

Illinois Storage Corridor

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US Department of Energy

National Energy Technology Laboratory

2022 Carbon Management Research Project Review Meeting



Illinois State Geological Survey

PRAIRIE RESEARCH INSTITUTE

Presentation Outline

- Project Overview
- Carbon Capture Assessment
- Site Characterization – Modeling – Class VI components
- Summary

Project Team



Illinois Storage Corridor CarbonSAFE Phase III

Illinois Storage Corridor is a region with significant previous CCS-related activity

Project builds upon IBDP, CarbonSAFE Phases I and 2 and many other studies.

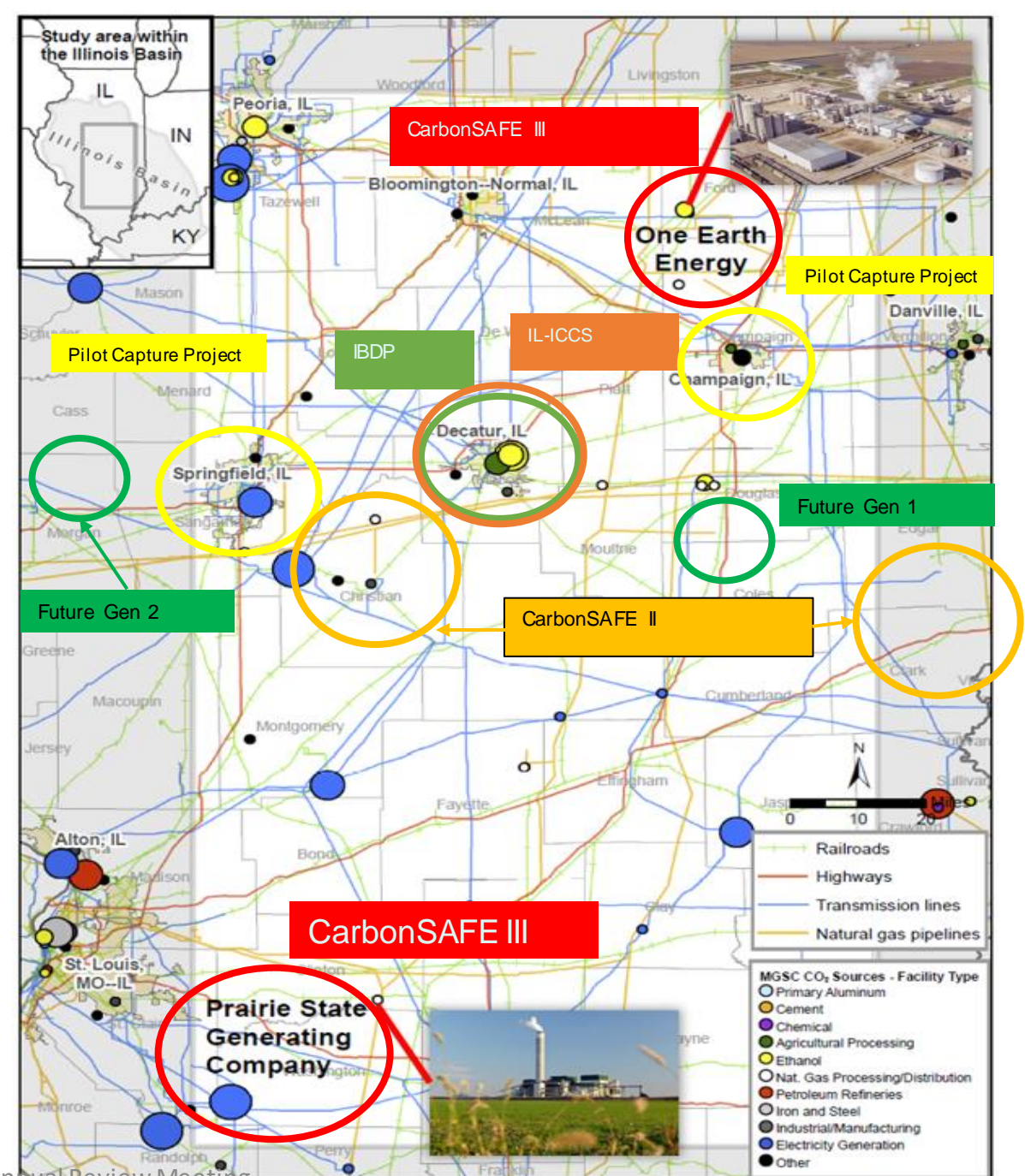
2 separate sites are being investigated to develop Class VI permits

One Earth Energy

Ethanol source: Mt Simon Storage Complex –
Possible Storage Hub (0.5 to 1.7 MTPA CO₂)

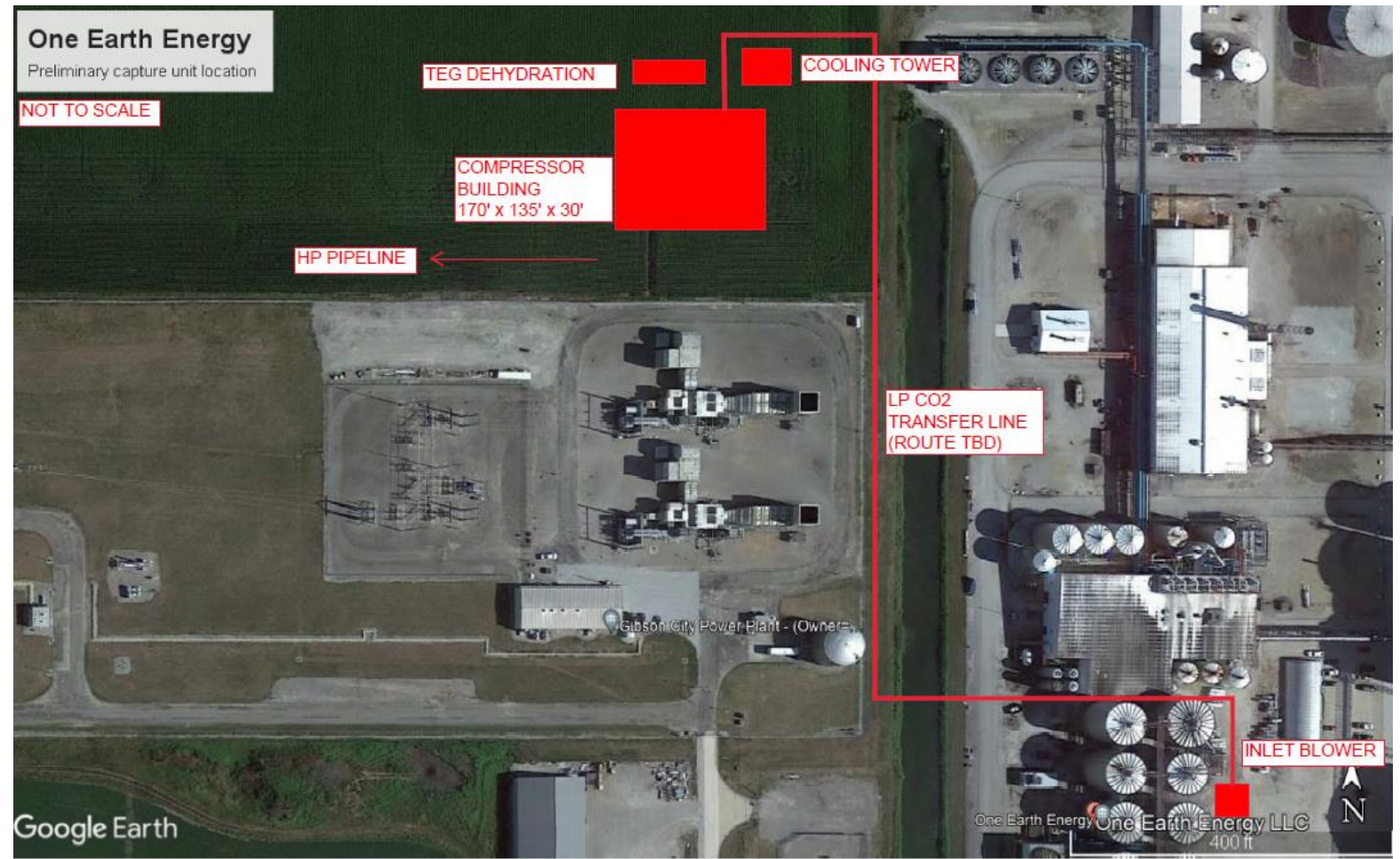
Prairie State Generating Company

Coal-fired power source: FEED study completed
Capture +8 million tons CO₂ per year



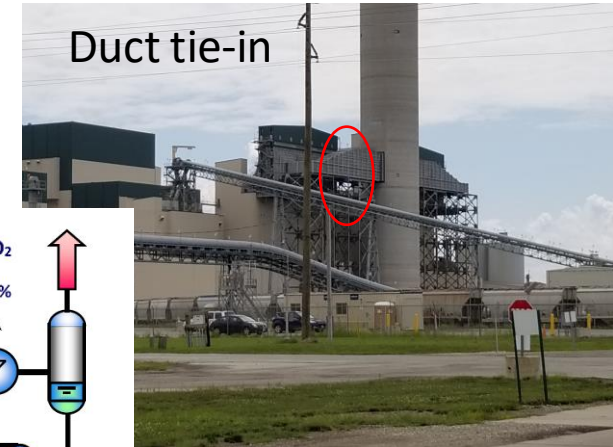
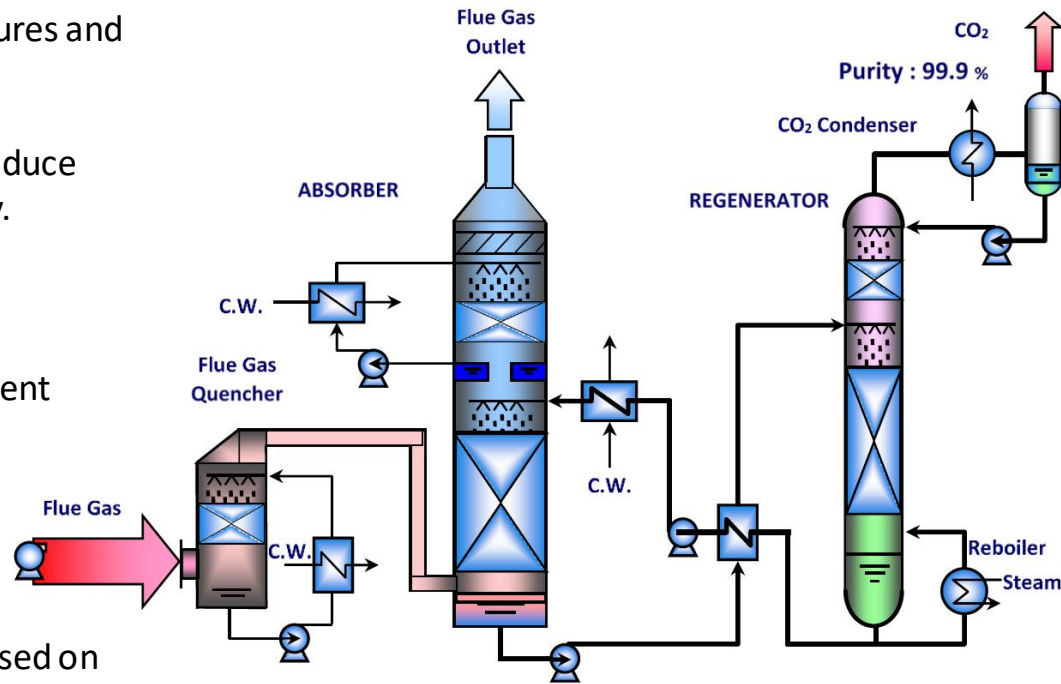
Ethanol FEED study

- Scope: CO₂ Compression and Dehydration Facilities
 - 1,290 tonne/day (458,000 tonne/year, 25.6 MMscfd)
 - Inlet 0 psig, Discharge 1,500 psig



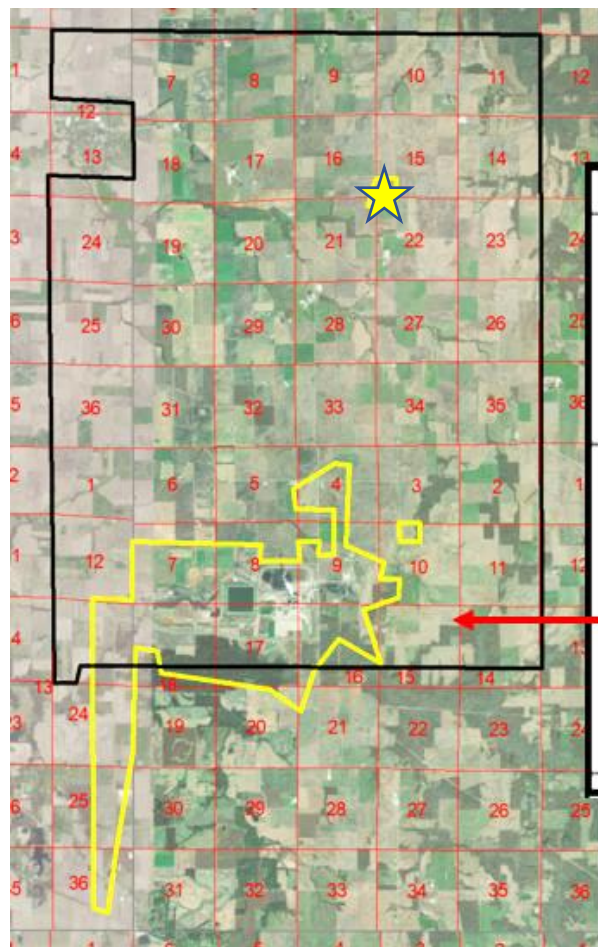
Prairie State FEED

- The PSGC plant was commissioned in 2012 and uses pulverized coal and super critical technology to run at high temperatures and pressures.
- Two 800-megawatt power units produce over 12 million tons of CO₂ annually.
- Capture will be from 1 unit:
 - 25,760 short tons/day of CO₂
 - 6Mta + ~2Mta CO₂ from solvent regeneration
- FEED: Capture of this CO₂ will be based on the KM CDR Process™ CO₂ capture technology from Mitsubishi Heavy Industries (MHI).

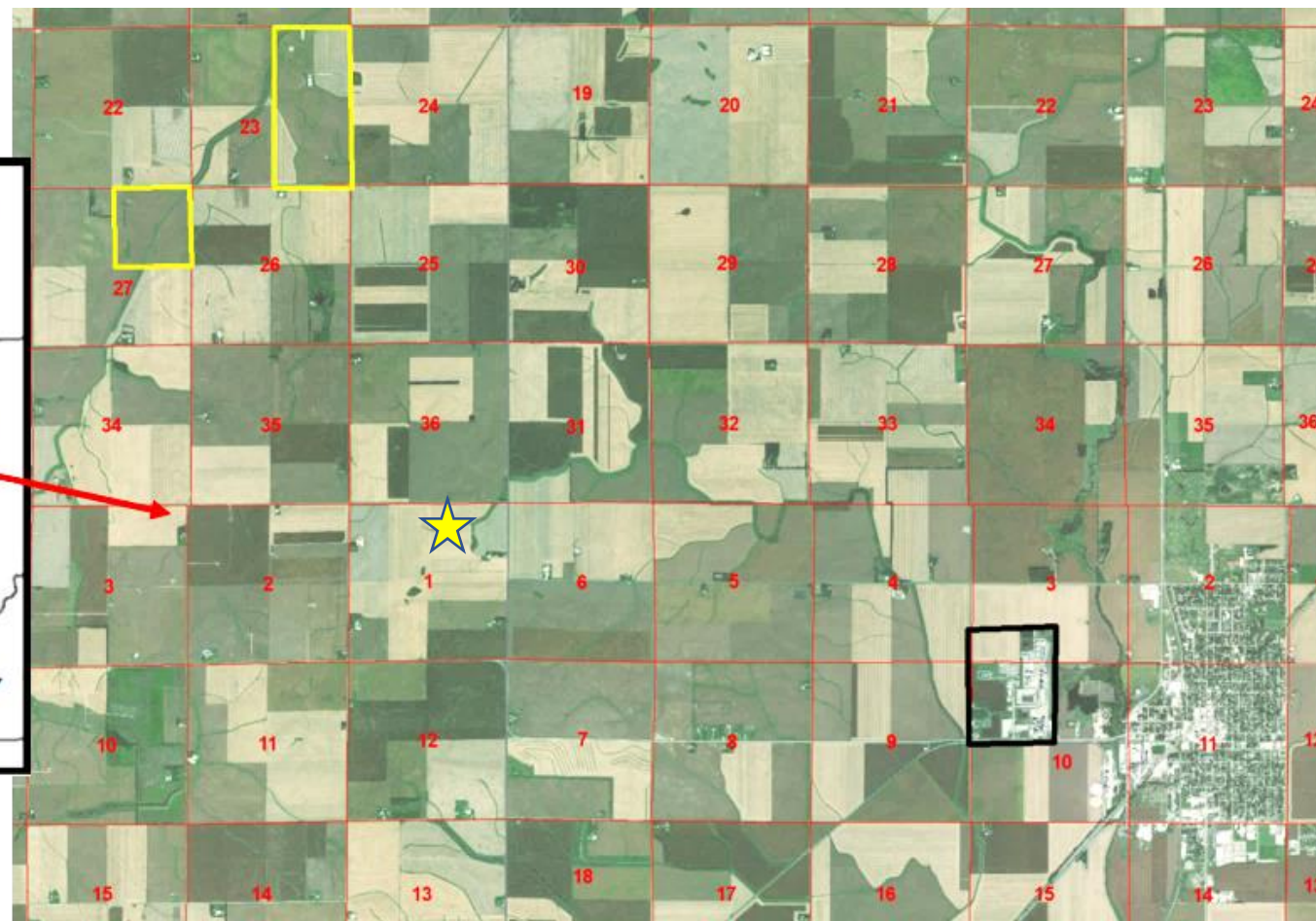


Setting of Sites

★ = characterization well



Site #2

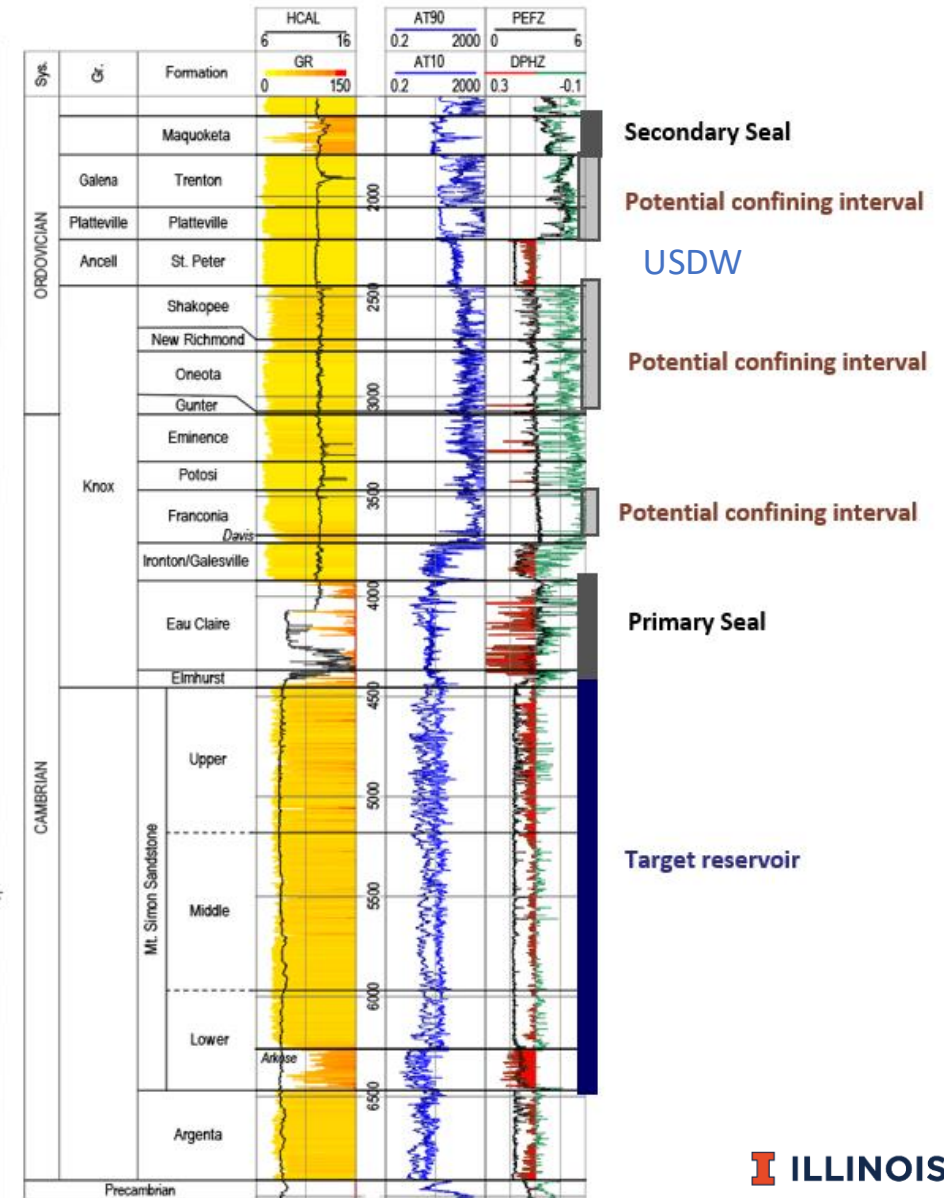
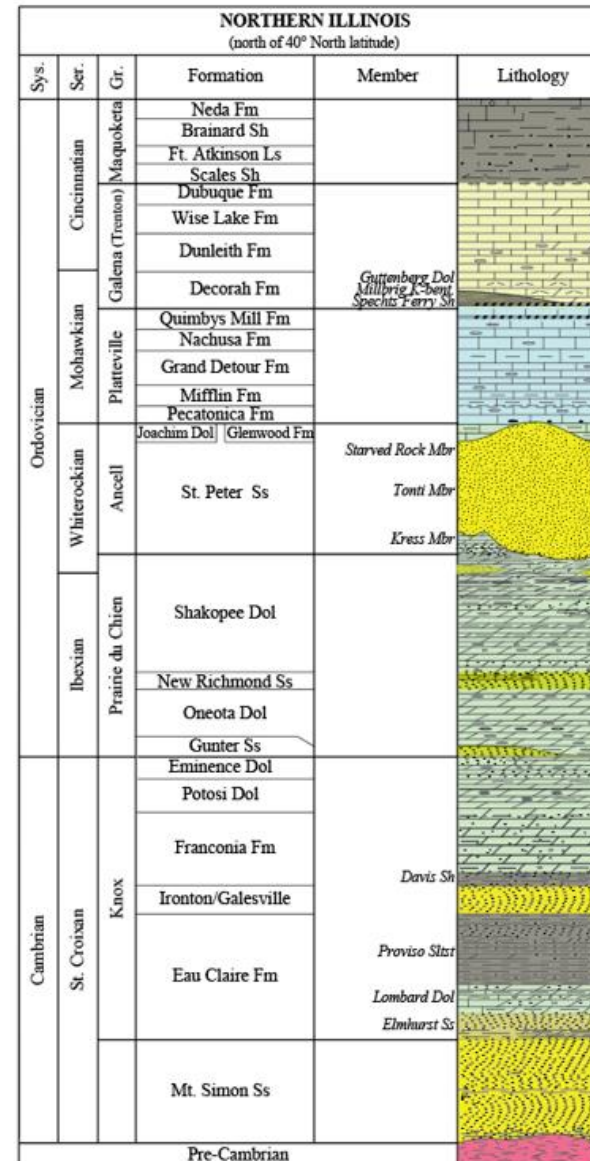


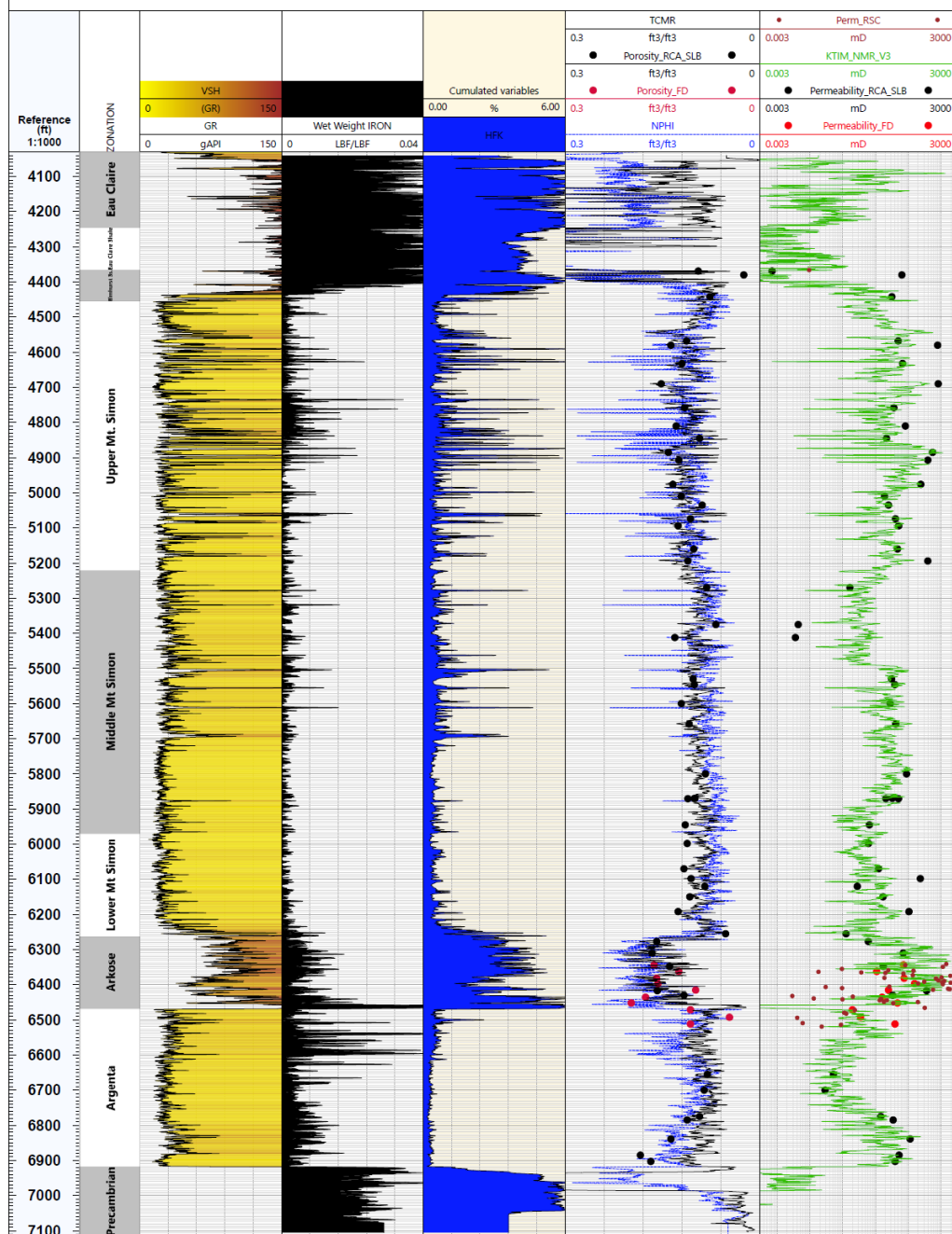
Site #1

Full Diameter Core:

- Ironton/Galesville – 10ft
- Eau Claire – 60 ft
- Mt Simon – 180 ft

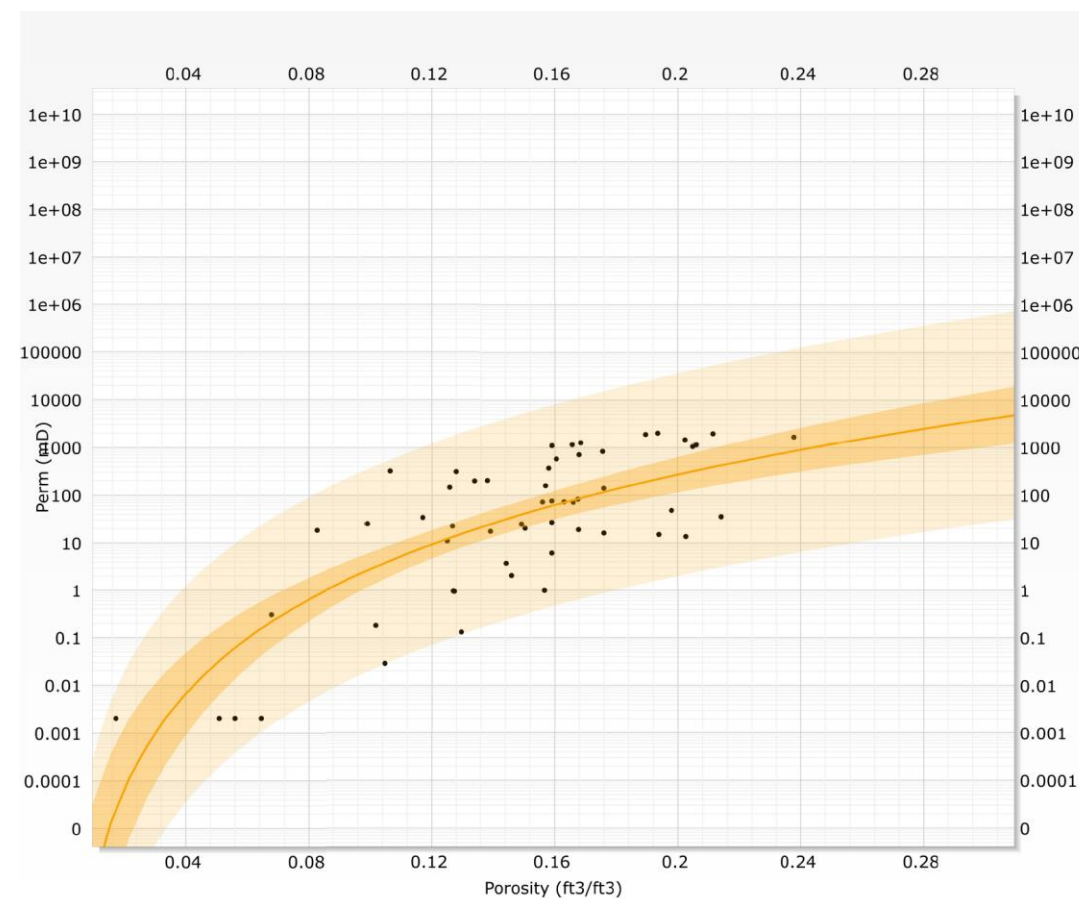
RSWC ~ 130 samples



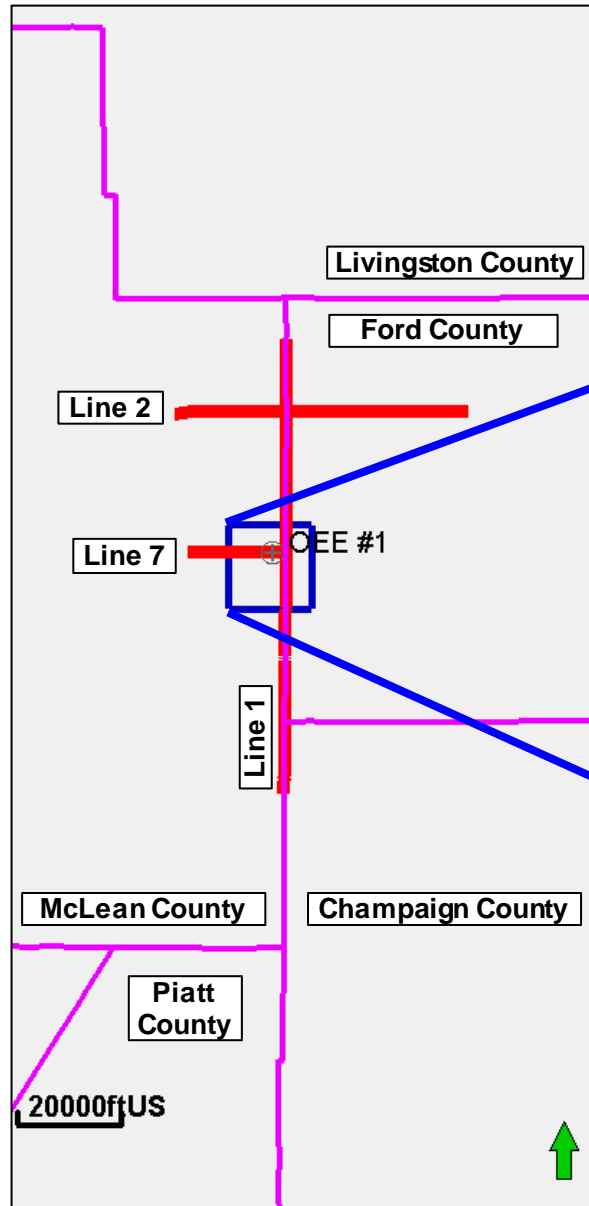


Mt Simon Storage Complex

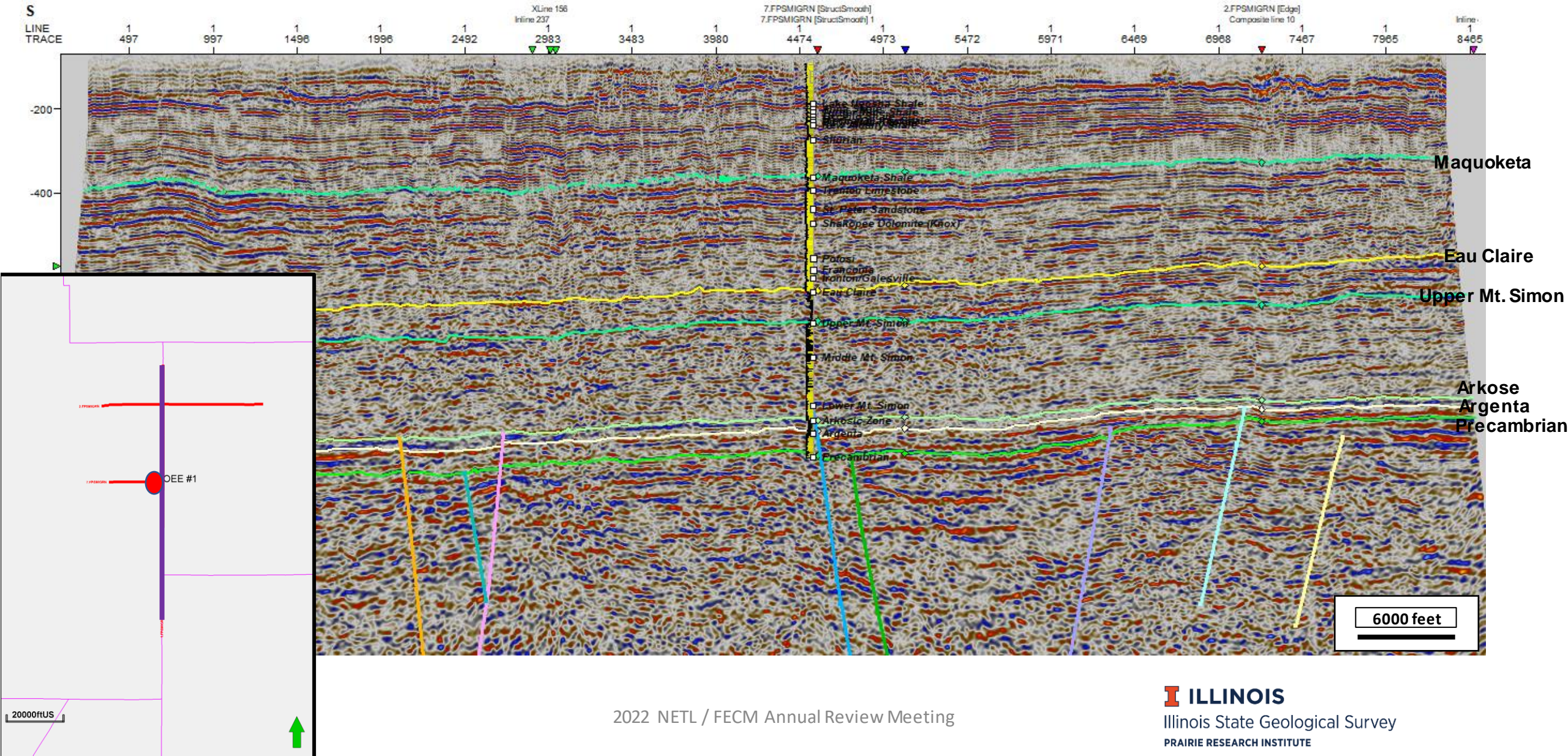
“Arkose Zone”



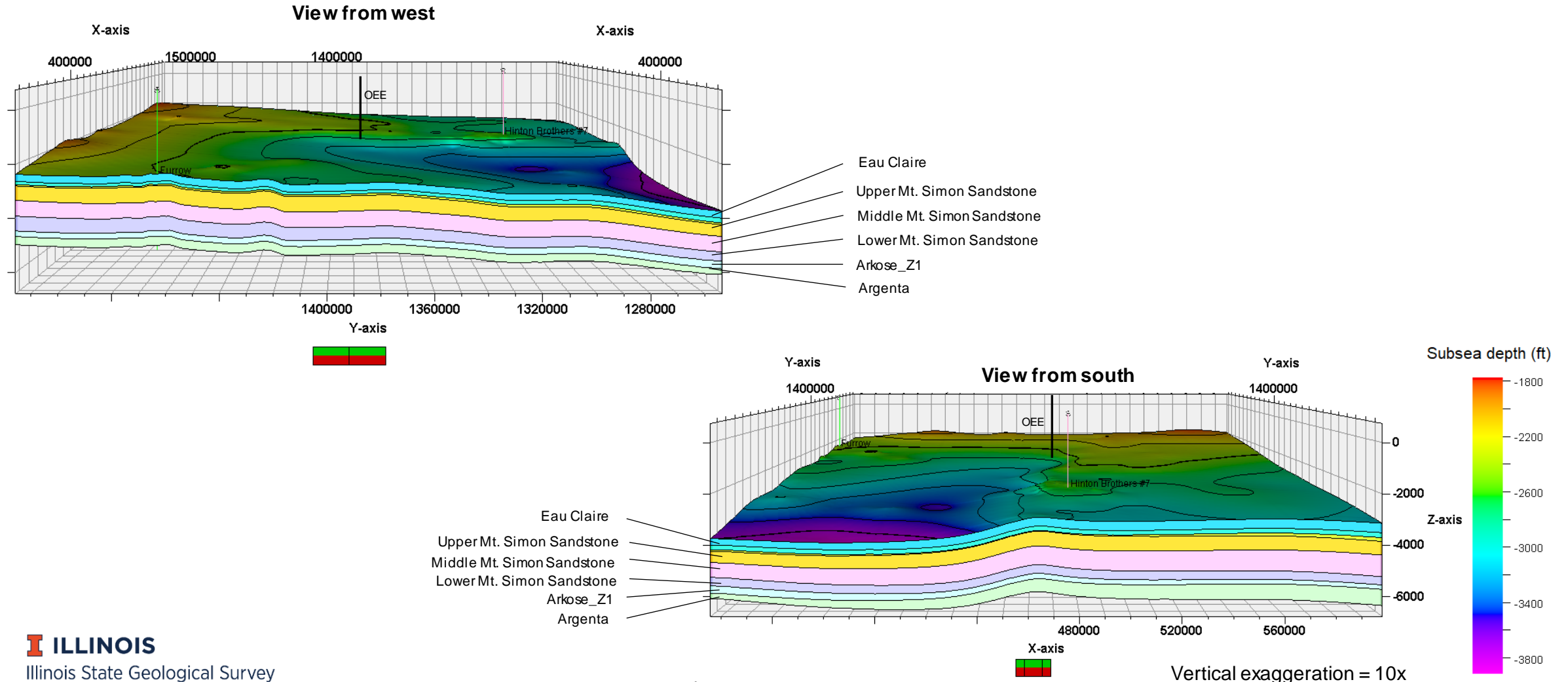
3D Survey at One Earth – 20,000 receivers: 7mi² over 40TB data



One Earth Energy 2D Seismic: Line 1



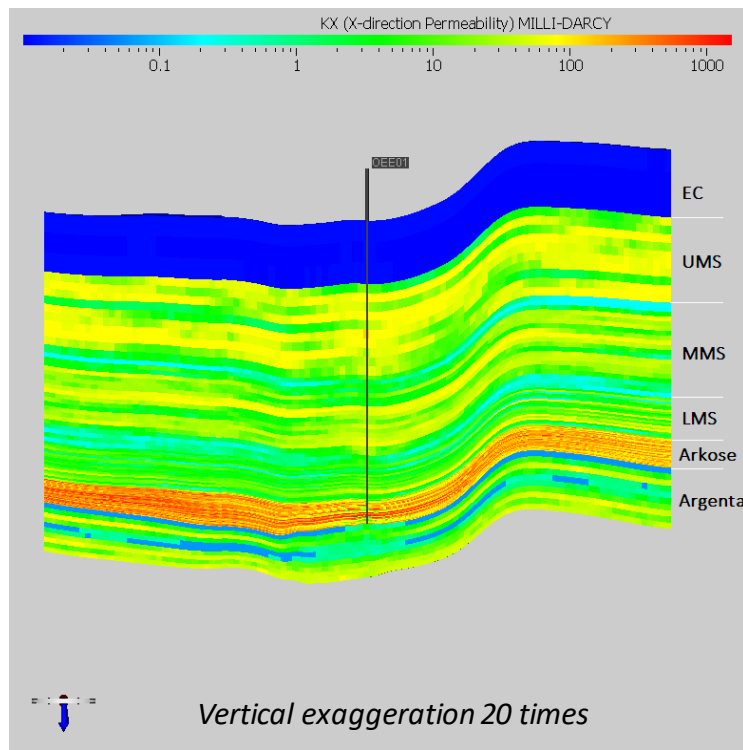
Structural framework model



OEE geocellular model

Heterogeneous model, storage units (MS+ Argenta) averaging 11%, 44 md

KTIM_Core model showing permeability



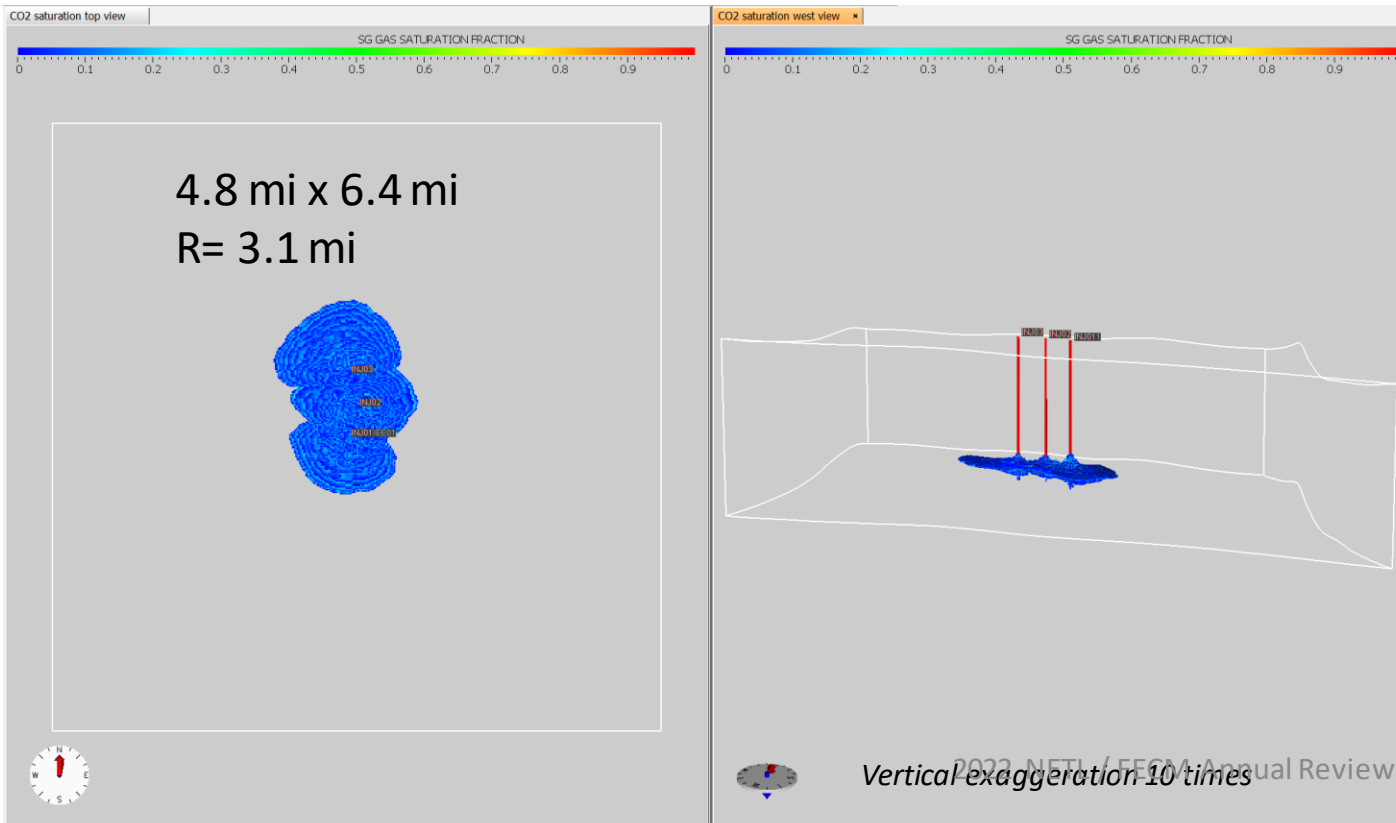
| Unit | Thickness, ft | Porosity, % | Permeability, mD |
|------------|---------------|-------------|------------------|
| Eau Claire | 537 | 5 | 0.01 |
| Upper MS | 720 | 11 | 31 |
| Middle MS | 740 | 9 | 15 |
| Lower MS | 320 | 9 | 12 |
| LMS Arkose | 200 | 16 | 308 |
| Argenta | 460 | 12 | 18 |

Cell averaging 1000 ft x 1000 ft x 21 ft (250 ft x 250 ft x 21 ft around well)
1980 ft thick Mt. Simon, 460 ft Argenta, 537 ft caprock (Eau Claire)

Dynamic Simulation

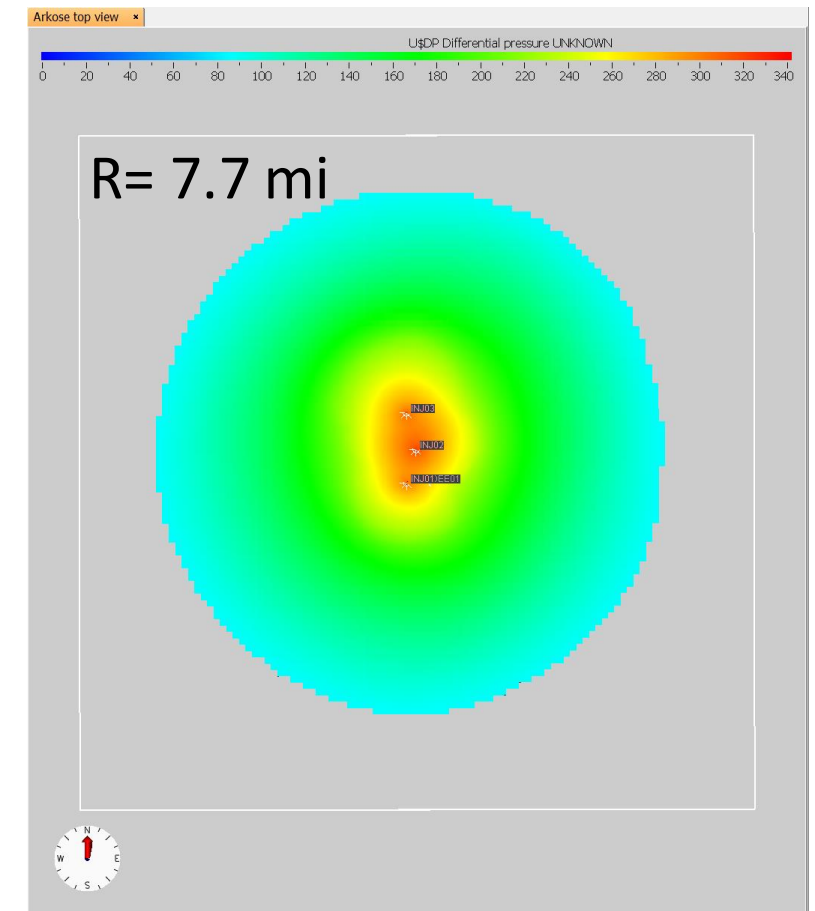
CO₂ Plume

- 3 well Injection at 1.5 Mt/yr each for 20 yr with perforation in Arkose zone (200 ft)
- Vertical extension: all CO₂ remains within Lower Mt. Simon



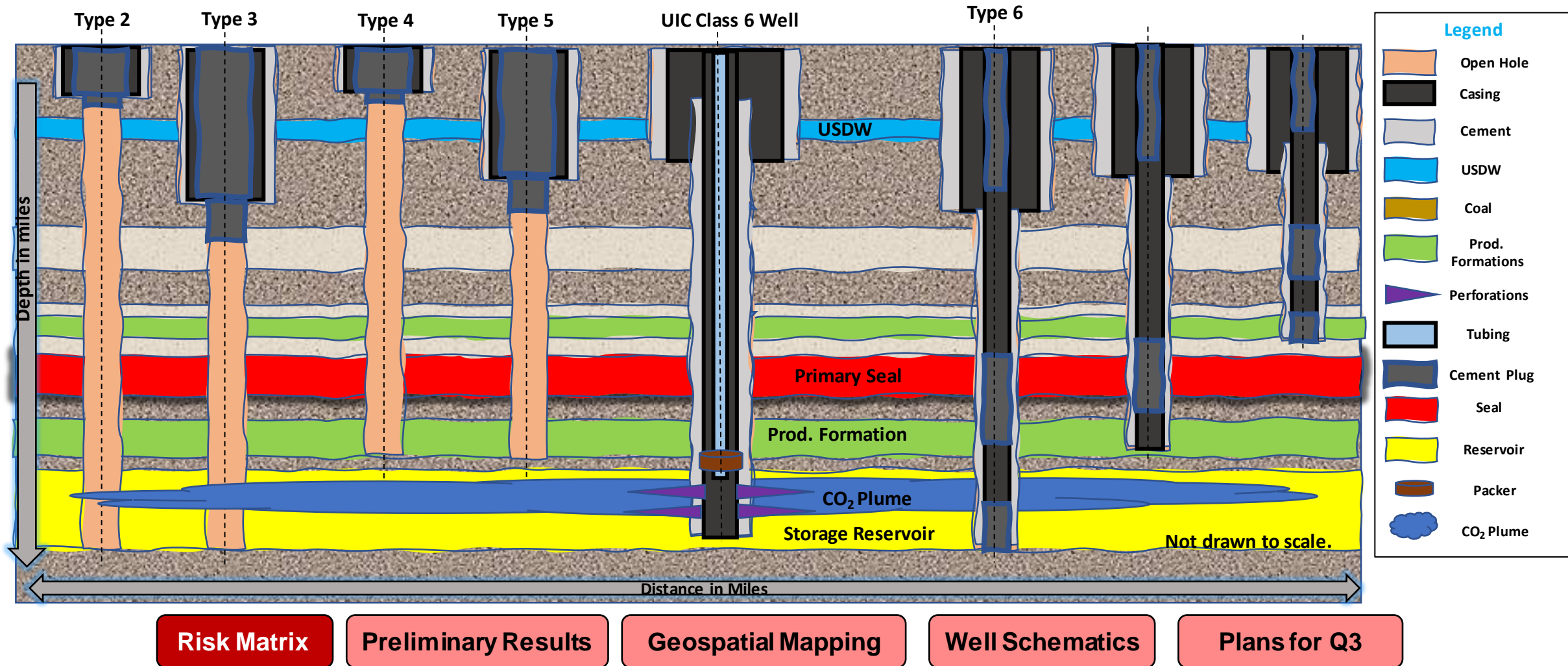
AoR

- Threshold differential pressure for AoR determination is 86 psi
- AoR = 185 mi² based on DP ≥ 86 psi

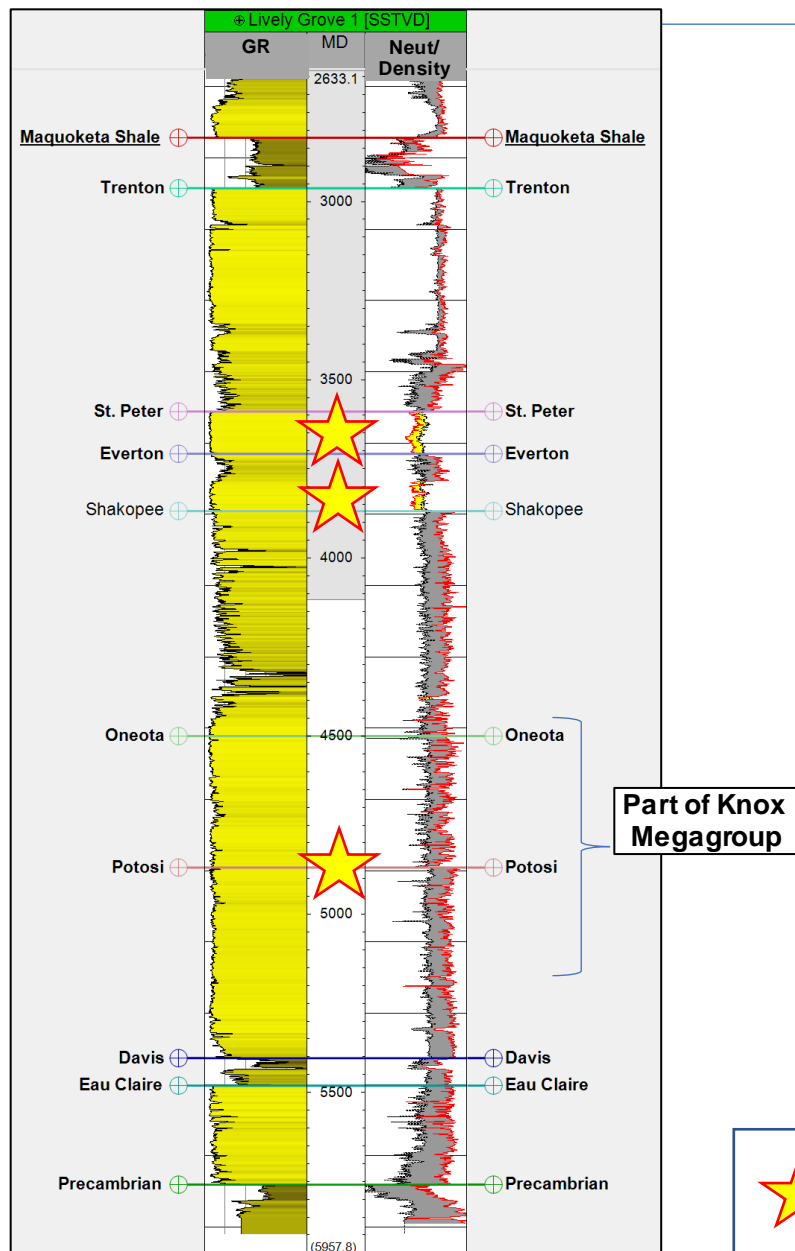


TTU Legacy Wells Risk Assessment

Types of Wells within the AoR based on well construction details reported



Lively Grove #1 Well Results



- Well reached Total Depth of 5890' MD on August 11, 2021.
- Acquired whole core in the Maquoketa Shale, St. Peter Sandstone, and the Knox.
- Acquired extensive log suite for petrophysical, geomechanical, and reservoir analyses
- Well data confirms presence of potential injection reservoirs:
 - St. Peter Sandstone
 - 119' MD thick
 - Everton Sandstone
 - 85' MD thick
 - Knox Dolomite Megagroup (includes Potosi and Oneota)
 - 680' MD thick (top Oneota to base Potosi)
- Well data also confirms the presence of the primary seal Maquoketa Shale.

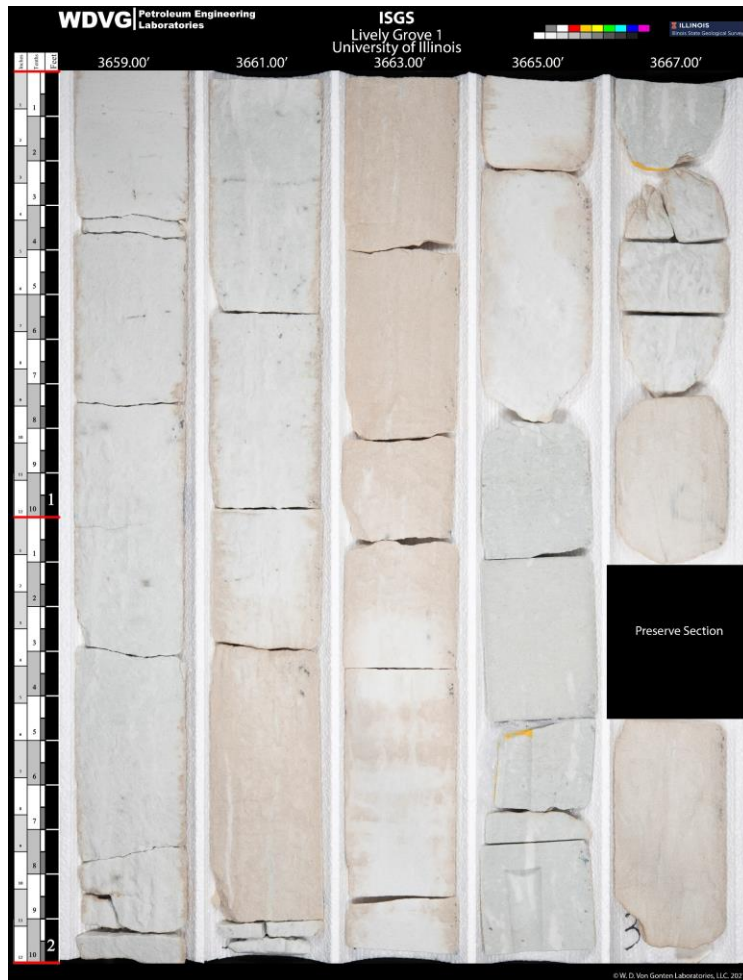


Potential injection reservoir

- ## Injection zones



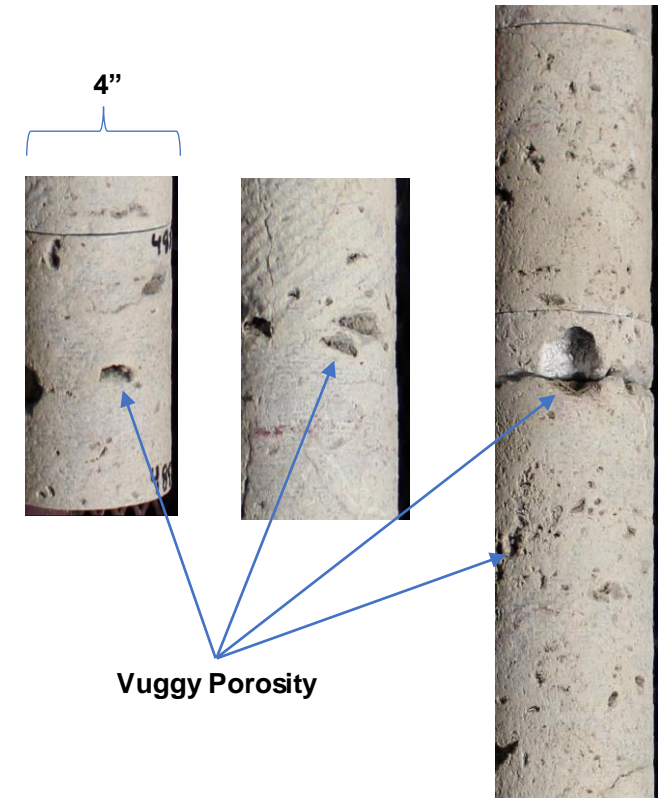
Lively Grove #1 Core and Sidewall Core of Storage Reservoirs



St. Peter Sandstone:
 Whole core (slabbed)
 Ave. Porosity: 11%
 Ave. Permeability: 68md



Everton Sandstone:
 Rotary sidewall core
 Ave. Porosity: 10%
 Ave. Permeability: 122md



Potosi Dolomite:
 Whole core
 Ave. Porosity: 6%
 Permeability of Knox vuggy intervals
 injection tested: 10,000-30,000md

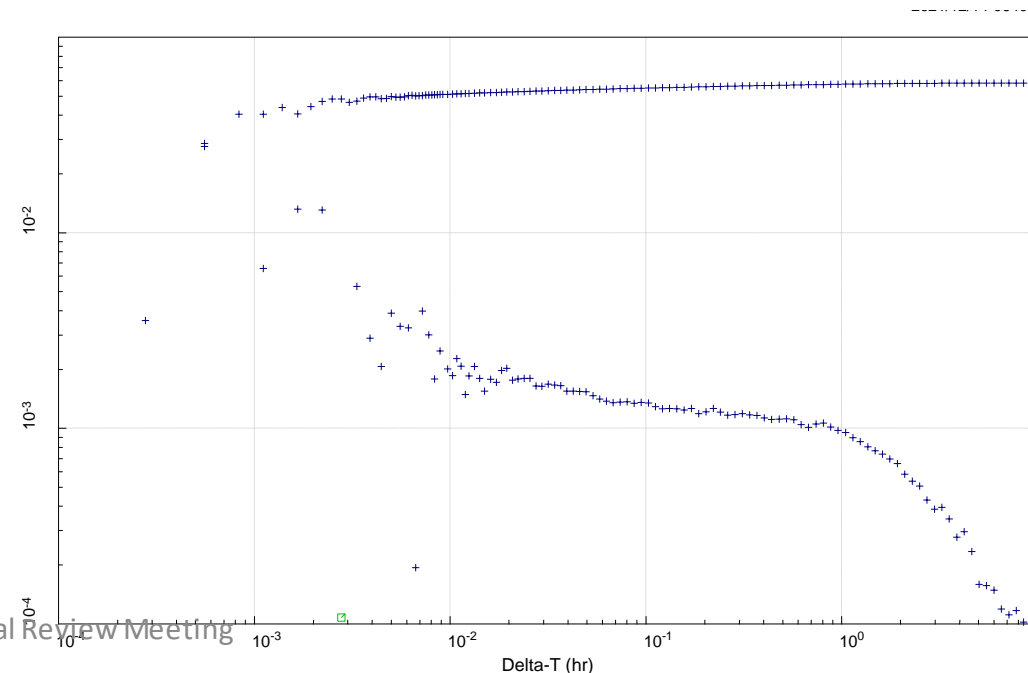
Lively Grove Well Test Results: Knox 2

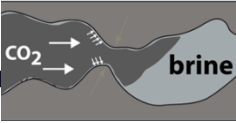
Derivative Analyses: $kh = 35,000\text{-}50,000 \text{ md-ft}$

- Test interval: 1-2 ft (FMI log)
 - Vuggy/cavernous porosity
 - Good cement behind pipe
- Perf interval: 4505-4509 ft
- Tested high skin
 - Near wellbore lower perm $k_{\text{horz-nw}}$
 - Far wellbore very high perm $k_{\text{horz-fw}}$
- Suspected deep cement into cavernous porosity
 - Acid treatment
- Post-acid test
 - Very high perm

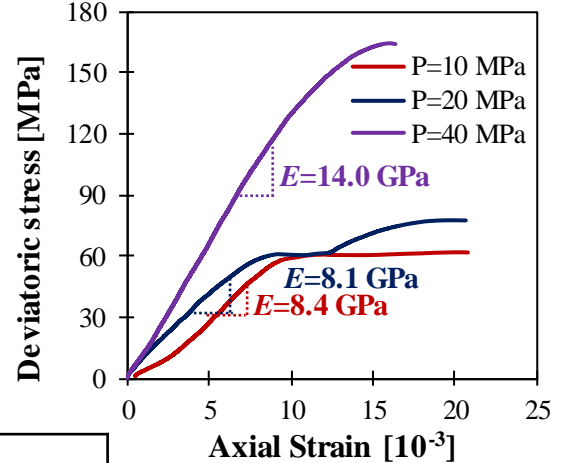
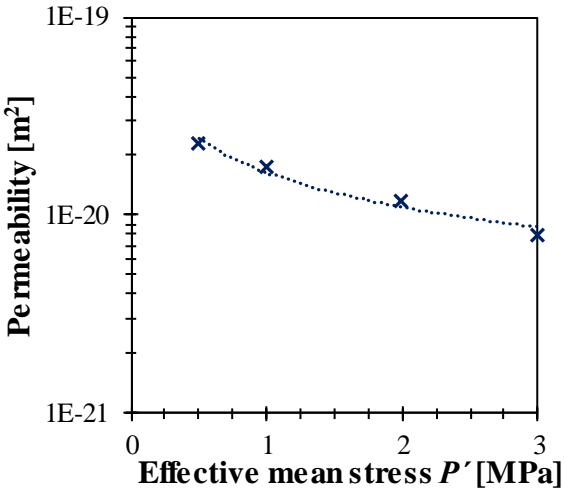
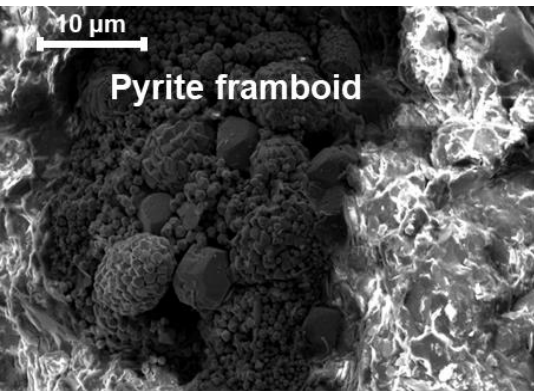
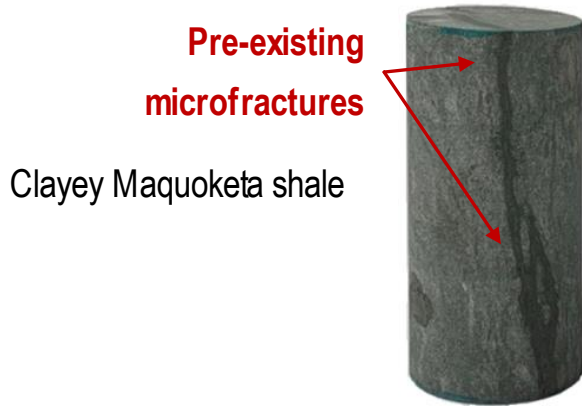
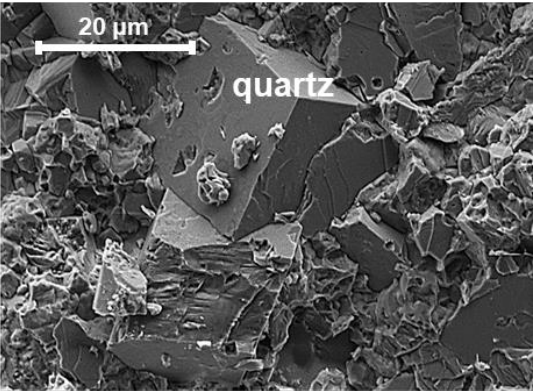
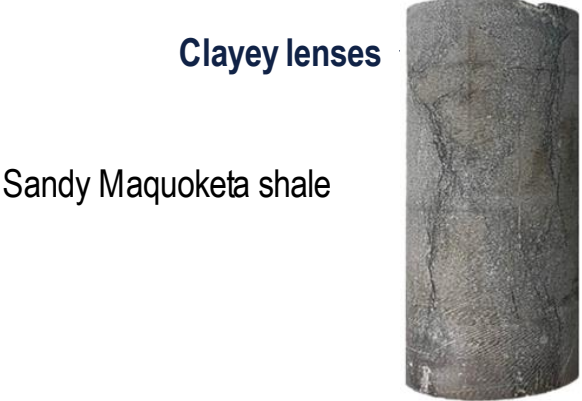
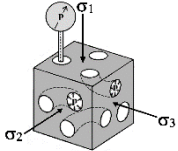
| Knox 2 | P_{frac} psi/ft | $k_{\text{horz-nw}}$ (md) | $k_{\text{horz-fw}}$ (Darcy) | Comment |
|-----------|-----------------------------|------------------------------|---------------------------------|----------------|
| Pre-acid | 0.82-0.9 | 50-100 | - | Low Res gauge |
| Post-acid | - | - | 18-25 | High Res gauge |

Use 2 ft height for perm estimate



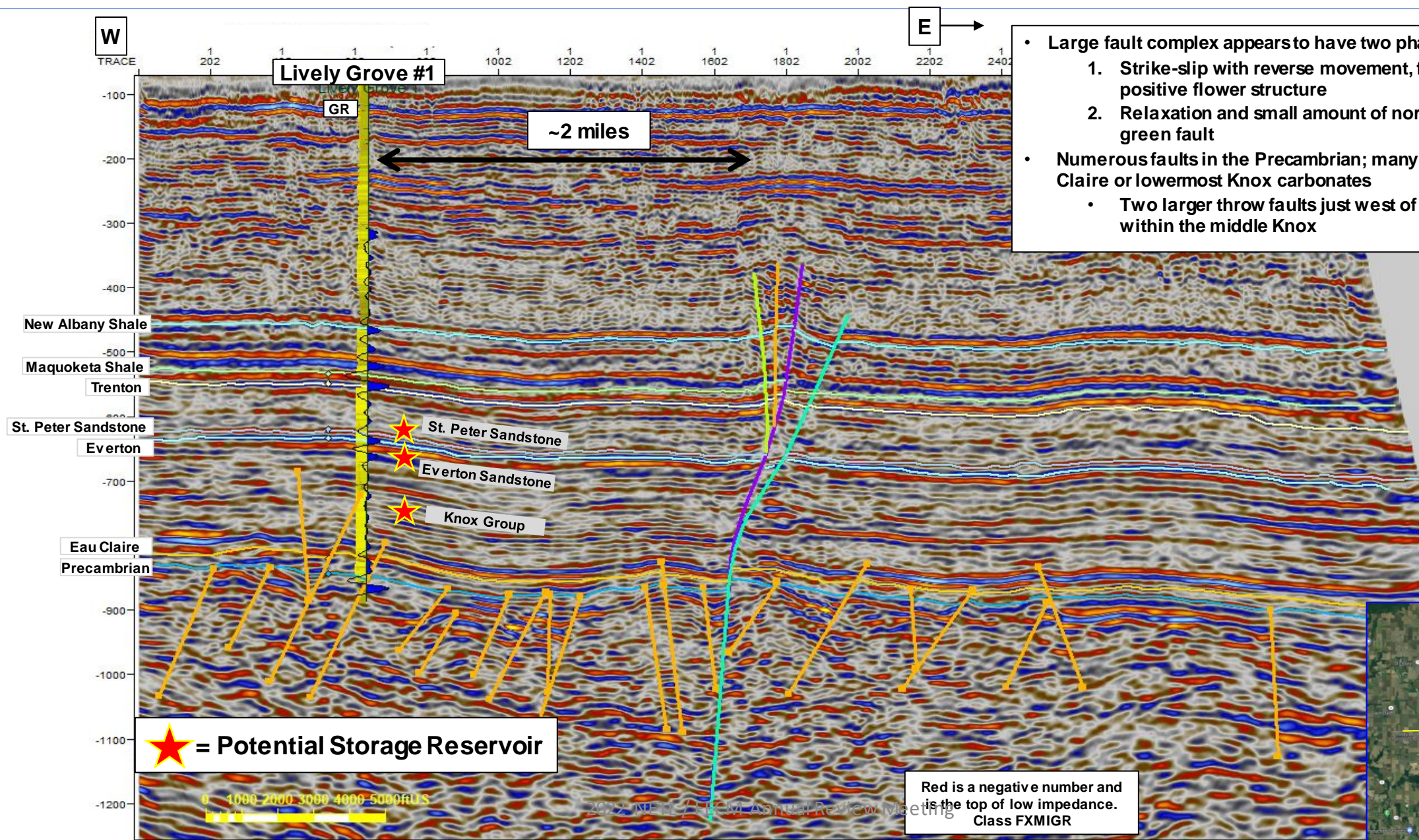


Maquoketa shale

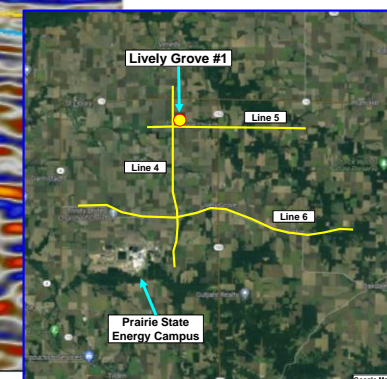


| Formation Prairie State well | Index properties | | | |
|---------------------------------|------------------------|--------|---------------------------|---------------------|
| | Well/ Depth | Facies | Dominant pore size d [nm] | Porosity ϕ [-] |
| Maquoketa shale | PS1/ \approx 2800 ft | Sandy | 100 | 0.047 |
| | PS1/ \approx 3232 ft | Clayey | 15 | 0.056 |
| | LG/ \approx 2918 ft | Clayey | <4 | 0.050 |

Washington County/Prairie State Line 5

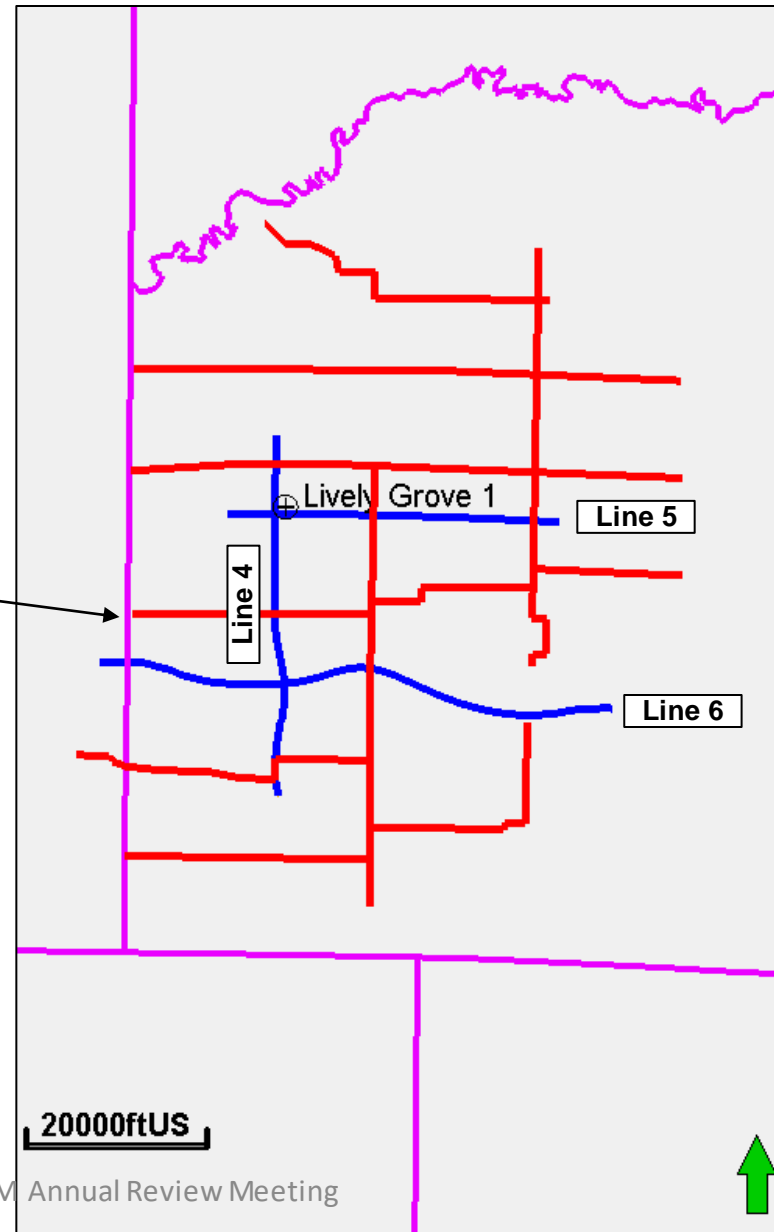


- Large fault complex appears to have two phases of movement:
 1. Strike-slip with reverse movement, forming a narrow positive flower structure
 2. Relaxation and small amount of normal slip along the green fault
- Numerous faults in the Precambrian; many tip out in the Eau Claire or lowermost Knox carbonates
 - Two larger throw faults just west of the well tip out within the middle Knox



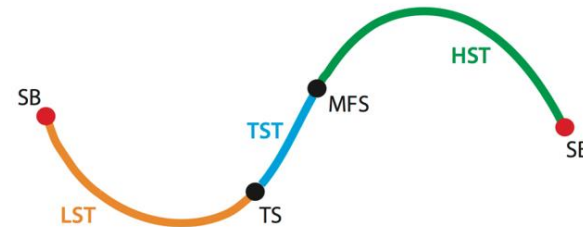
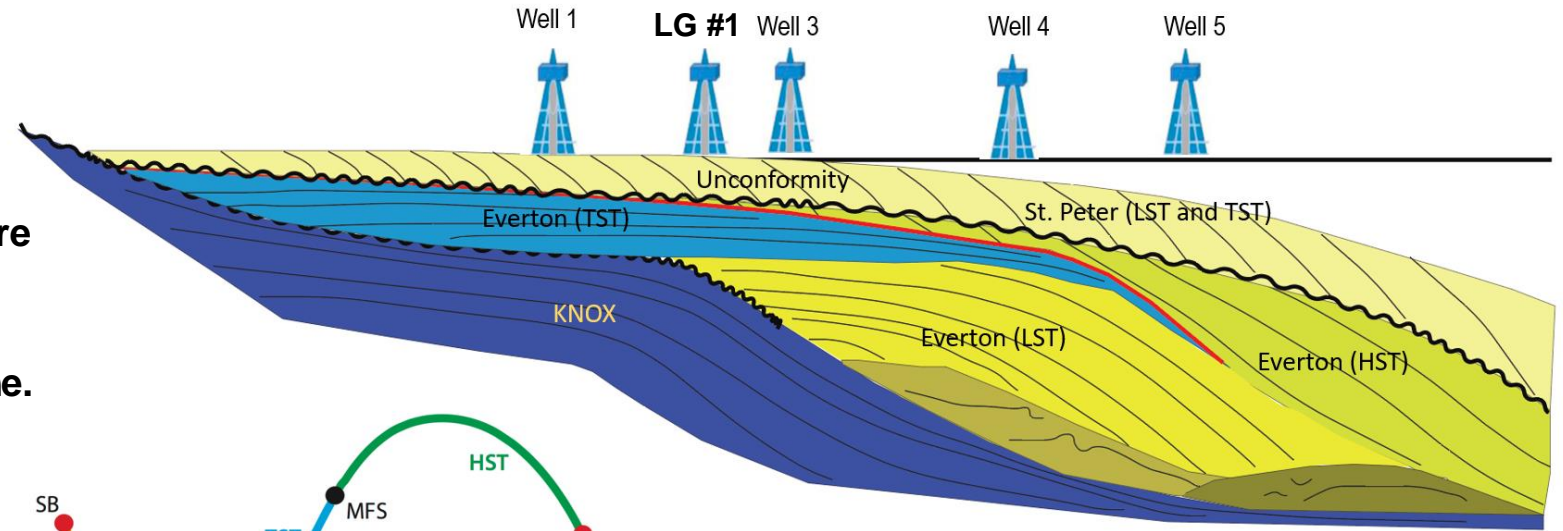
Additional 2D seismic acquired at Prairie State

- Acquired additional 2D seismic around Lively Grove well and existing seismic
- Characterize fault on Line 5 and possible fault/feature on Line 6
- Expand area to be studied for placement of initial CO₂ injection wells.
- New seismic lines shown in **red**
 - Lines follow existing public roads, hence some lines have small bends/curves
- Completed acquisition on July 1, 2022

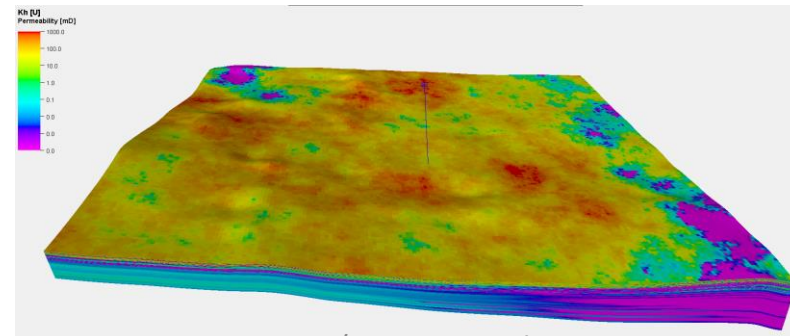
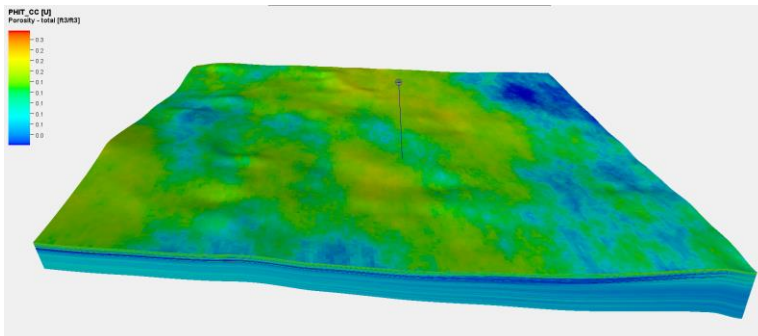


Sequence-stratigraphic Interpretation of St. Peter and Everton formations

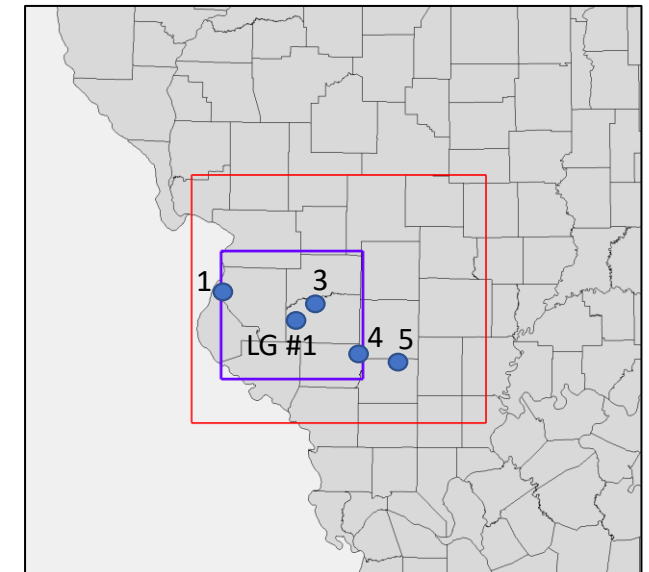
- A sequence-stratigraphic framework was developed through the integration of sedimentological and petrophysical data.
- Sequence boundaries and system tracts were picked from well logs.
- Framework explains the distribution of the Everton Dolomite and the Everton Sandstone.



Feeds into Geostatic Models

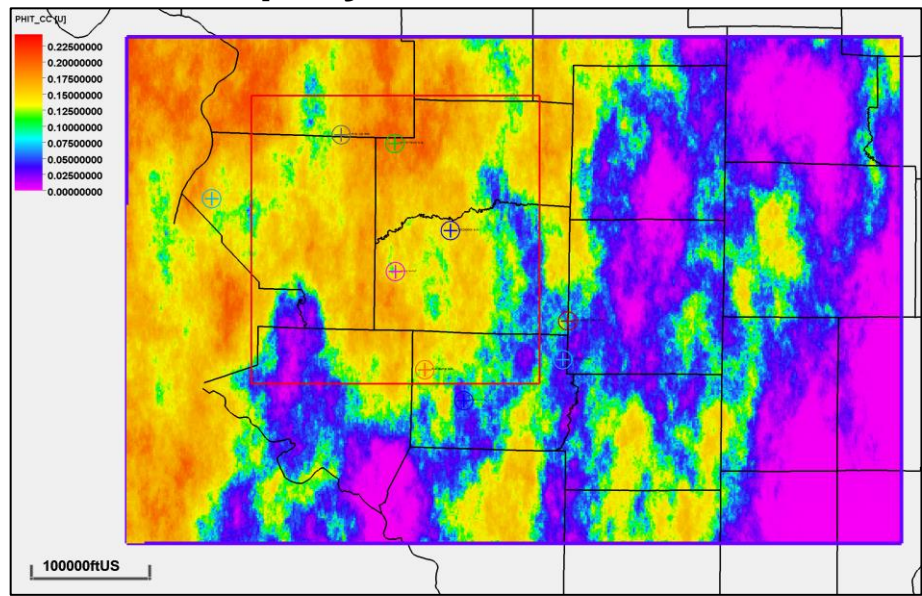


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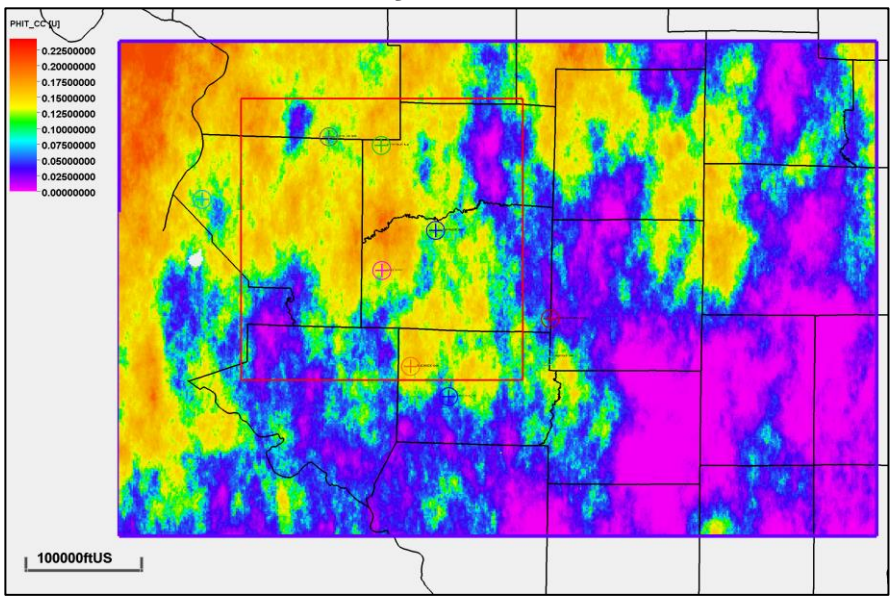


St. Peter Sandstone Porosity and Permeability

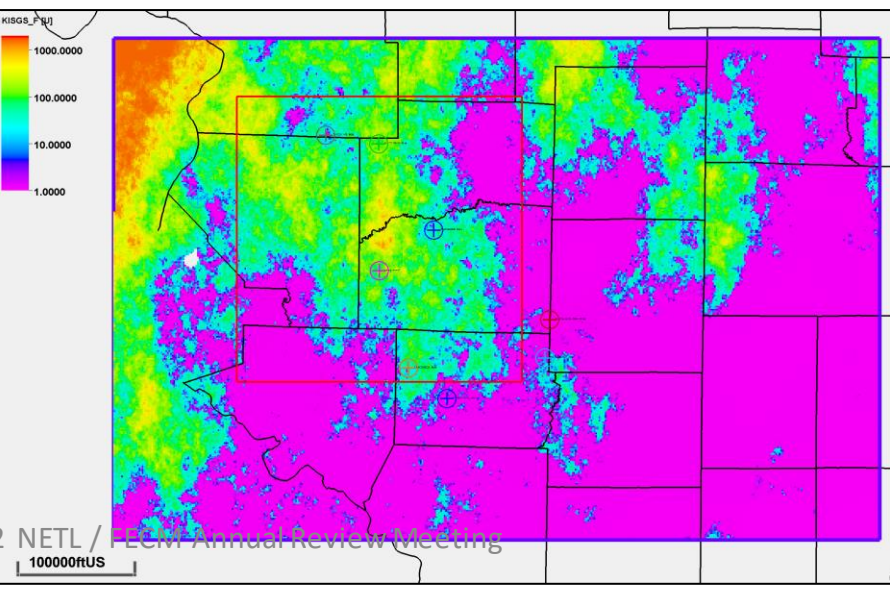
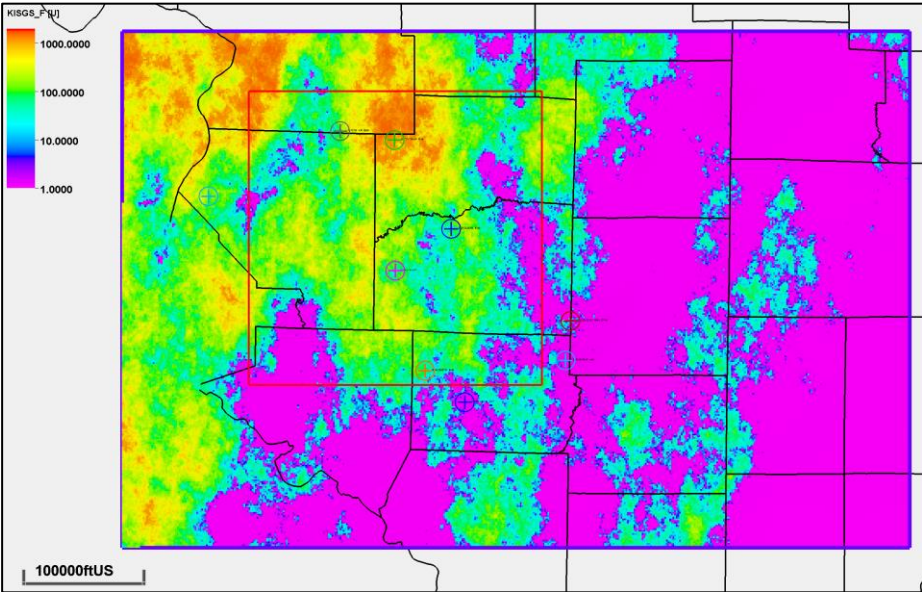
Top layer in St. Peter Ss



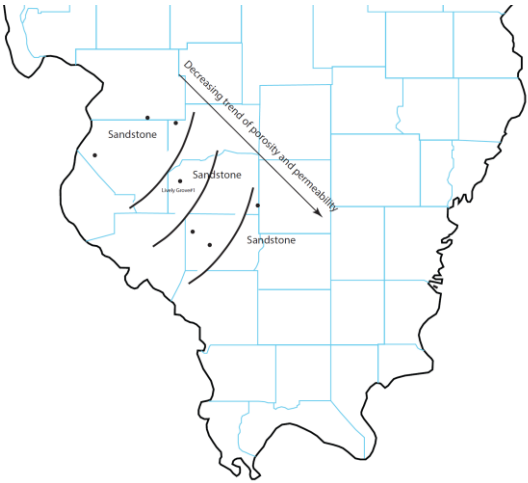
Bottom layer in St. Peter Ss



Porosity



Permeability

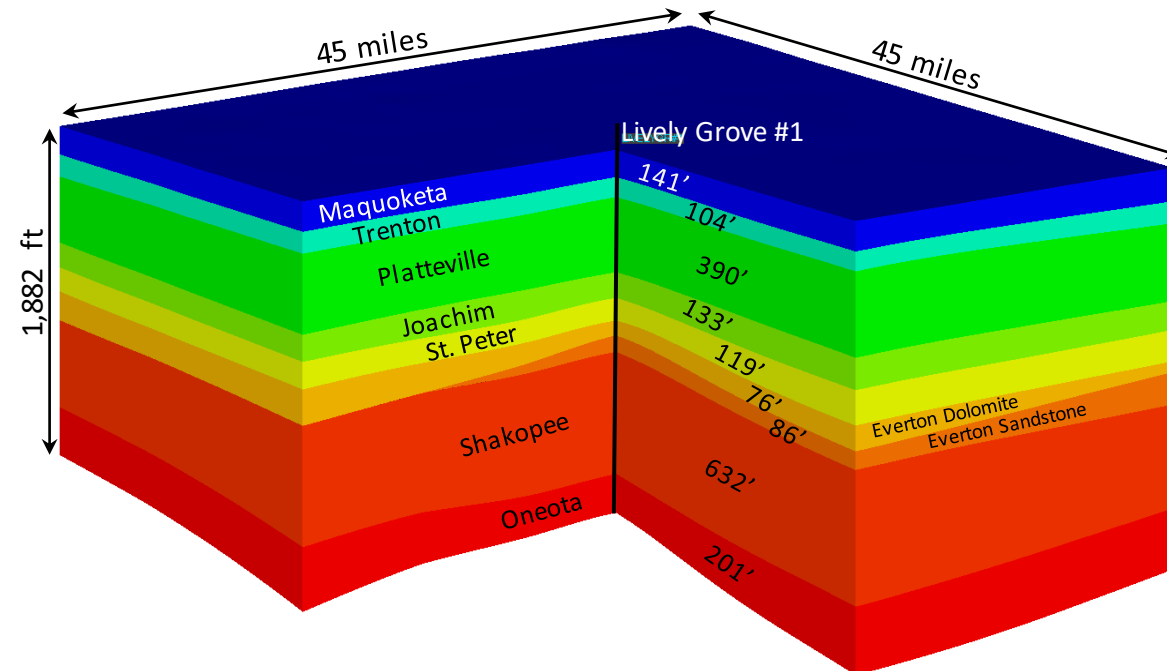


Trend surface
used in Porosity
model

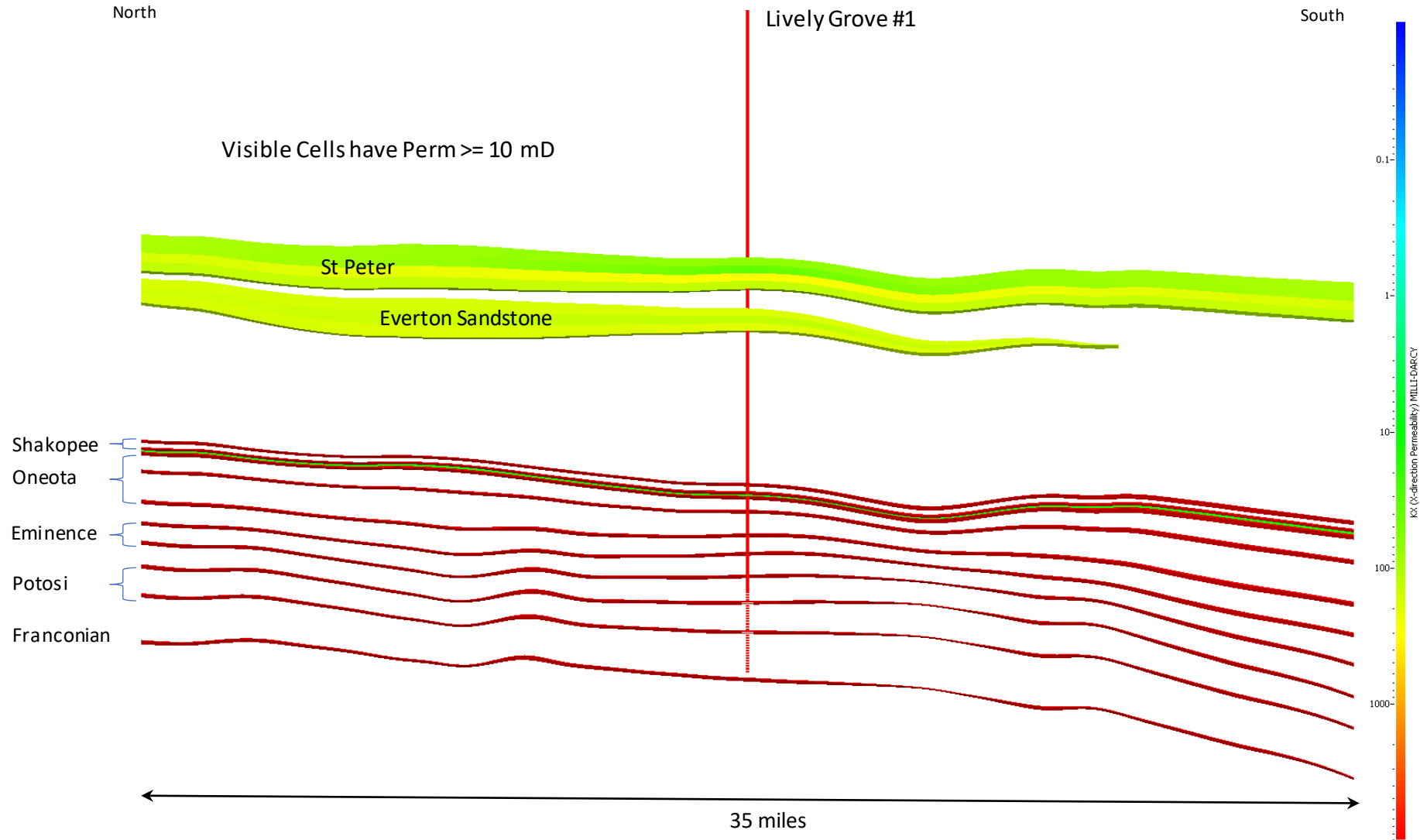
St Peter/Everton: Model Description

- Nexus Simulation model: 45 x 45 miles
 - Based on geologic model, 3-D heterogeneity
 - Includes overburden/underburden formations
- Model Size
 - Grid cells: 1320' x 1320' areally
 - Cell thickness varies: 2.5 ft in St Peter and Everton
 - 182 layers (113 within St Peter and Everton)
 - Total blocks: 6 million
- Boundary Conditions
 - Infinite-acting aquifer on edges
 - Top and Bottom sealed (no flow)
- Injection Constraint
 - $P_{max} = 0.9 * 0.62 \text{ psi/ft} * \text{depth} + 15$
 - Applied at top of perf interval
- Includes WWDW#1
 - Injects into St. Peter sandstone

| Parmeter | Value |
|-----------------------|-----------------------|
| Initial Pressure | 1,607 at 3,693 ft, MD |
| Resertoir temperature | 98 °F at 3,693 ft, mD |
| Salinity | 50,745 ppm |
| Fracture gradient | |
| St. Peter Ss | 0.58 psi/ft |
| Everton Ss | 0.66 psi/ft |



Permeability: Cross-Section



Summary

- Extensive subsurface data has been collected for 2 separate sites for Class VI permit development
 - Well drilling
 - Well testing
 - 2D seismic
 - 3D seismic (at One Earth site)
 - Geomechanical analyses
- Legacy Well classification
- Risk analyses - NRAP
- One Earth Class VI nearing completion
- Washington County site undergoing simulations of various well placement scenarios

