An Assessment of Geological Carbon Sequestration Options in the Illinois Basin

Phase II Year One Update

MGSC Project Team

presented by
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Midwest Geological Sequestration Consortium
www.sequestration.org

MGSC Project Advisors and Partners

- Utilities: Ameren, Louisville Gas and Electric, and Cinergy
- Industry: Aventine Renewable Energy, American Air Liquide, British Petroleum*, Drummond Coal*, LincolnLand Agri-Energy, Peabody Energy, Power Holdings, and Schlumberger*
- NGO and trade groups: Environmental Defense*, IL, IN, and KY Oil & Gas Associations, IL Corn Growers Association, Electric Power Research Institute, Interstate Oil and Gas Compact Commission
- State government: IL Office of Coal Development, (DCEO), IL Department of Natural Resources

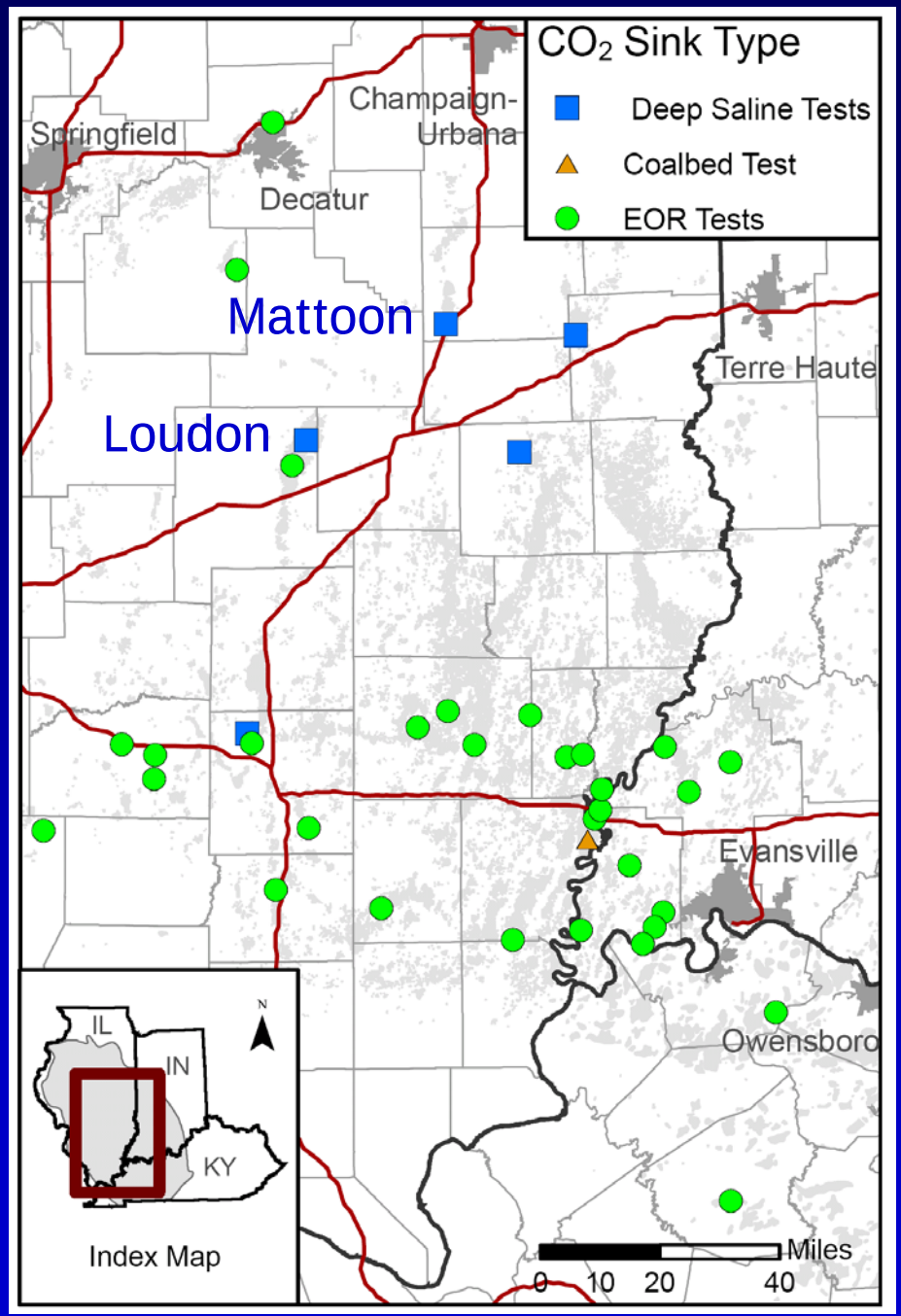
* *new in Phase II*

Project Structure

- Illinois State Geological Survey (ISGS) serves as Lead Technical Contractor
- PI's and co-PI's from the Illinois, Indiana, and Kentucky geologic surveys make up the leadership of MGSC
- Project has been divided into 17 tasks and 88 subtasks, including six test site tasks
- Thirty-one organizations involved: 3 geologic surveys and 28 other subcontractors

Field Testing: The Heart of Phase II

- Six field tests proposed
- CBM: Coop well at Shakespeare Oil site
- Inject/soak/produce (single well), immiscible, and miscible EOR at four sites; new drilling at two of these to optimize CO_2 flooding pattern
- One deep saline reservoir test, the Multi-Opportunity Sequestration Test (MOST) site with two major reservoir targets to 8,300 ft



Potential Test Sites-Phase II-Year 2

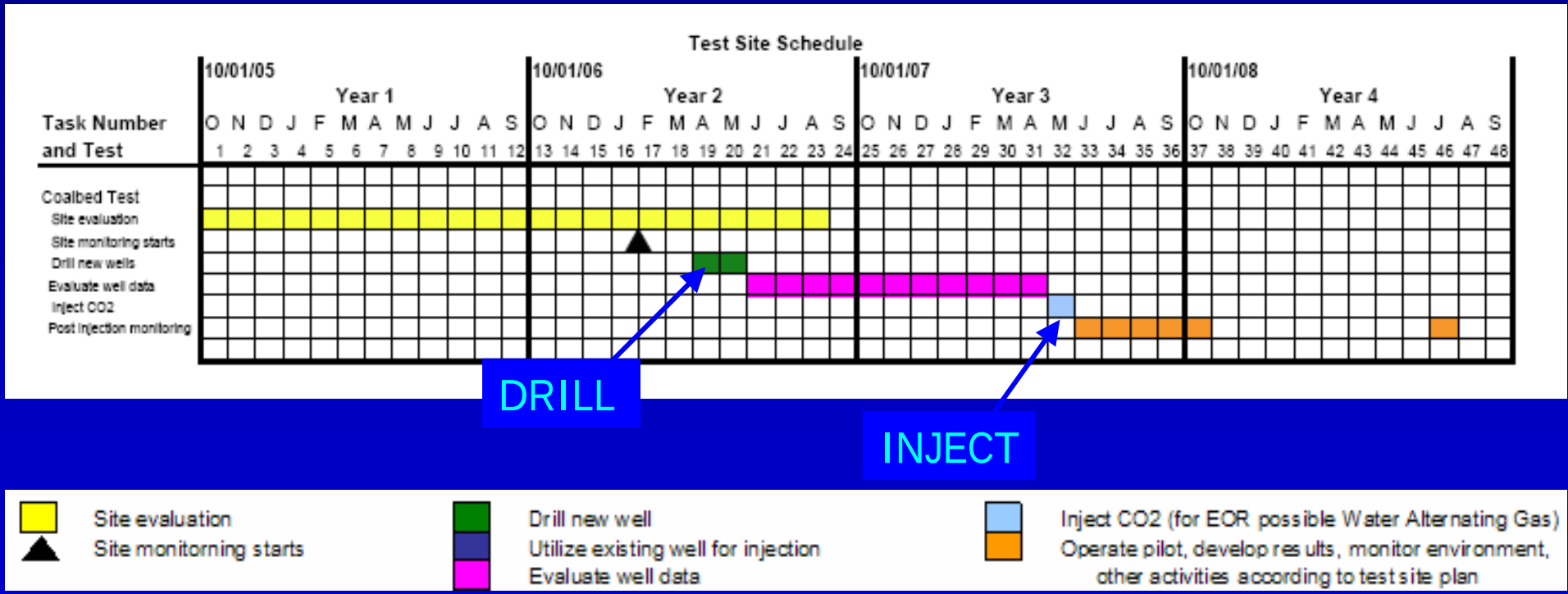
-1 coal seam site

-31 mature oil field sites for EOR

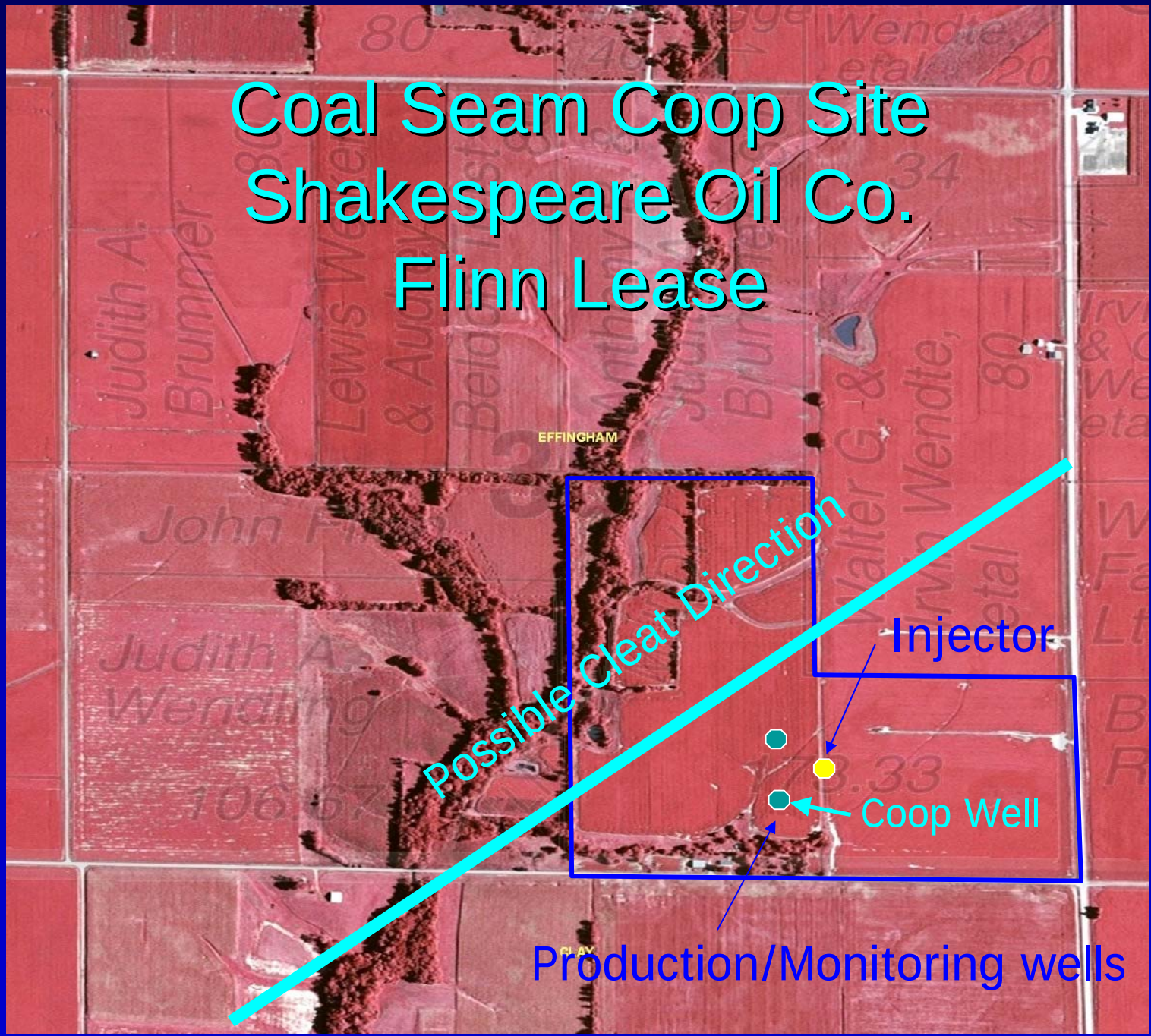
-5 deep saline reservoir sites, Loudon and Mattoon fields most promising

Phase II Field Activities

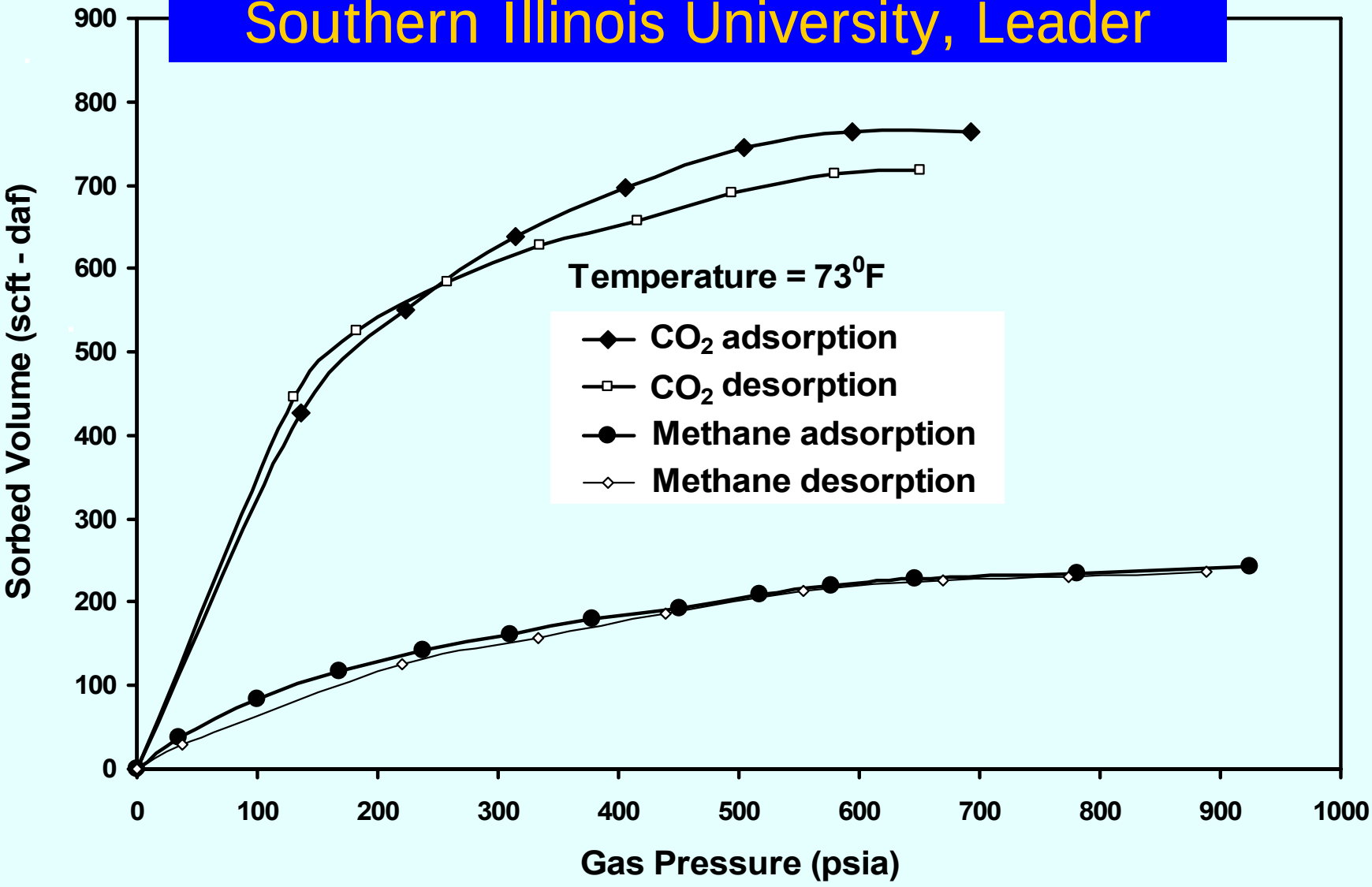
Task 7-Coalbed Site



Coal Seam Coop Site
Shakespeare Oil Co.
Flinn Lease

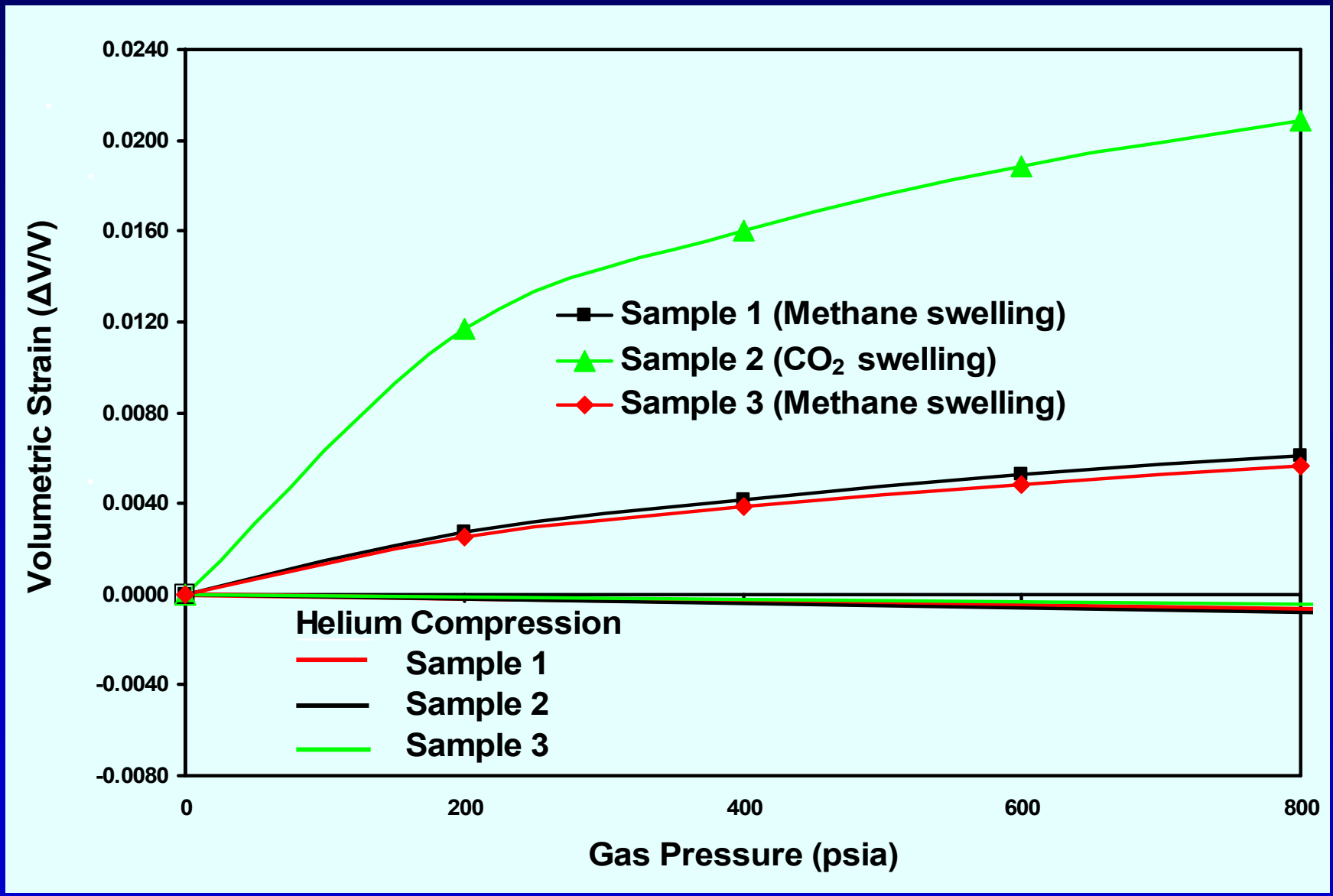


Flinn Lease Samples—Herrin No. 6 Coal
Southern Illinois University, Leader

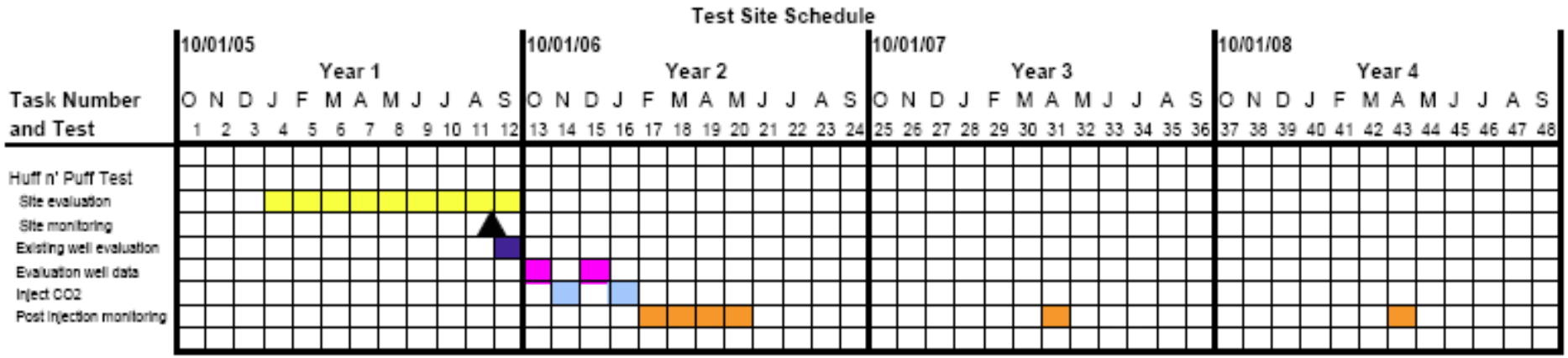


from Satya Harpalani, SIU

Flinn Lease Samples—Herrin No. 6 Coal



Phase II Field Activities
Task 8-Single Well Inject/Soak/Produce



Site evaluation
Site monitorning starts

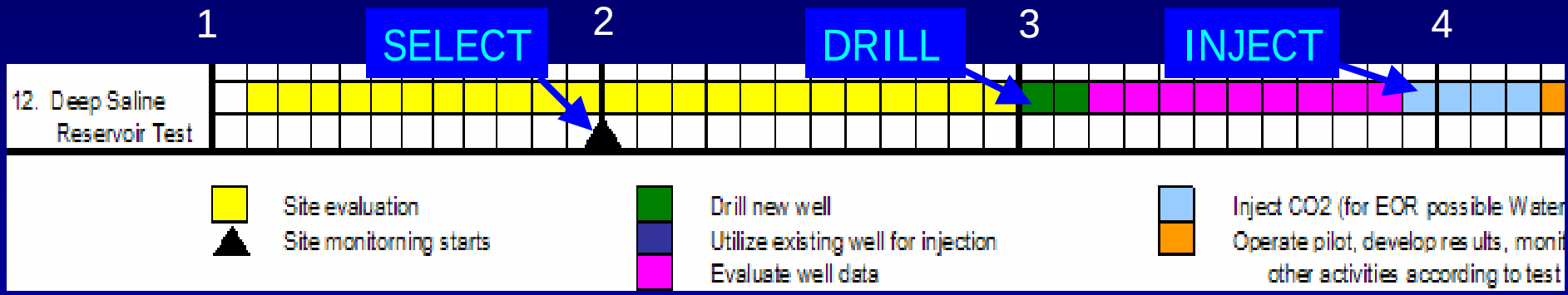
Drill new well
Utilize existing well for injection
Evaluate well data

Inject CO2 (for EOR possible Water Alternating Gas)
Operate pilot, develop results, monitor environment, other activities according to test site plan

Phase II Field Activities
Task 8-Single Well Inject/Soak/Produce

- Fourteen nominated properties screened
- Three sites in Indiana considered but locations and property sale precluded further consideration
- Current candidate is operated by Petco at Loudon Field, Fayette County, IL
- NEPA form completed; detailed characterization underway

Task 12-Deep Saline Reservoir Test



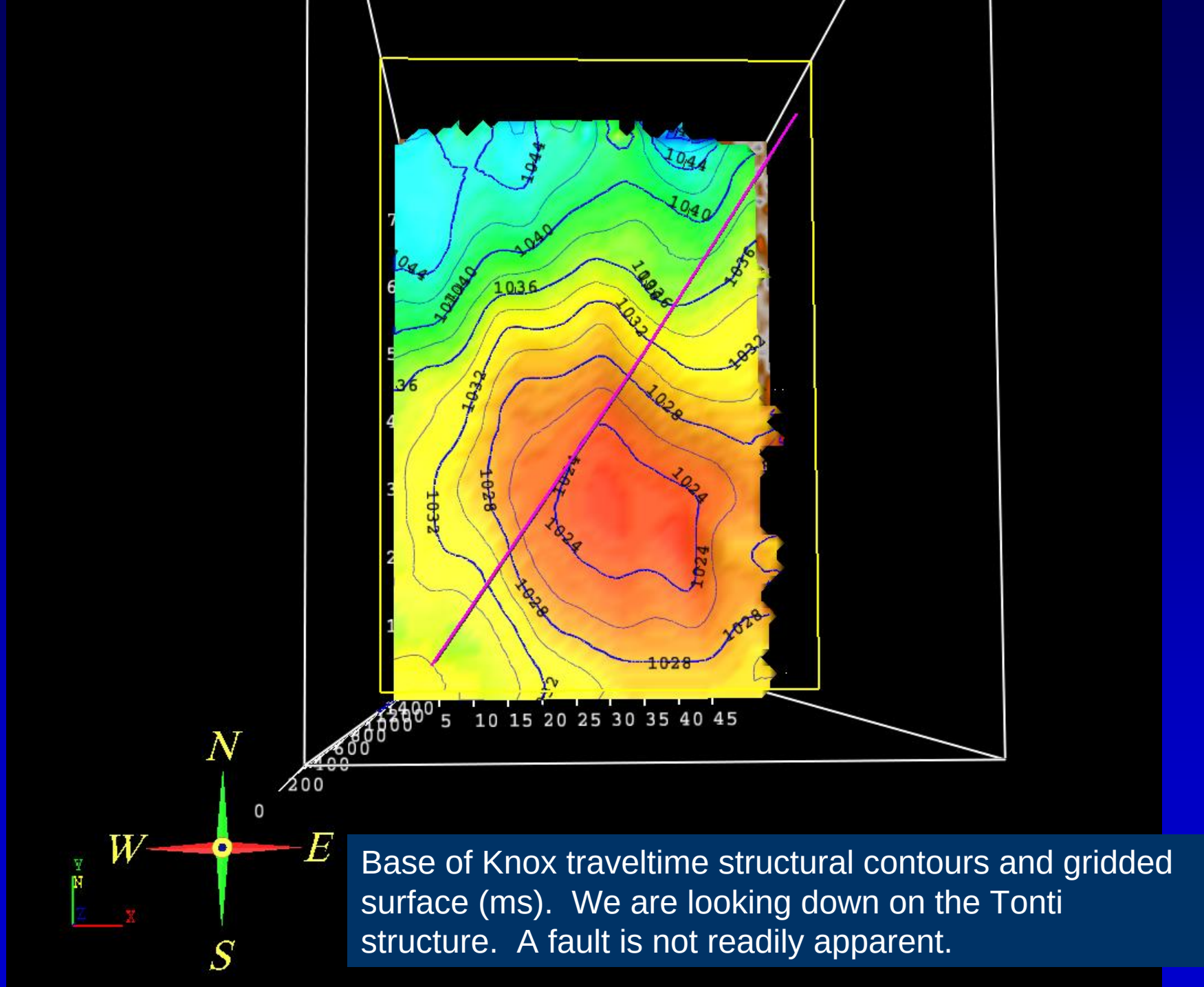
- Extensive cooperation from field operator looked for
- Evaluation will include 2D and 3D seismic
- Aiming for a full year of advance site monitoring (MMV)
- Deep, expensive (~$1.6 million to drill and complete), and requiring extensive planning and subcontractor collaboration
- Up to 9 months well-data assessment pre-injection
- Injection at end Year 3-early Year Four

Seismic Attribute Processing of 3D and 2D Seismic Data Can Enhance Visualization of Deep Faulting Brigham Young University, Leader

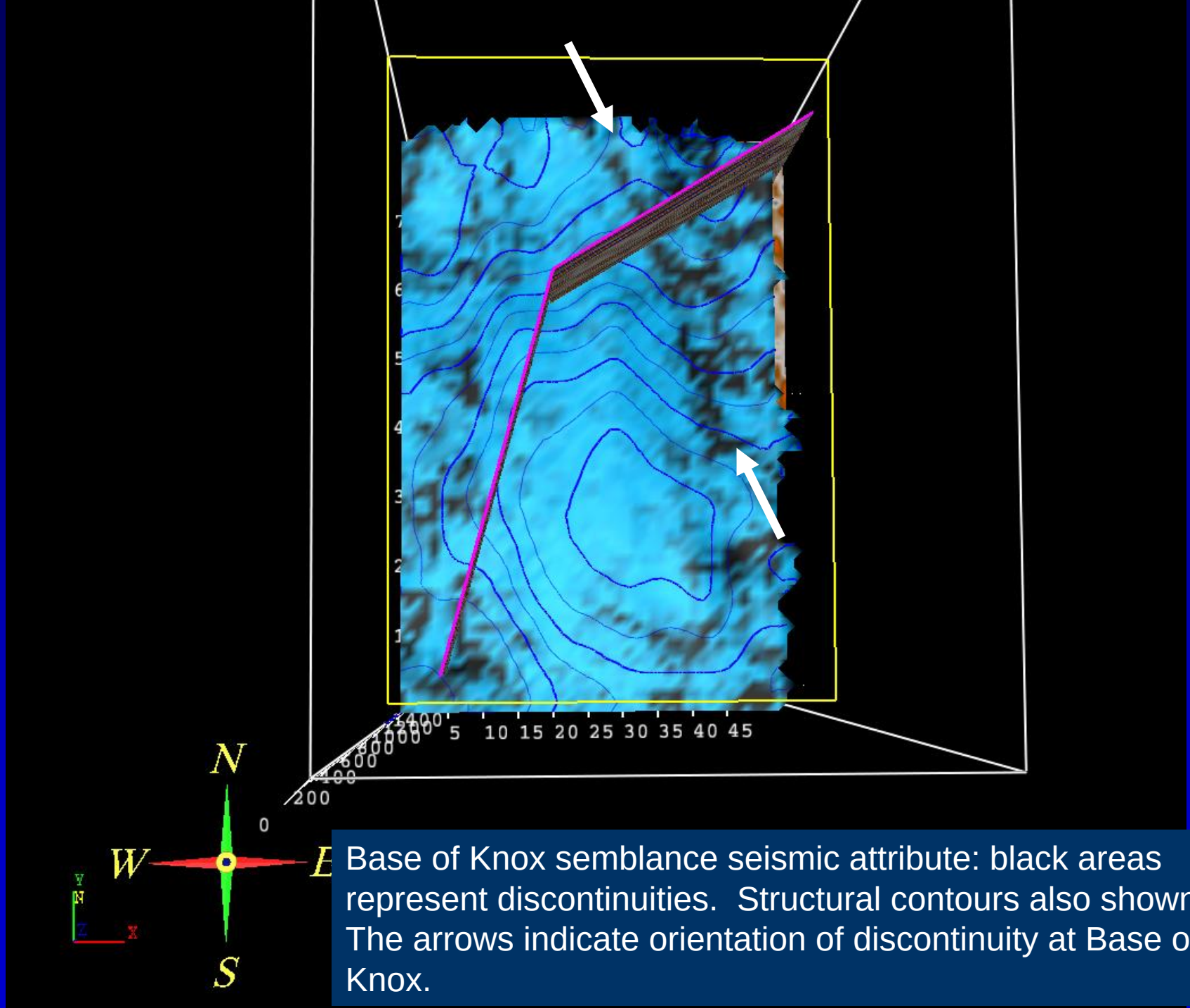
- Landmark's Geoprobe, ProMAX2D, and SeisWorks3D applications utilized at BYU

- Two computations were performed at or near the base of the Knox Supergroup reflector, which is the deepest highly coherent event near the Mt Simon Sandstone:
  - (1) semblance seismic attribute analysis to detect and map discontinuities related to fracturing or faulting; this is particularly useful for "seeing“ small-scale fractures
  - (2) spectral decomposition analysis to detect anomalies in thickness as estimated from the constructive interference of multiple waveforms centered over the target reflector

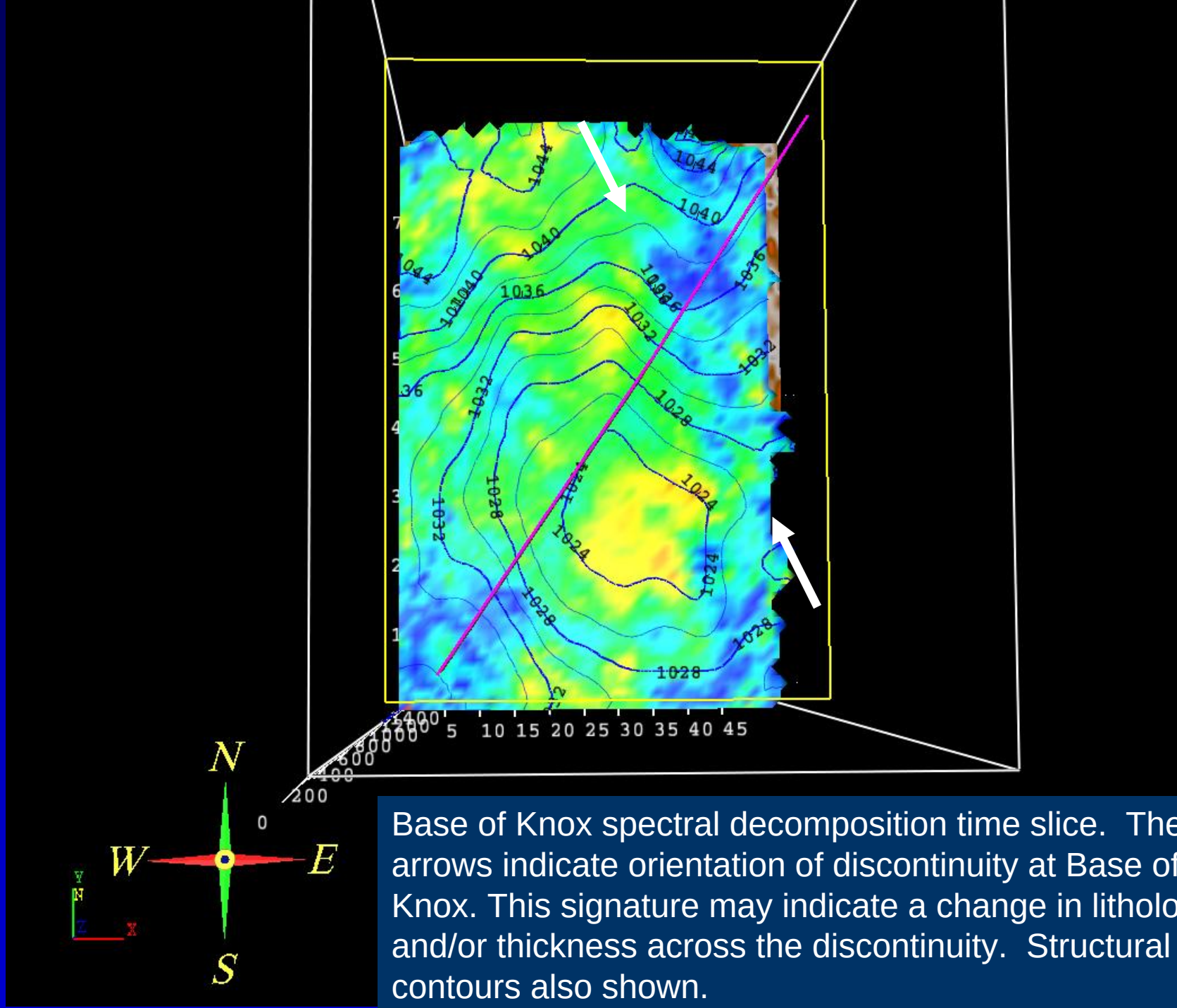
(from John McBride, BYU)



Base of Knox traveltime structural contours and gridded surface (ms). We are looking down on the Tonti structure. A fault is not readily apparent.



Base of Knox semblance seismic attribute: black areas represent discontinuities. Structural contours also shown. The arrows indicate orientation of discontinuity at Base of Knox.



Base of Knox spectral decomposition time slice. The arrows indicate orientation of discontinuity at Base of Knox. This signature may indicate a change in lithology and/or thickness across the discontinuity. Structural contours also shown.

Results of Advanced Seismic Analysis

- Discontinuities associated with faults and fractures can be mapped in 3D using semblance and spectral decomposition analyses
- The structure beneath Tonti Field is undercut by a NNW-trending reverse fault, which was not readily apparent from conventional seismic visualization using an amplitude display. This fault may breach the target sequestration reservoir.

CO_2 Reservoir and Injection Specifications

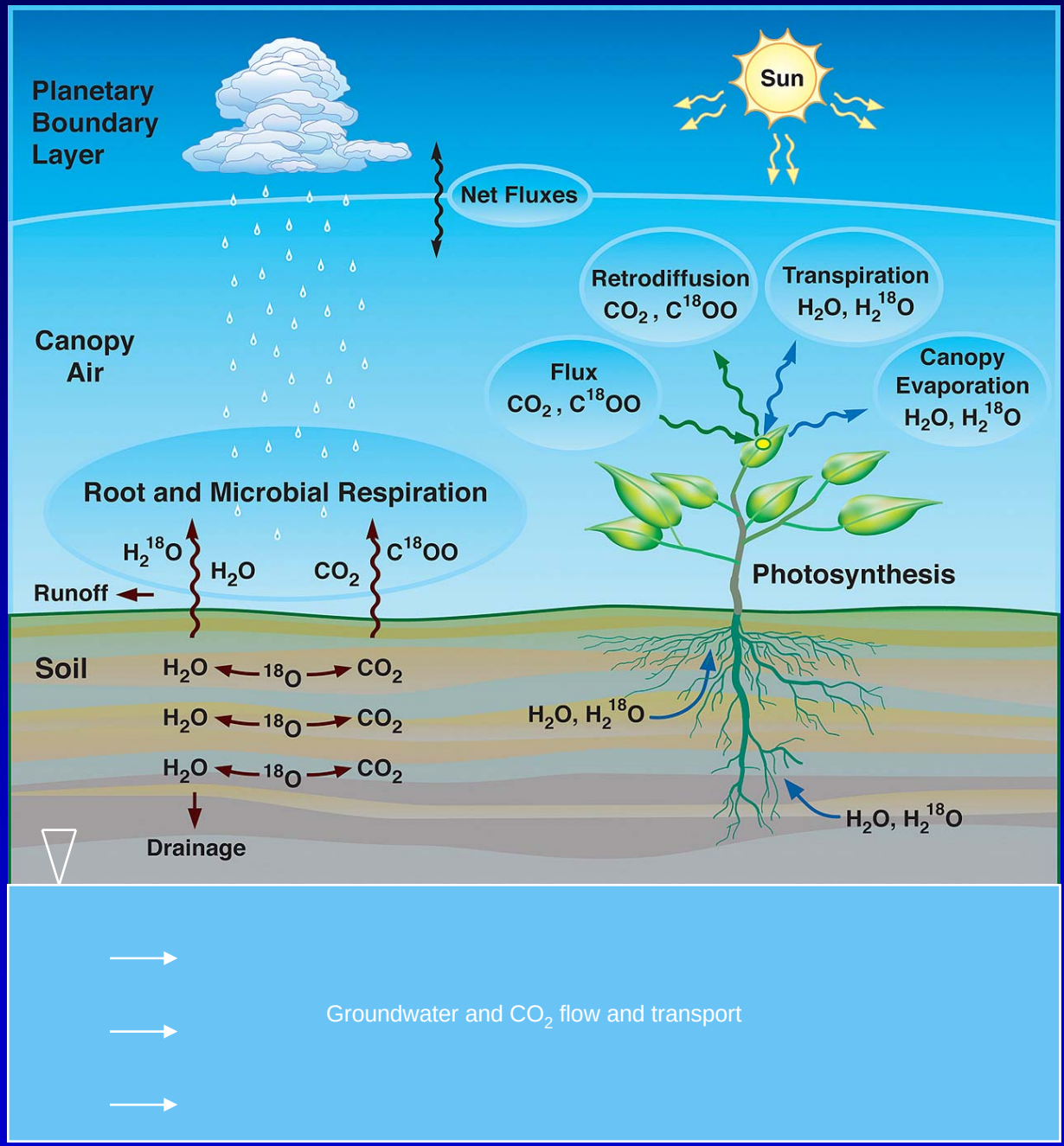
Parameter	Coal Test		Oil Huff n Puff		Oil: Well Conv		Oil: New well		Oil: New Well		Deep Saline	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Depth (feet)	800	1200	1000	2000	1500	3000	1500	3000	1500	3000	6000	10,000
Discovery Reservoir Pressure (psia)	320	520	400	870	600	1,300	600	1,300	600	1,300	2400	4300
Current Reservoir Pressure (psia)	320	520	400	1400	600	2100	600	2100	600	2100	2400	4300
Reservoir Temp (°F)	69	75	71	81	76	97	76	97	76	97	120	180
Maximum Injection Pressure (BHP, psia)	480	960	600	1600	900	2400	900	2400	900	2400	3600	8000
Water Injection Rate, (bbl/d)	10	50	50	300	100	500	100	500	100	500	500	2000
CO_2 Injection Rate, (Mscf/d)	2.4	110	15	740	220	1200	220	1200	220	1200	1300	5,000
CO_2 Injection Rate, (ton/d)	0.14	6.2	0.88	44	13	72	13	72	13	72	74	300

Injection Pump Skid and Controls
Trimeric Corporation, Leader

Propane-fired CO_2 Line Heater

Task 5-Monitoring, Mitigation, and Verification (MMV) Program

- Develop a tailored and dynamic program specific to each site to focus on greatest potential risks for CO_2 leakage from injection formation
- Use multiple techniques to monitor CO_2 migration
- Monitor pre-, during, and post- CO_2 injection
- Develop site specific mitigation plans
- Extent of MMV program will depend on amount of CO_2 injected, duration of study, and potential risks for CO_2 migration (knowledge of site geology)



MMV Plan to Include atmosphere (saline reservoir only), vadose zone, and groundwater

from Curt Oldenburg, LBNL

Resource and Capacity Considerations

- Data Availability and Methodology
  - Quality
  - Quantity
- Degree of uncertainty
- Economics
- Scale of Assessment
  - Field, Region, State, Basin, Continent, World

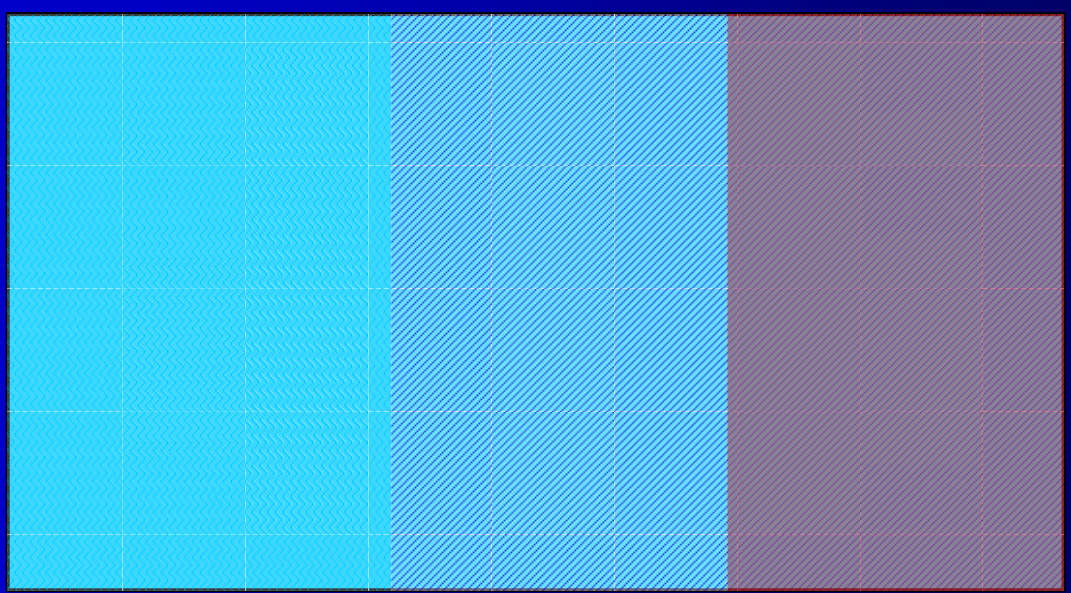
Total CO_2 Geologic Storage

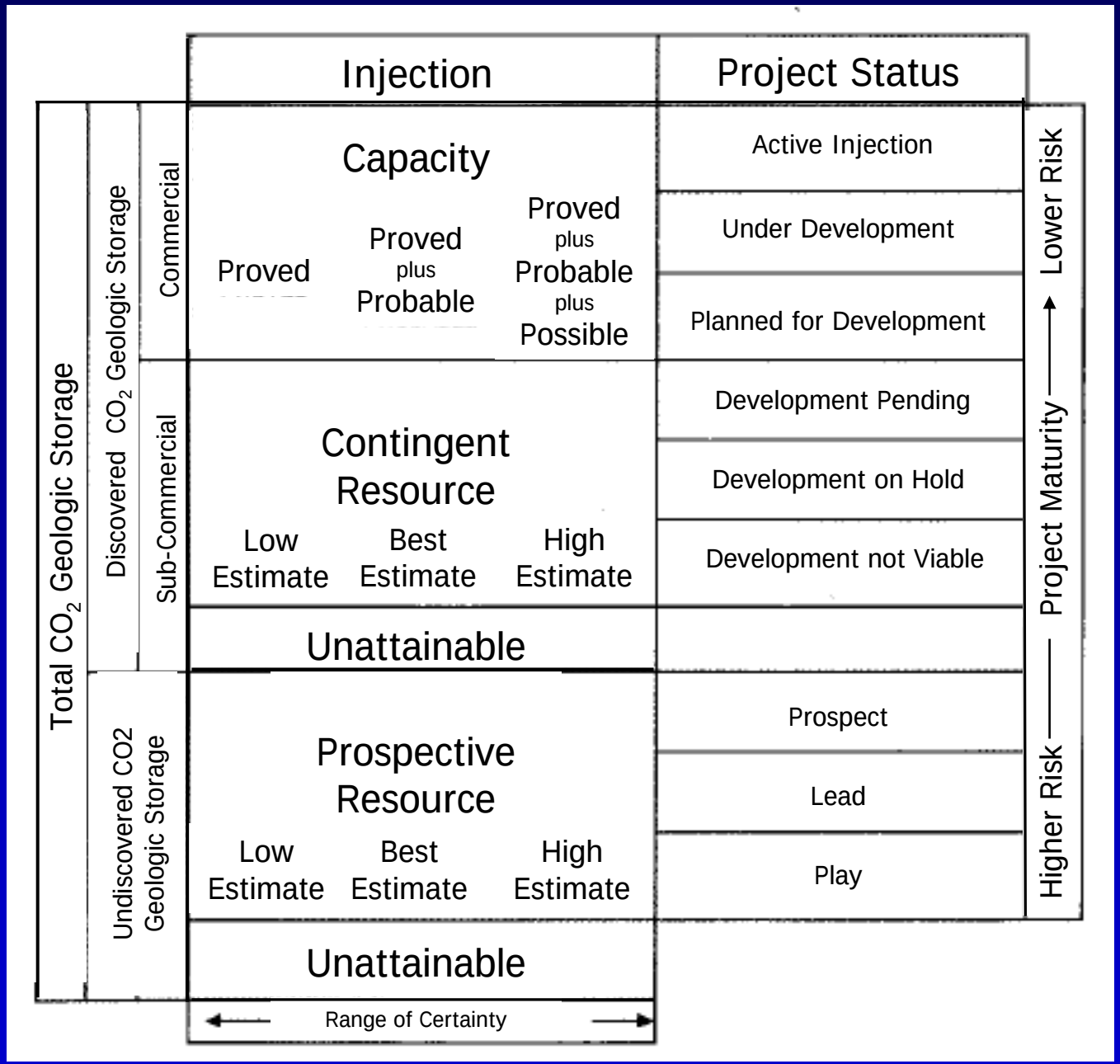
Undiscovered CO2 Geologic Storage

Discovered CO_2 Geologic Storage

Sub-Commercial

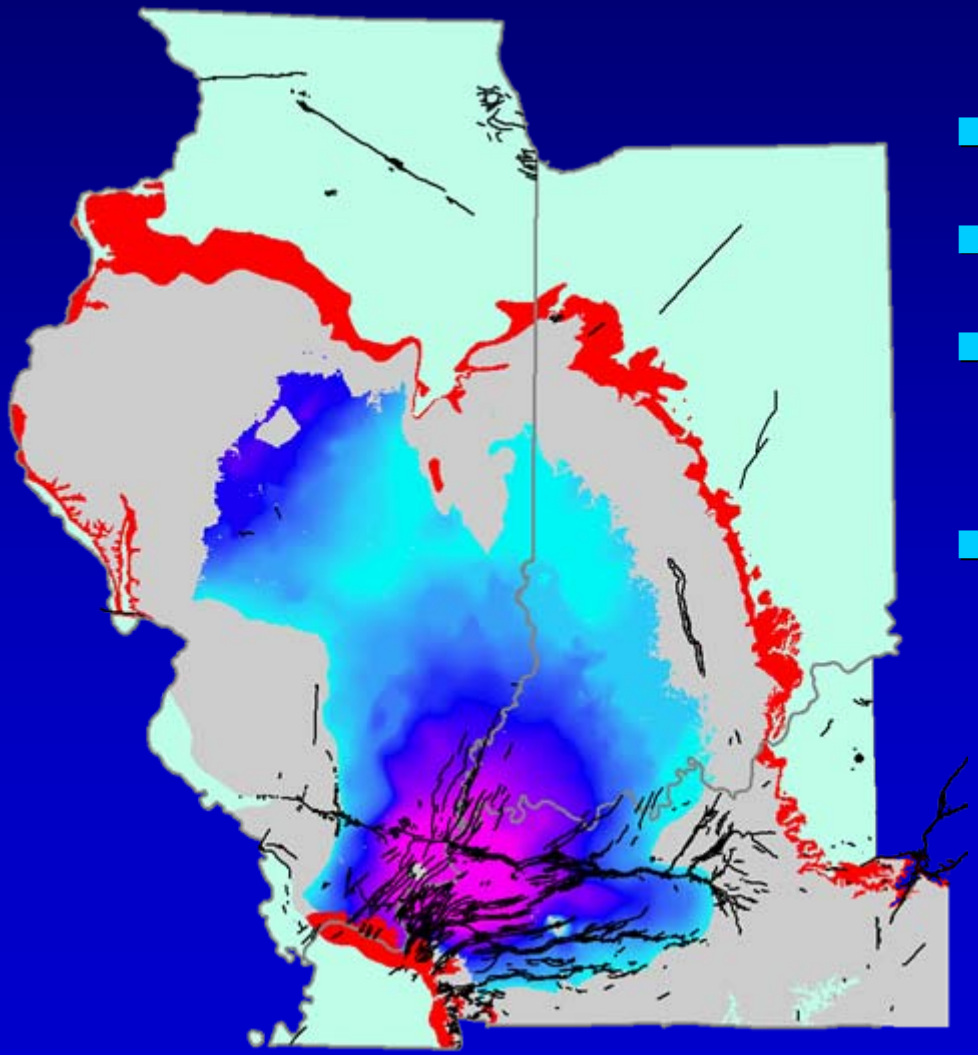
Commercial



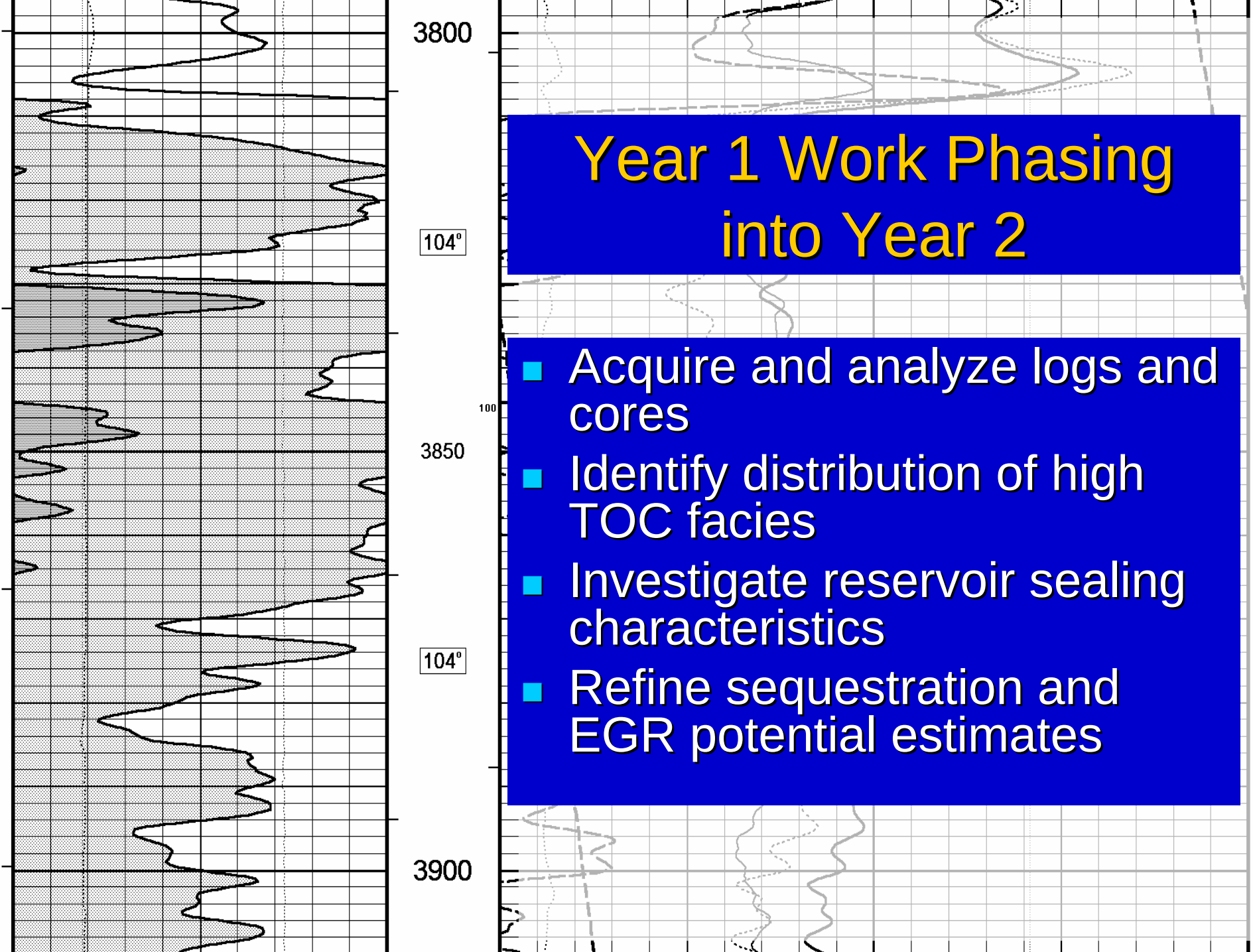


Based on SPE/SPEE/WPC Guidelines for Petroleum Reservoirs

Devonian New Albany Shale
Kentucky Geological Survey, Leader



- Regional seal
- >460’ max thickness
- >4,500’ max depth to top
- Preferentially adsorbs CO_2 (sequestration and EGR potential)



Year 1 Work Phasing into Year 2

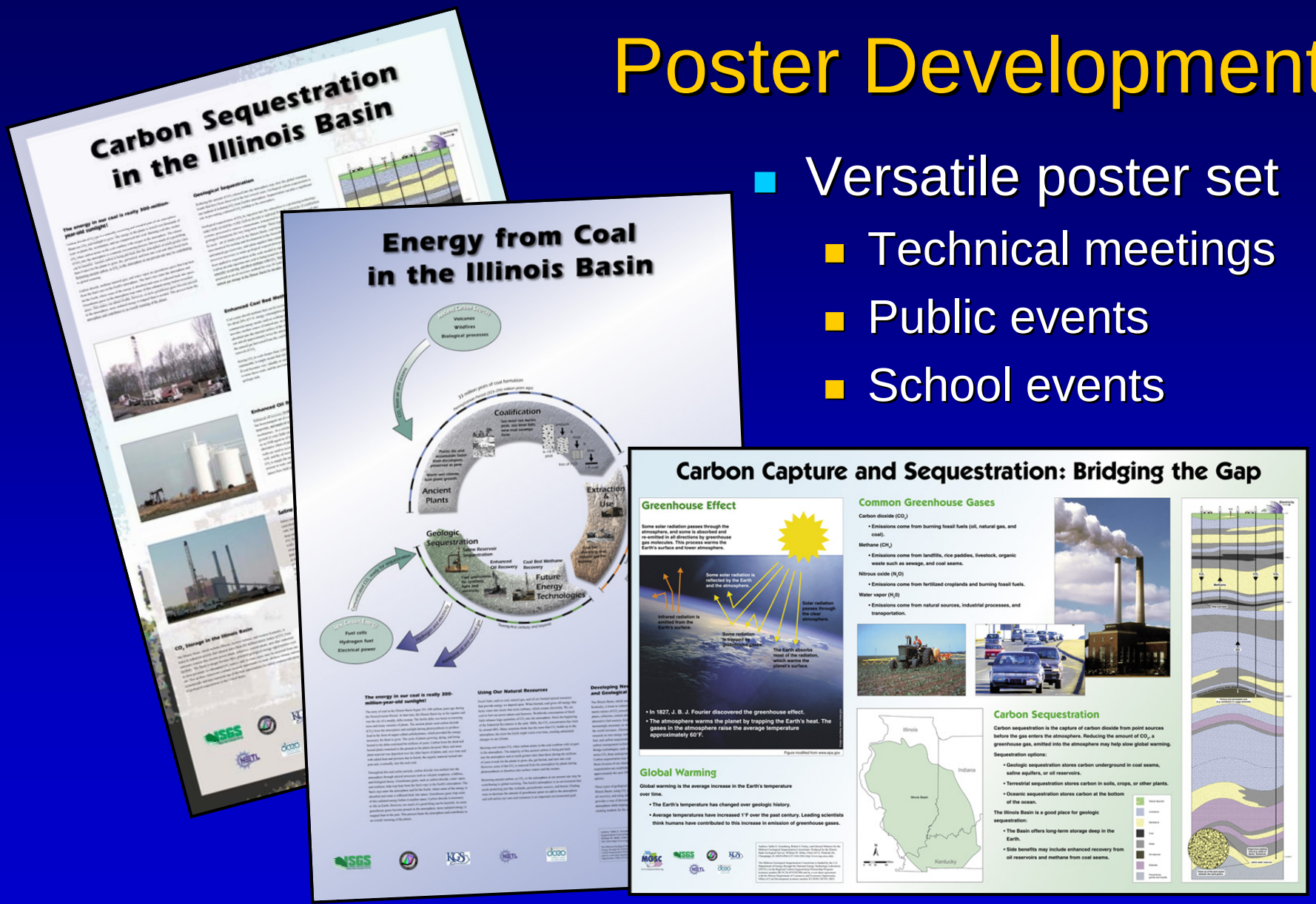
- Acquire and analyze logs and cores
- Identify distribution of high TOC facies
- Investigate reservoir sealing characteristics
- Refine sequestration and EGR potential estimates

Getting the Word Out
Outreach for Phase II – Year 1

- 5th Annual Carbon Sequestration Conference
- ISGS Centennial Open House (1000 visitors)
- 9th Annual Coal Conference (110 teachers)
  - Department of Commerce and Economic Opportunity
- FutureGen Public Scoping Meetings
  - Tuscola (150 general public)
  - Mattoon (200 general public)
- Riddle Elementary School
  - 250 4th and 5th graders

Poster Development

- Versatile poster set
  - Technical meetings
  - Public events
  - School events



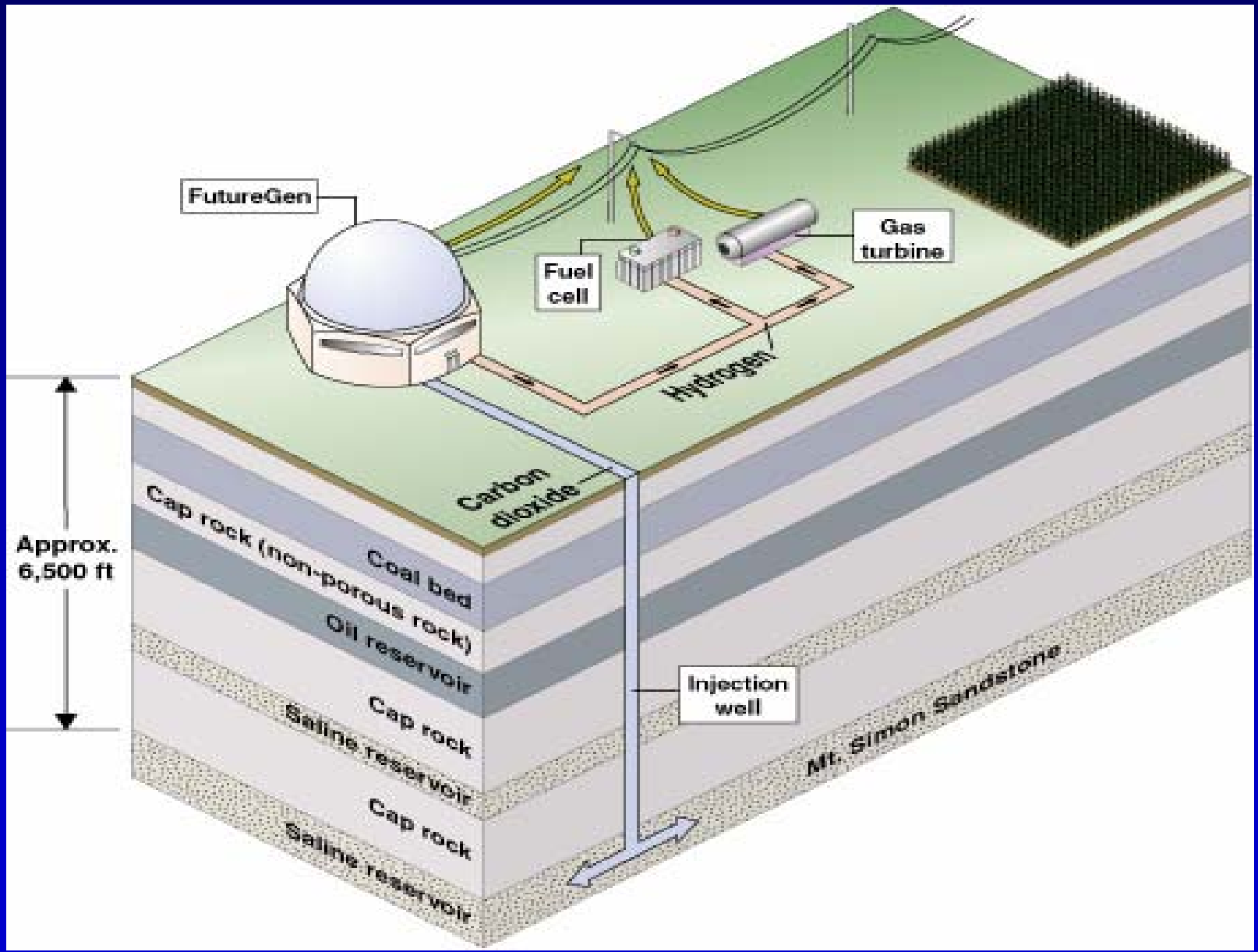
Special Acknowledgement to Daniel Byers, ISGS, and Reviewers

Sequestration Model

- Demonstrates
  - Illinois Basin stratigraphy
  - Sequestration in deep saline reservoir
  - Enhanced oil recovery
- Discussion Opportunities
  - Enhanced coal bed methane
  - Sedimentary rocks
  - Porosity, permeability
  - Global warming, greenhouse gases

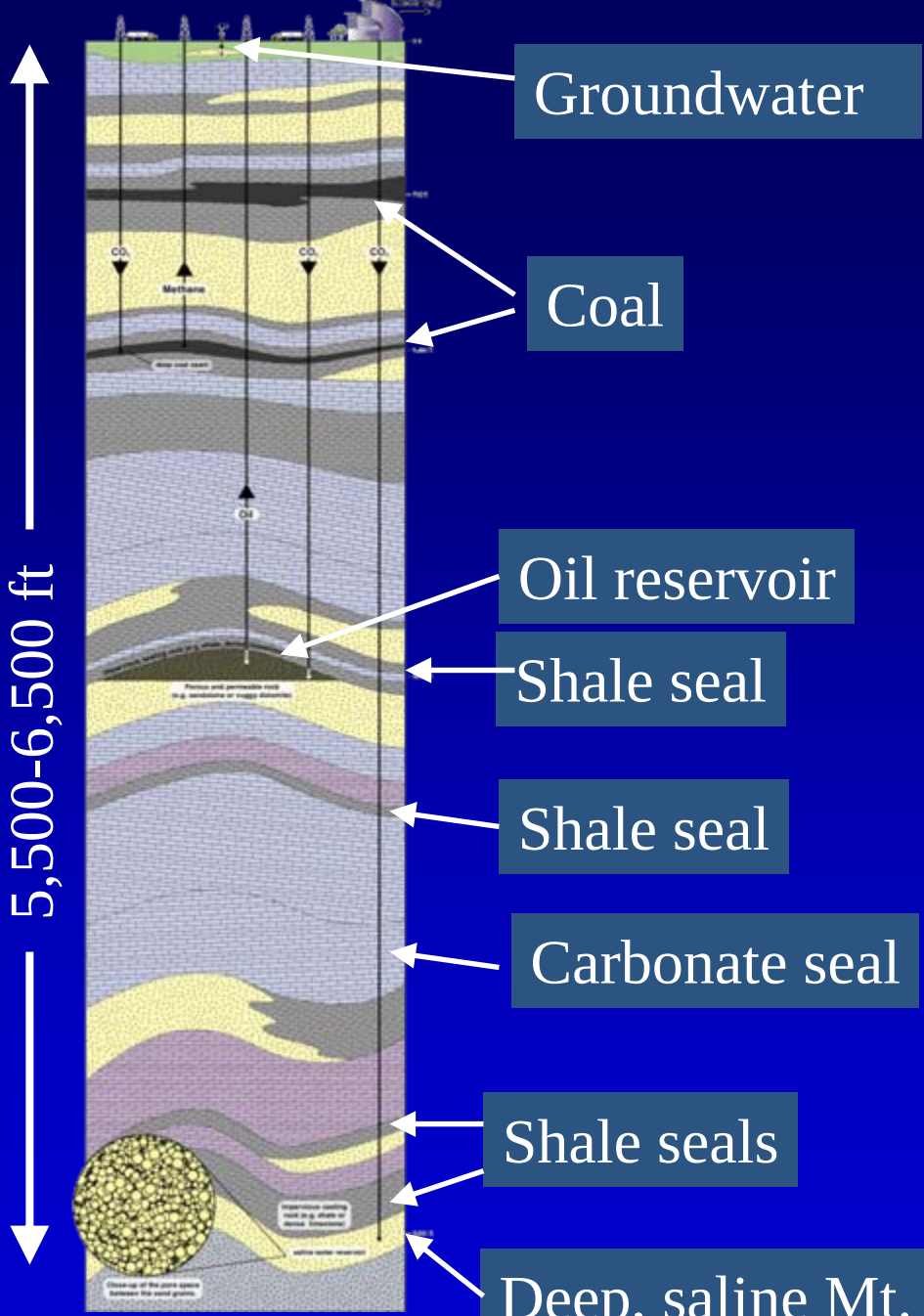
Special Acknowledgement to Mike Dodd, ISGS

Sequestration at Mattoon and Tuscola



Riddle Elementary School

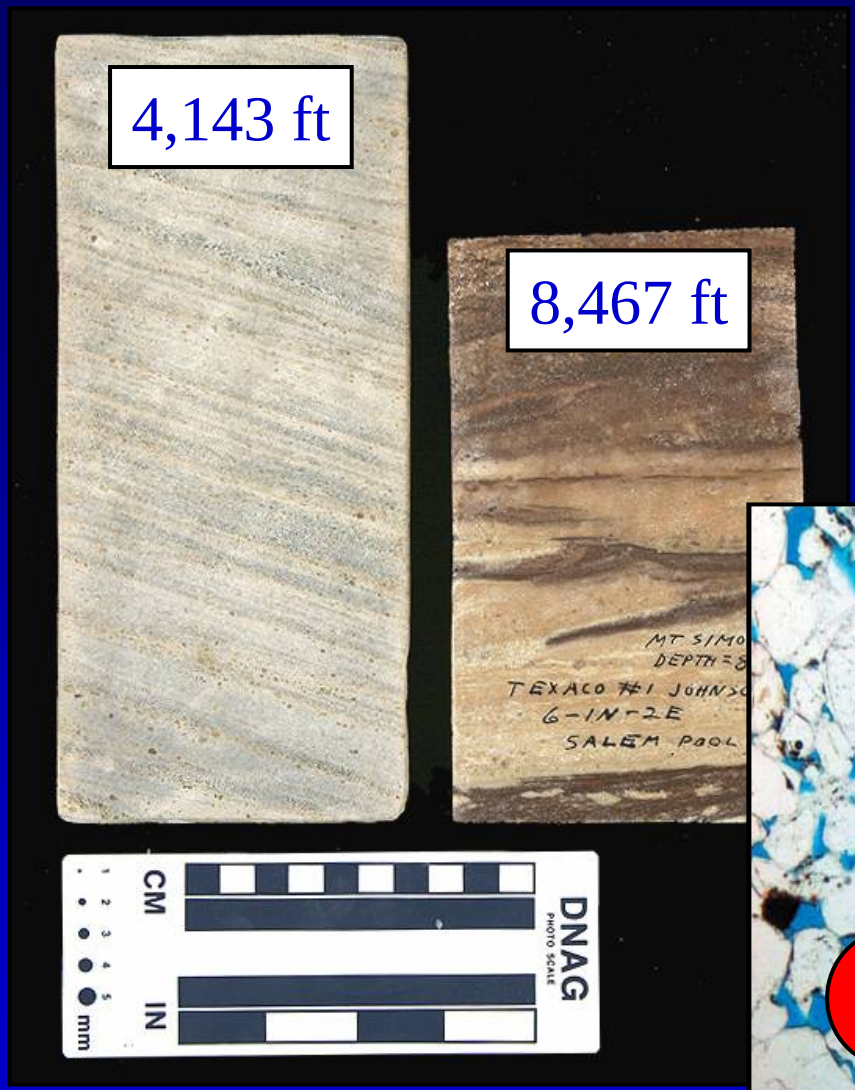
- Six 30 minute presentations
- Coal and Energy
- CO_2 and Photosynthesis
- Greenhouse gases
- Sedimentary Rocks
- Porosity
- Sequestration
- FutureGen



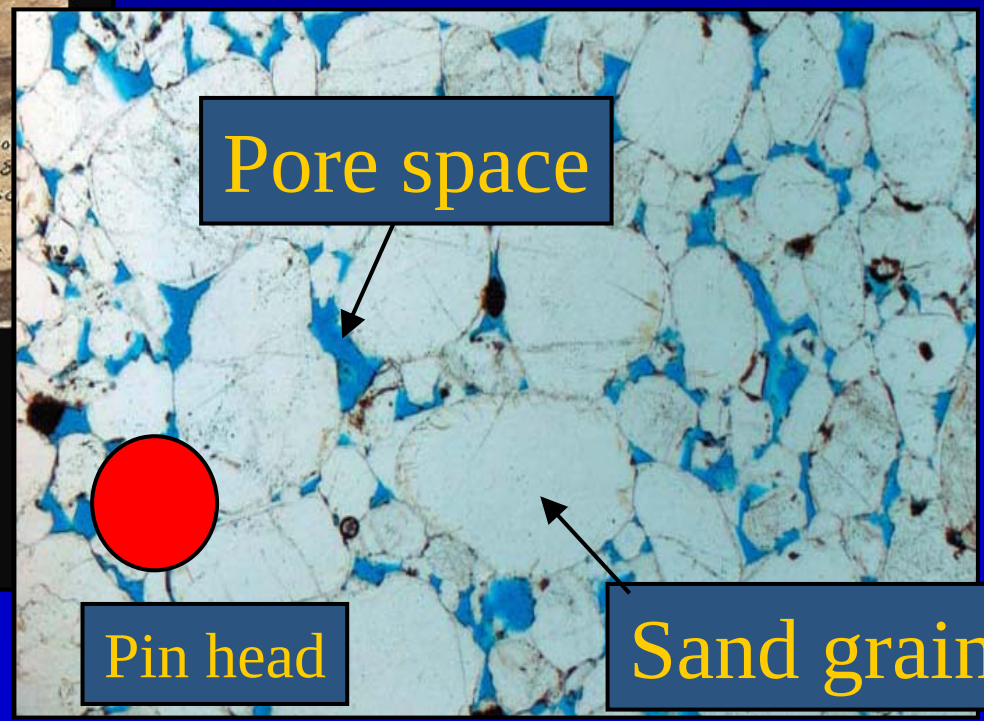
Mt Simon Sandstone Saline Reservoir

- Illinois Basin geology contains multiple seals for carbon dioxide (CO_2) above the Mt. Simon Sandstone
- Monitoring other sandstones above the Mt. Simon Sandstone can provide warning of any problems

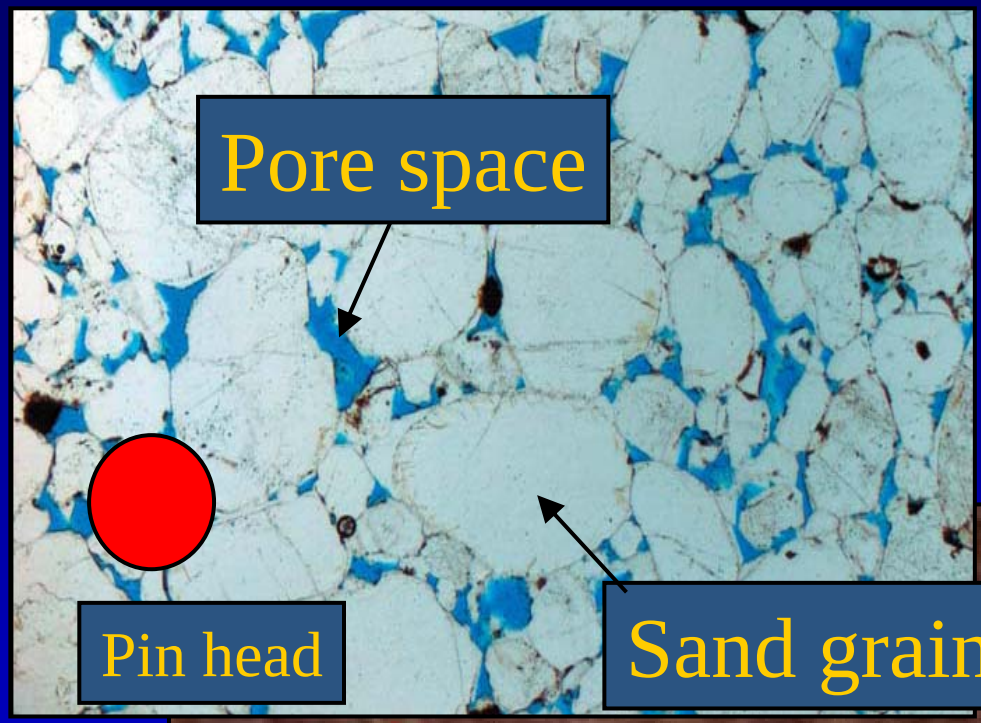
Storing CO_2 in Sandstone a Reservoir



- Using technical information to answer basic questions



Comparing Sinks and Seals



Sinks: where does it go?

Seals: what keeps it in?

Year 1 Topical Reports Completed and in Final Review

- "CO_2 Capture Options for Ethanol Plants"
  - Trimeric Corporation
- "Updated Characterization of Emission Sources in the Illinois Basin"
  - Illinois State Geological Survey

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