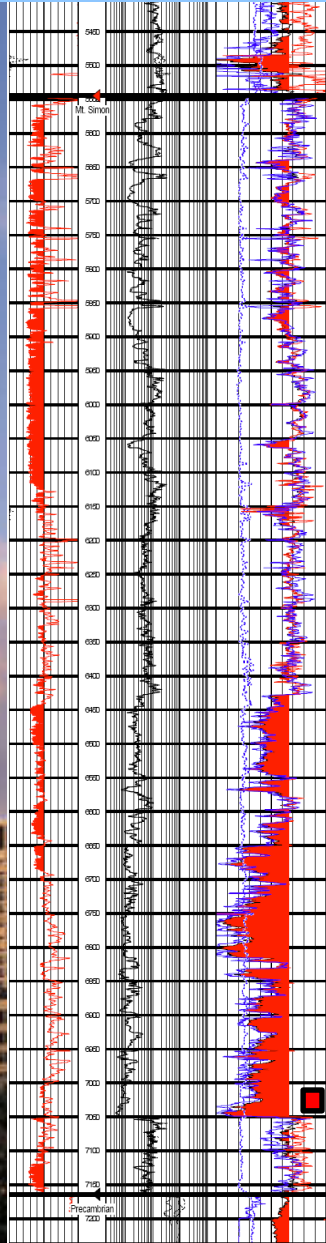
Mt. Simon Porosity and its Relationship with Depth



Thickness of the Mt. Simon is 1600 feet

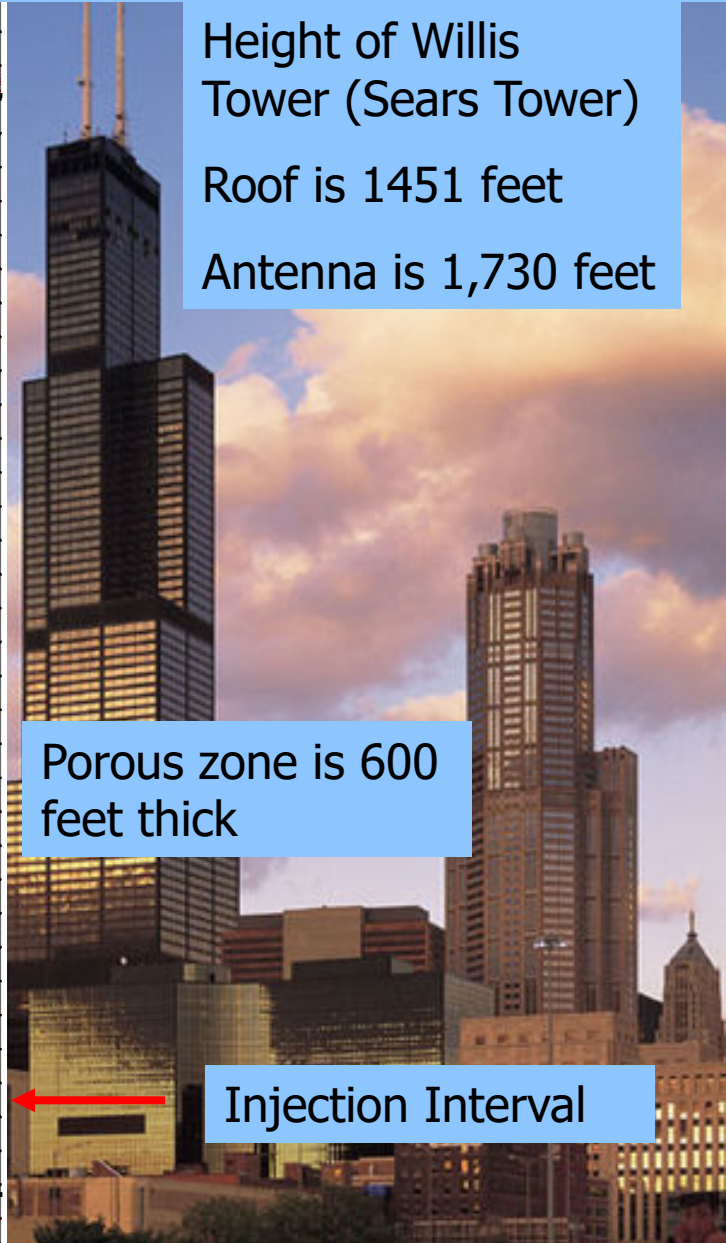
Height of Willis Tower (Sears Tower)
Roof is 1451 feet
Antenna is 1,730 feet

Washington Monument is 555 feet tall



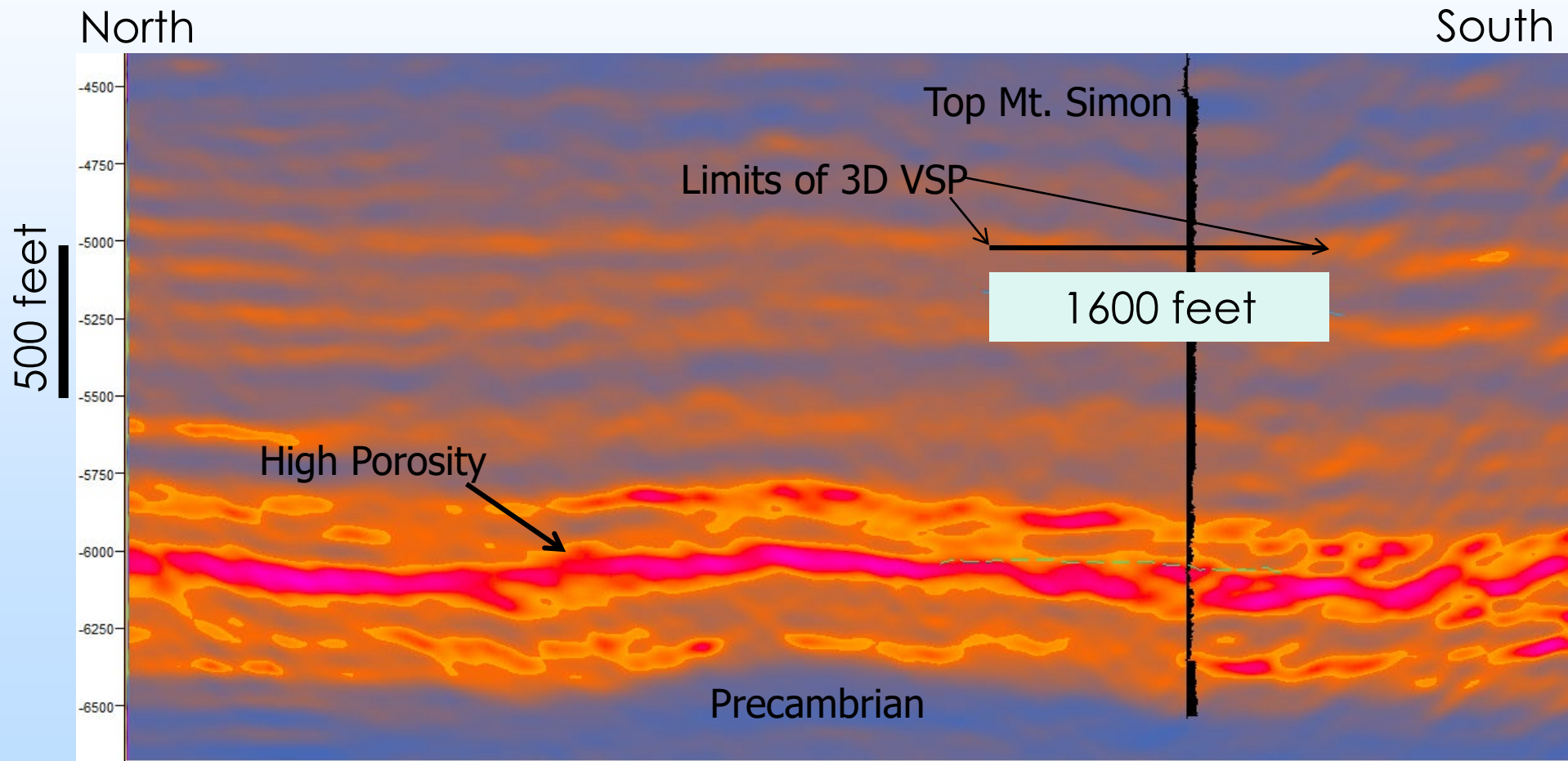
Porous zone is 600 feet thick

Injection Interval

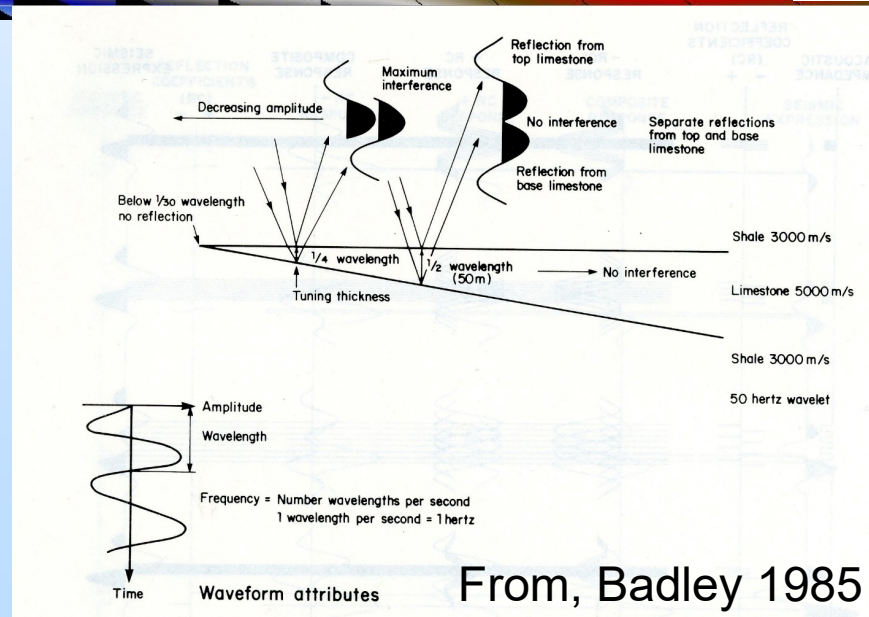
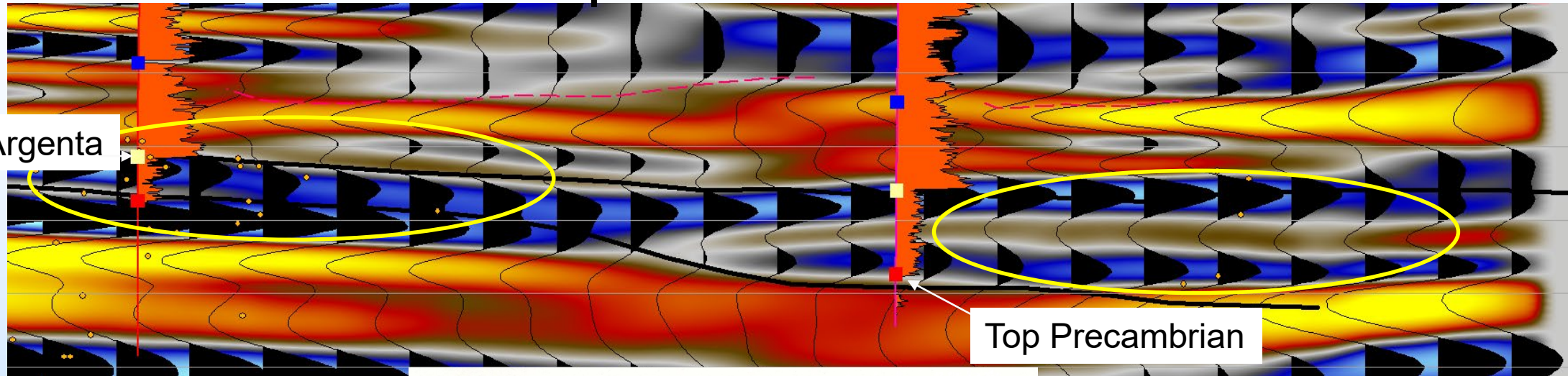


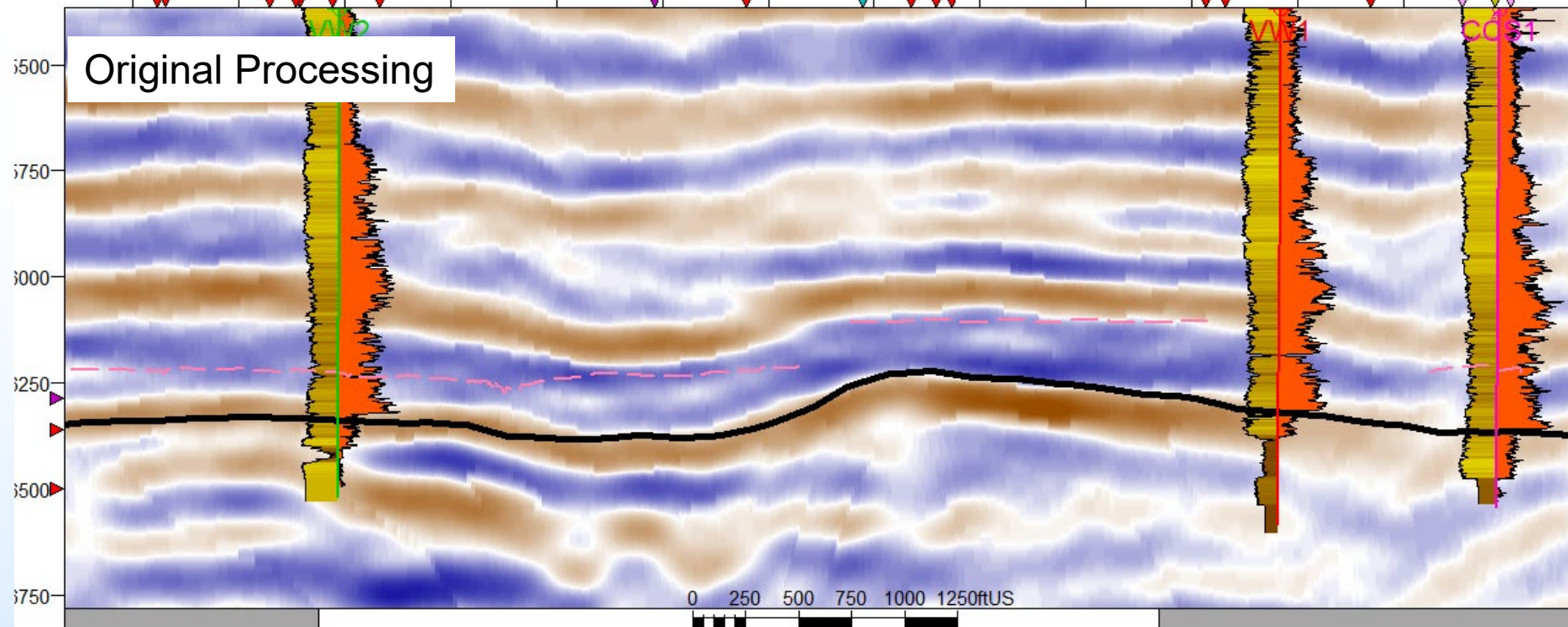
Limitations of the data

Limitations of the data

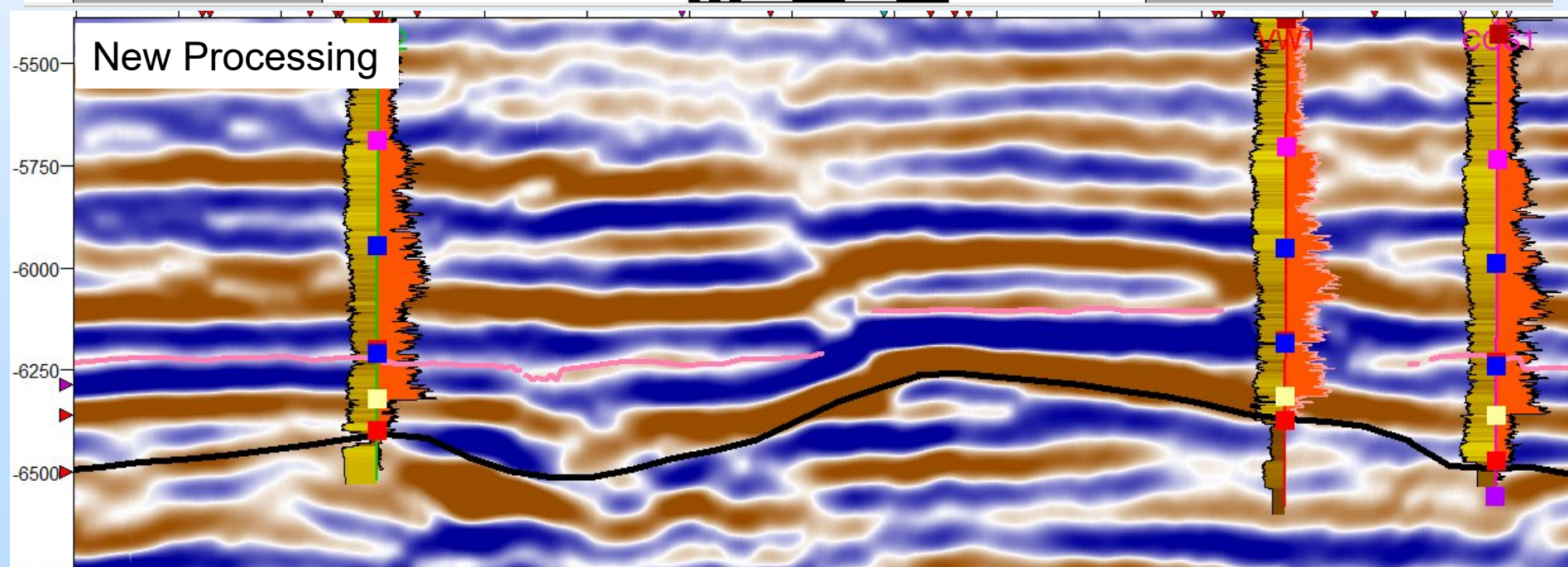


Doublet changing to a single peak for top of Precambrian

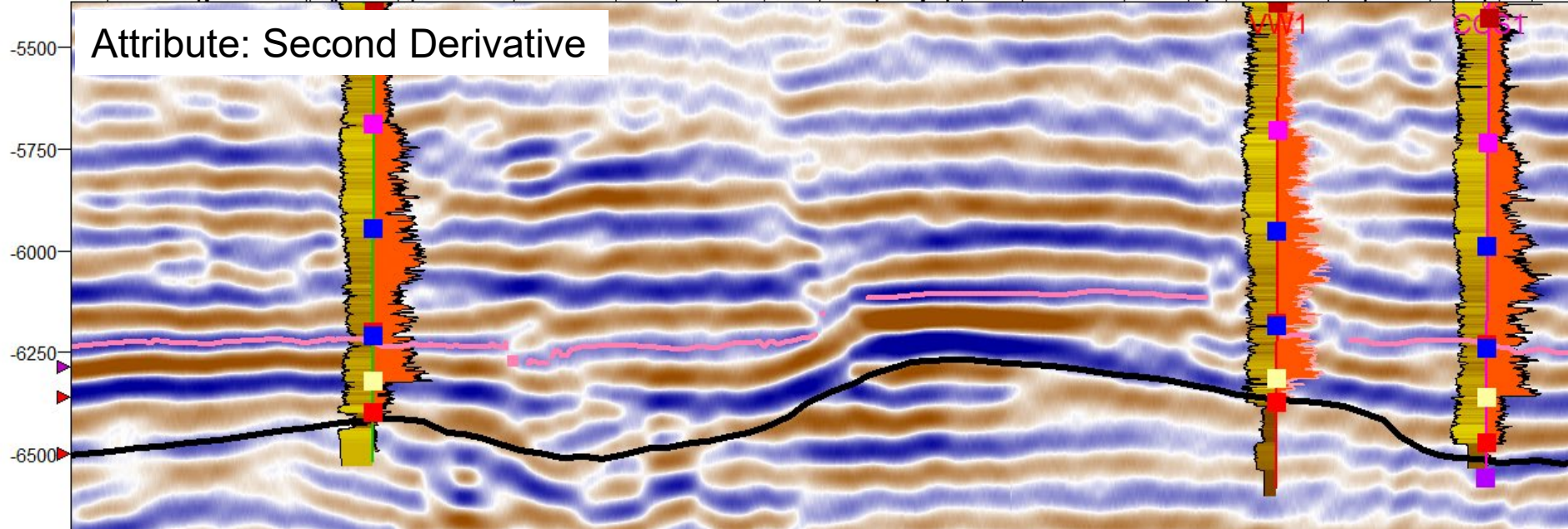
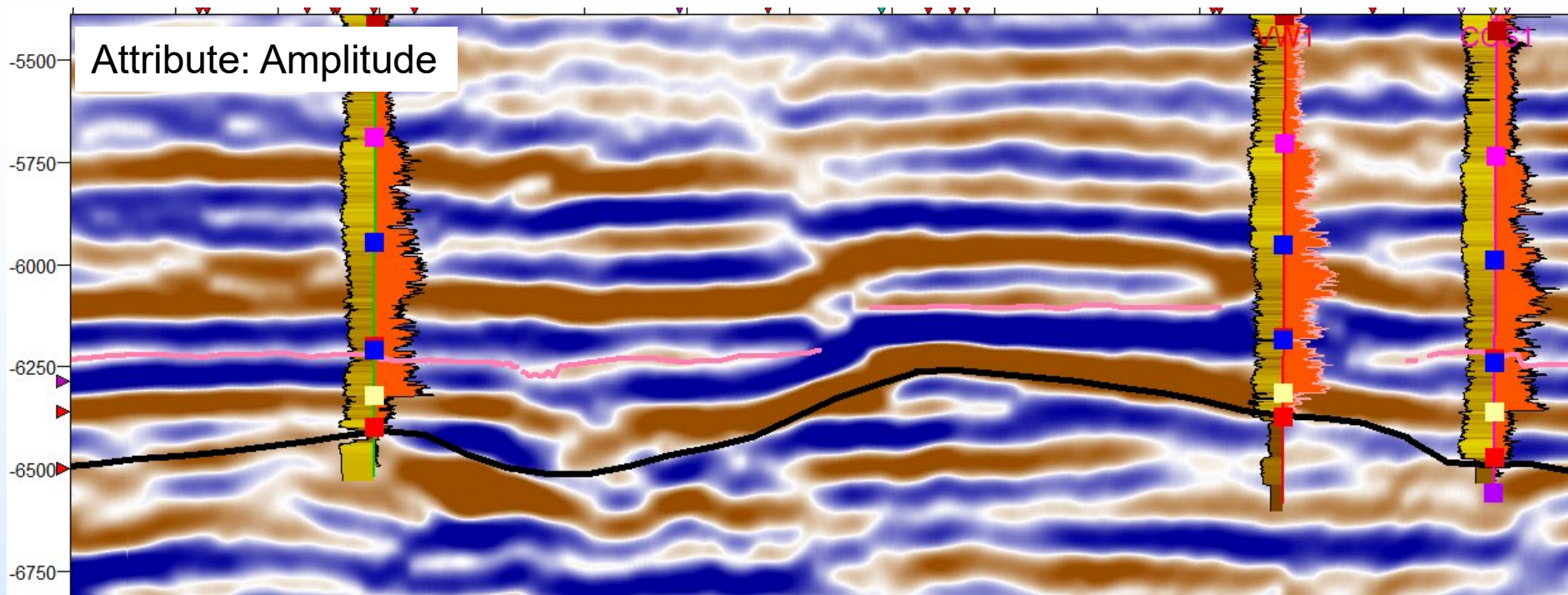




Original
Seismic
processing
compared
with new
processing



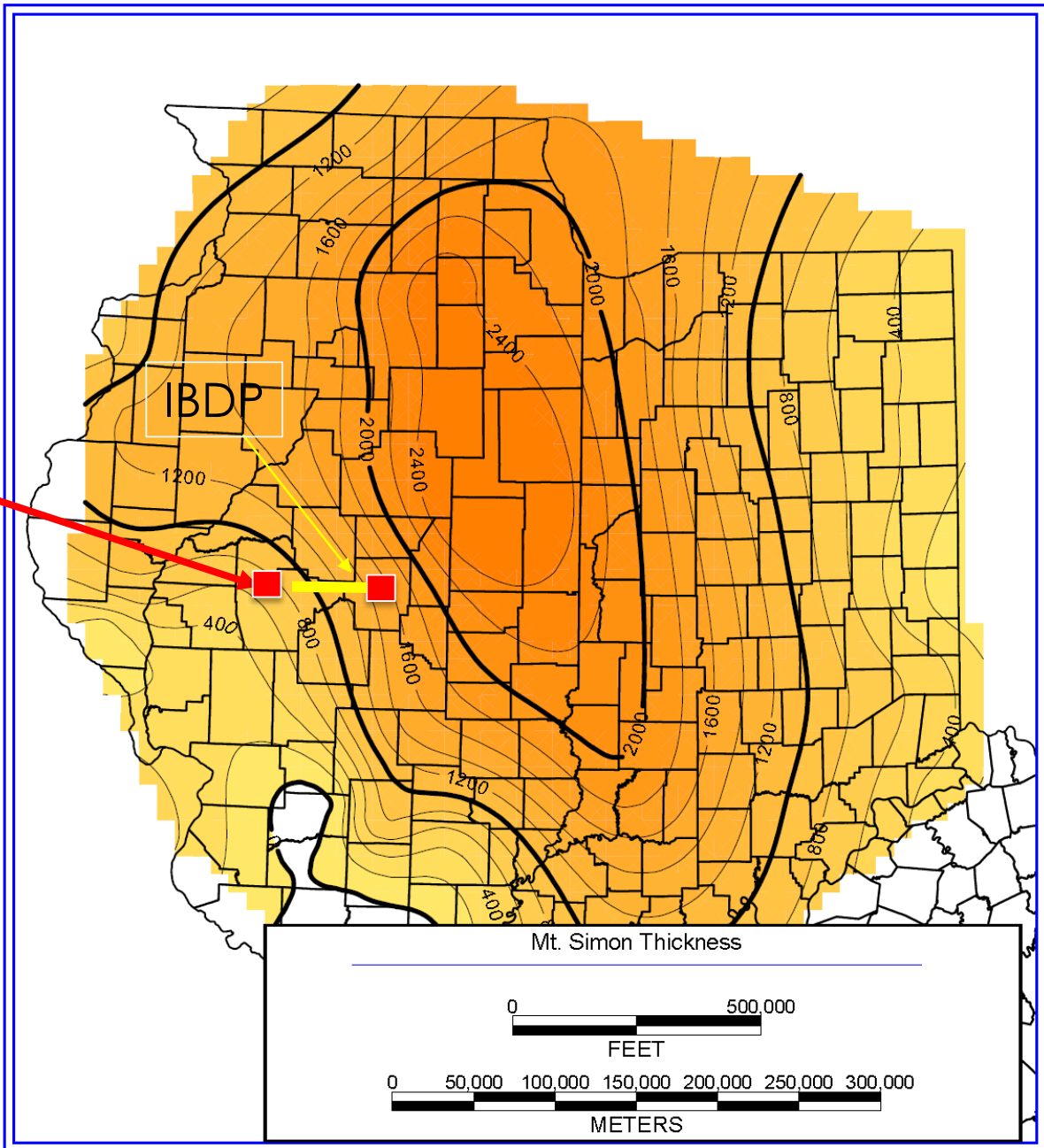
Comparison of attributes



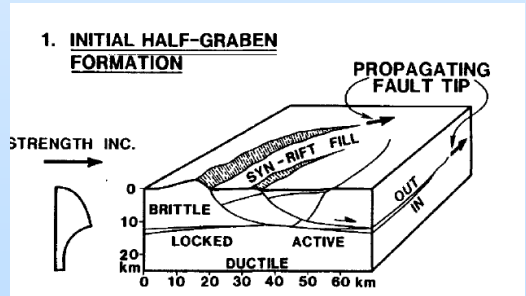
Regional Geology

Regional Mt. Simon thickness

■ Location of IBDP

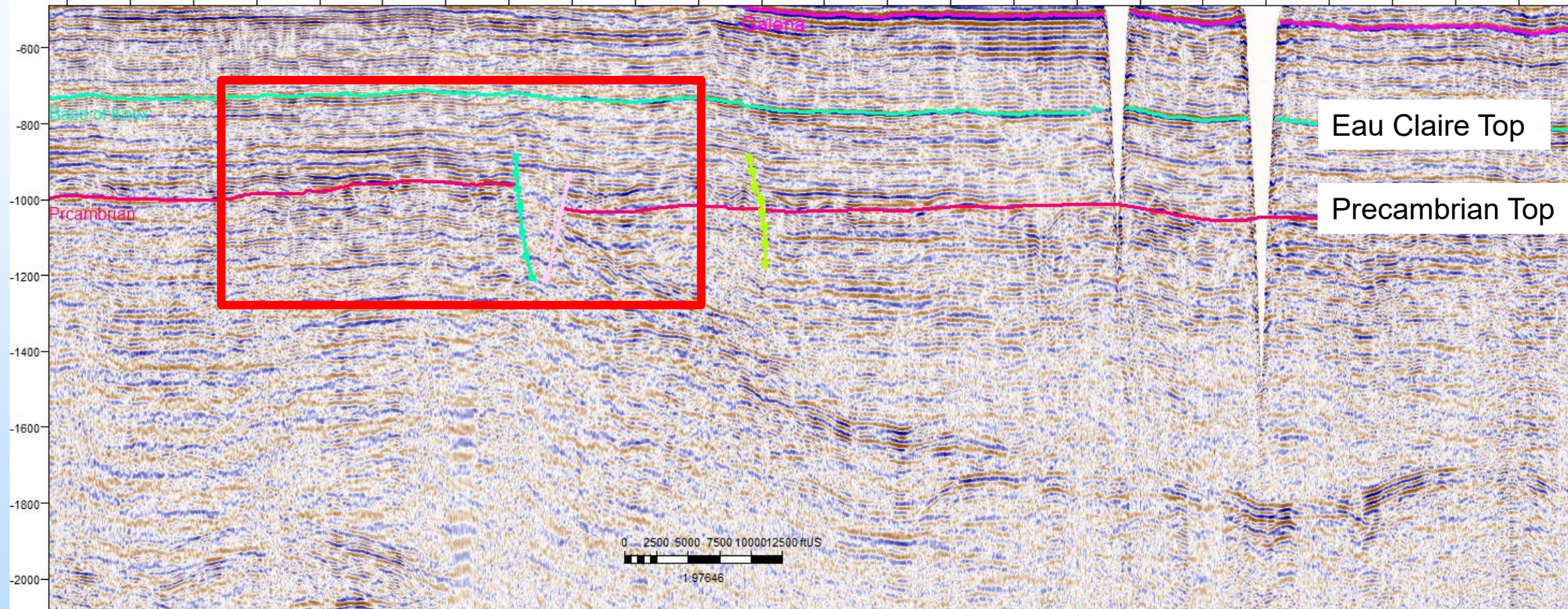


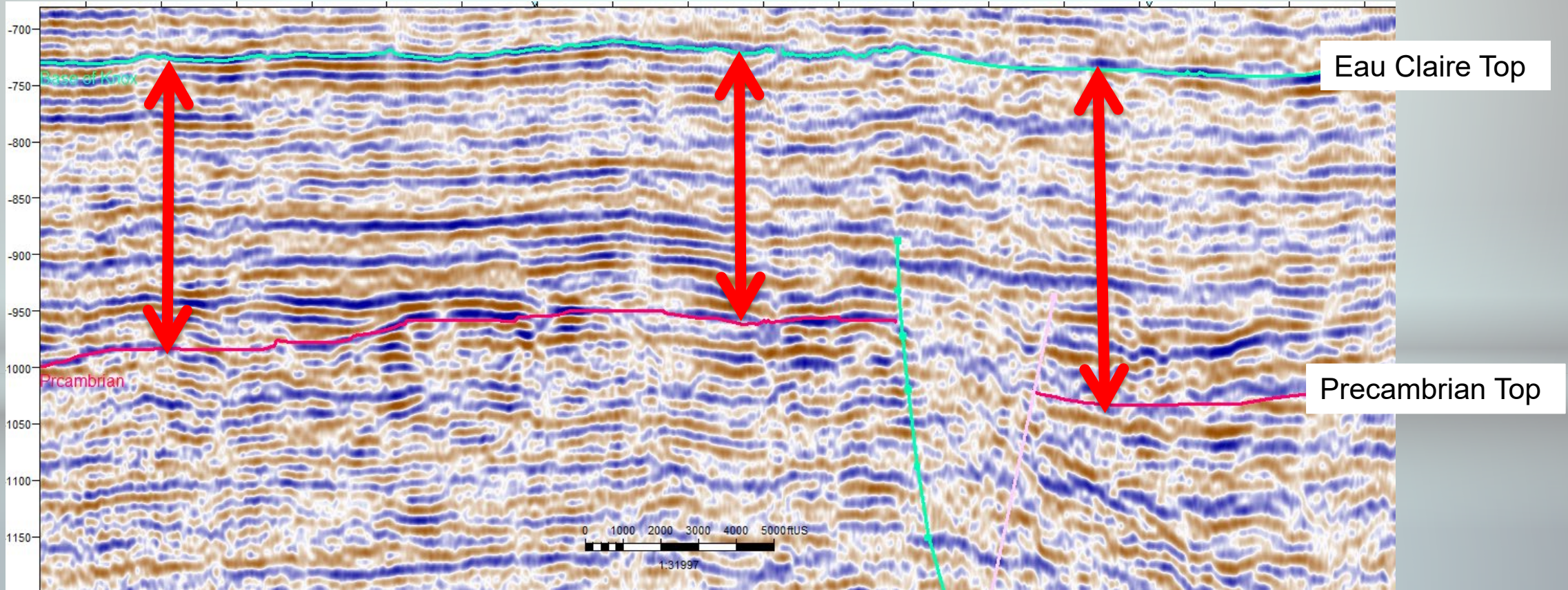
FutureGen II Site



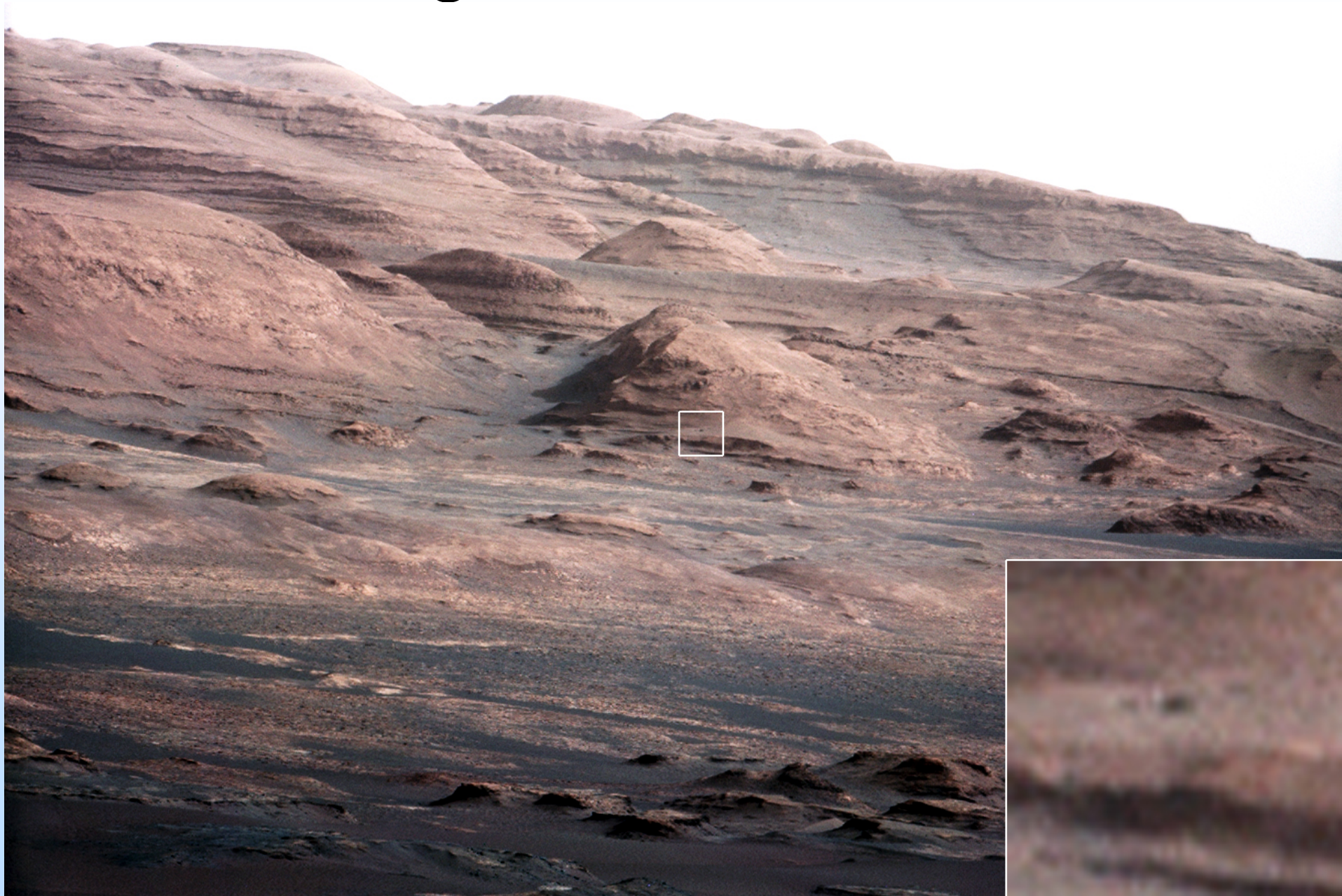
J.J. LAMBIASE &
W. BOSWORTH,
1995

Proximal Precambrian Highs on structures are one source of arkose



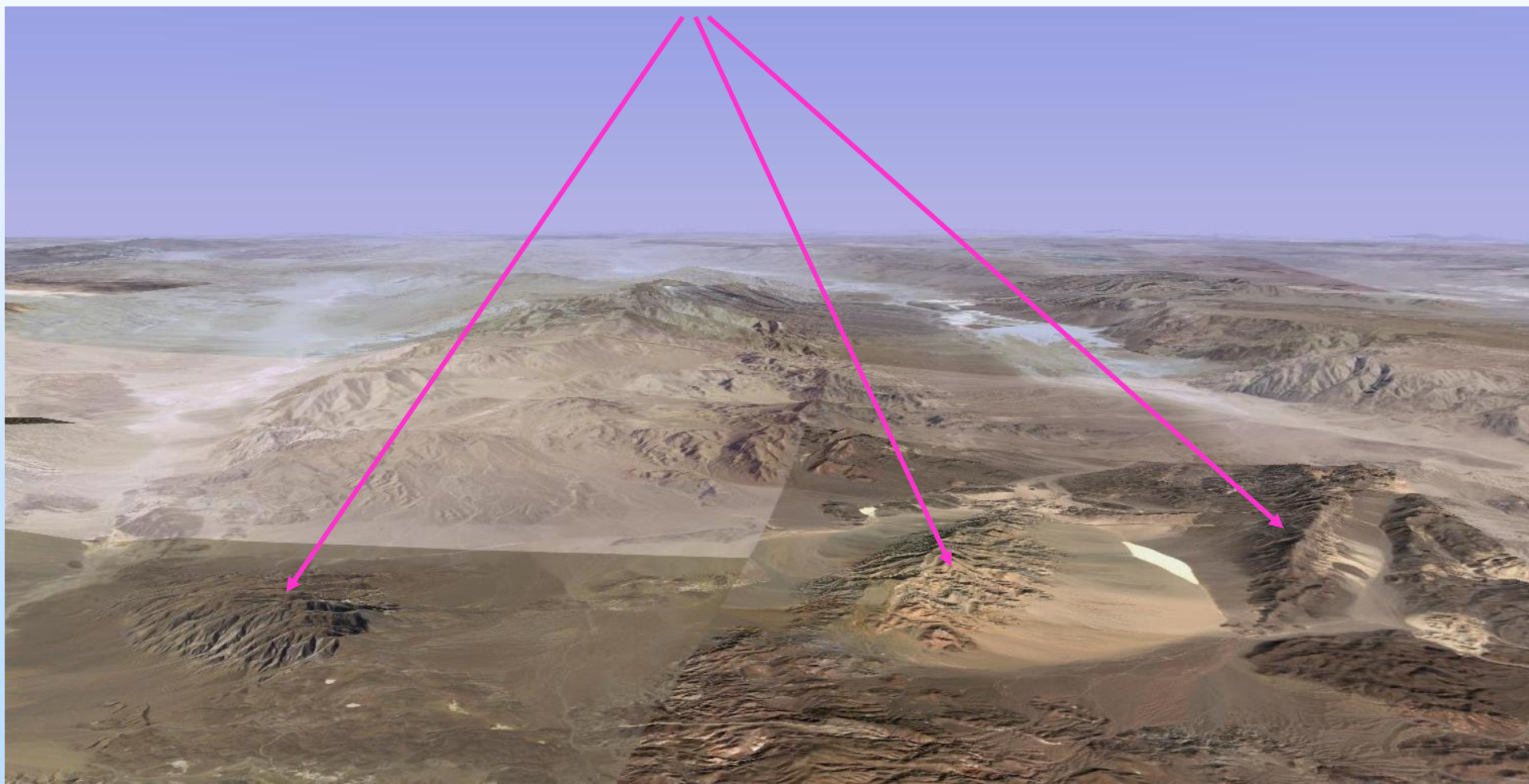


No Land Vegetation in the Precambrian

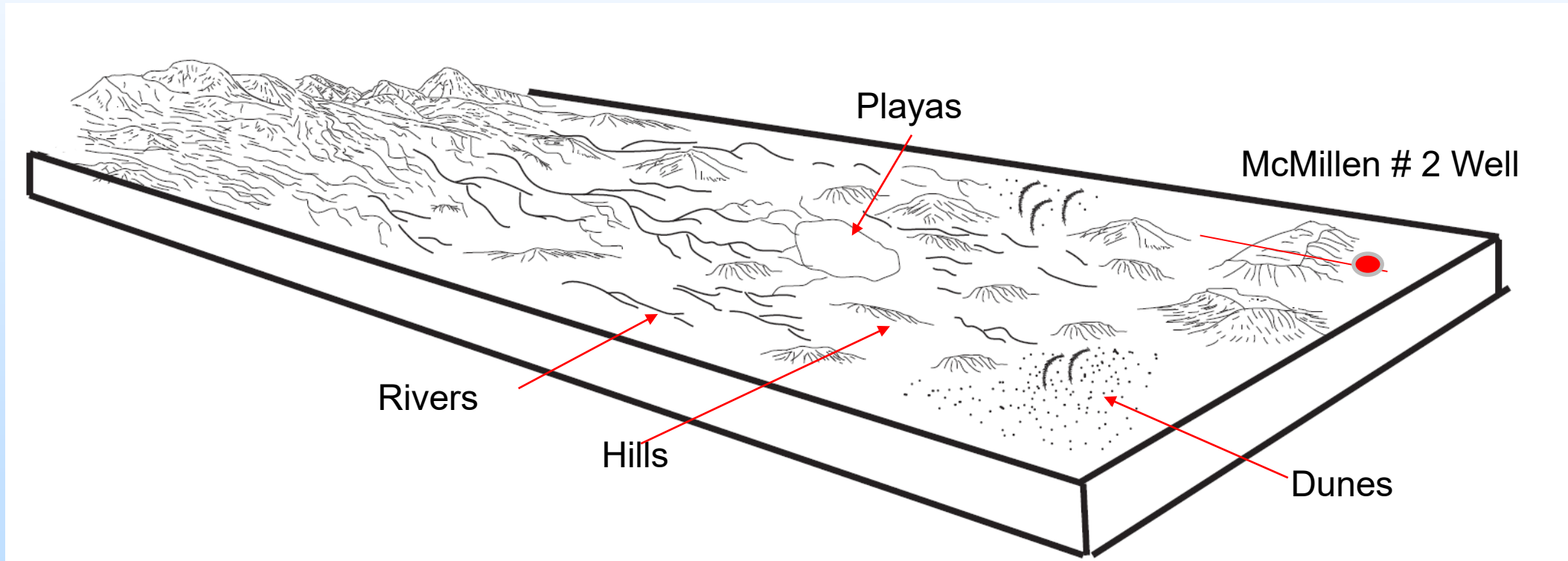


Death Valley Analog

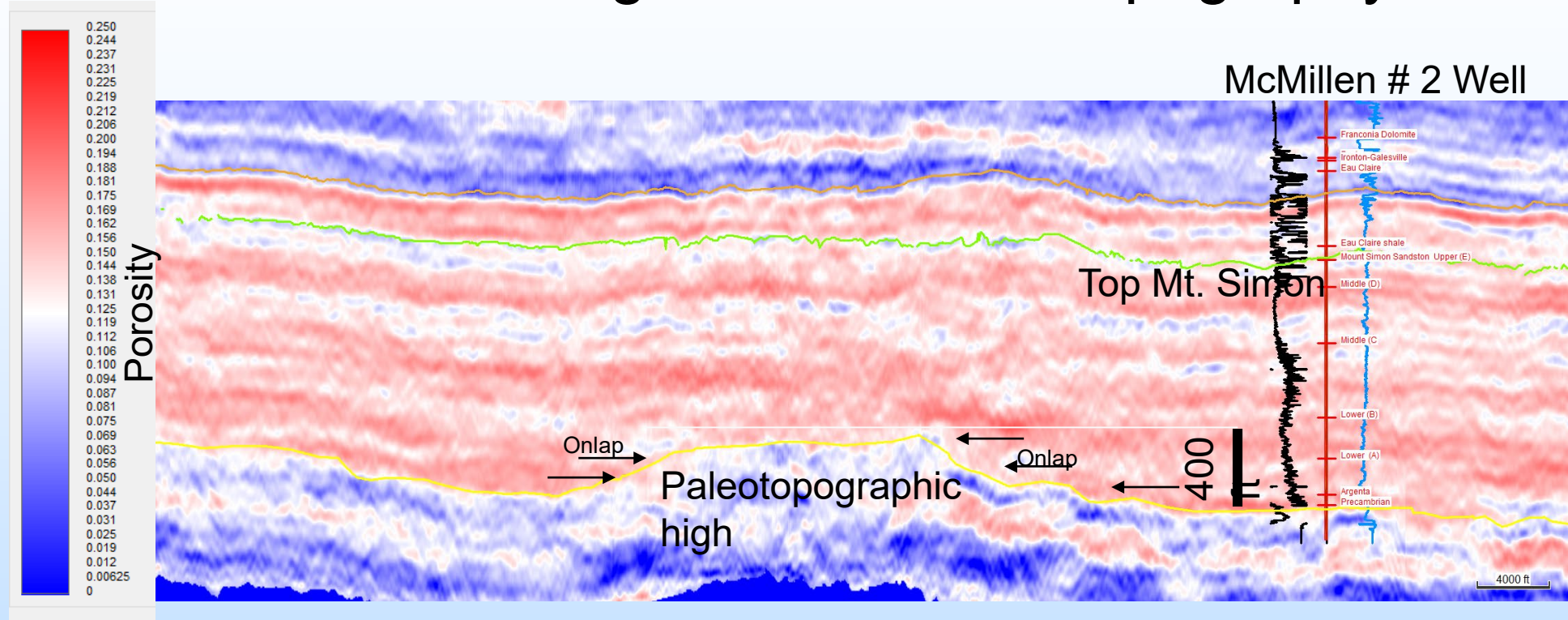
Topography that could become buried hills



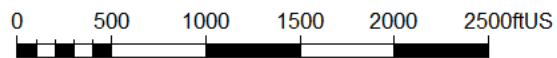
Depositional Model of Lower Mt. Simon



Understanding Precambrian Topography



Could we have
predicted the
location of induced
microseismic
events

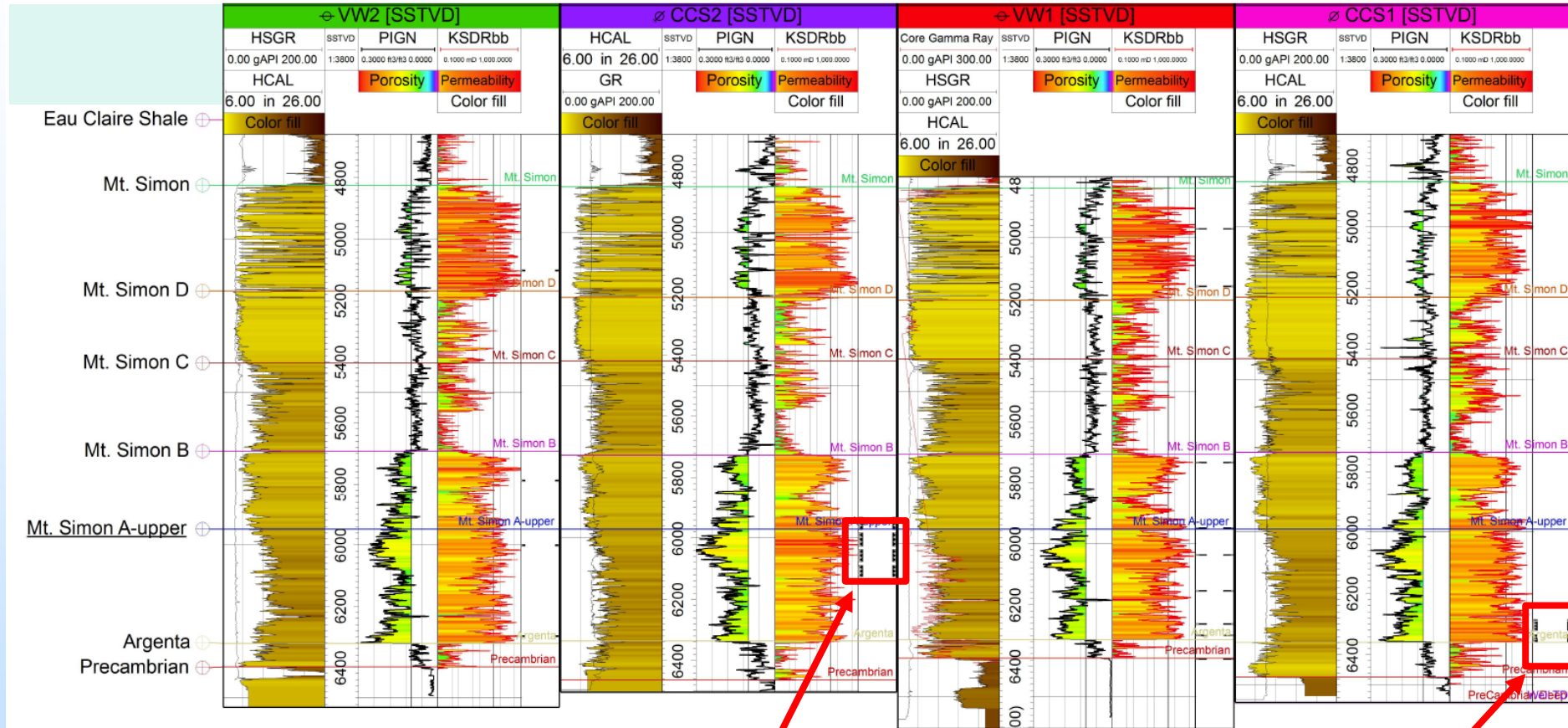


Microseismicity and Precambrian

- **Why are we studying the Precambrian?**
 - There were 5512 microseismic events with location information (by 1/1/20)
 - 3199 had a magnitude greater than -1.00
 - About 80% of these are in the Precambrian & all 5 events >1.0 are in Precambrian
- **There is a time lag before Precambrian microseismic events started to occur**
 - First injection occurred on November 17, 2011
 - First event 1 month after start of injection
 - Less than 2 months before events in Precambrian became active (7th event & may even be the 4th event)
- **CCS2 injection has only increased the lower reservoir (below baffle near VW1) to 1/2 of the pressures achieved during CCS1 injection**

North

South



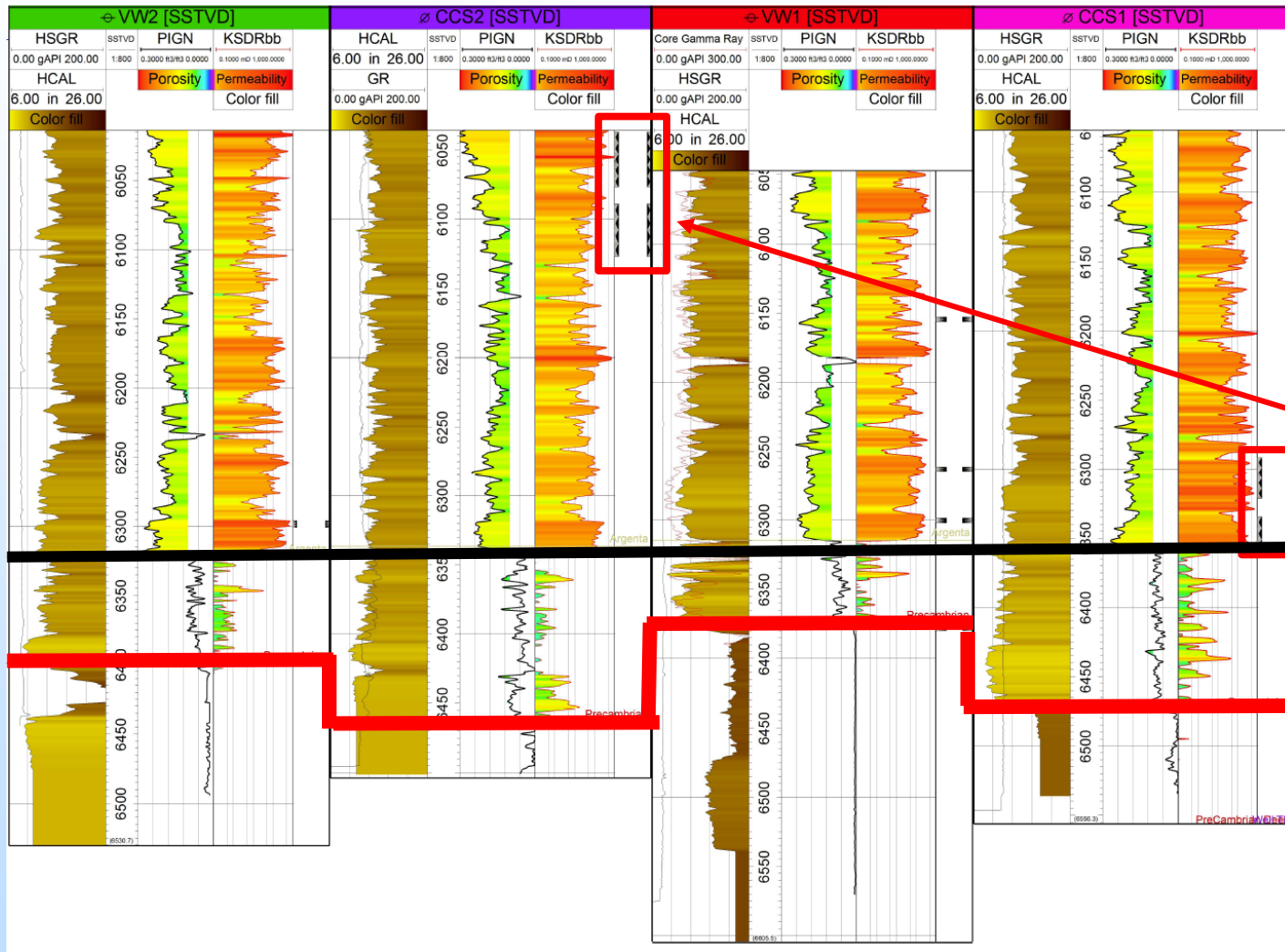
Injection interval CC2

Injection interval CC1



North

South



Injection Interval

Top Argenta

Top Precambrian



North

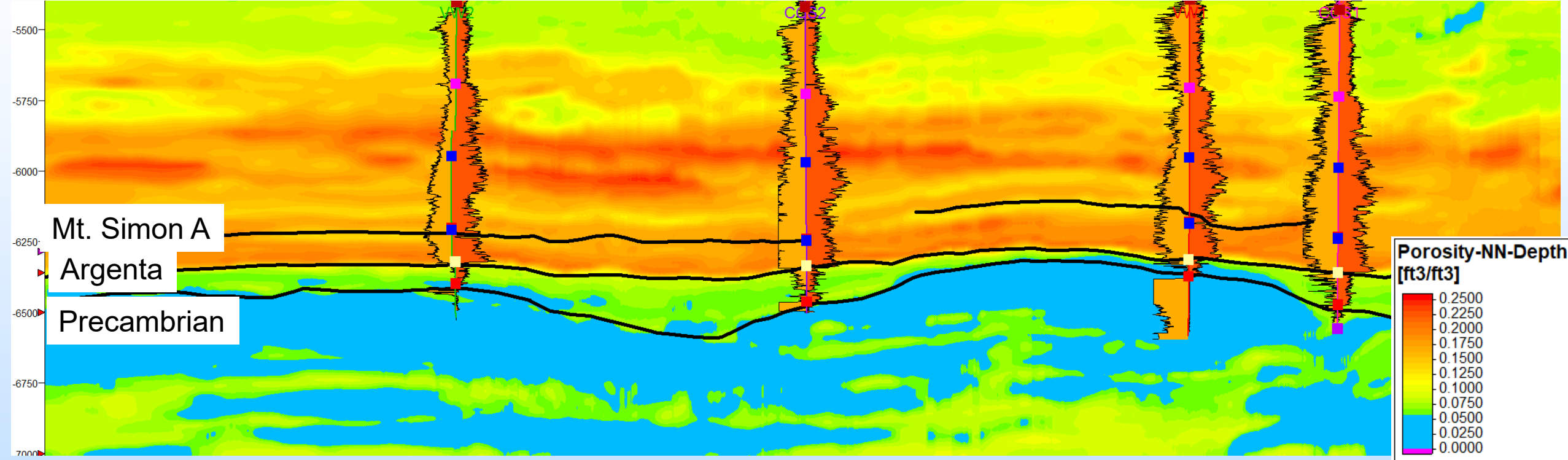
VW #2

CCS #2

VW #1

CCS #1

South



Mt. Simon A
Argenta
Precambrian



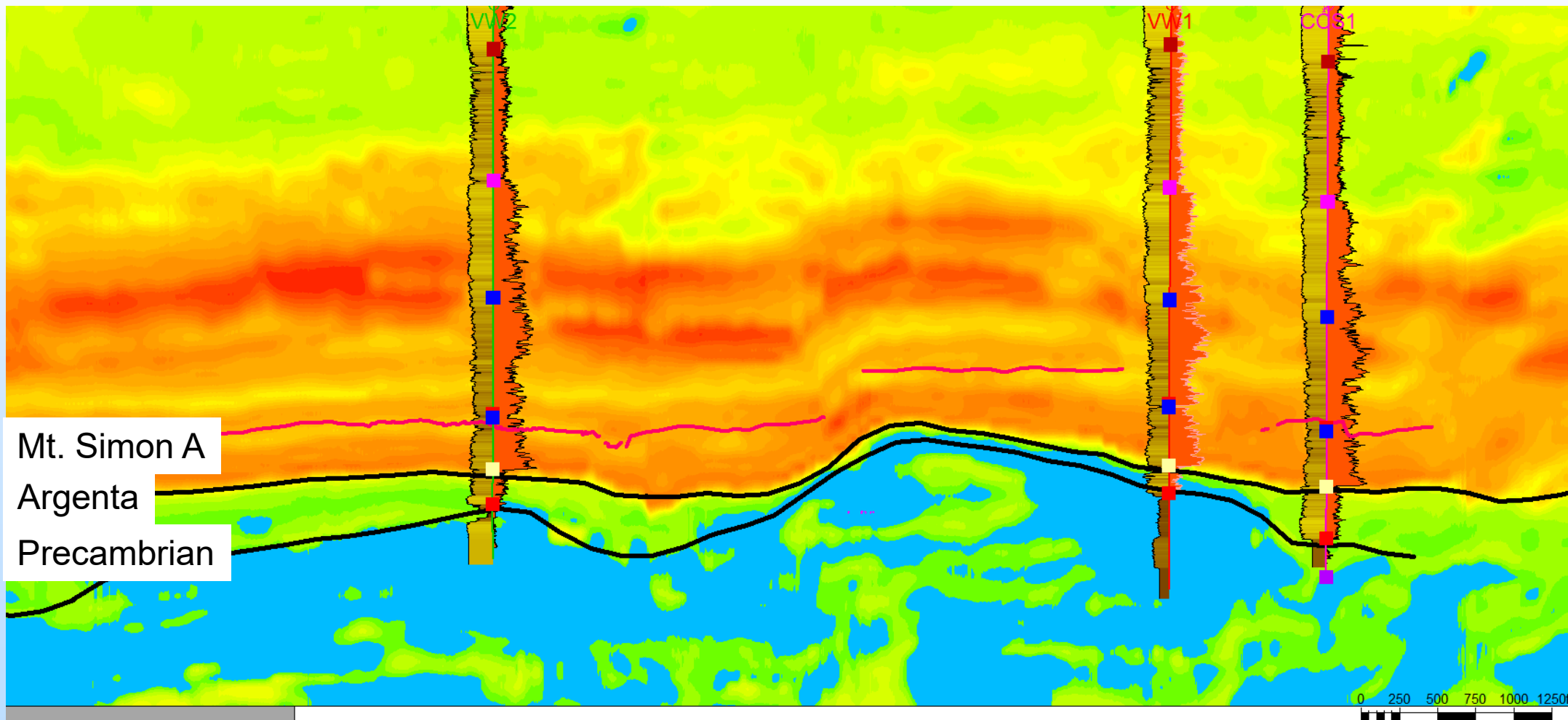
North

VW #2

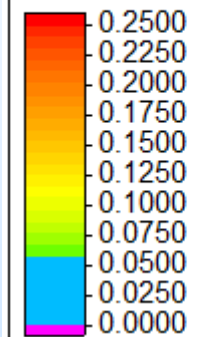
VW #1

CCS #1

South



Porosity-NN-Depth
[ft³/ft³]

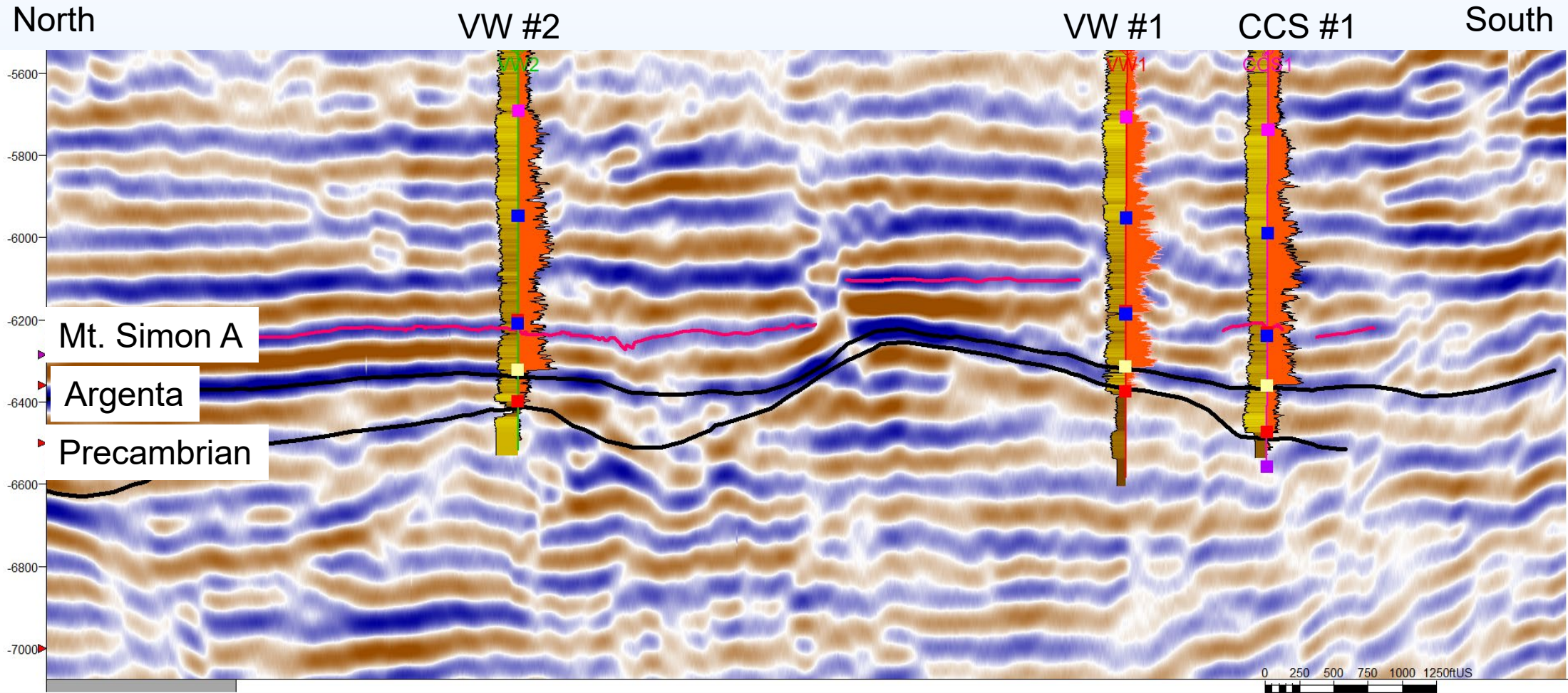


Mt. Simon A
Argenta
Precambrian

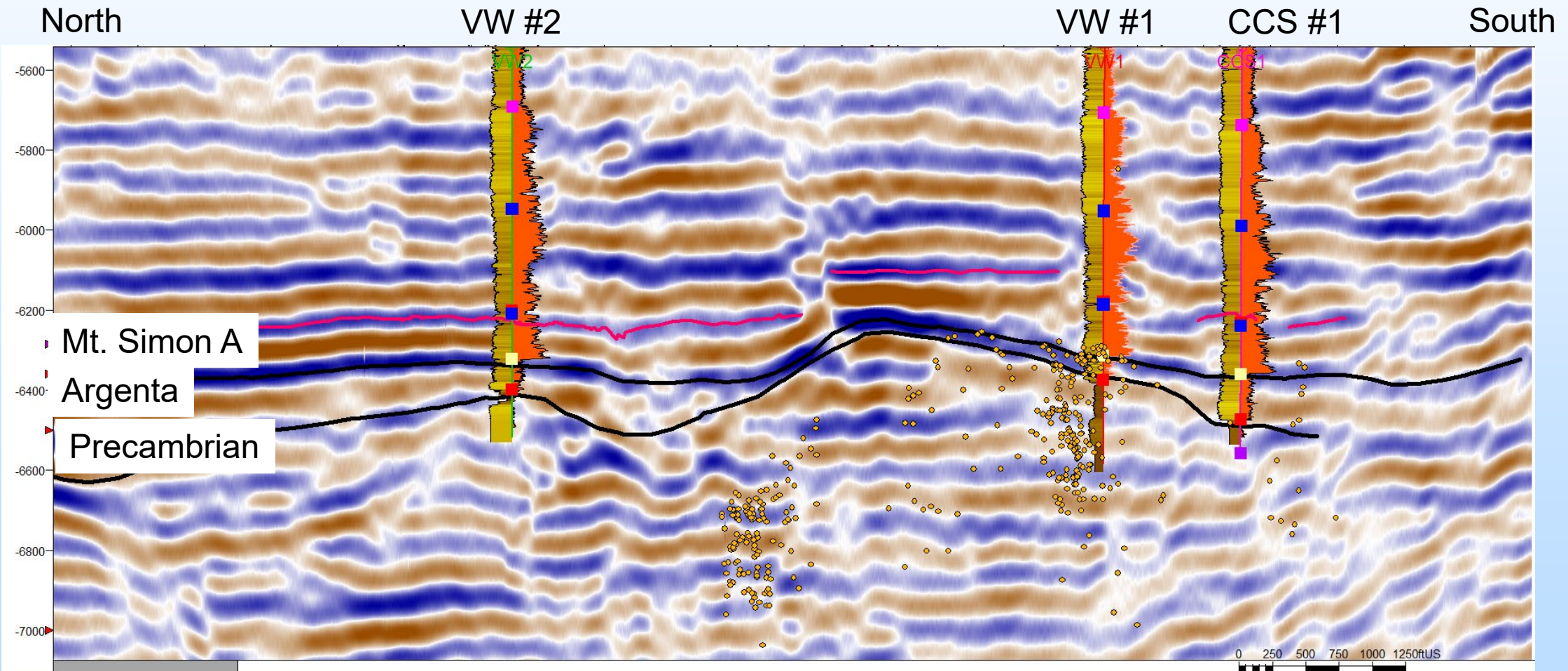
0 250 500 750 1000 1250ft



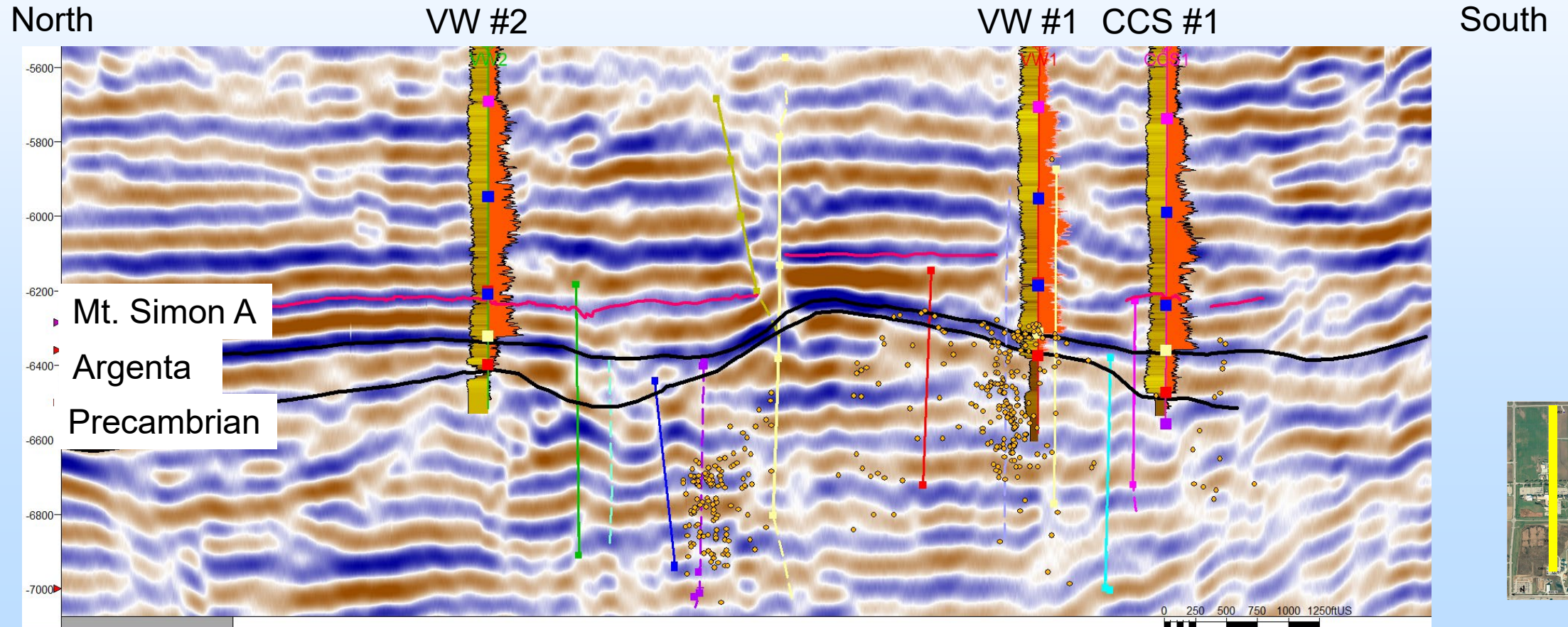
Seismic Profile



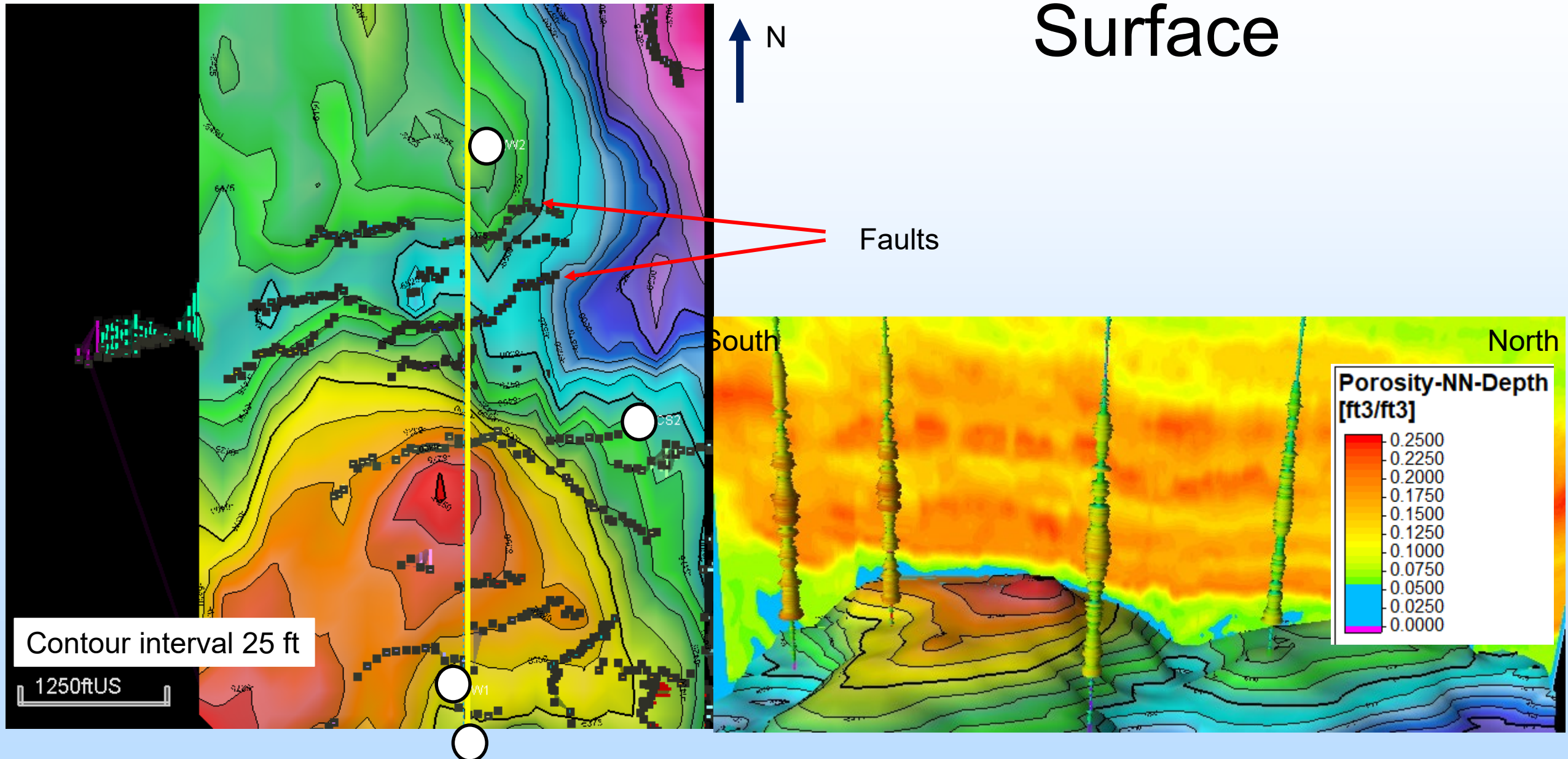
Seismic Profile with Microseismic



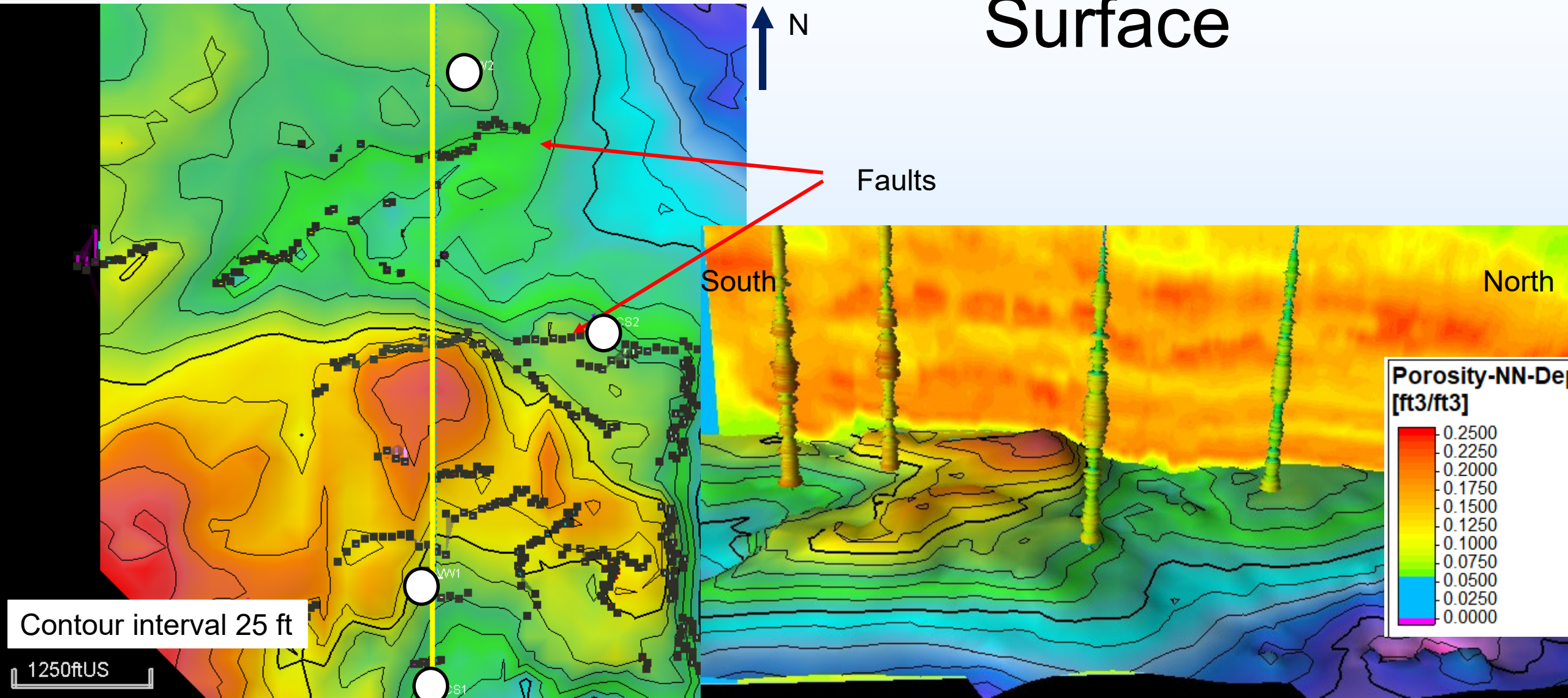
Seismic Profile with Microseismic and Faults



Top Precambrian Surface

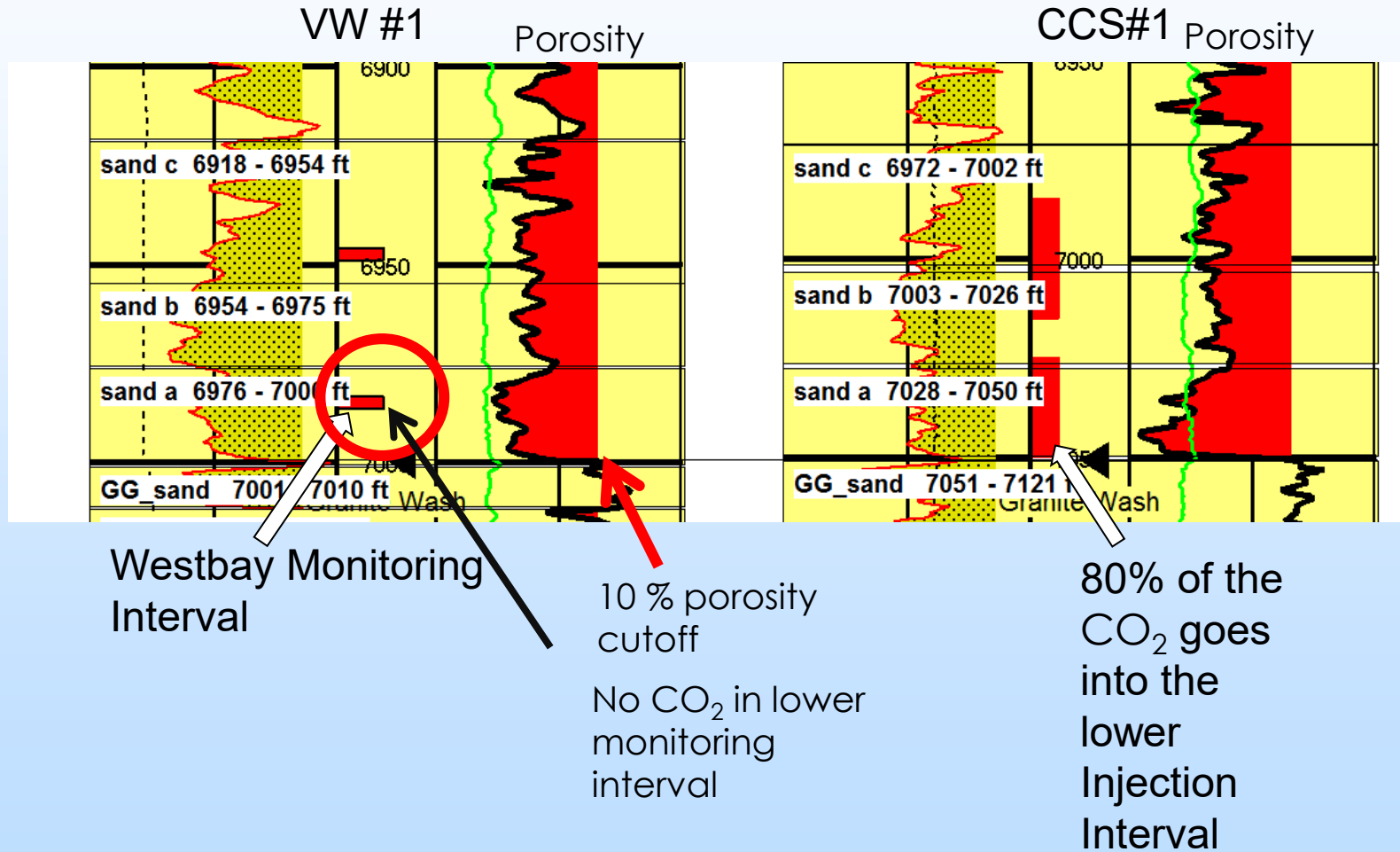


Top of Argenta Surface

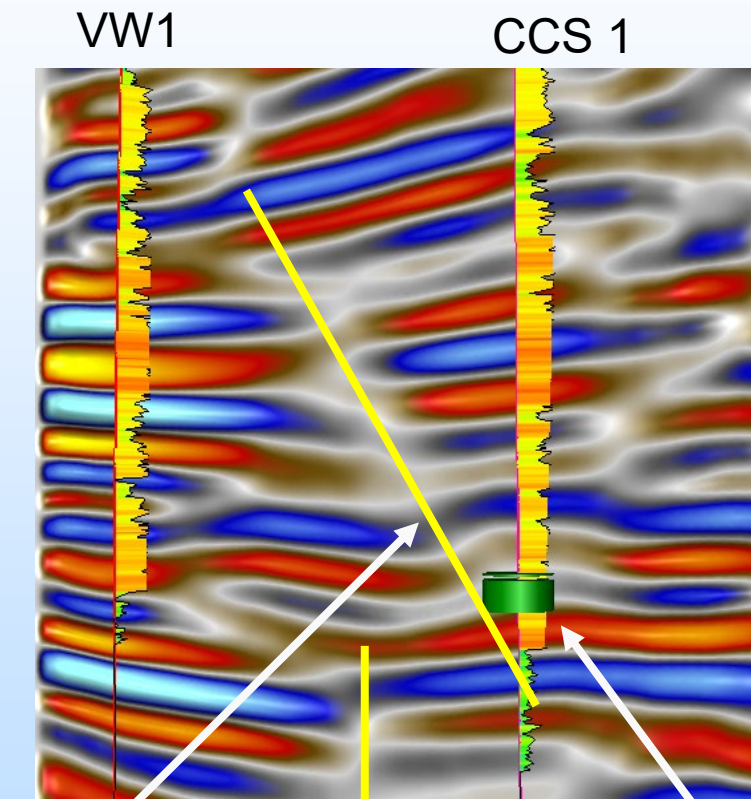


Understanding CO₂ Movements

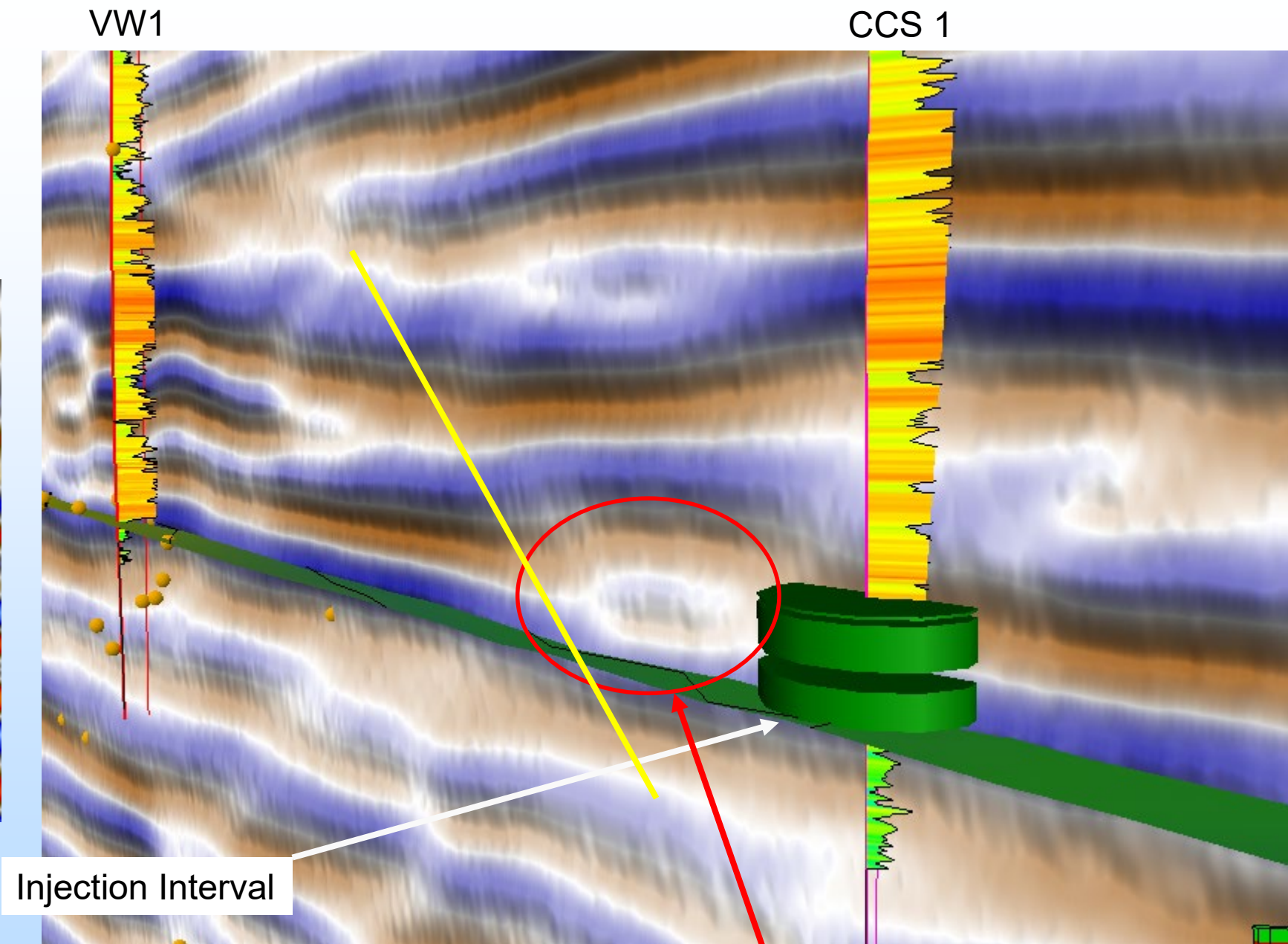
Why does the CO₂ not enter the equivalent stratigraphic interval in the monitoring well



3D VSP



Possible Fault

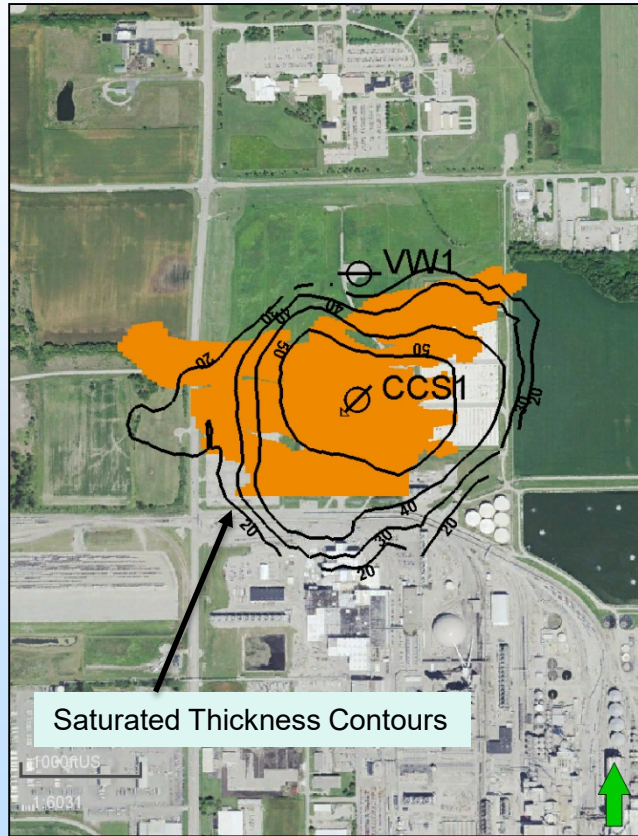


Injection Interval

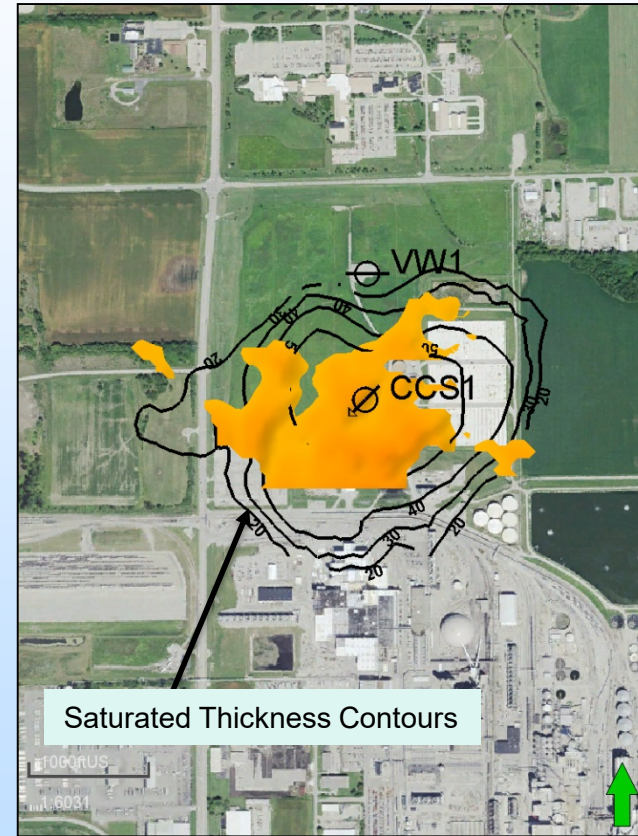
Precambrian topography?

Qualitative Time-Lapse Attributes: Inferring Seismic Detection Limit with Saturated Thickness

NRM Attribute



NRMS Attribute



The CO₂ plume limits may have been caused by either a fault and/or Precambrian topography

Thank You

