# Fourth Annual Conference on Carbon Capture & Sequestration

*Developing Potential Paths Forward Based on the Knowledge, Science and Experience to Date*

*Geologic Sequestration*

# Deep Saline Reservoirs as a Carbon Sequestration Target in the Illinois Basin

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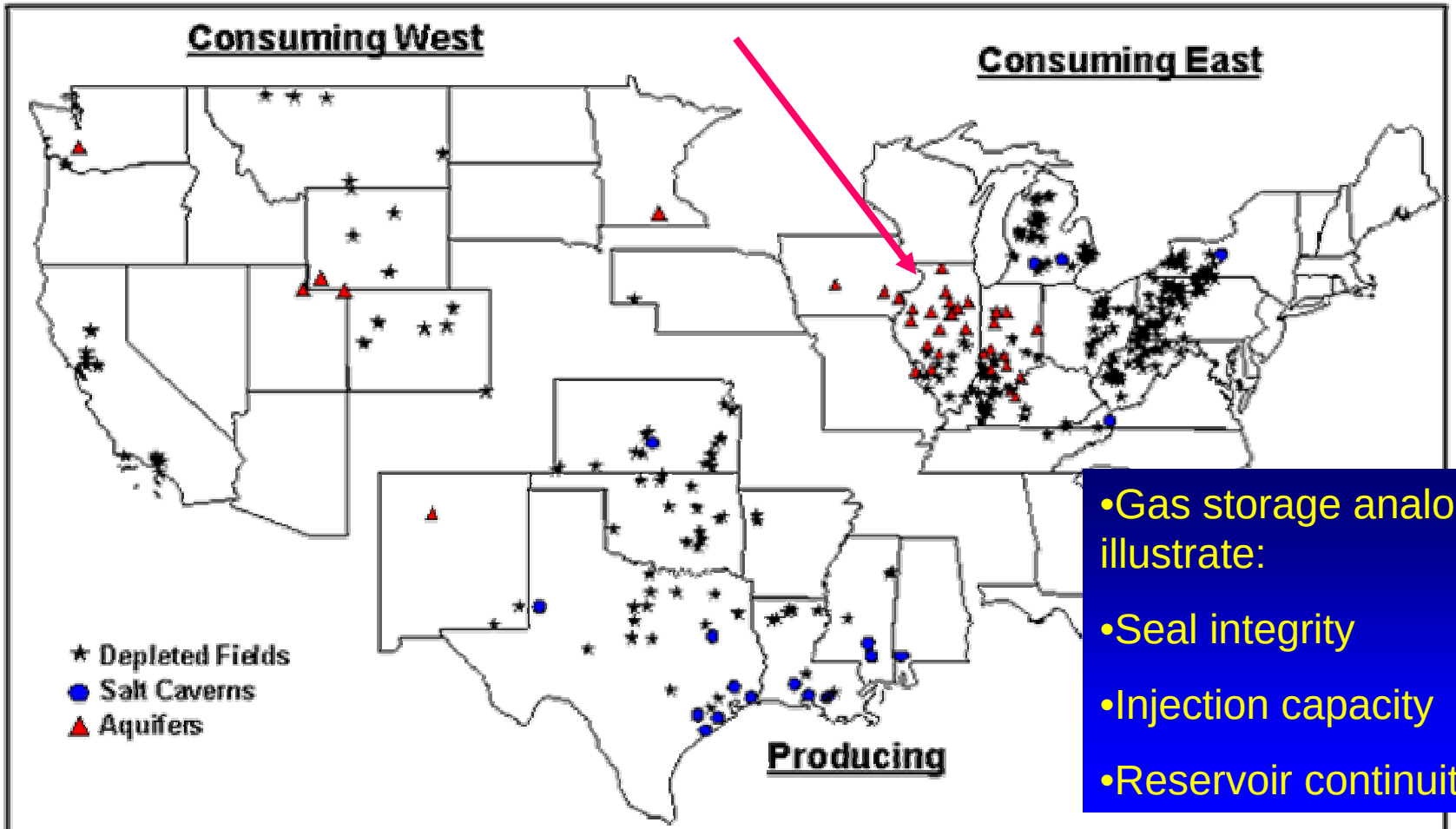
May 2-5, 2005, Hilton Alexandria Mark Center, Alexandria Virginia

# Illinois Basin has the Largest Concentration of Saline (Natural Gas Storage) Reservoirs in the US

**Figure 2. Underground Natural Gas Storage Facilities in the Lower 48 States**




Source: Energy Information Administration, EIAGIS-NG Geographic Information System, Underground Storage Database, as of June 2002.

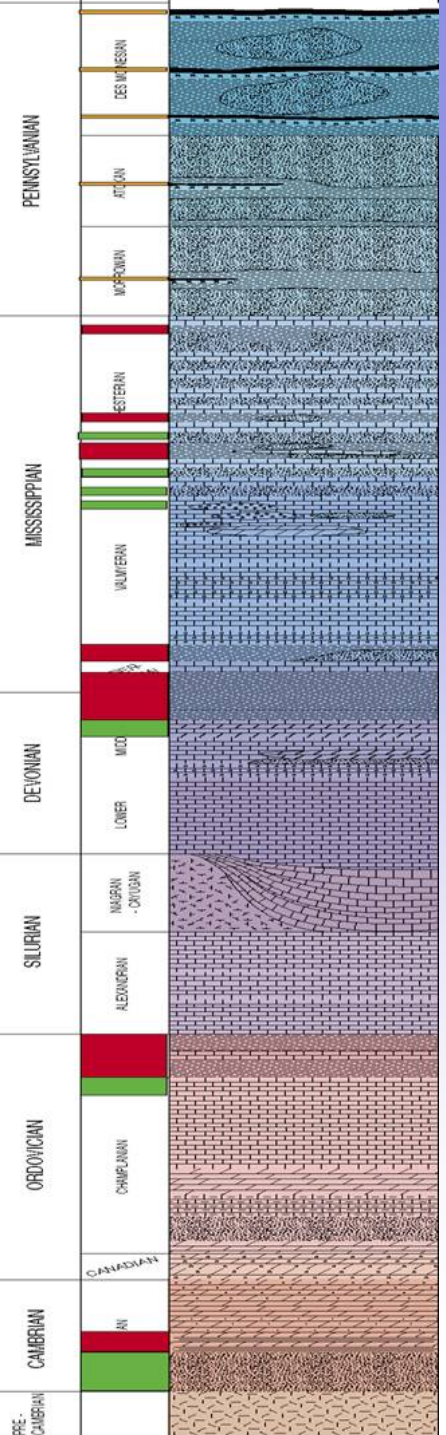
www.eia.doe.gov/pub/oil_gas/natural_gas/ analysis_publications/storagebasics/storagebasics.pdf

- Gas storage analogs illustrate:
- Seal integrity
- Injection capacity
- Reservoir continuity

# Gas Storage Projects
# What have we learned?

- Manlove Gas Storage Project
  - Discontinuous low permeability layers behave as baffles
  - Some are laterally continuous across most of reservoir
  - Porous zones can be lenticular
- Other gas storage projects in Illinois Basin
  - Mt. Simon has good seal (Eau Claire)
  - Some other saline formations have good reservoir quality but lack a seal

# Seals




Mississippian (Seals)

New Albany (Seal)

Maquoketa (Seal)

Eau Claire (Seal)

Mt. Simon (Sink)

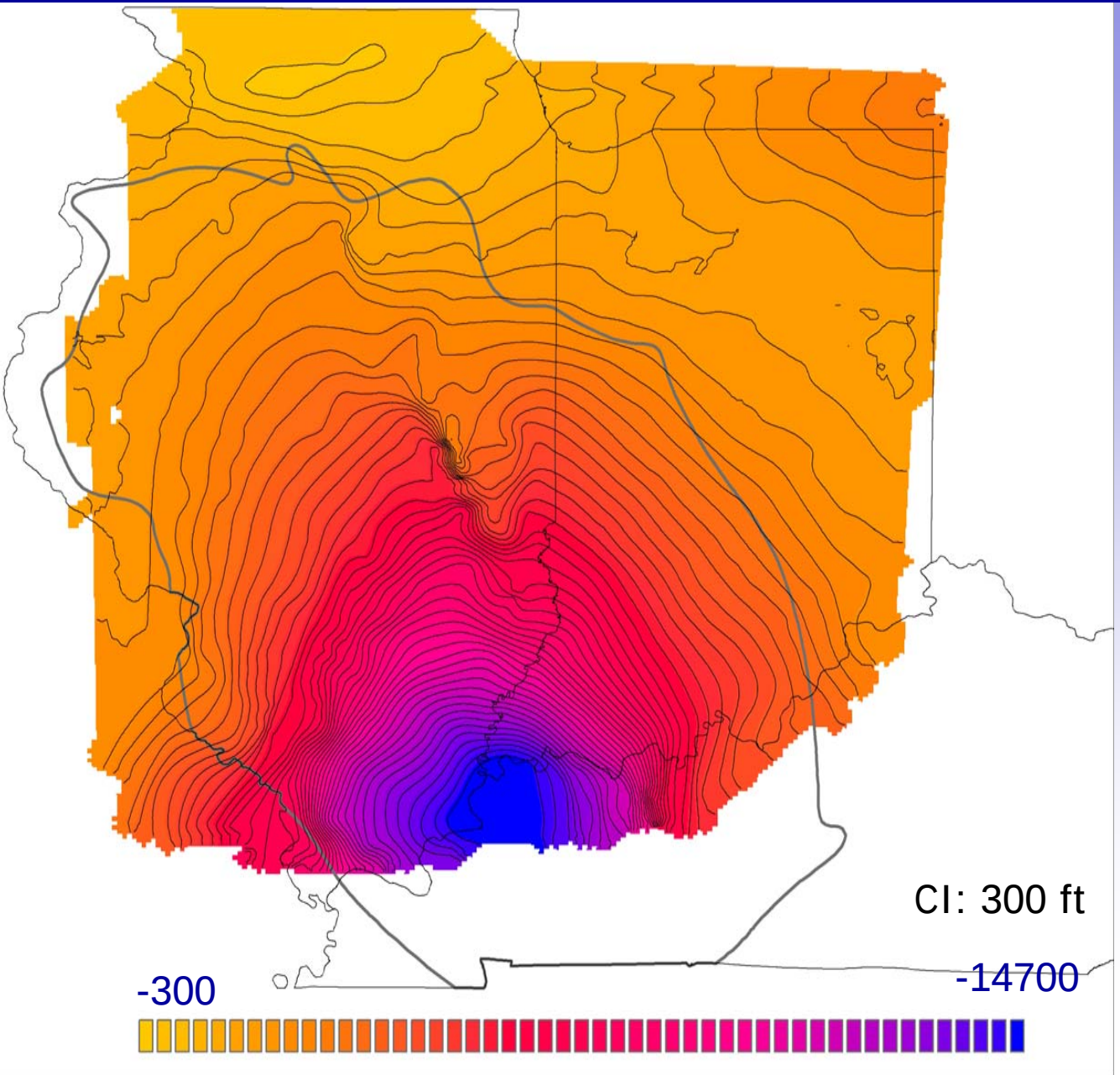
- New Albany Group
  - Silurian and Devonian
- Maquoketa Group
  - Ordovician
- Eau Claire Formation
  - Mt. Simon areas

Potential Seal

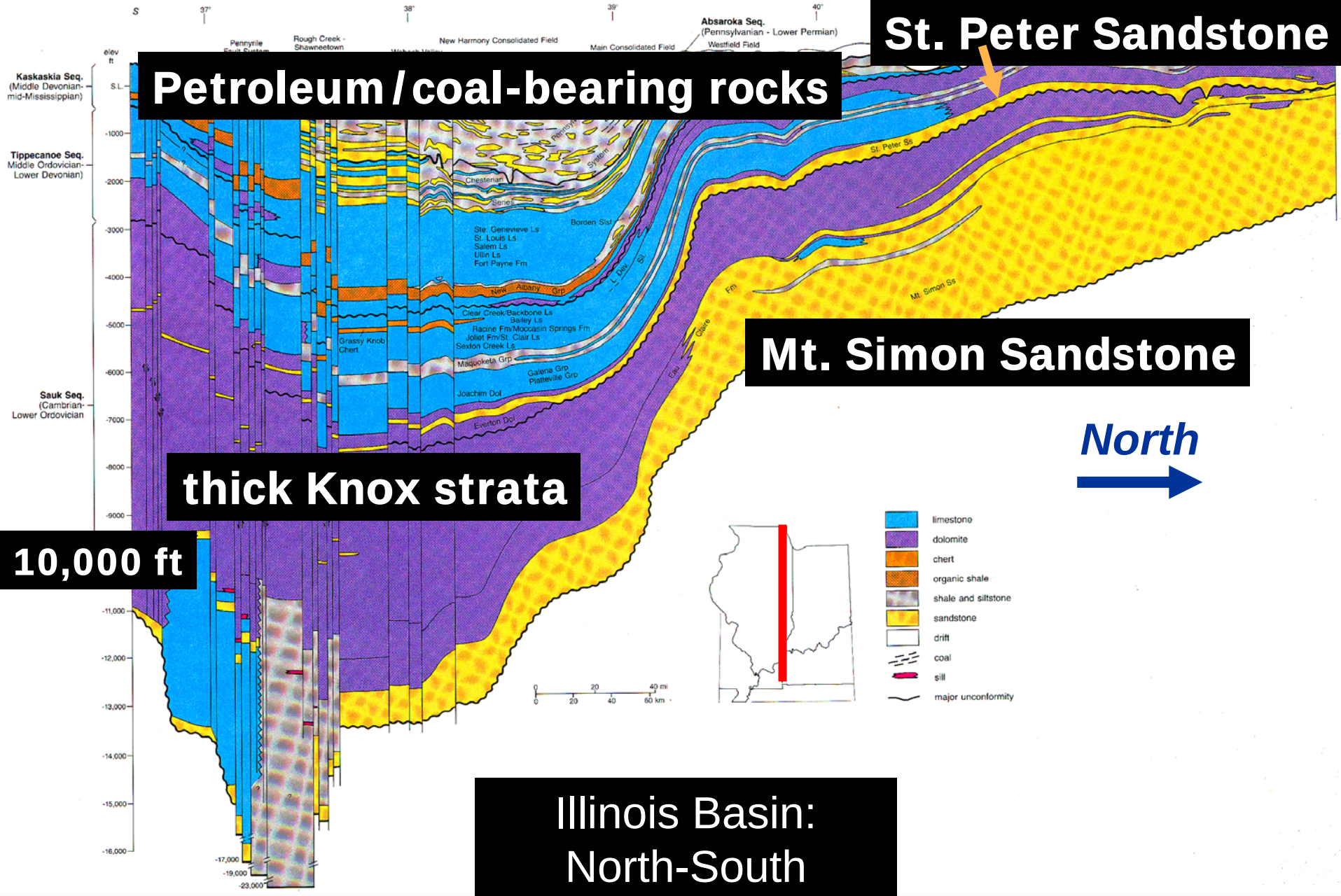
Potential Sink

Coal Bed Potential Sink and Seal

# Structure: Top of Mt. Simon

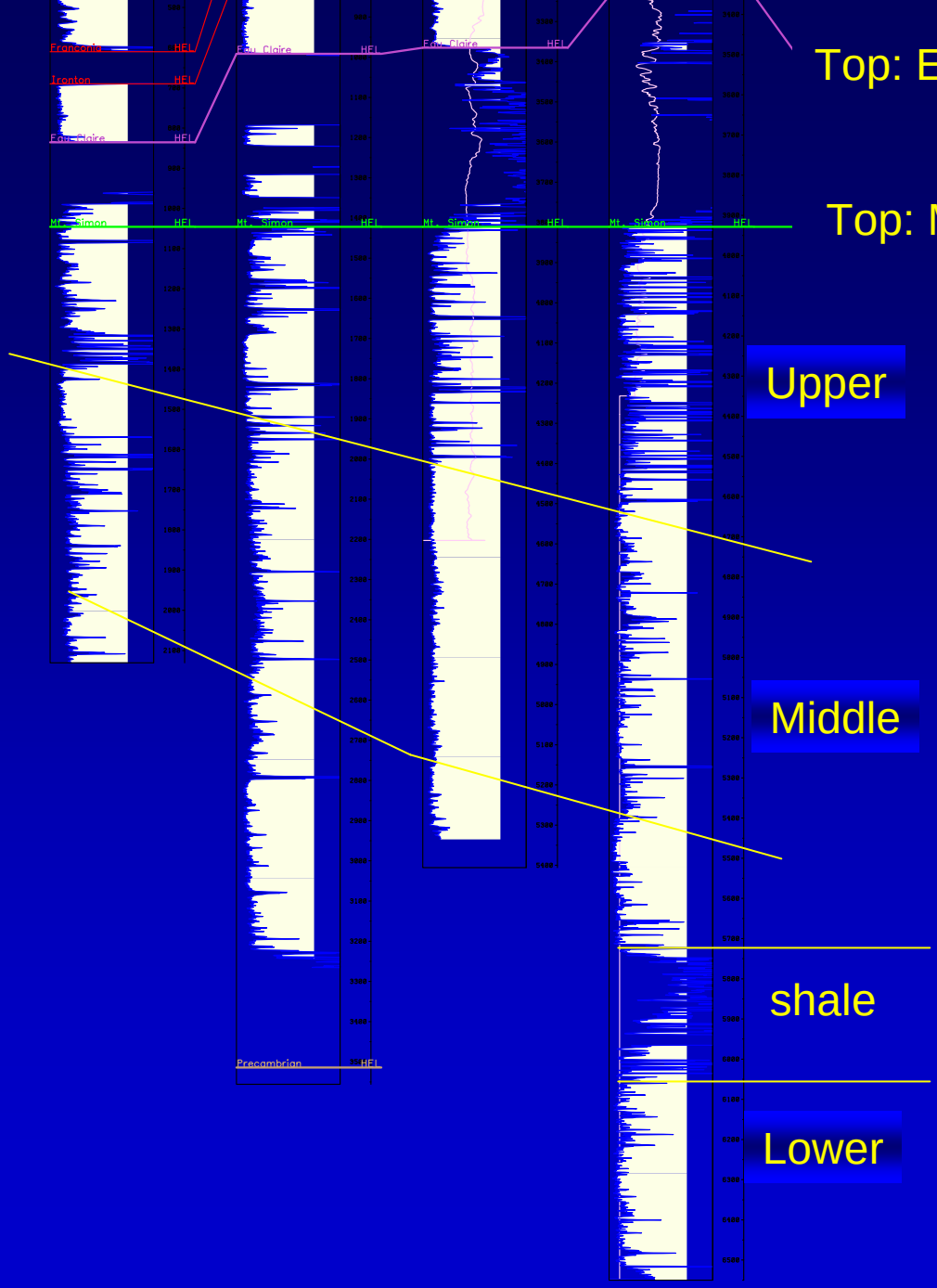



Mt. Simon ranges from -300 to a projected -14,700 feet below sea level




Illinois Basin: North-South Structural Cross-Section

Kolata (1991)




Top: Eau Claire

Top: Mt. Simon

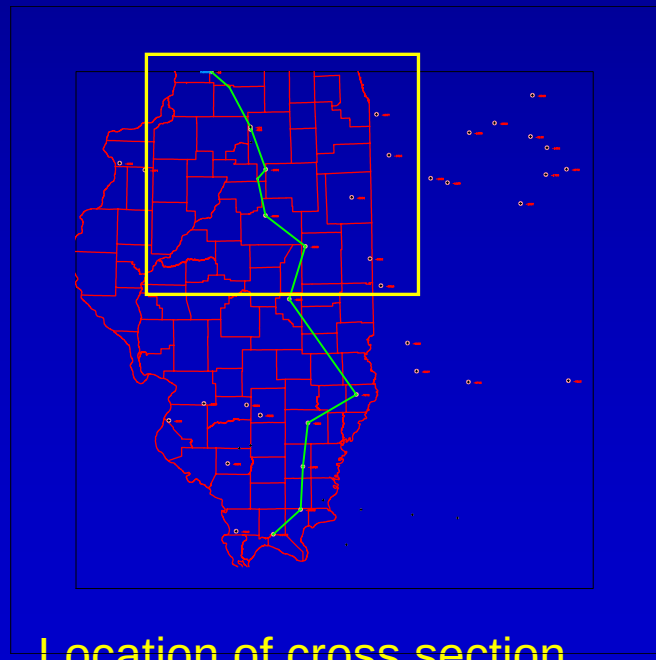
Datum: Top of Mt. Simon Sandstone

Upper

Middle

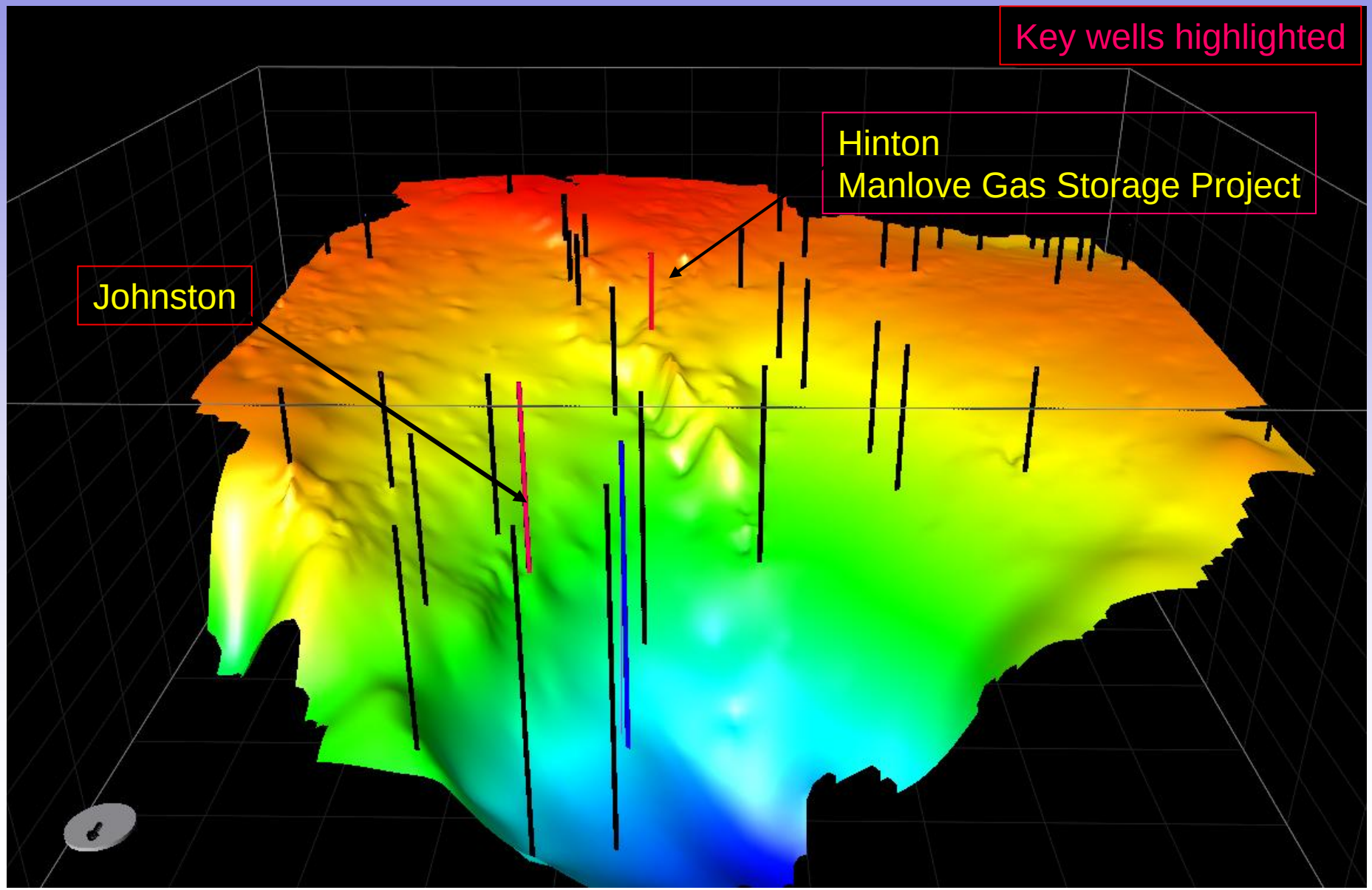
shale

Lower

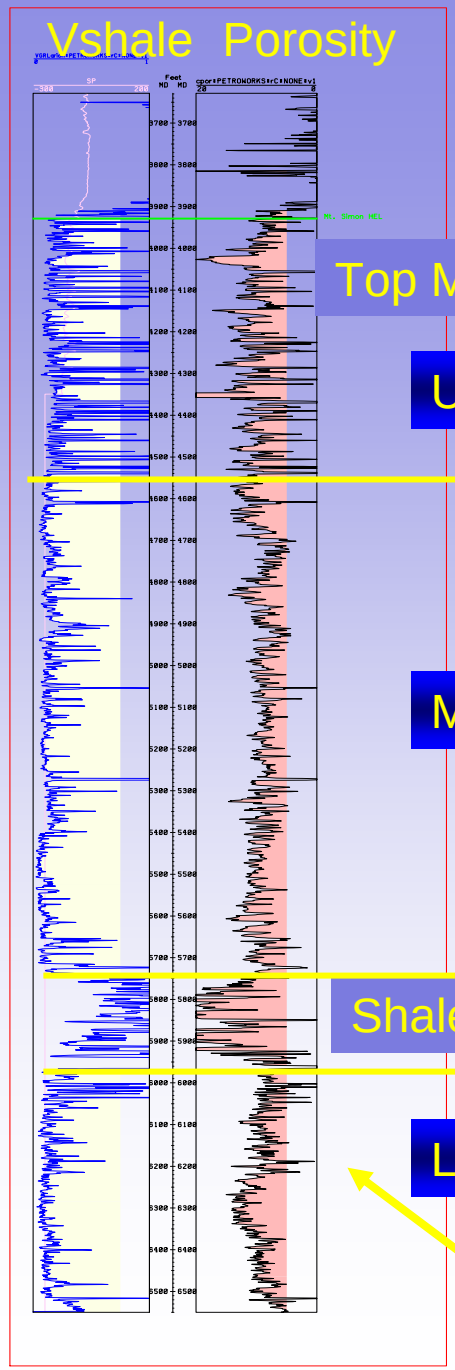


Location of cross section

# Model of Mt. Simon Structure



# Hinton # 7 in Manlove Field




Top Mt. Simon

Upper

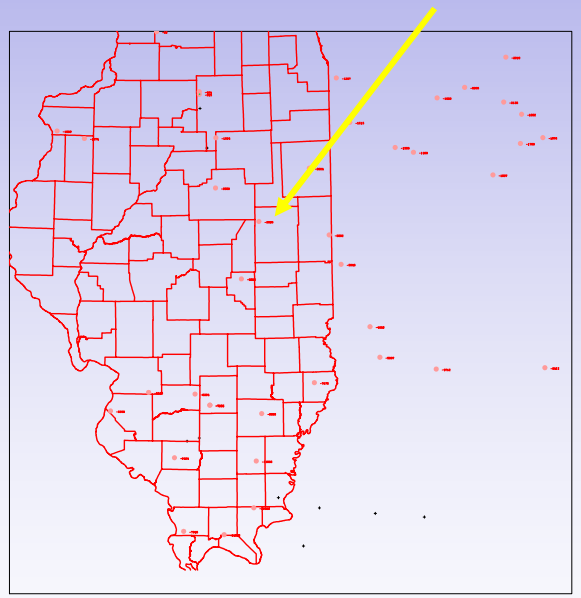
Middle

Shale

Lower

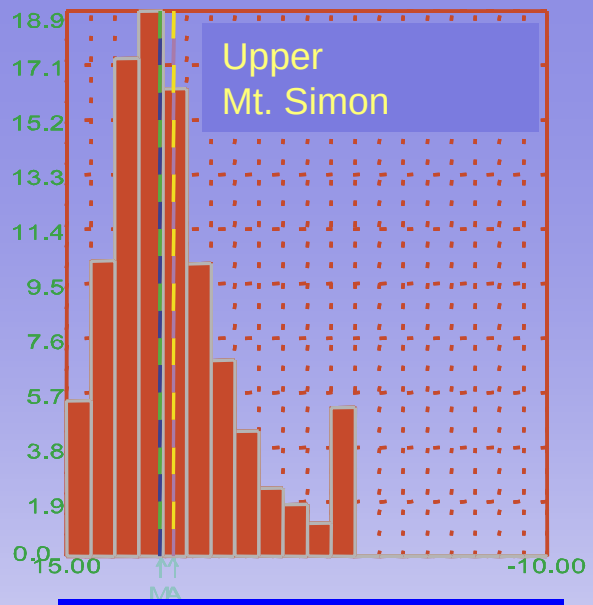
5% cut off for porosity

No significant loss of porosity in 2000 feet of Mt. Simon strata

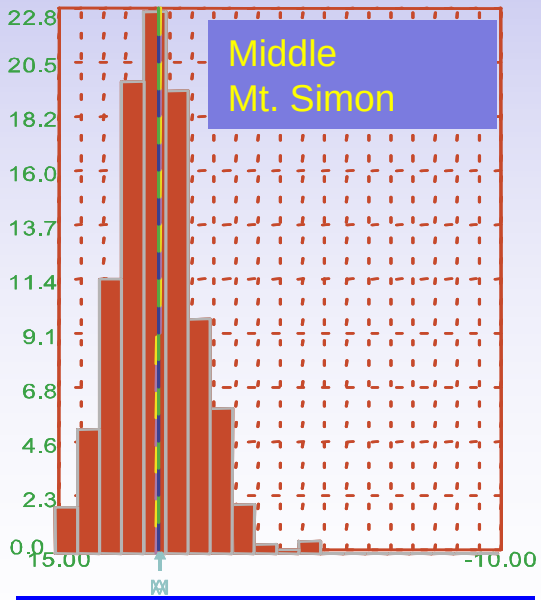


Location of Hinton #7

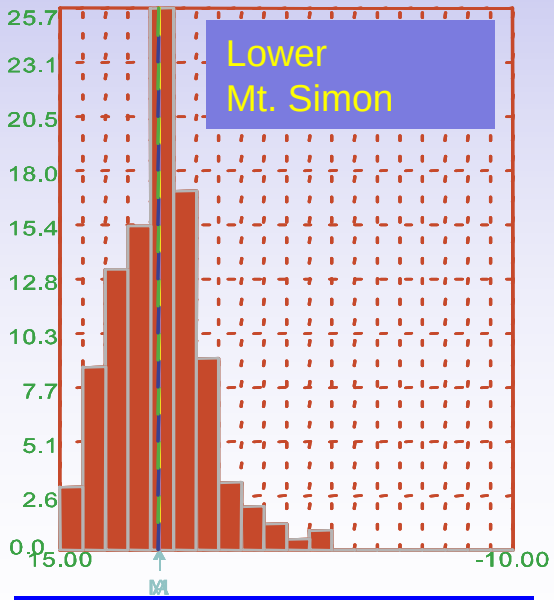
# Distribution of porosity in the Hinton No. 7 Manlove Gas Storage Project



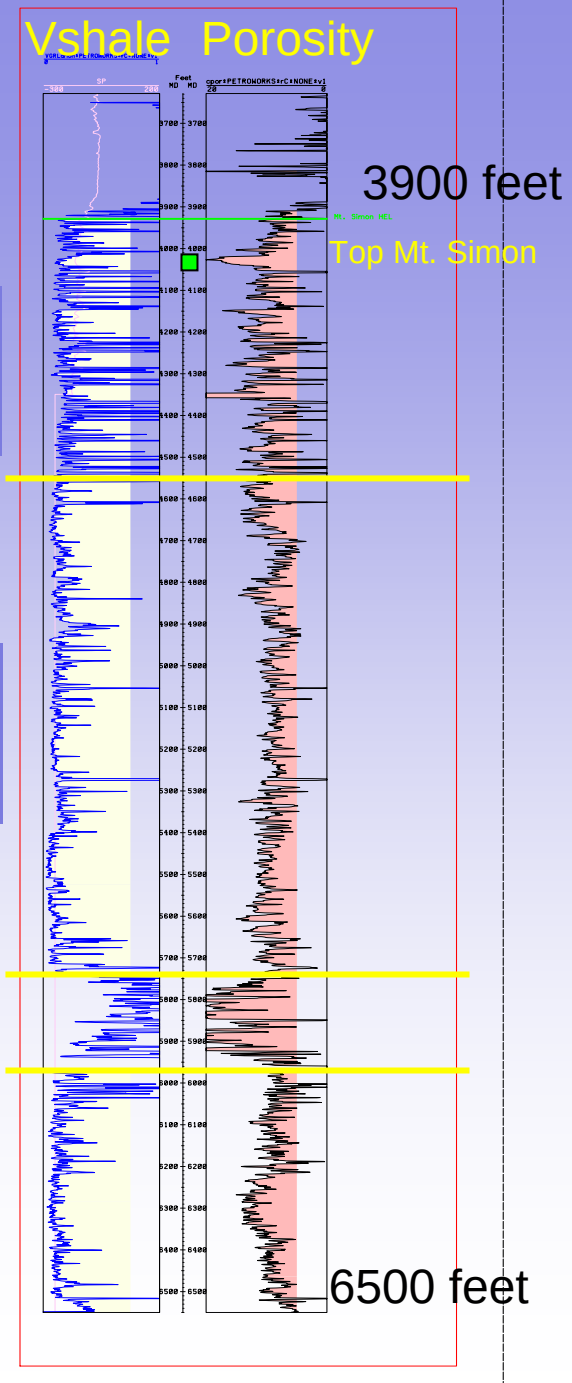

Median Porosity: 10%




Median Porosity: 9.3%

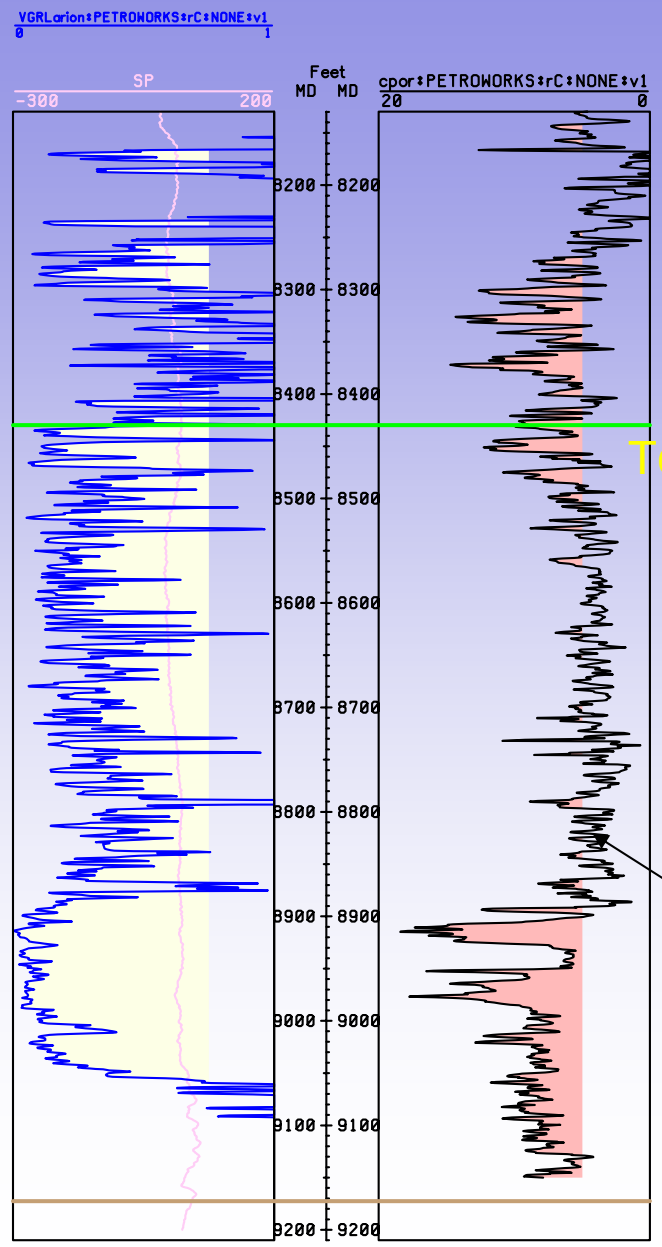



Median Porosity: 9.5%



Vshale

Porosity (from Sonic)



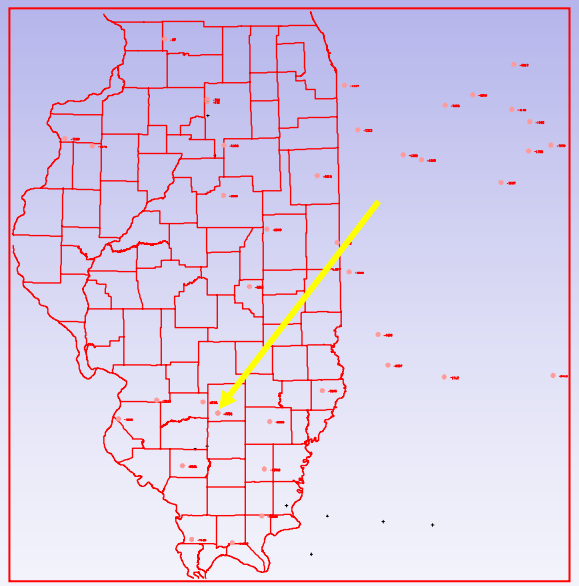

8400 feet

Top Mt. Simon

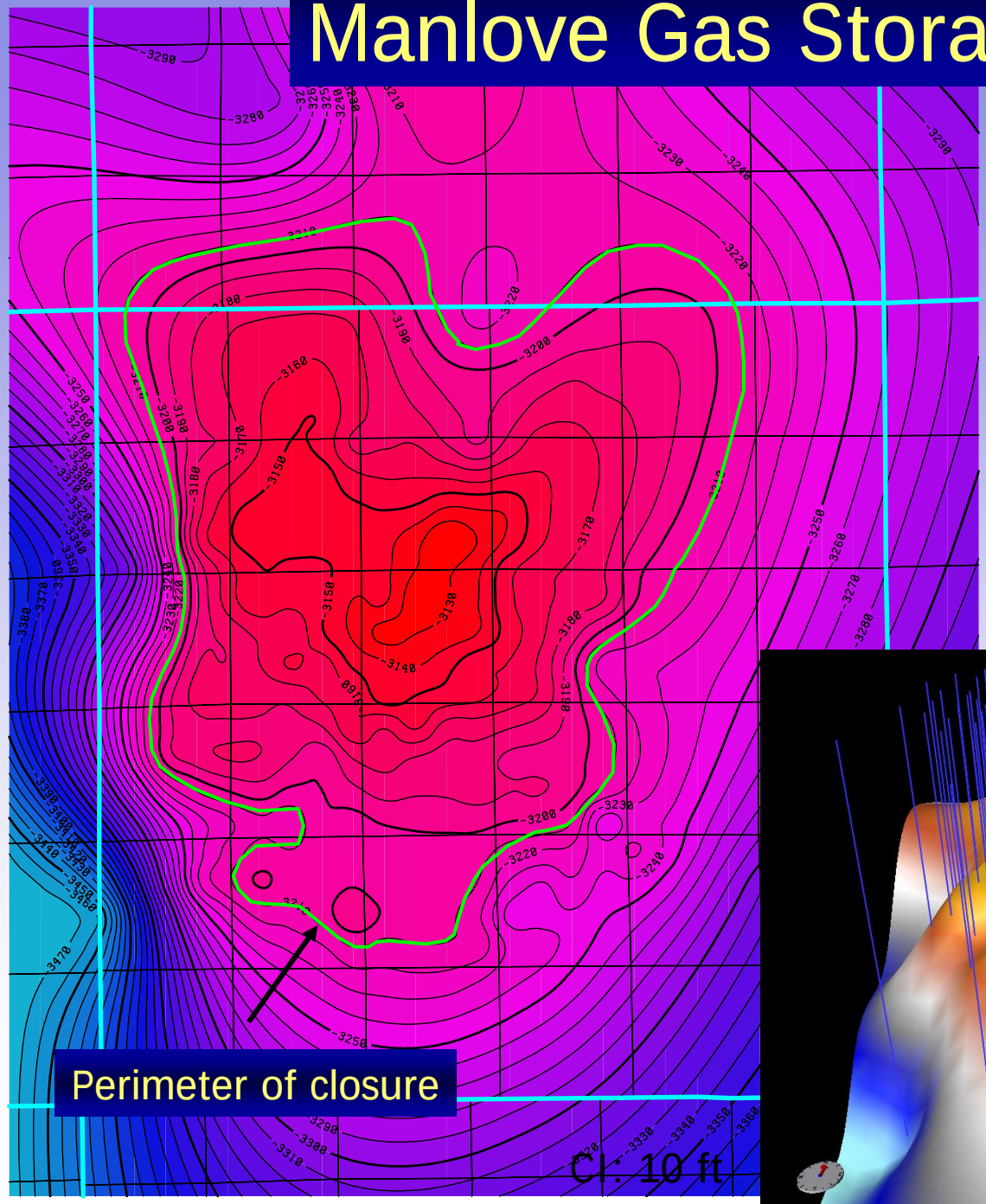
9200 feet

5% cut off for porosity

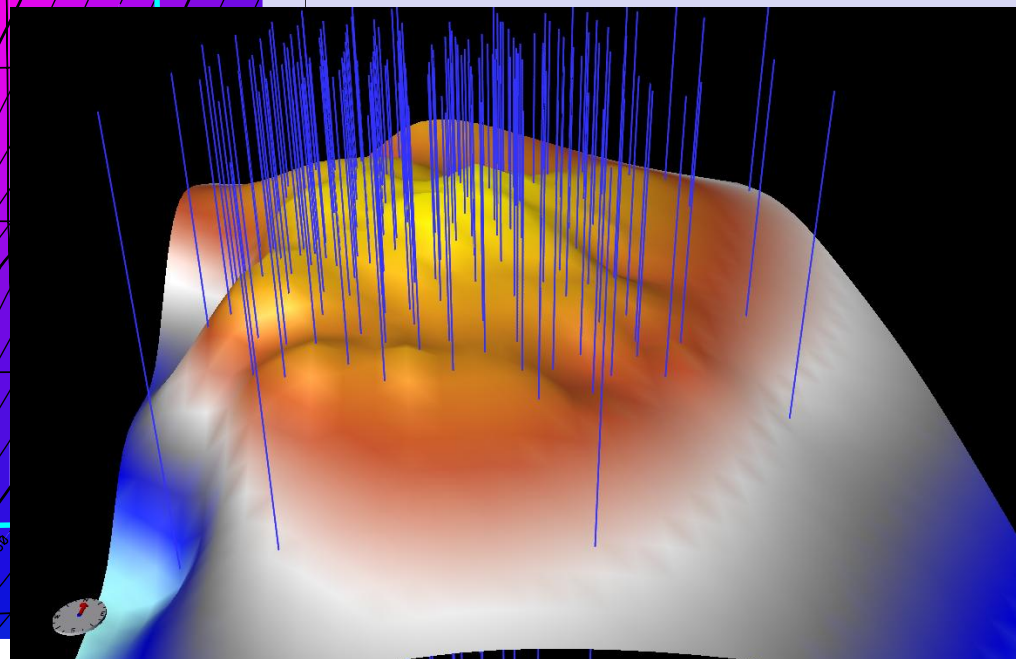
Wireline log of the
R.S. Johnson No. 1
Salem Field



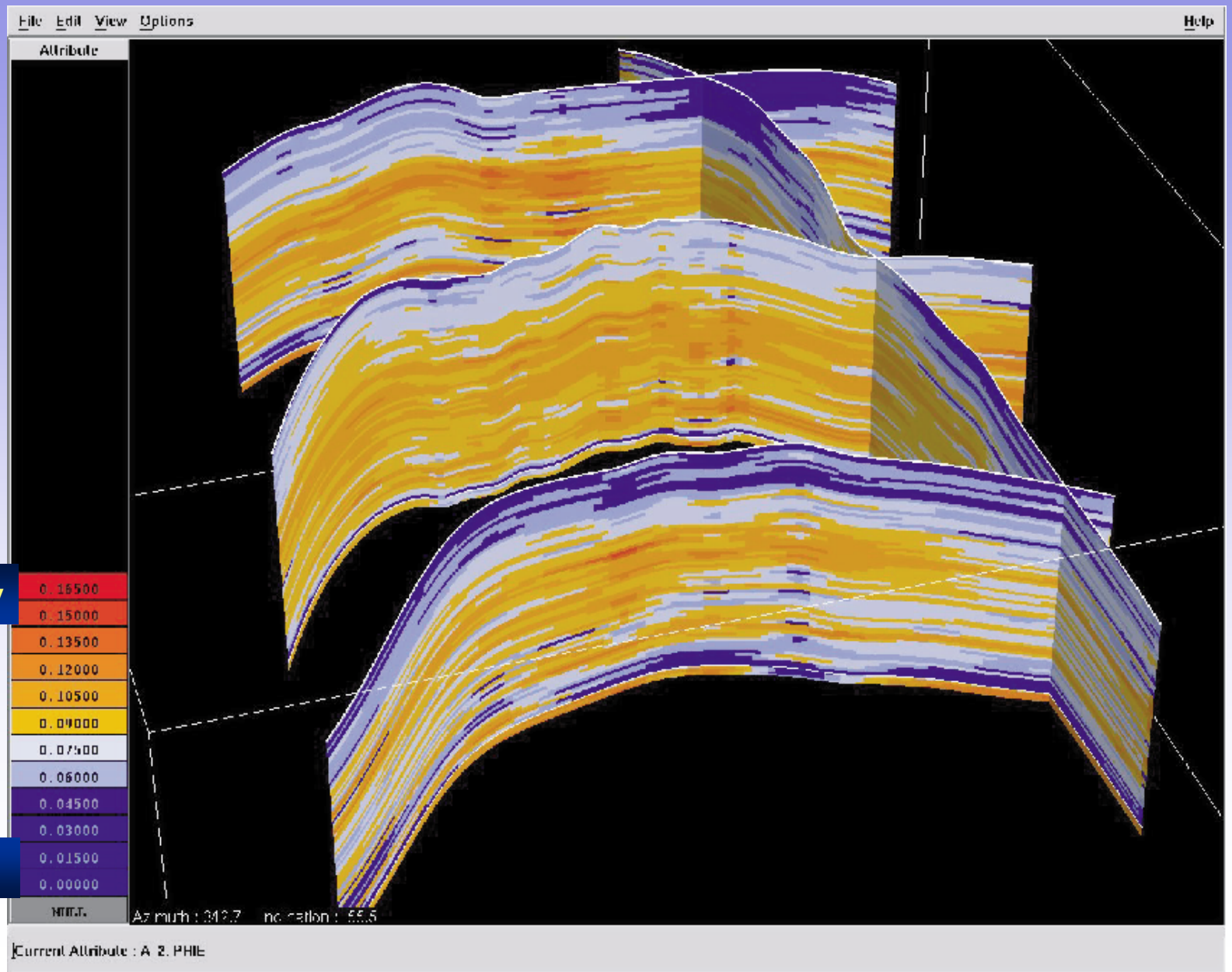
# Manlove Gas Storage Project




The Manlove Project has
90 feet of closure,
is 5 miles long and 4 miles wide



# Porosity Variation in Manlove

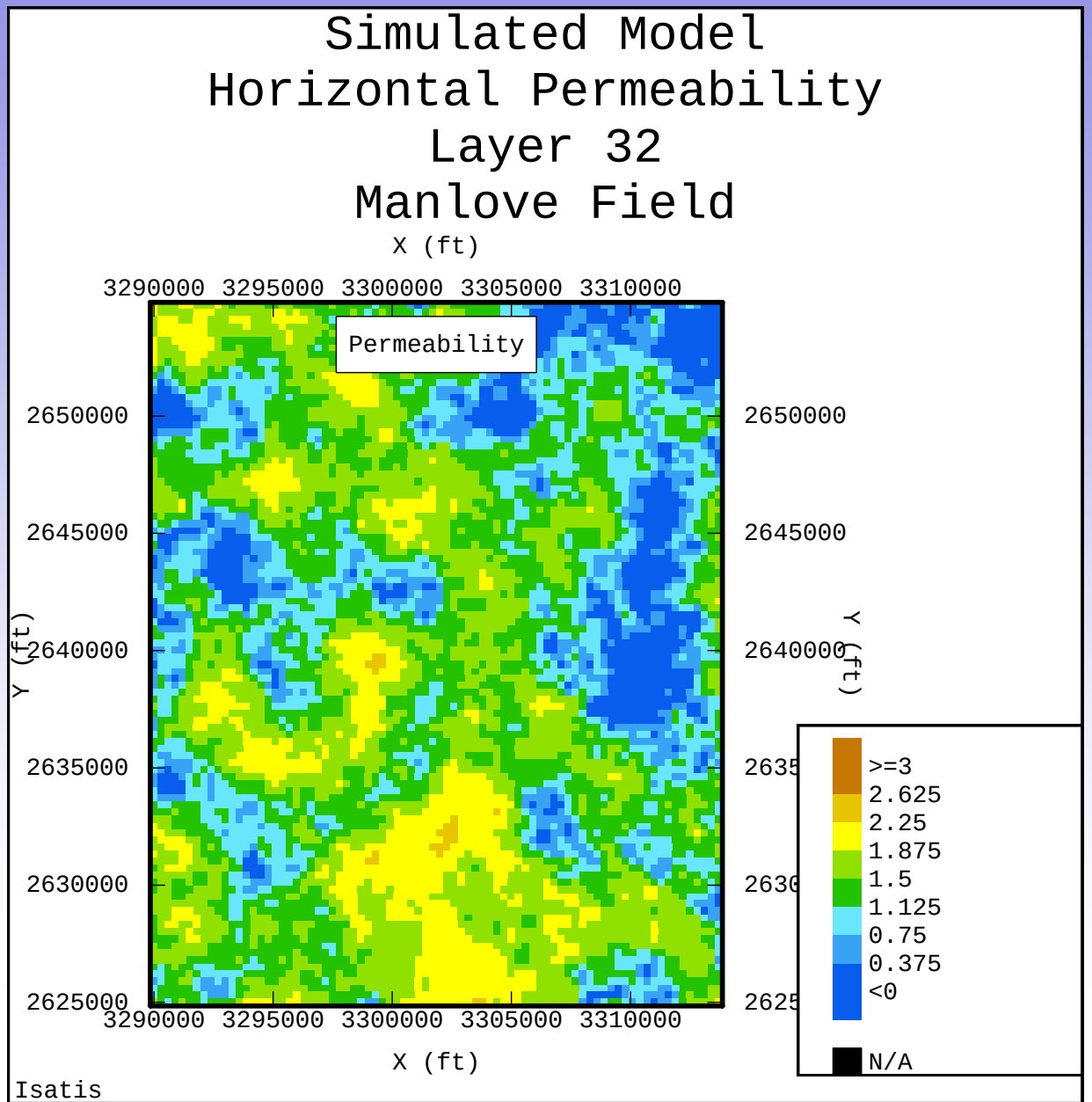



High Porosity

Low Porosity

Comparison: Regression and Simulation

Manlove Field, Layer 32 (96ft from top of Mt. Simon)



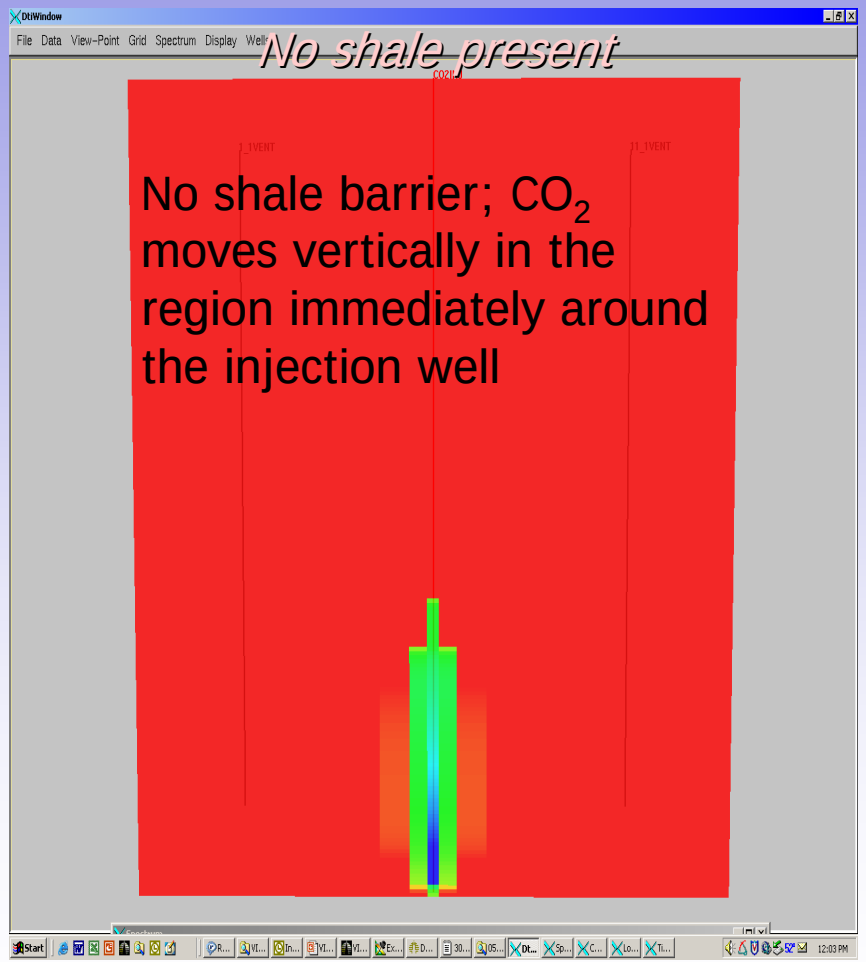
# Saline Formation Storage: Impact of Vertical No-Flow Barriers

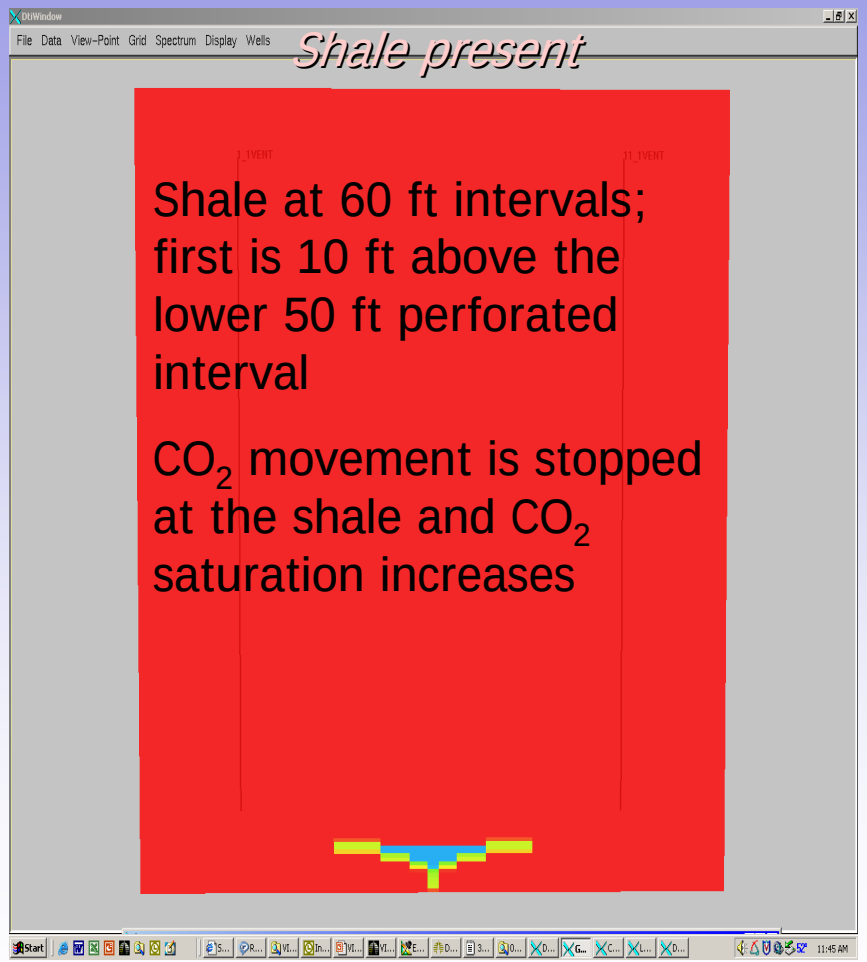
- 5000’ x 5000’ x 1000’ modeled volume
- $k_h$ = 10 md; $k_v$ 1= md; $\phi$ = 8%
- depth = 6000 ft; $p_i$ = 2400 psia
- Open system modeled (only modest pressure increase)
- Injection at base of 1000 ft interval
- Trapped gas 18%

<u>Observations</u>

- No-flow barriers (within-reservoir shales or siltstones) allow saturation buildup and store more $CO_2$ in smaller areas
- Importance of reservoir characterization with respect to local storage in a large structure

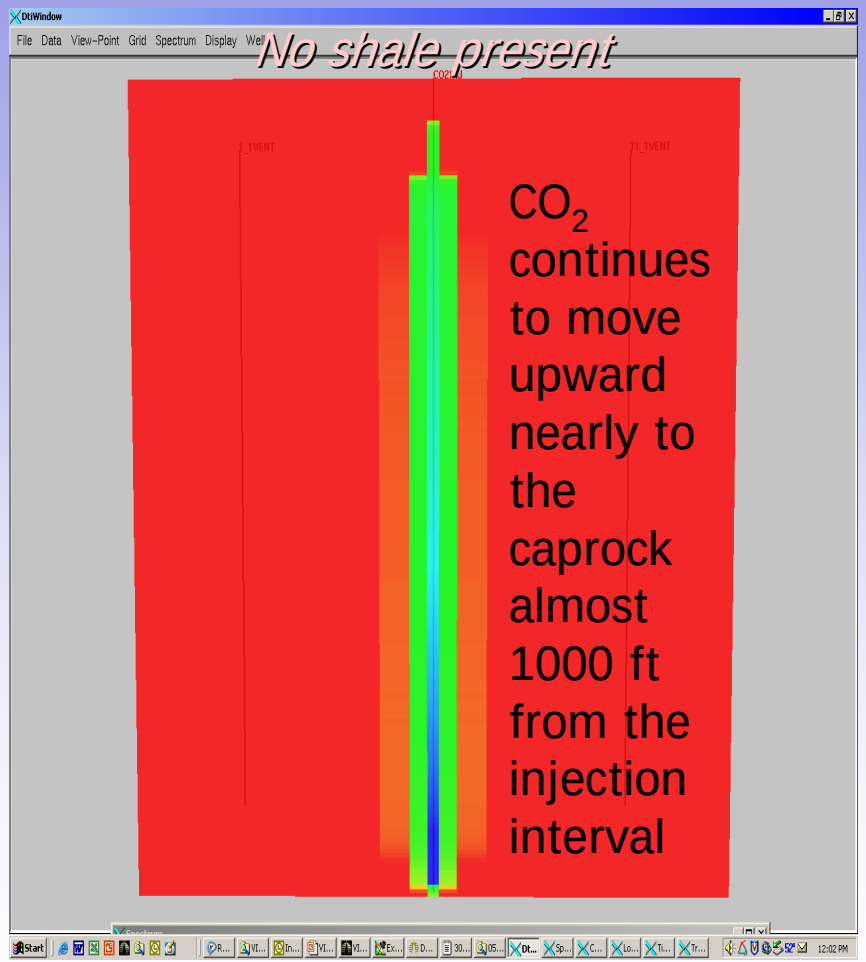
# Impact of Vertical No-Flow Barriers

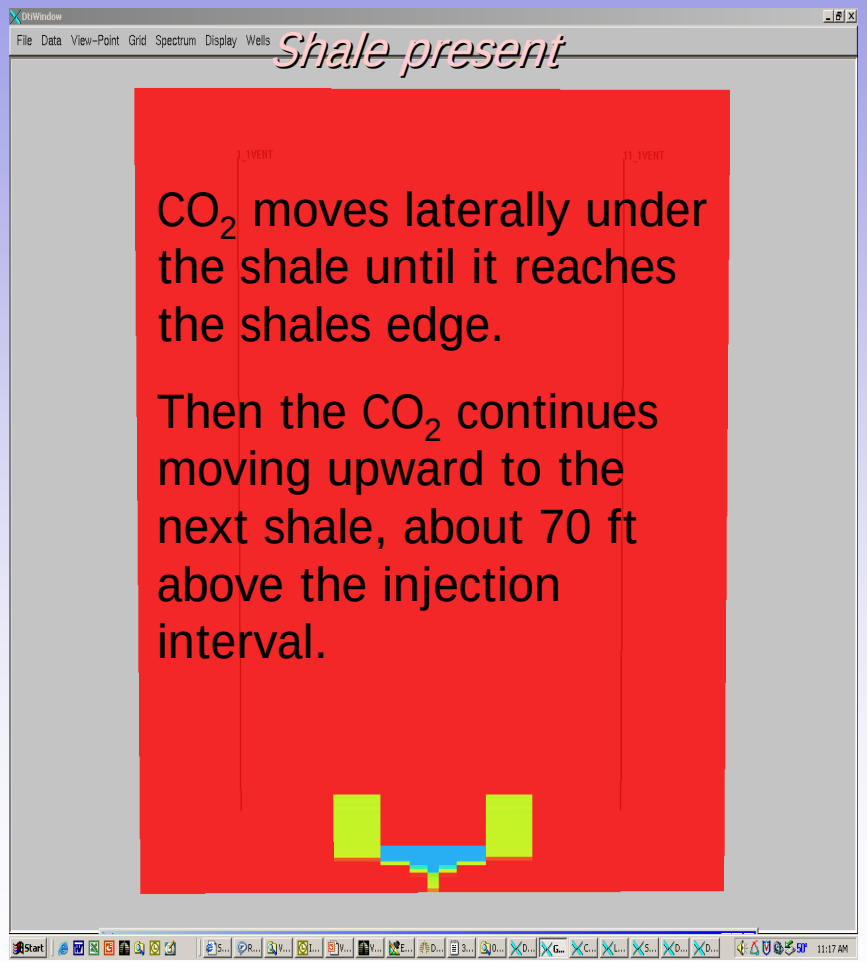



10 years injection

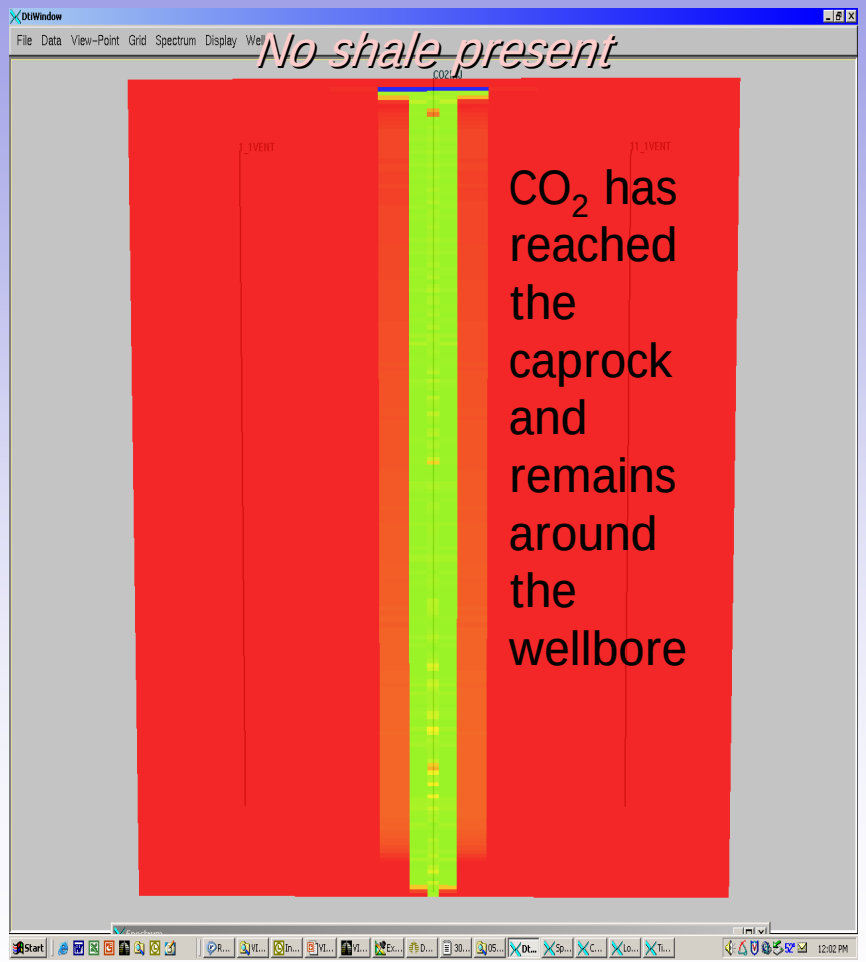
# Impact of Vertical No-Flow Barriers

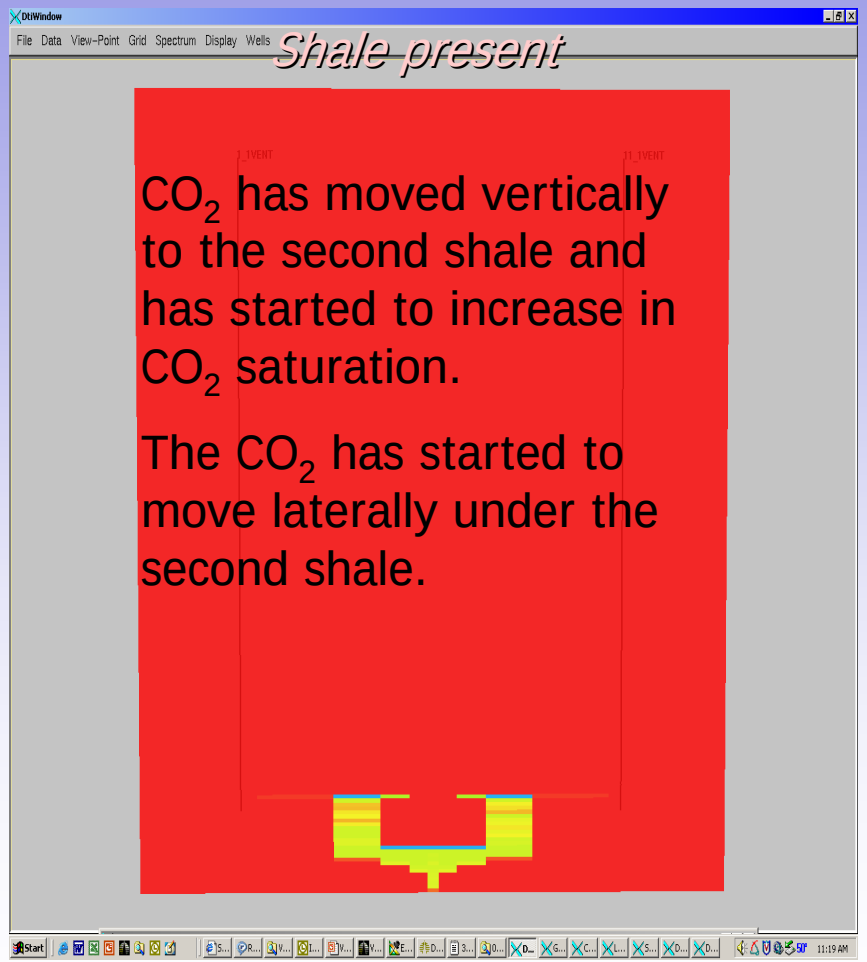



After 30 years injection

# Impact of Vertical No-Flow Barriers



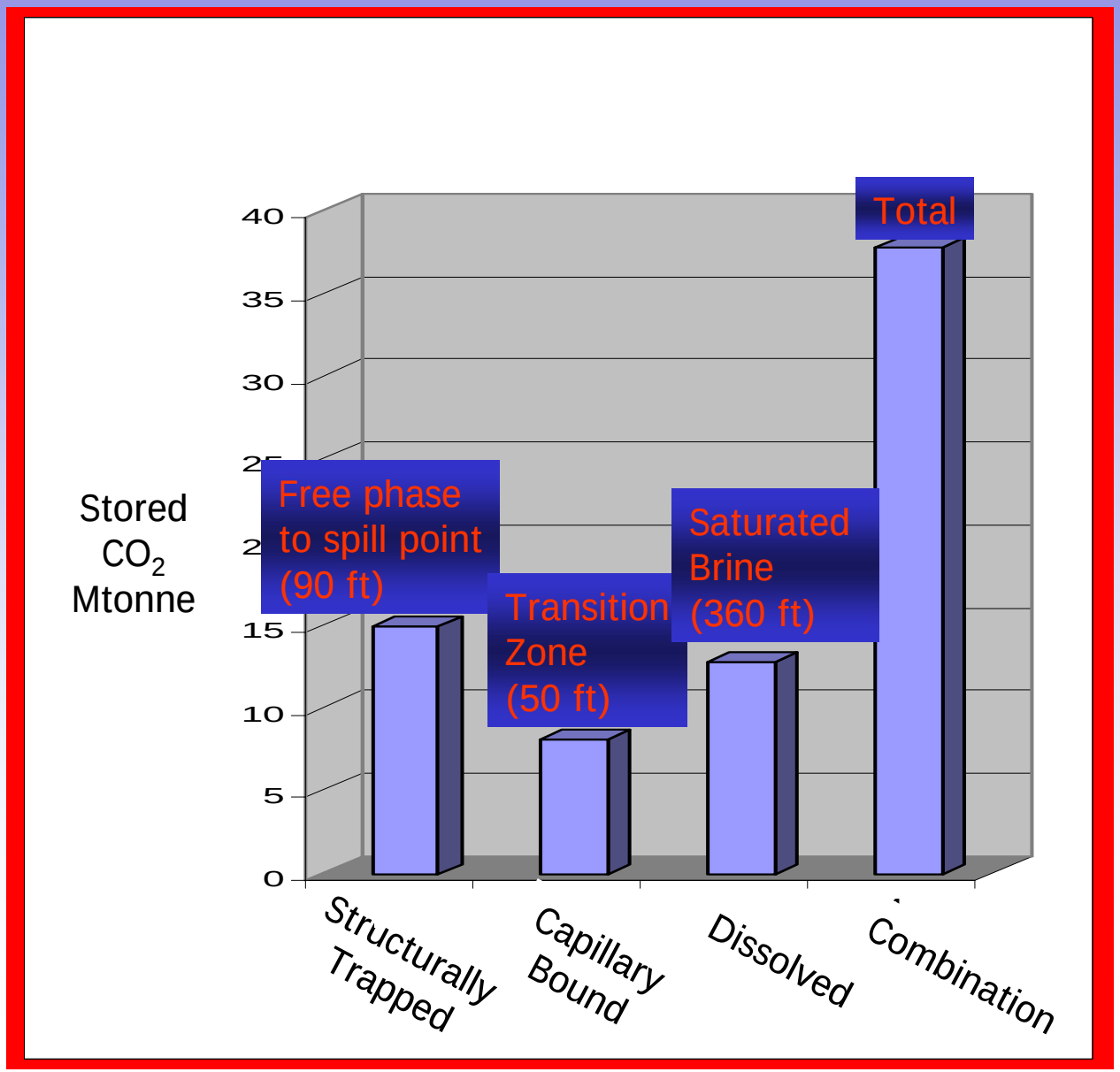

100 yrs shut-in following 30 years injection

# Storage Mechanisms: Geologic Structures

- Structure (Saline)
  - Free phase $CO_2$
    - mobile
    - immobile (capillary trapping)
  - Dissolution
    - saline, formation water

- No Structure
  - Dissolution in saline, formation water

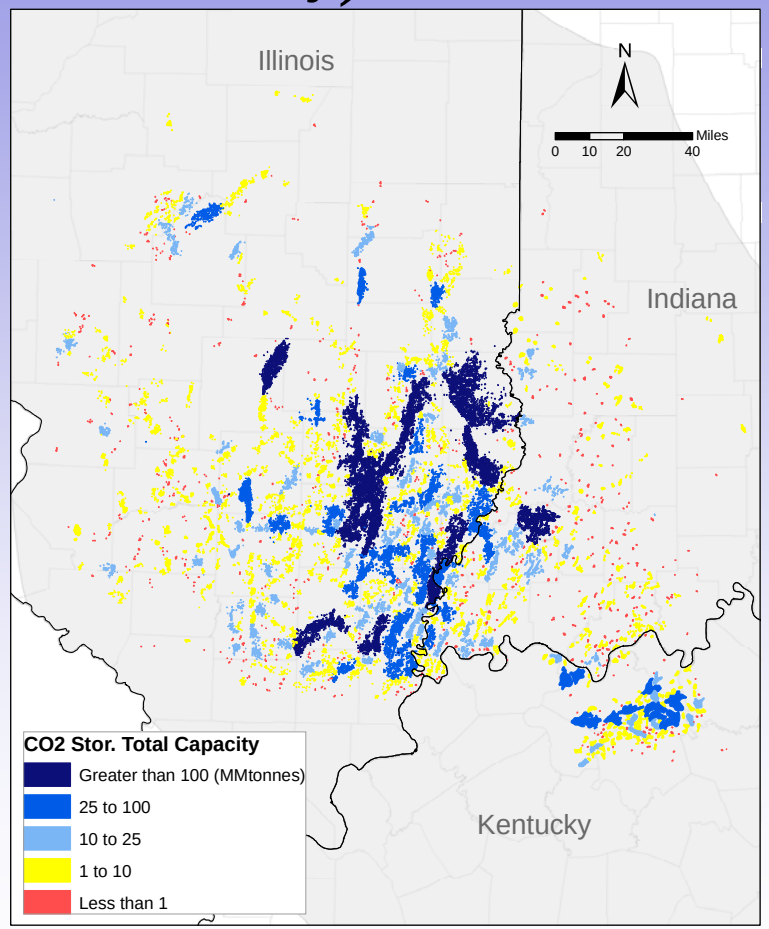
# Underground Gas Storage Analog




A Manlove analog should hold up to 36 Mtonnes of $CO_2$

# $CO_2$ Storage: Saline Water Bearing Formations (Structure Only)

- Mt. Simon: 5.9 Btonne
  - Mobile, free phase
    2,800 Mtonne
  - Immobile, free phase
    1,200 Mtonne
  - Dissolved phase
    1,900 Mtonne
- St. Peter: 1.9 Btonne
  - Mobile, free phase



# Summary

- Lower reservoirs can occur more than 2000 feet below the top of the Mt. Simon and have median porosities of over 9% at depths greater than 8,000 feet
- Upper Mt. Simon has thin, laterally discontinuous low-permeability barriers
- Low permeability zones behave as baffles, that restrict, but do not stop, vertical communication within the reservoir
- The baffles increase the lateral extent of sequestration potential in the Mt. Simon