Using a Petroleum System Approach for Evaluation of CO_2 Sequestration Potential in Saline Reservoirs

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Abstract

Evaluation of the CO_2 sequestration potential of a saline reservoir would benefit from methodologies developed to analyze a petroleum system. Petroleum system analysis emphasizes the importance of the: 1) seal, 2) trapping mechanism, 3) overburden, 4) reservoir rock, 5) source, 6) preservation, and 7) critical moment. This type of systematic approach is readily modified for analysis of the sequestration potential of a formation or region. The key differences in analytical methodologies are that: the source would refer to the surface potential of the site, preservation is the length of time CO_2 would be sequestered, and critical moment is the time sequestration starts.

The Cambrian Mt. Simon sandstone of the Illinois Basin is used to illustrate how this approach could be used to define the sequestration fairway. For example, Mt. Simon reservoir suitability is constrained by amount of overburden, depositional system, and the Precambrian topography. Sequestration traps may not necessarily be defined by structural or stratigraphic traps, but instead may also be found in areas of low structural dip and high reservoir preservation potential. The preservation potential of the reservoir is controlled by water salinity, reservoir heterogeneity, and lithology. The critical moment or first injection of CO_2 may become important when multiple injection sites in a basin become operational. Finally, the surface conditions, such as urban areas and water bodies may limit the location of CO_2 sources. These examples from the Mt. Simon demonstrate an orderly approach to examining all pertinent data that should be considered when evaluating an individual site or a formation for its sequestration potential.

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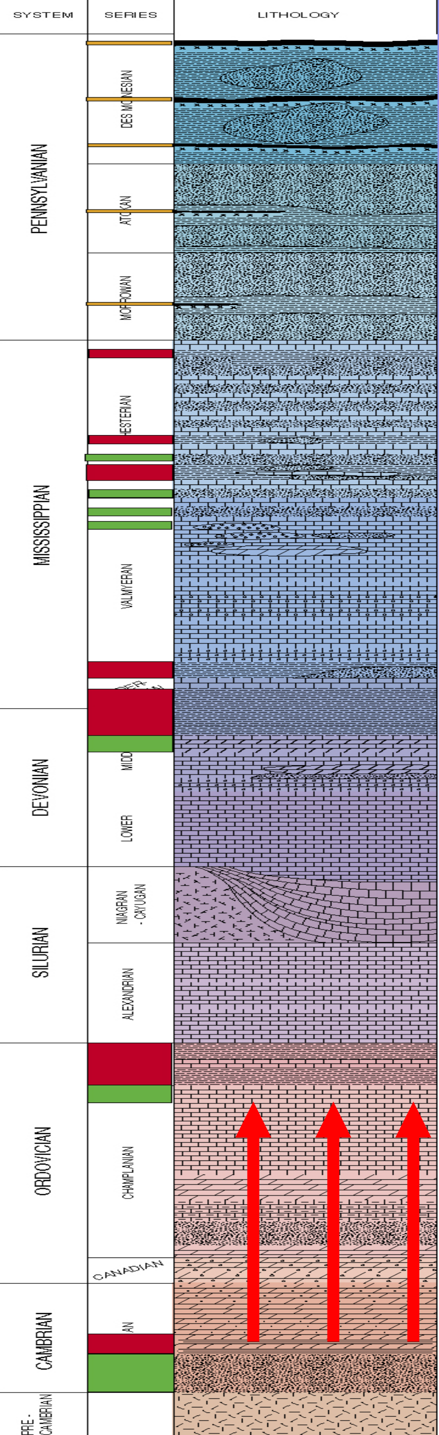
Carbon System Analysis Emphasizes

- Seal
- Trapping mechanism
- Overburden
- Reservoir
- Source
- Preservation
- Critical moment

Uncertainty of the Seal
(Goal: Find a safe place)

Not all Apparent Seals are Seals

Preservation Potential is low in this system



Trenton

1000 feet

Ironton Galesville

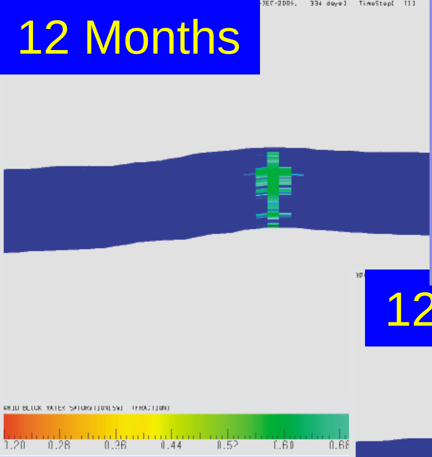
- <u>Herscher Gas Storage Field</u>
  - Injected natural gas into Ironton Galesville
  - Traveled 1000 feet vertically through fractures in Knox Dolomite even though core samples showed zero permeability

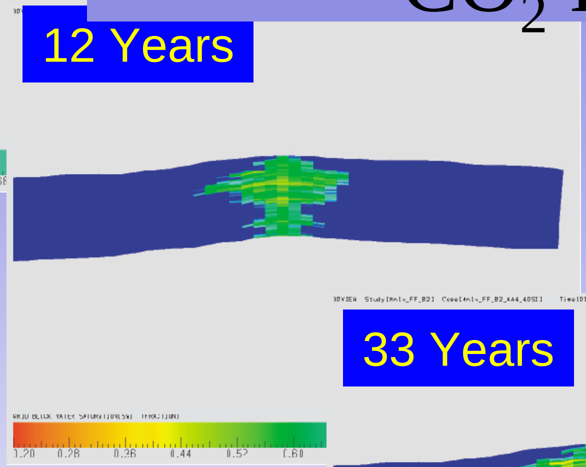
Trapping Mechanism

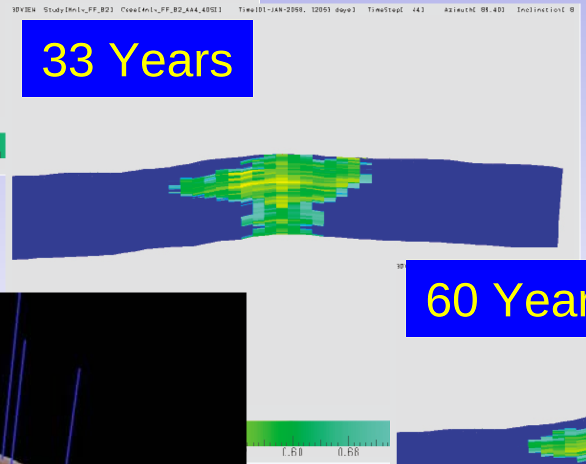
Structure or Regional Dip
Which one is better?

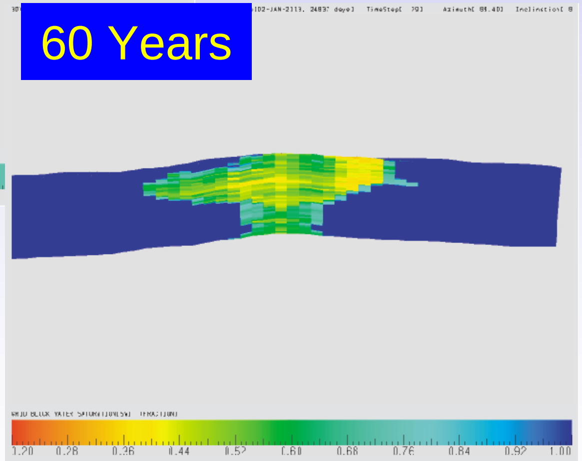
Flow Simulation in the Mt. Simon at the Manlove Gas Storage

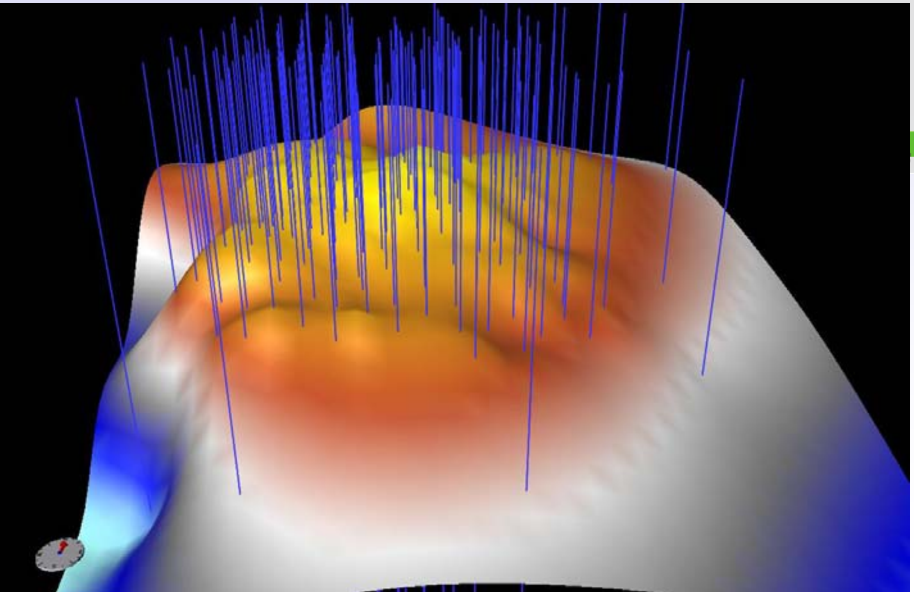
CO_2 Flow Through Time





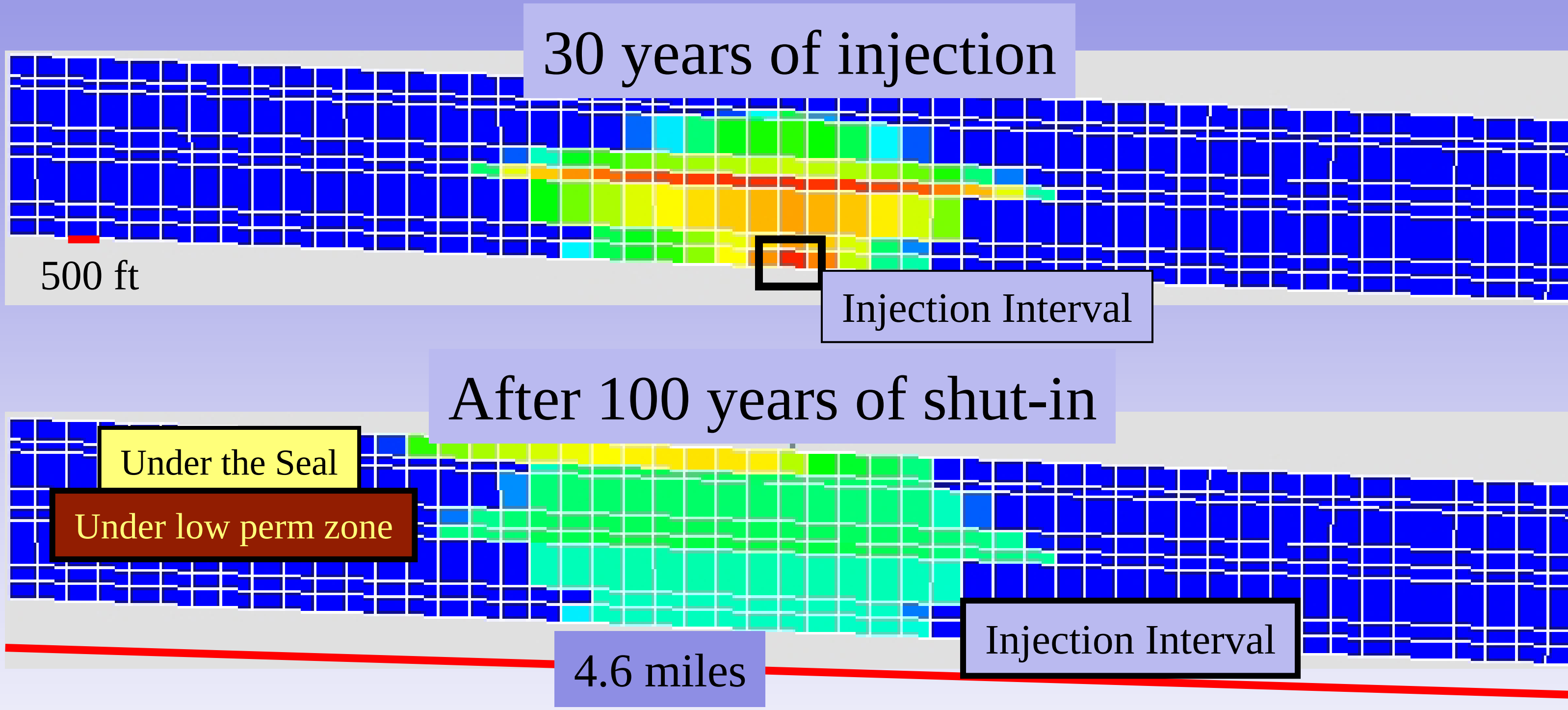


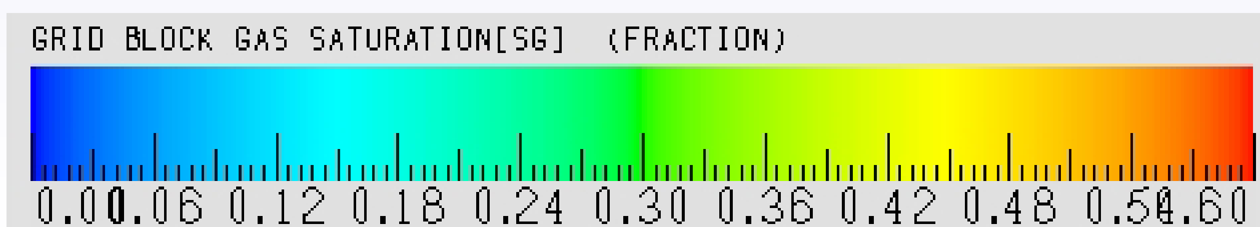




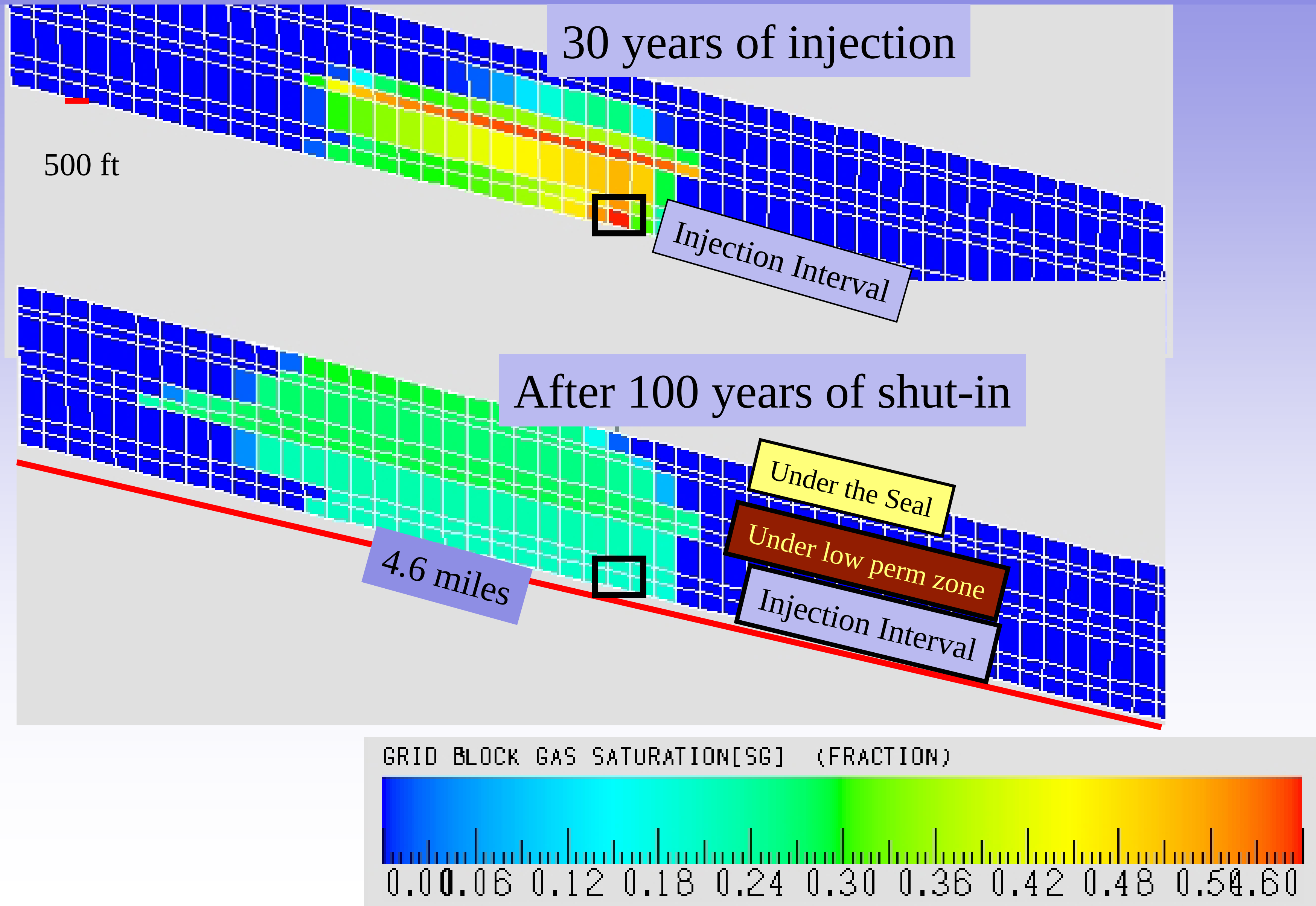
Regional Dip
(Preservation Potential)
How long will CO_2 stay sequestered?

Injection into the Weaber-Horn
1 degree dipping beds





Injection into the Weaber-Horn
5 degree dipping beds



Regional Dip

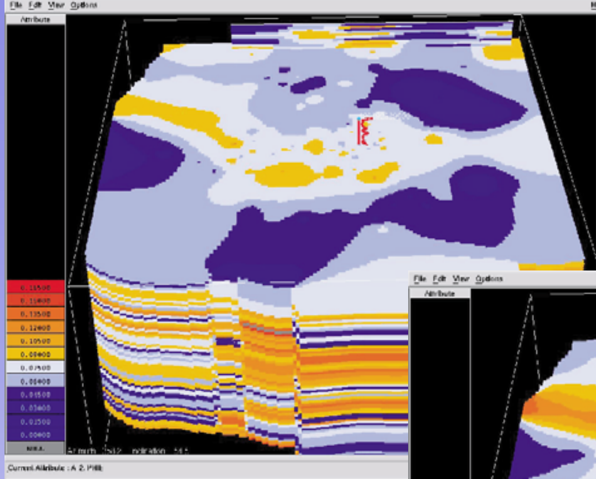
- The regional dip of the stratigraphic layers is commonly less than 1 degree dip
  - However, some areas have higher dips and need to be identified
- Injection of 1 million tonnes/year causes the CO_2 to migrate a maximum distance of
  - 4,200 feet at 0 degree dip
  - 10,750 feet at 5 degree dip

Reservoir Quality

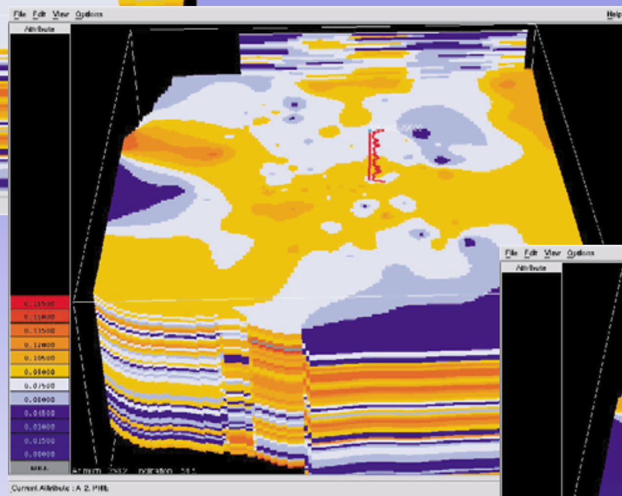
Outliers may be Important

- The average reservoir characteristic such as porosity is a nice number to add as statistic but the anomalous values (such as 1 Darcy perm) may have greater influence)
- Constantly review the data and find what does not fit the average or our common earth model

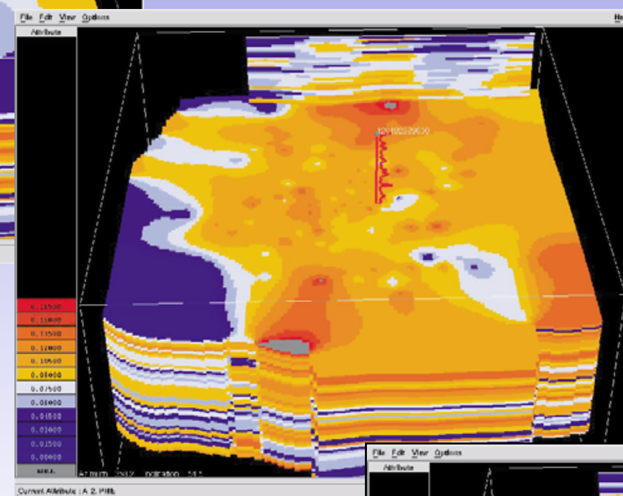
How laterally continuous are the poor quality reservoir intervals?



4,000 feet

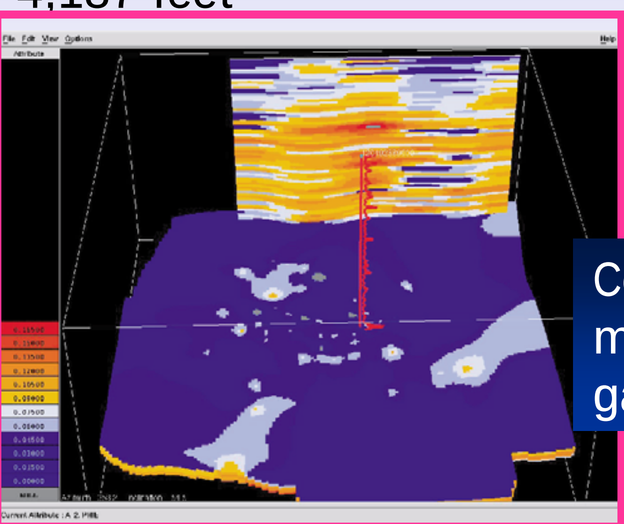


4,034 feet

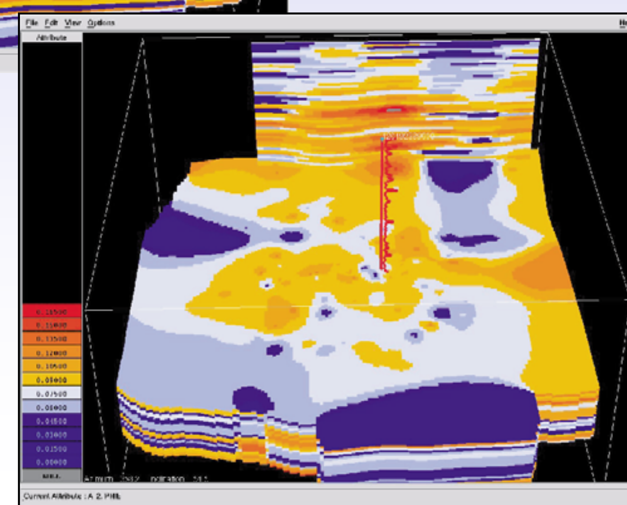


4,056 feet

4,187 feet

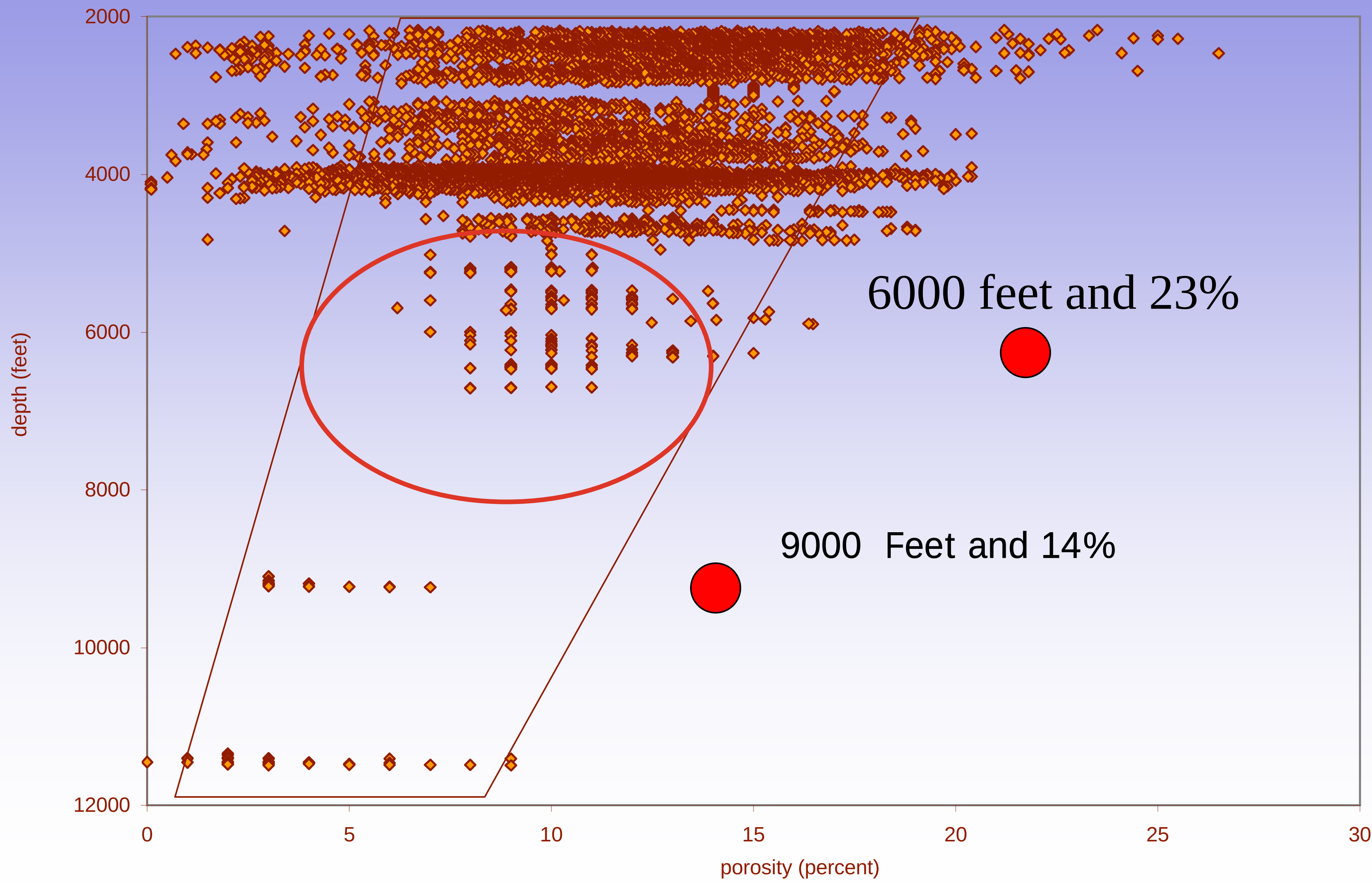


Continuous shales may form internal gas caps

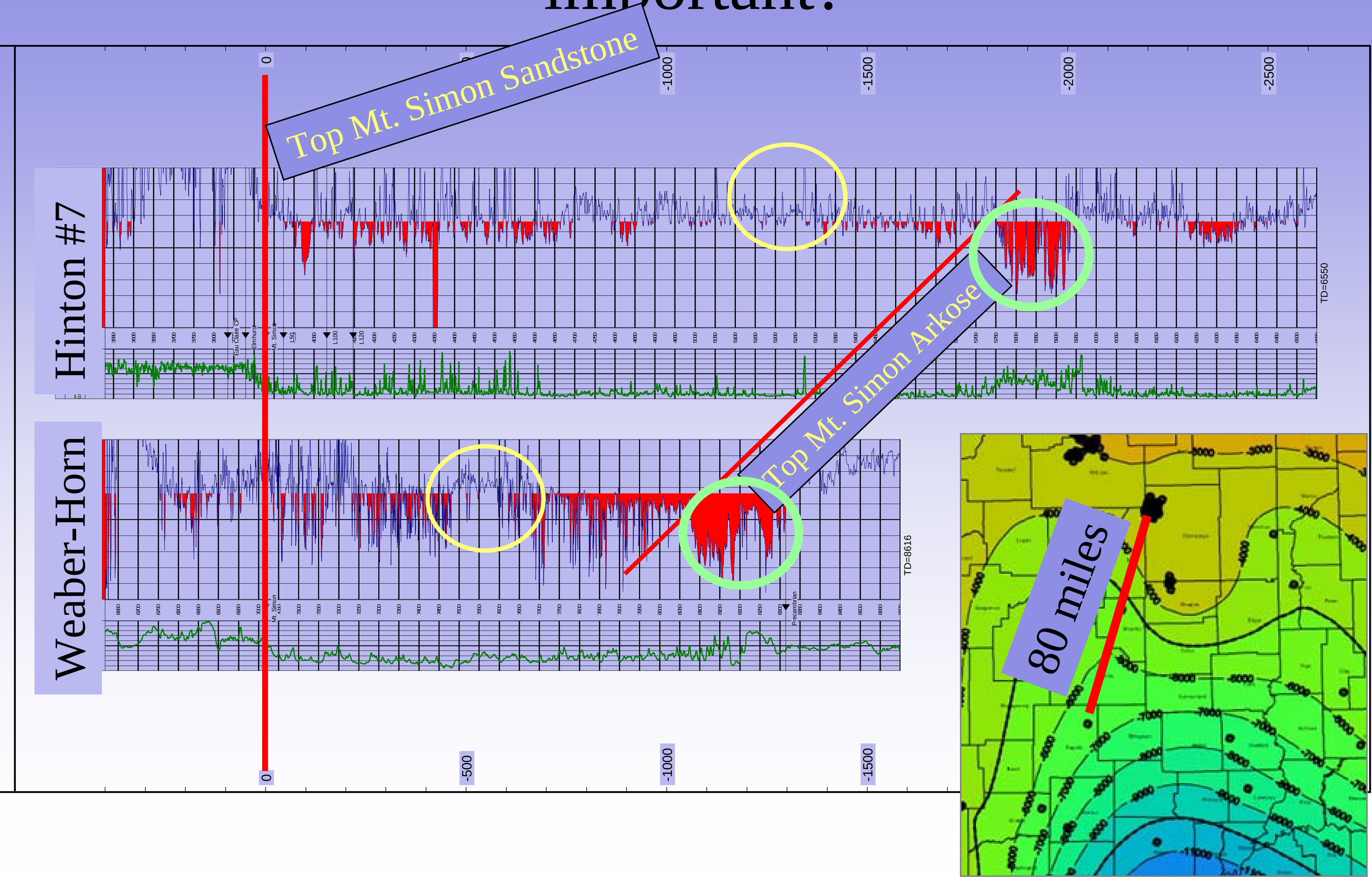


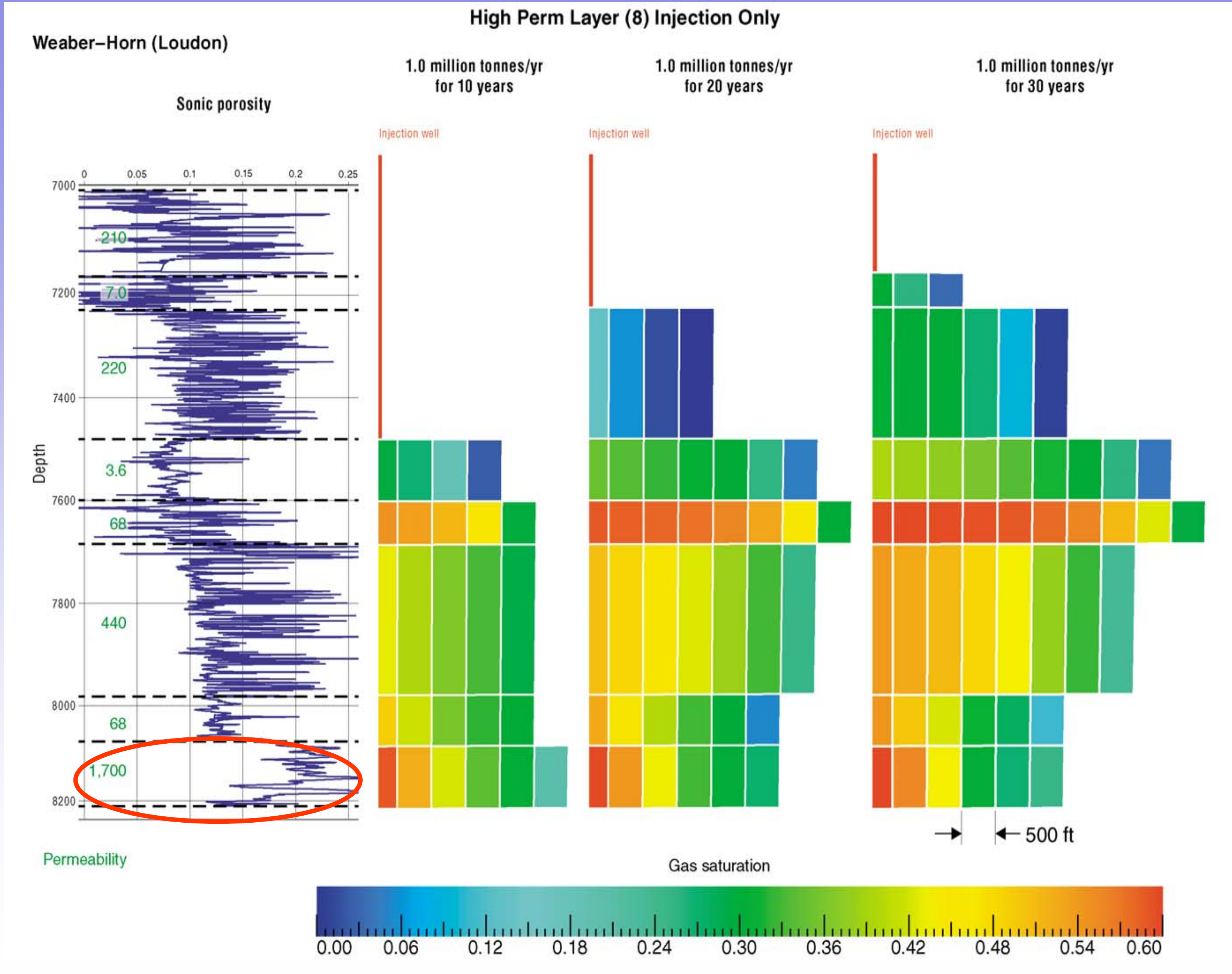
4,132 feet

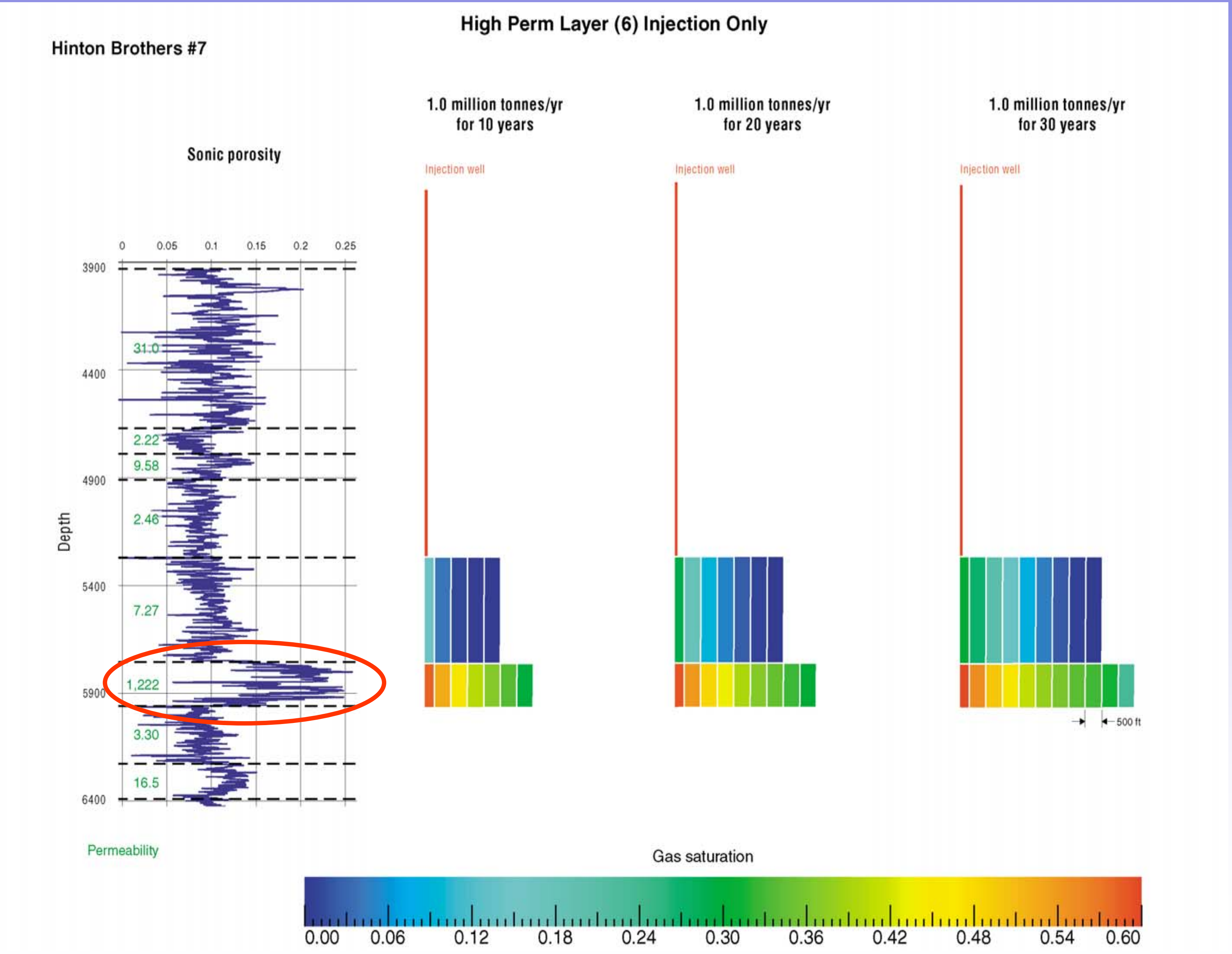
Porosity and its Relationship with Depth



Where is the outlier and how might it be important?




High Perm Layer (8) Injection Only
Weaber–Horn (Loudon)
Sonic porosity
1.0 million tonnes/yr for 10 years
1.0 million tonnes/yr for 20 years
1.0 million tonnes/yr for 30 years
Injection well
Injection well
Injection well
0
0.05
0.1
0.15
0.2
0.25
7000
7200
7400
7600
7800
8000
8200
Depth
210
7.0
220
3.6
68
440
68
1,700
Permeability
500 ft
Gas saturation
0.00
0.06
0.12
0.18
0.24
0.30
0.36
0.42
0.48
0.54
0.60


High Perm Layer (6) Injection Only
Hinton Brothers #7
Sonic porosity
0
0.05
0.1
0.15
0.2
0.25
3900
4400
4900
5400
5900
6400
Depth
31.0
2.22
9.58
2.46
7.27
1,222
3.30
16.5
Permeability
1.0 million tonnes/yr
for 10 years
1.0 million tonnes/yr
for 20 years
1.0 million tonnes/yr
for 30 years
Injection well
Injection well
Injection well
500 ft
Gas saturation
0.00
0.06
0.12
0.18
0.24
0.30
0.36
0.42
0.48
0.54
0.60

Surface Conditions

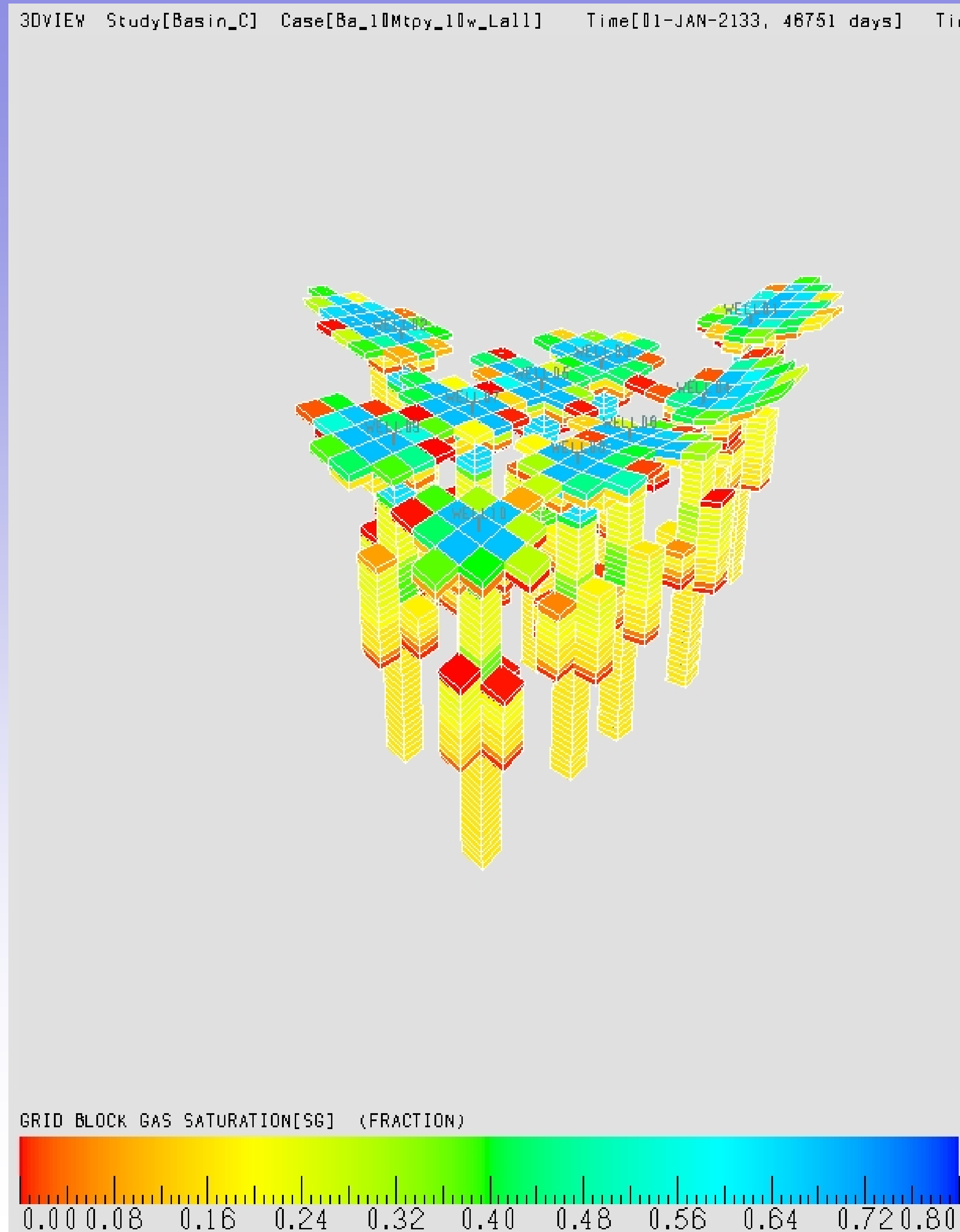
Source

The Source of CO_2

- Is it an ethanol plant
- Coal fired power plant
- Other
- Important because there may be impurities in the gases
  - Mercury
  - H_2S
  - Water

Critical Moment

When do the sequestration projects start?


3DVIEW Study[Basin_C] Case[Ba_10Mtpy_10w_Lall] Time[01-JAN-2133, 46751 days] Ti
GRID BLOCK GAS SATURATION[SG] (FRACTION)
0.00 0.08 0.16 0.24 0.32 0.40 0.48 0.56 0.64 0.72 0.80

Conclusions

- An orderly approach to examining all pertinent data must be completed when evaluating an individual site or a formation for its sequestration potential.
- You need to look at the entire sequestration system when locating a new CO_2 emitter

End of Presentation