

Illinois and CCS-FutureGen

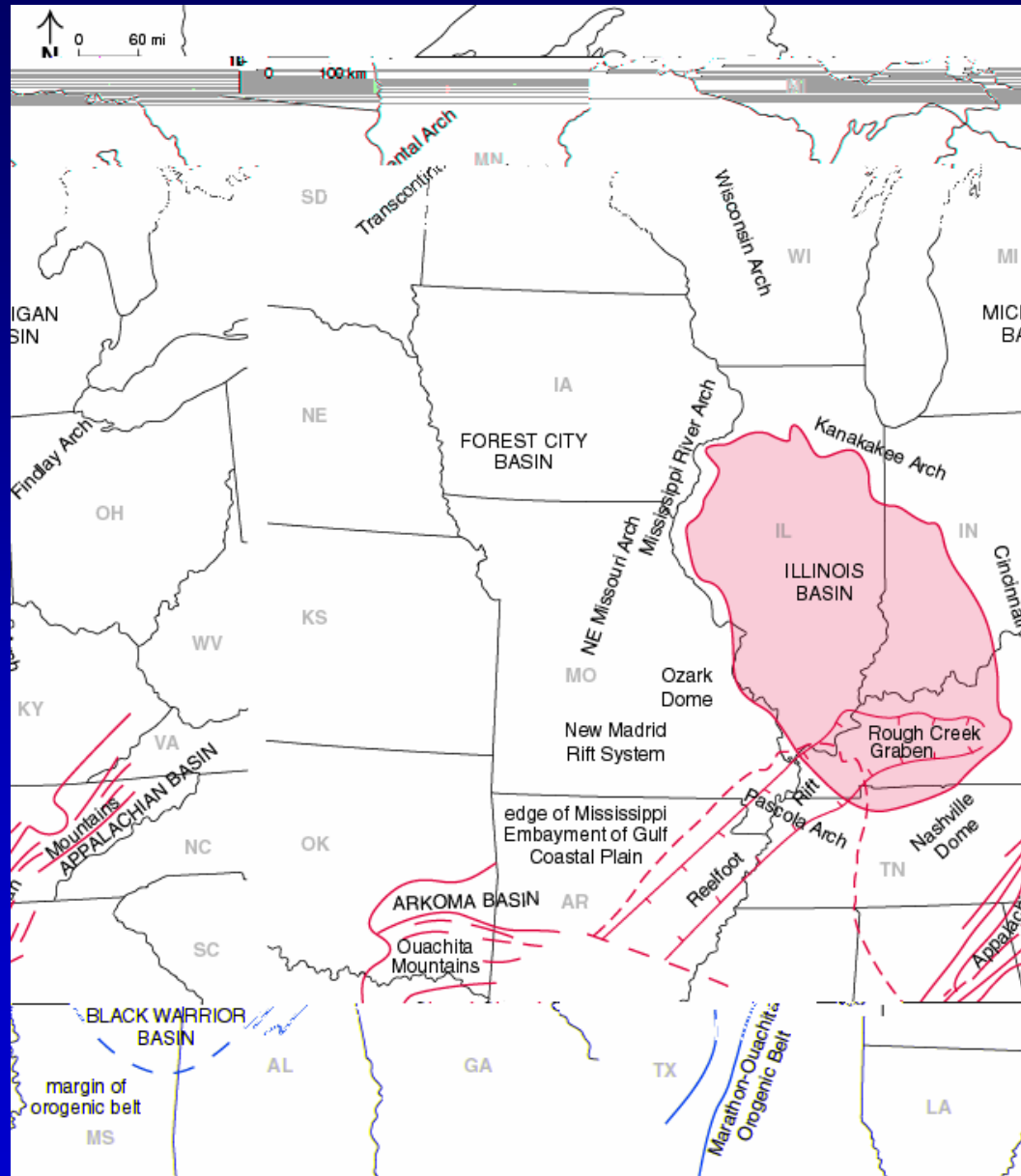
Carbon Sequestration, FutureGen, and Coal Gasification Development in the Illinois Basin

Robert J. Finley
Illinois State Geological Survey

December 7, 2007
Lexington, Kentucky

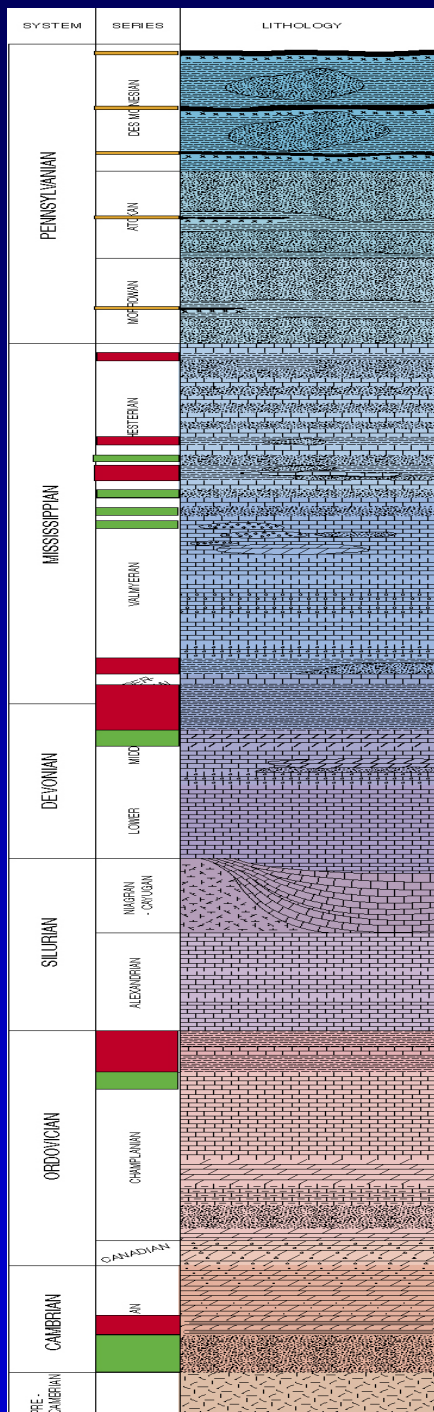


Illinois Basin



Midwest Geological Sequestration Consortium, A DOE Regional Carbon Sequestration Partnership: Seeking Optimal Sinks

- High CO₂ storage capacity
- High CO₂ injection rate
- Storage mechanism assessment
- Major focus on reservoir characterization for coal seams, mature oil reservoirs, and deep saline reservoirs
- Structural characterization
- Outreach and web site enhancement
 - www.sequestration.org



Pennsylvanian coal seams

adsorption on coal

Mississippian sandstone and carbonate oil reservoirs

CO₂ EOR in mature fields

New Albany Shale

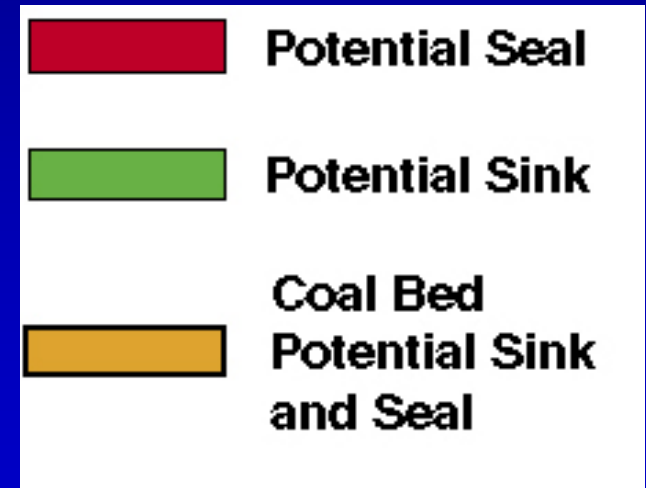
adsorption on shale

Maquoketa Shale

St. Peter Sandstone

Eau Claire Shale

Mt. Simon Sandstone

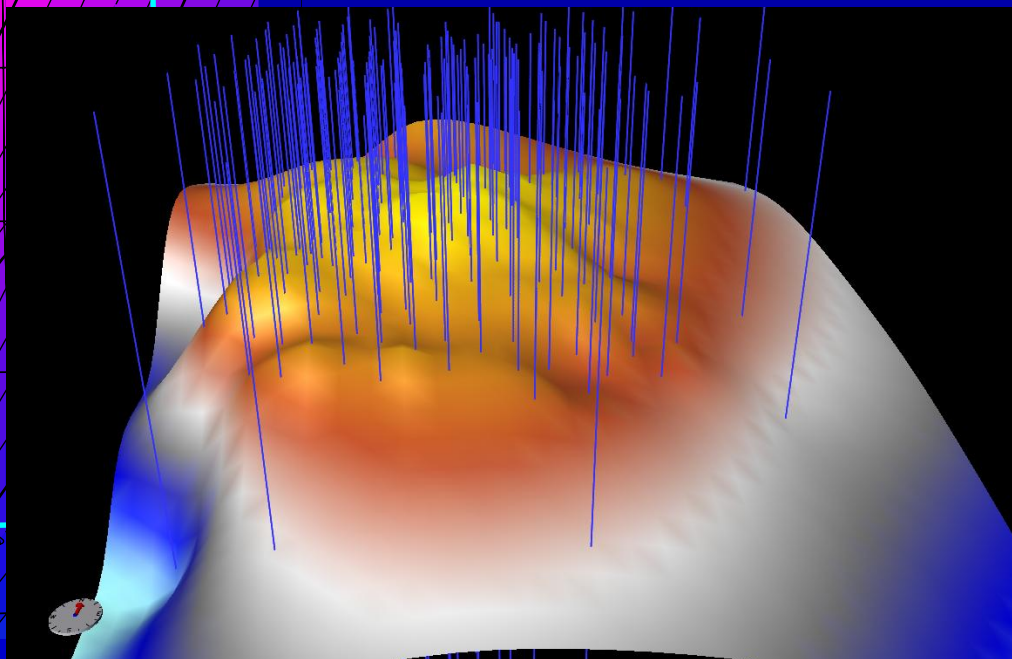
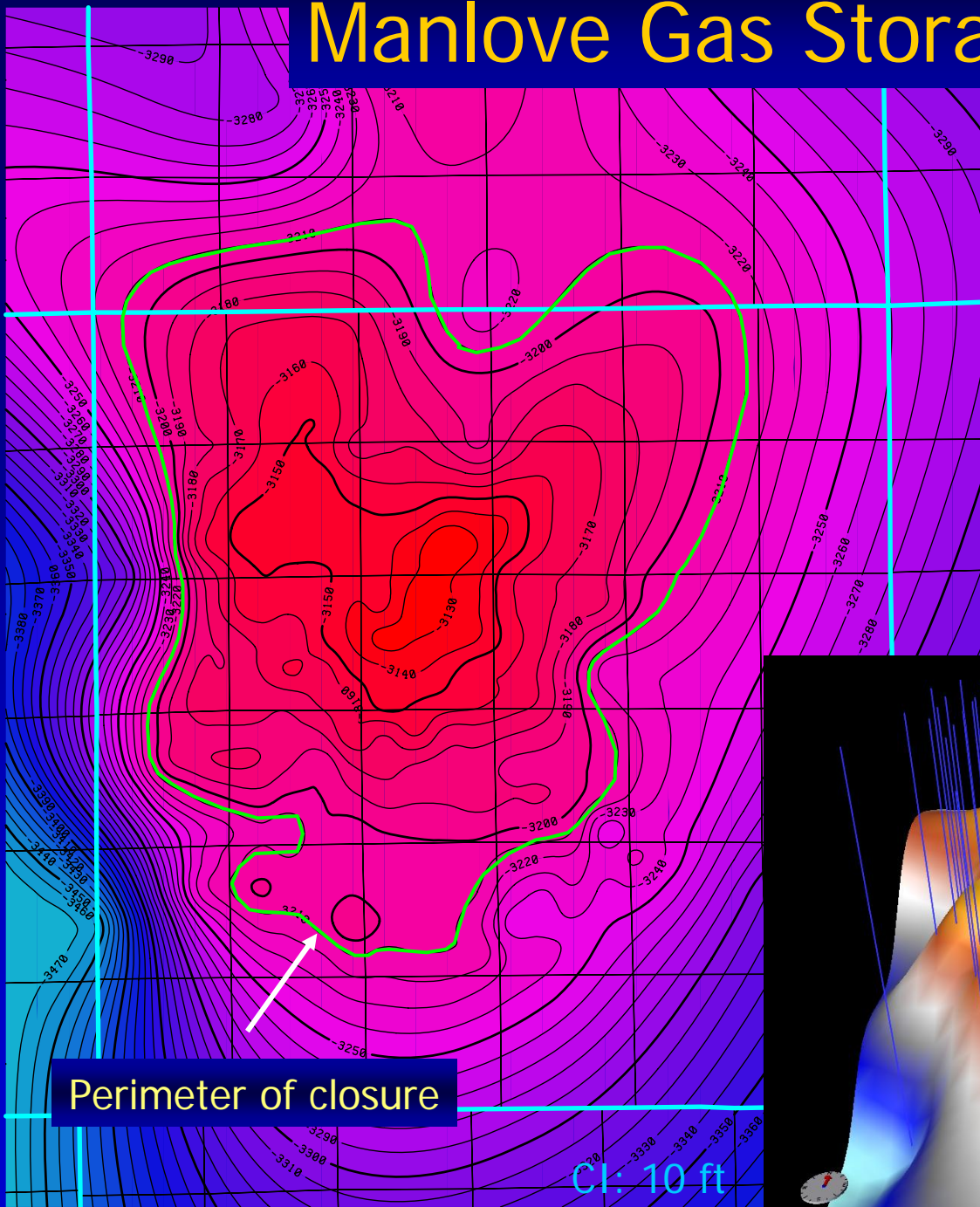


major saline reservoirs

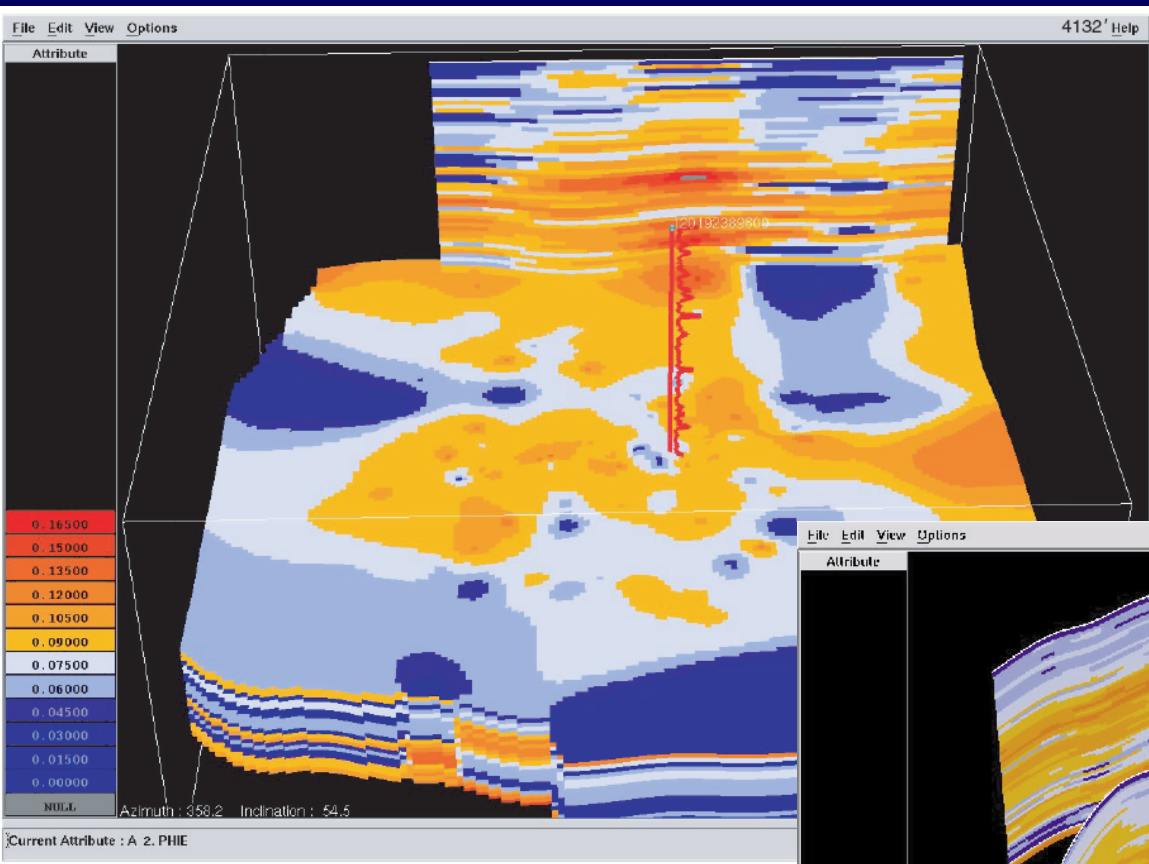
from Leetaru, 2004

Manlove Gas Storage Project

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

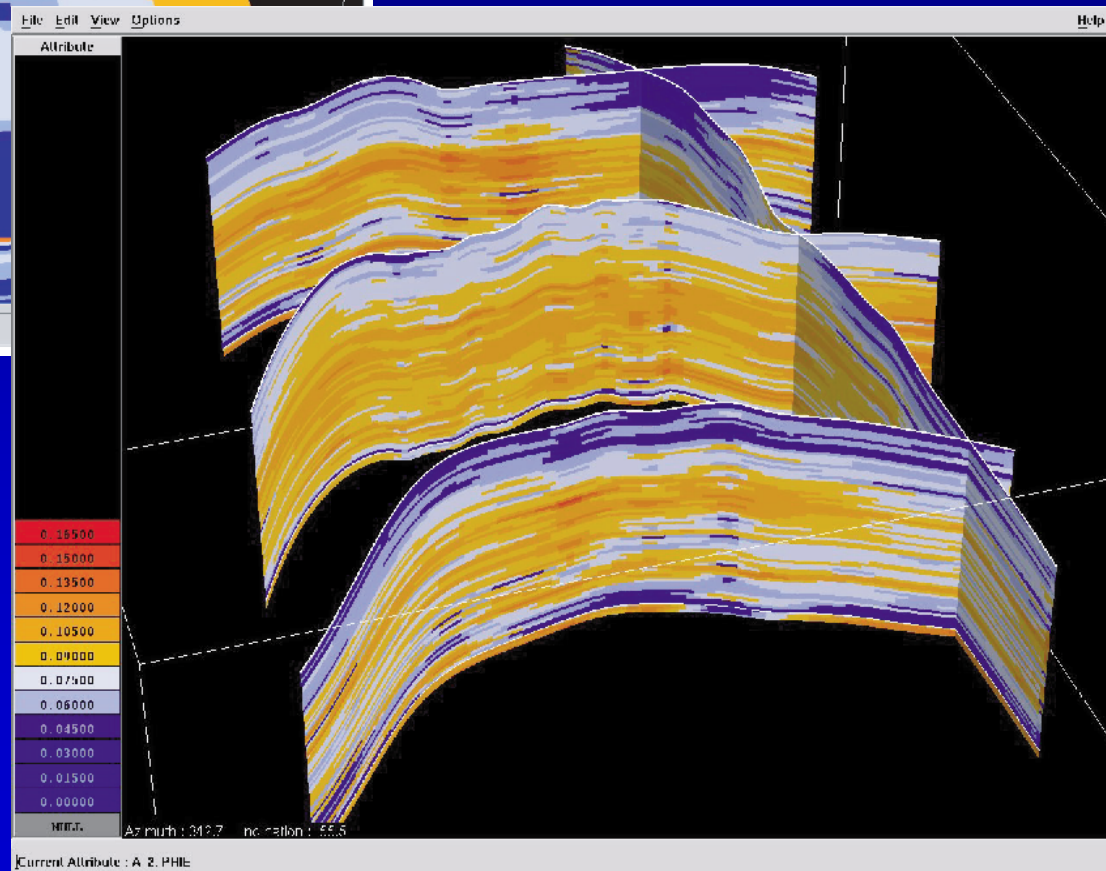


Mt. Simon Sandstone



High Porosity

Low Porosity



Sink Capacities*

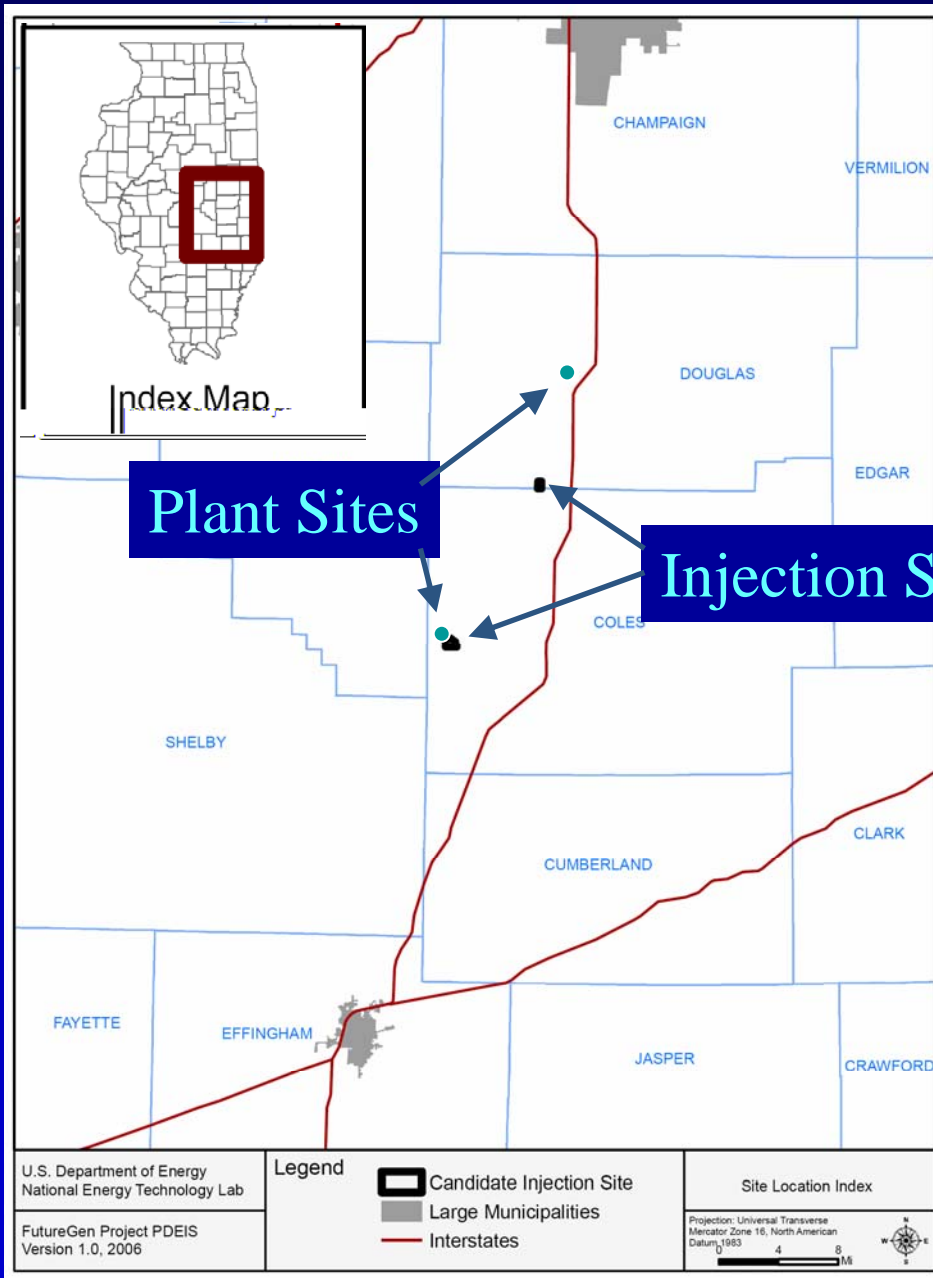
- Seven major coal seams: 2.3-3.3 billion tonnes
 - 6.7 trillion ft³ incremental methane(?)
- Mature oil reservoirs: 140-440 million tonnes
 - 860-1,300 million barrels incremental oil
- St. Peter Sandstone: 1.6-6.4 billion tonnes
- Mt. Simon Sandstone: 27-109 billion tonnes

*DOE, 2007, Carbon Sequestration Atlas of the United States and Canada

FutureGen: Near-Zero Emission Coal-Fired Electric Generation

- *FutureGen* is a 275 Mw, multifaceted demonstration of coal gasification, electricity generation, hydrogen production, *and carbon sequestration*
- Sequestration = CO₂ capture + transport + storage
- Illinois offers storage = geological sequestration potential over a wide area of the Illinois Basin

Mattoon and Tuscola FutureGen Sites

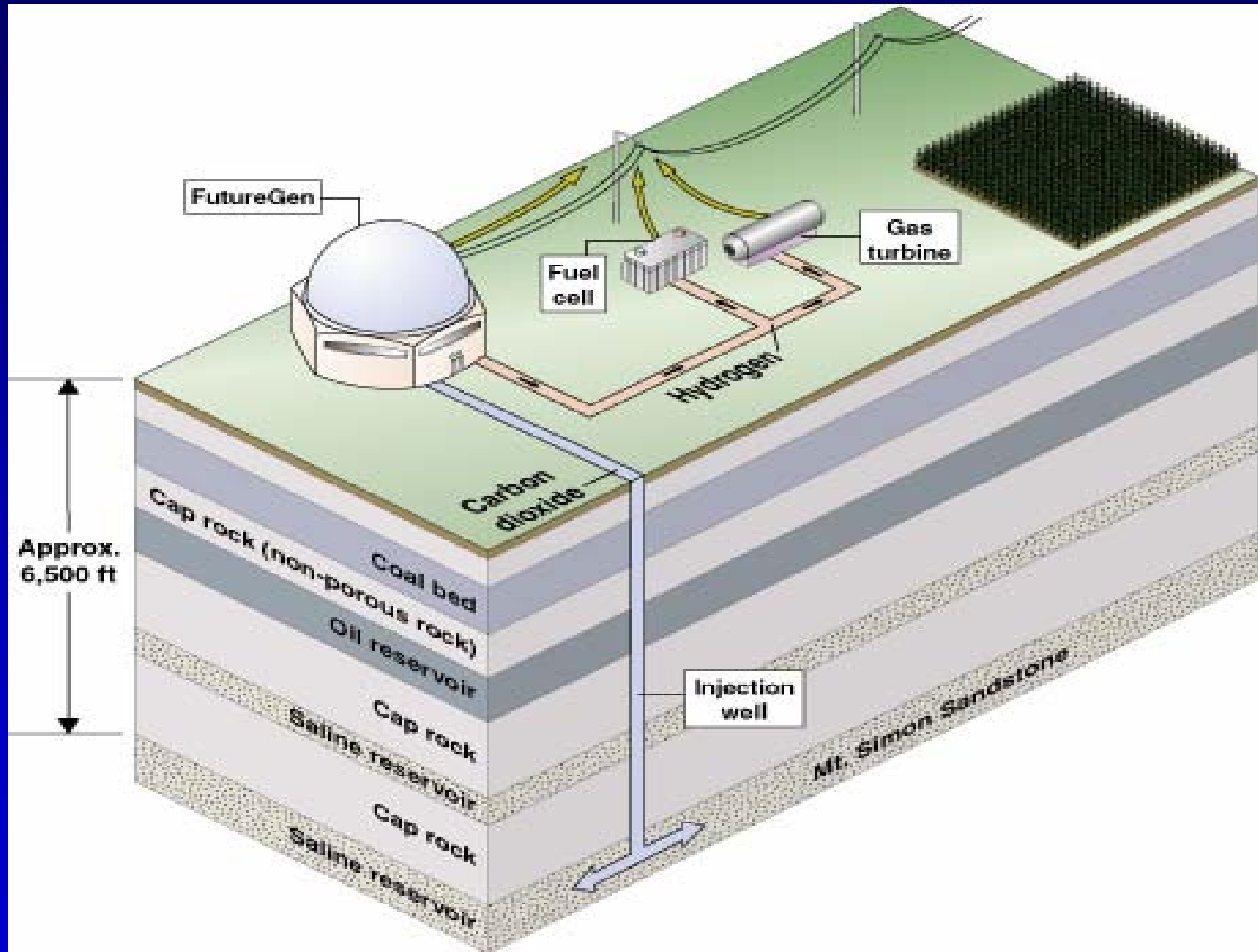


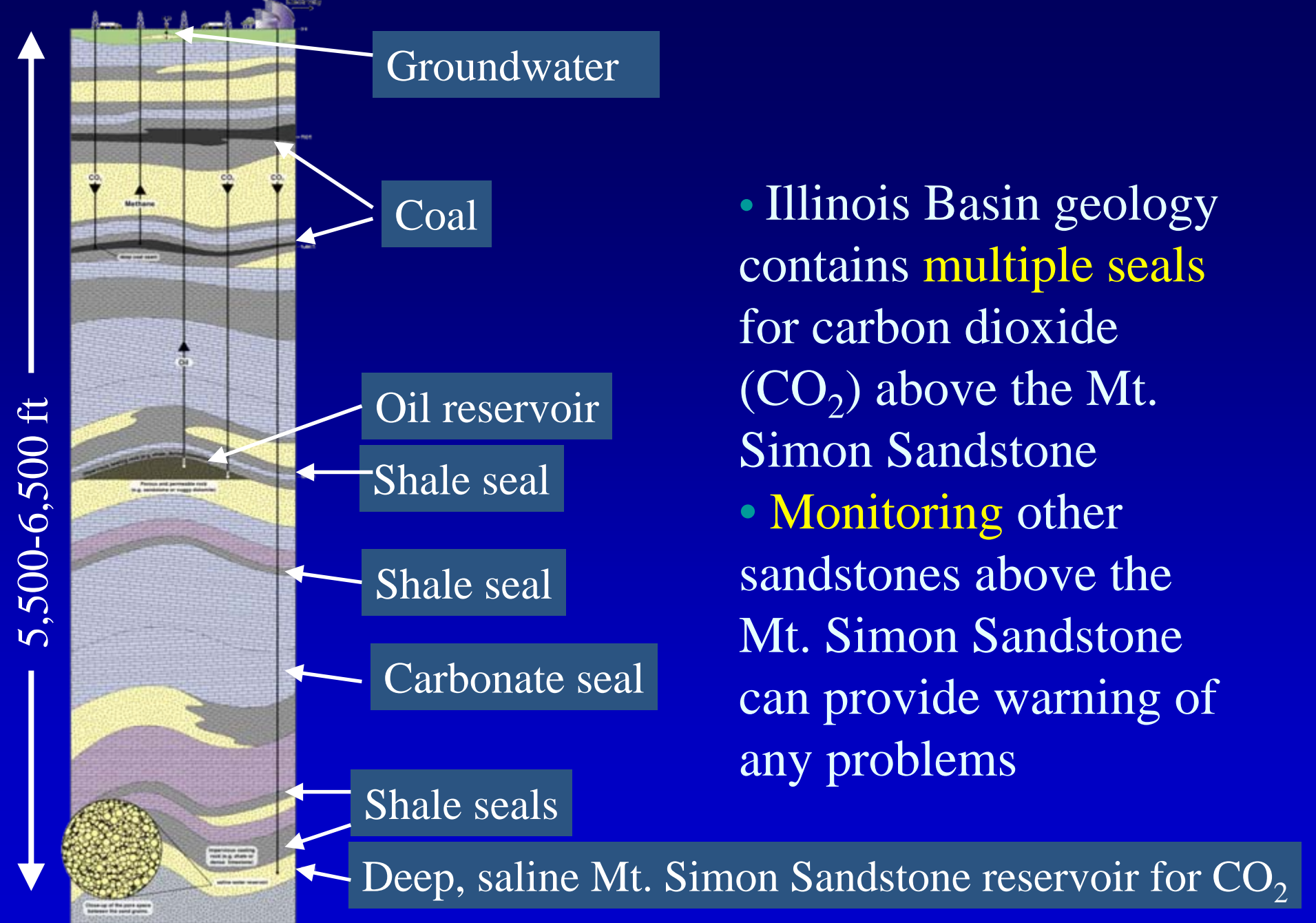
- Predominantly farm land
- Outstanding community support for FutureGen
- Familiarity with industrial facilities and coal mining or quarrying
- Excellent sequestration option on site or 10 mi via pipeline

Future Site of FutureGen



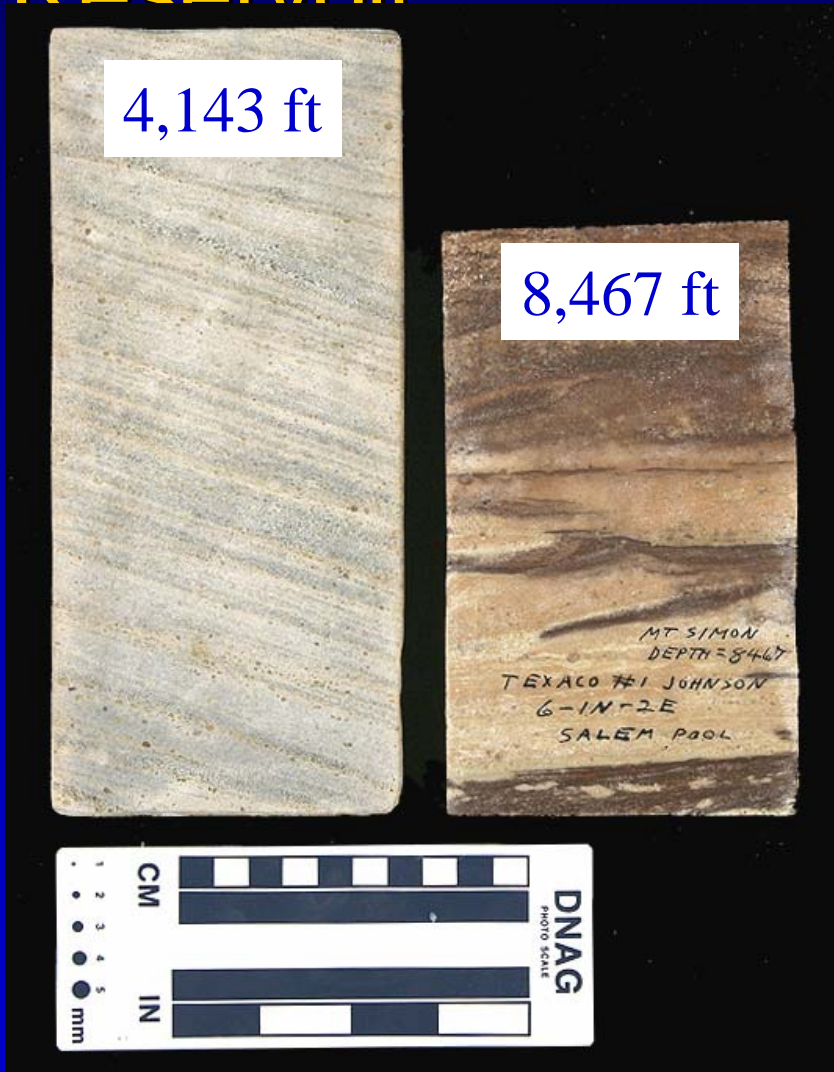
Sequestration at Mattoon and Tuscola





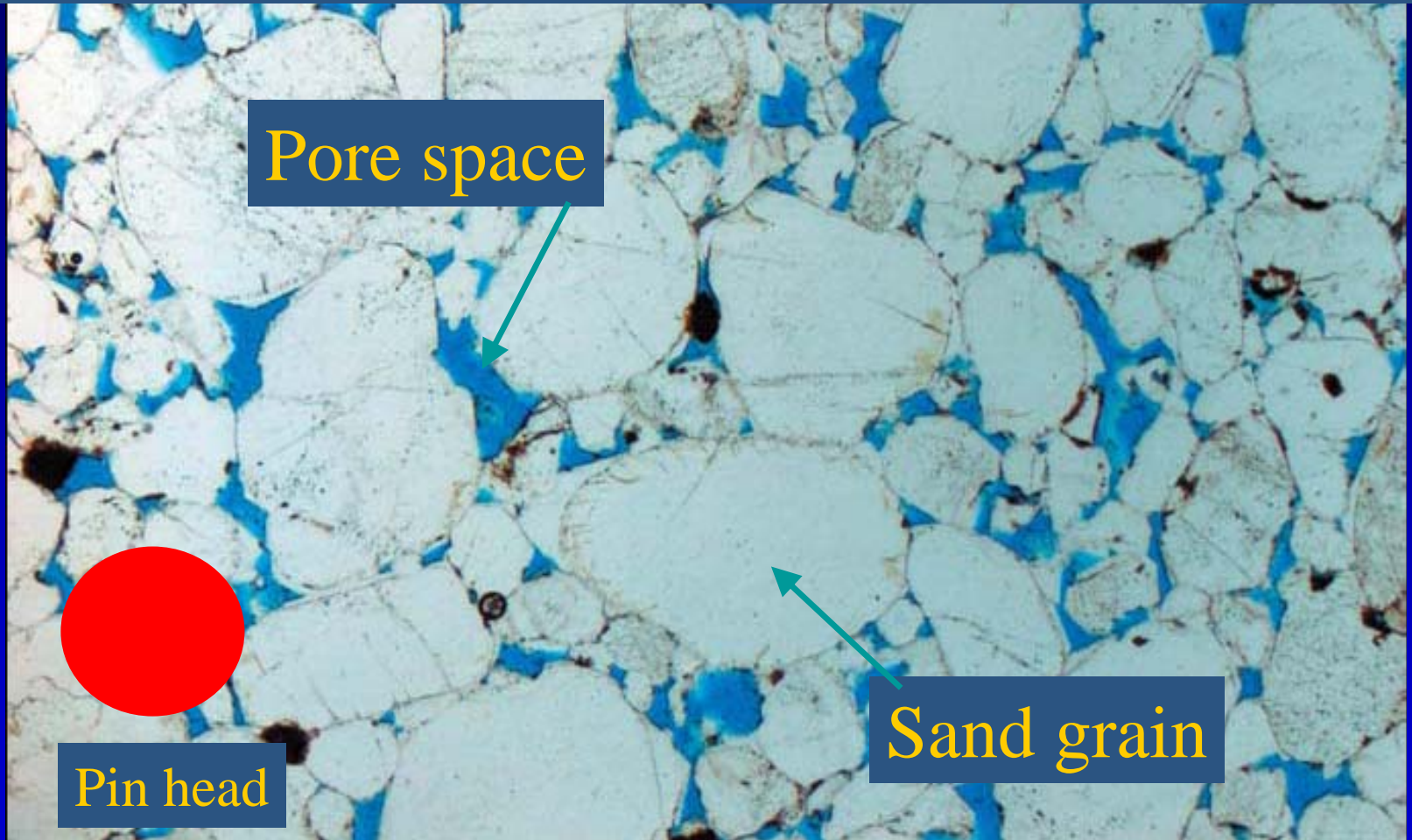
- Illinois Basin geology contains **multiple seals** for carbon dioxide (CO₂) above the Mt. Simon Sandstone
- **Monitoring** other sandstones above the Mt. Simon Sandstone can provide warning of any problems

Mt. Simon Sandstone Reservoir



- Mt. Simon Sandstone is used for natural gas storage in Champaign County, IL at 4,000 to 4,200 ft
- Mt. Simon core has been recovered from a few deep exploration wells, such as this sample from near Salem, IL at 8,467 drilled in 1966

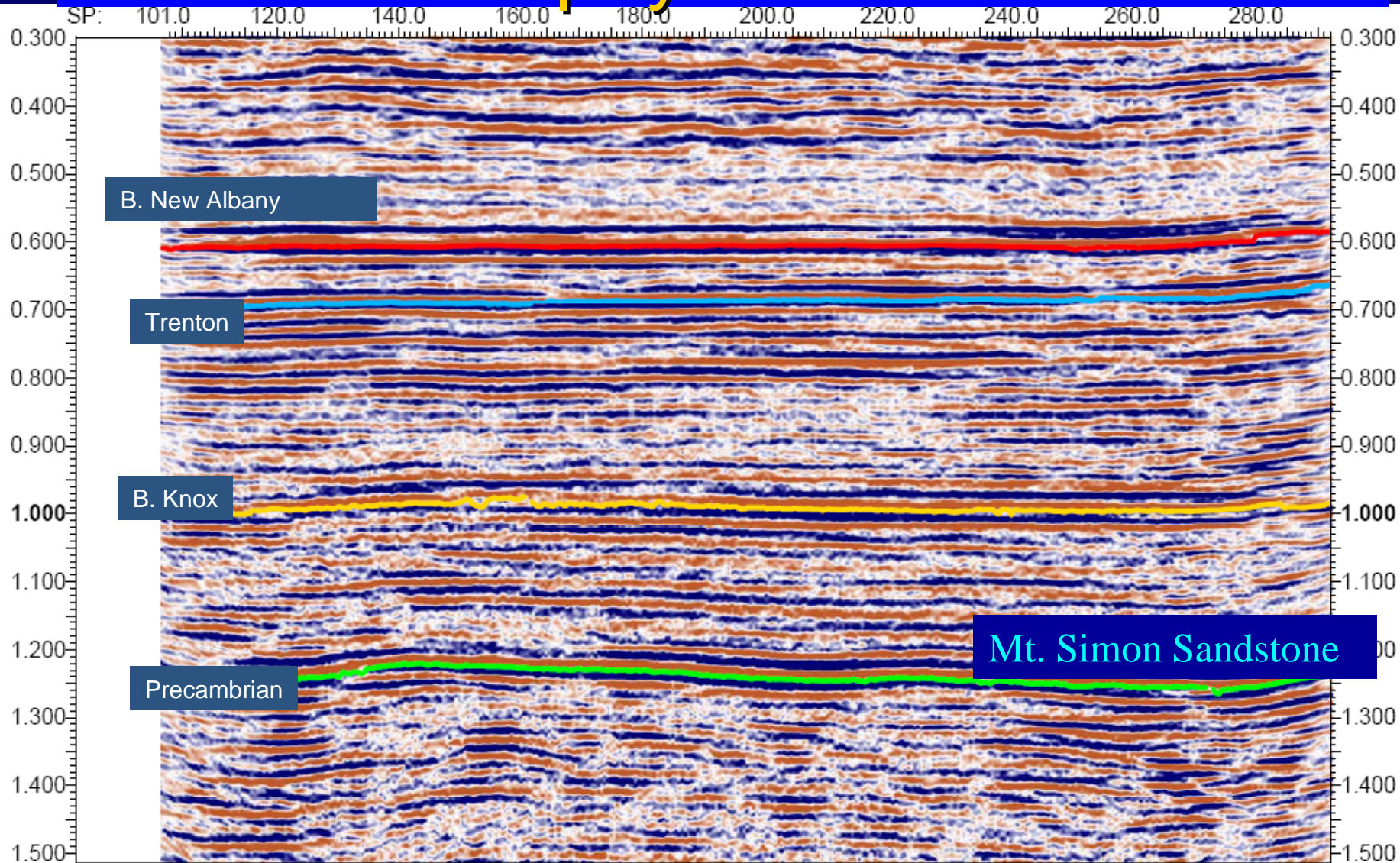
CO₂ Storage in Sandstone Reservoir Pore Space



VibroSeis Source Trucks

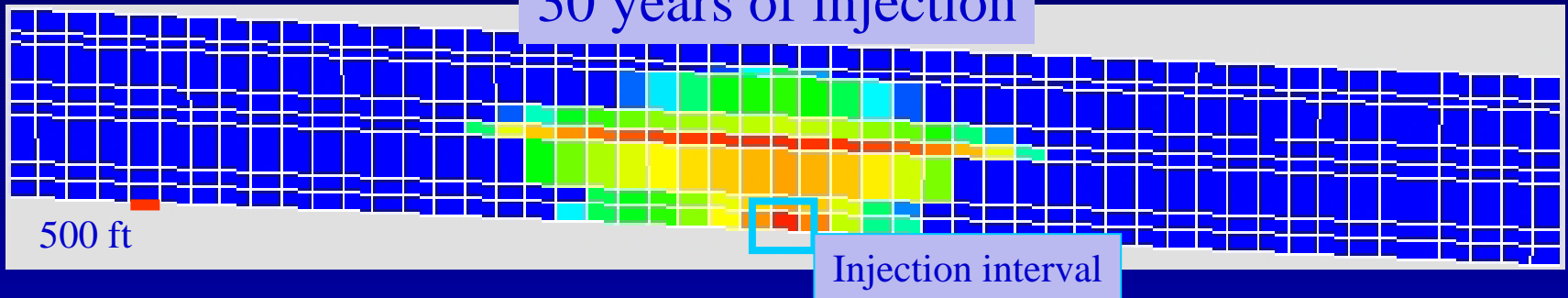


Mid-Illinois Basin 2D Geophysical Data

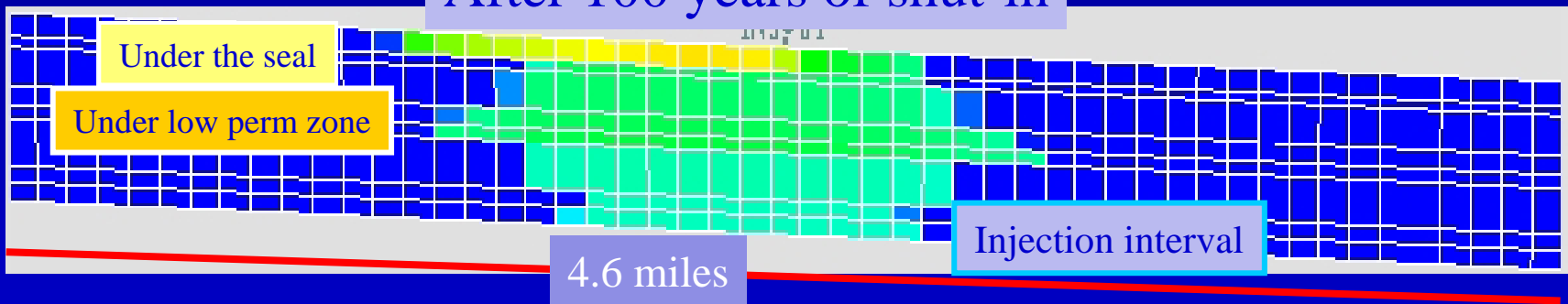


Injection into the Weaber-Horn 1 degree dipping beds

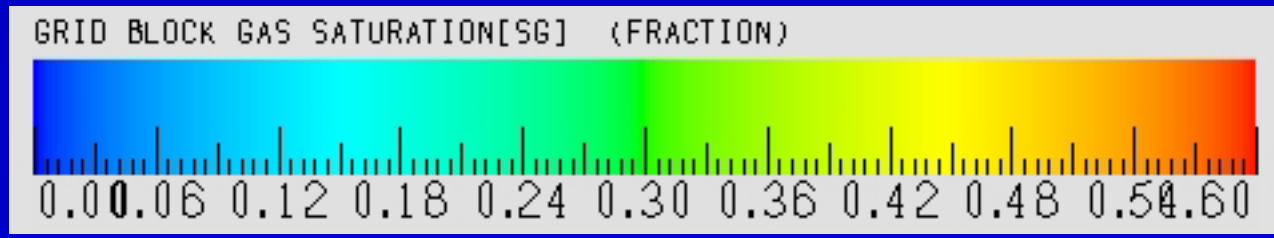
30 years of injection



After 100 years of shut-in



1 million tons/yr

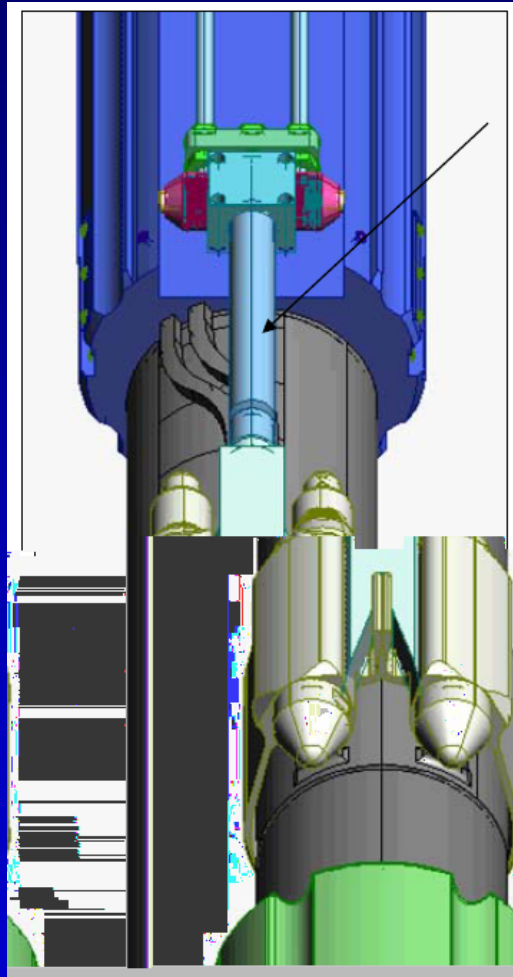


Midwest Geological Sequestration Consortium-Illinois State Geological Survey

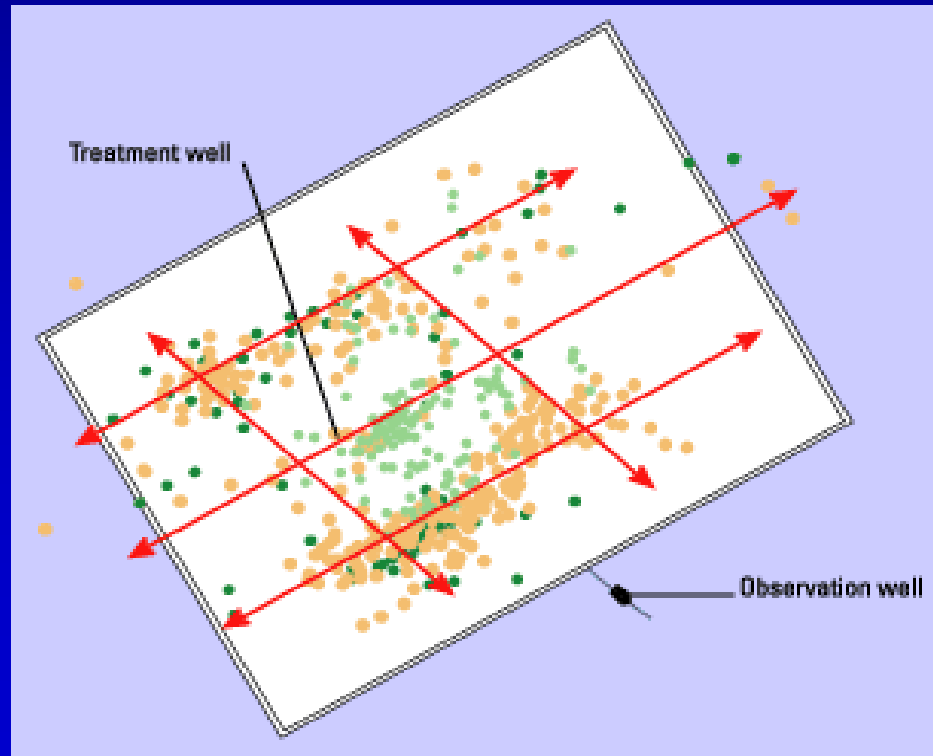
Sequestration Field Tests

- One single-well EOR test completed and reservoir simulation underway for second EOR, a five-spot pattern flood
- Coal seam injection test: two wells drilled, pressure transient testing completed, two more wells to be added to pattern
- Deep saline reservoir test site selected for 1 million ton test, 2D geophysics completed, well specs completed, baseline MMV to be initiated

Matrix Monitoring Strategies

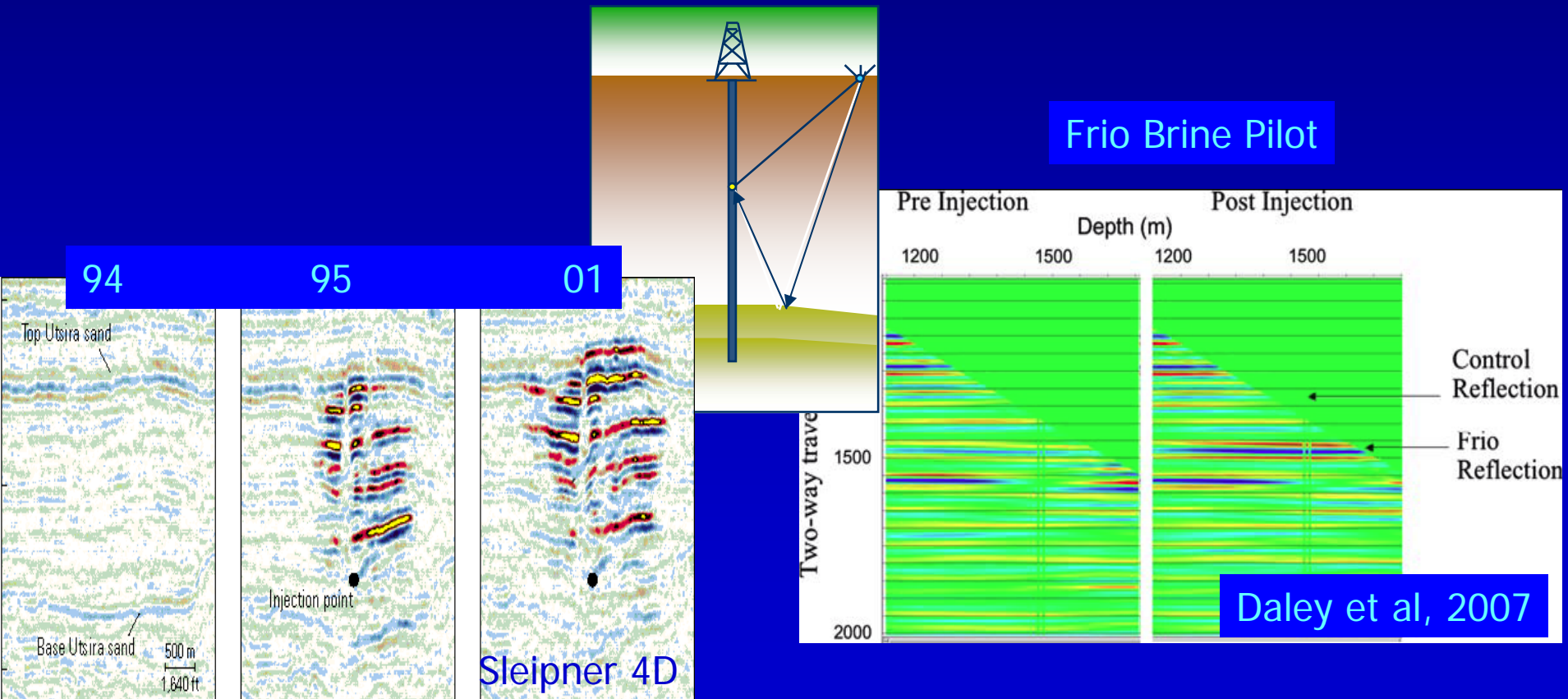


- Geophones run in on tubing, deployed to casing, avoids cement integrity problems, recoverable as needed
- Map any microseismic events monitored using clamped geophone array during active injection



Plume Monitoring Strategies

- Seismic response of plume based on repeat surface 3D (“4D”) similar to Sleipner project and offset or walkaway Vertical Seismic Profile (VSP) using geophone array



MMV in the Field

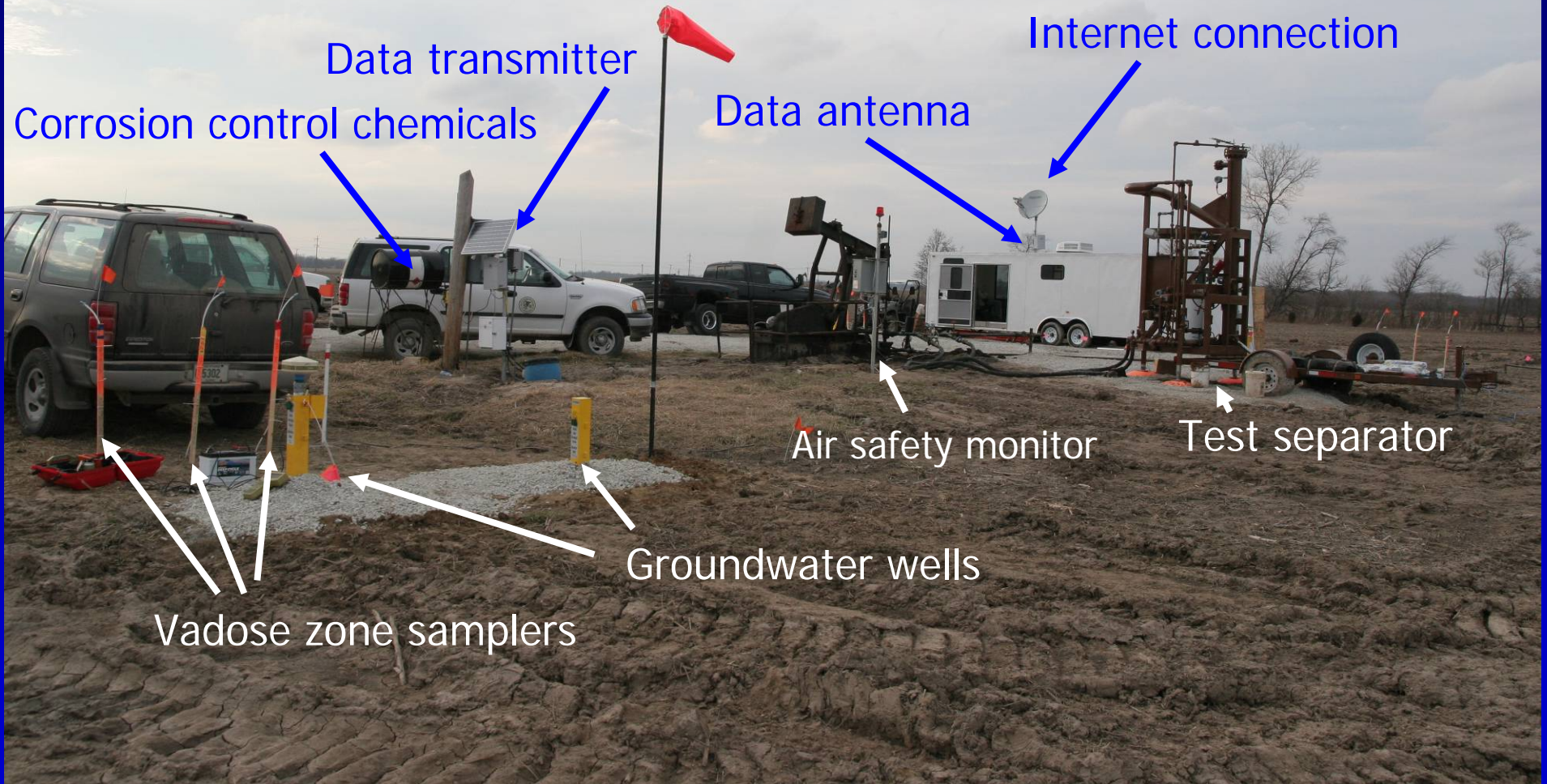
- Installing monitoring wells
- Installing vadose zone samplers
- Collecting background samples



Formation brine sampling

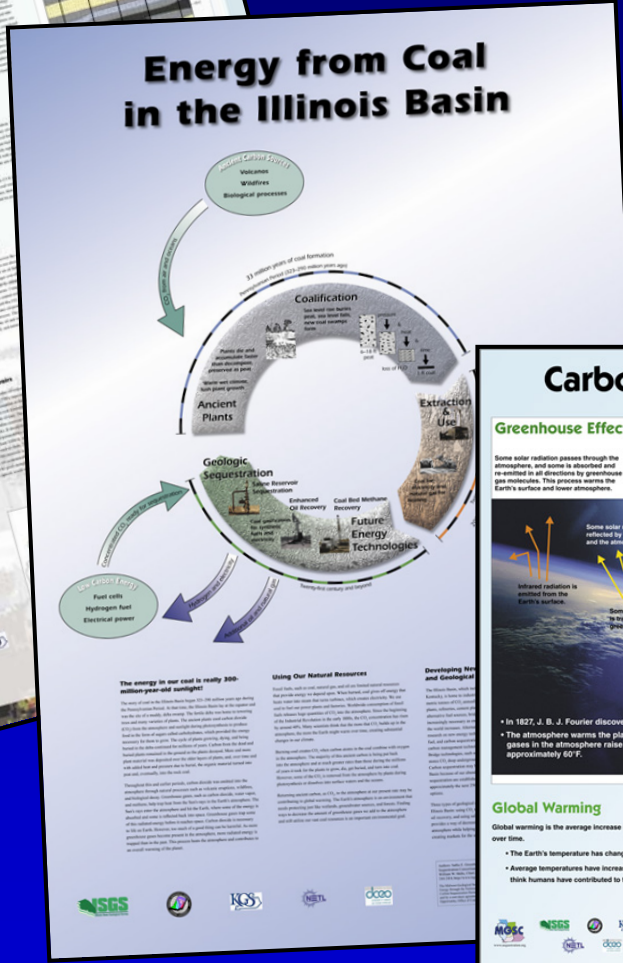
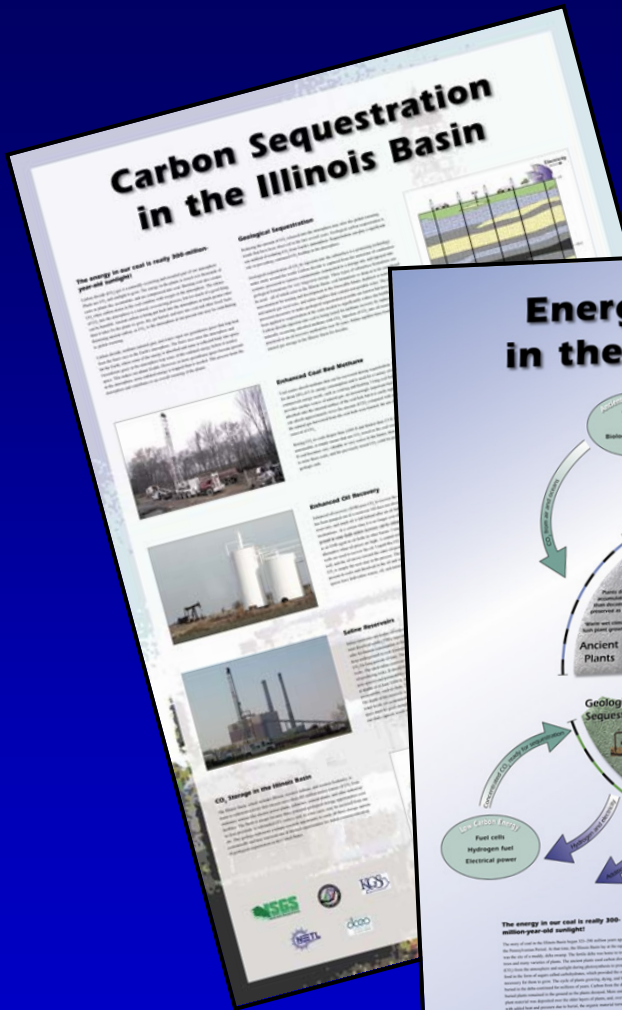


Single Well EOR Test Owens No. 1, Loudon Field



Poster Development

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



Carbon Capture and Sequestration: Bridging the Gap

Greenhouse Effect

Some solar radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. This process warms the Earth's surface and lower atmosphere.

Some solar radiation is reflected by the Earth and the atmosphere.

Solar radiation passes through the clear atmosphere.

The Earth absorbs most of the radiation, which warms the planet's surface.

Some radiation is trapped by greenhouse gases.

Infrared radiation is emitted from the Earth's surface.

In 1827, J. B. J. Fourier discovered the greenhouse effect.

The atmosphere warms the planet by trapping the Earth's heat. The gases in the atmosphere raise the average temperature approximately 60°F.

Figure modified from www.epa.gov

Common Greenhouse Gases

Carbon dioxide (CO₂)

- Emissions come from burning fossil fuels (oil, natural gas, and coal).

Methane (CH₄)

- Emissions come from landfills, rice paddies, livestock, organic waste such as sewage, and coal seams.

Nitrous oxide (N₂O)

- Emissions come from fertilized croplands and burning fossil fuels.

Water vapor (H₂O)

- Emissions come from natural sources, industrial processes, and transportation.

Carbon Sequestration

Carbon sequestration is the capture of carbon dioxide from point sources before the gas enters the atmosphere. Reducing the amount of CO₂, a greenhouse gas, emitted into the atmosphere may help slow global warming.

Sequestration options:

- Geologic sequestration stores carbon underground in coal seams, saline aquifers, or oil reservoirs.
- Terrestrial sequestration stores carbon in soils, crops, or other plants.
- Oceanic sequestration stores carbon at the bottom of the ocean.

The Illinois Basin is a good place for geologic sequestration:

- The Basin offers long-term storage deep in the Earth.
- Side benefits may include enhanced recovery from oil reservoirs and methane from coal seams.

Logos: NCS, IANIGLA, dcoo

Global Warming

Global warming is the average increase in the Earth's temperature over time.

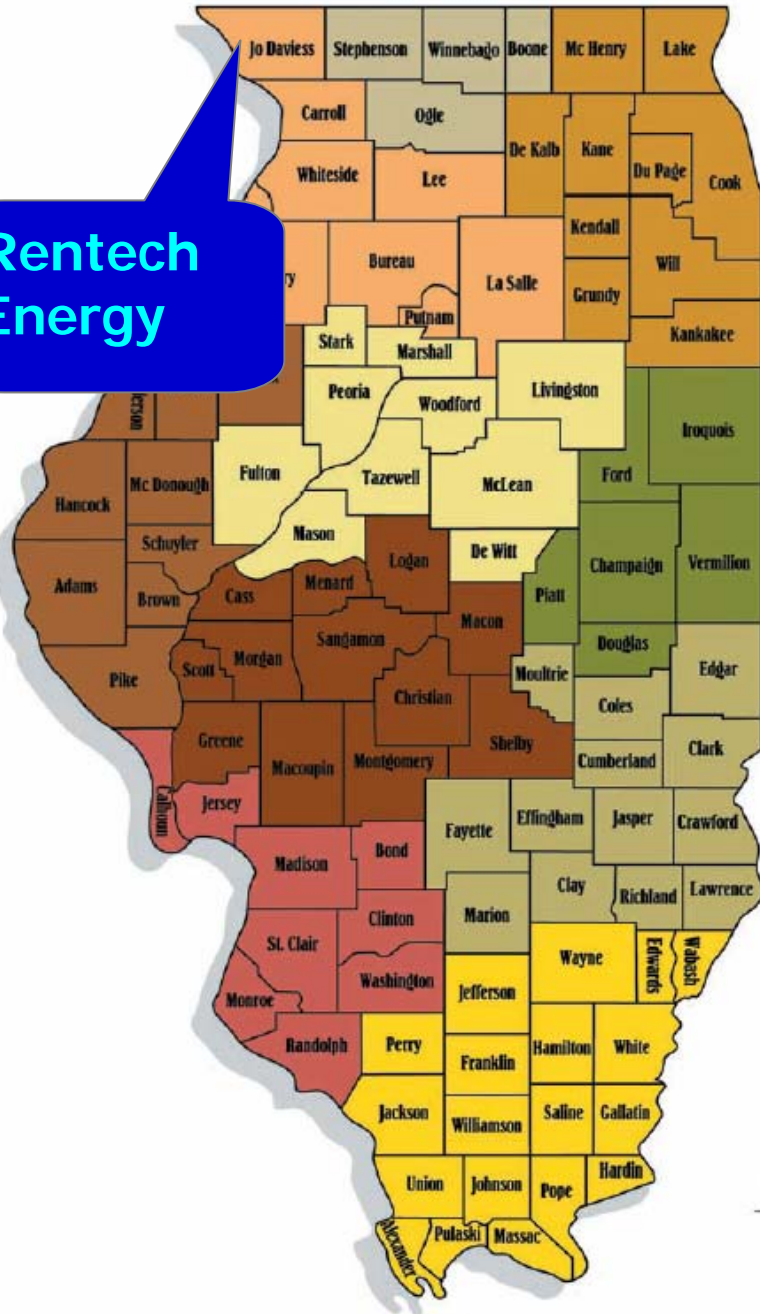
- The Earth's temperature has changed over geologic history.
- Average temperatures have increased 1°F over the past century. Leading scientists think humans have contributed to this increase in emission of greenhouse gases.

Logos: NCS, IANIGLA, dcoo

Multiple New Coal Gasification Projects In Progress to Use Illinois Coal

Rentech Energy

- Rentech Energy Midwest converting gas-fired ammonia plant to coal
- Will produce 920 tons ammonia fertilizer, 1,800 bbls F-T liquids and 76 Mw to grid daily
- Will use ConocoPhillips E-Gas technology and proprietary F-T coal-to-liquids technology
- \$700 million project



Multiple New Coal Gasification Projects In Progress to Use Illinois Coal

- ERORA Group and Tenaska, Inc. developing a 770 Mw (gross) IGCC facility
- Will use 1.8 million tons of coal annually
- Project cost: \$1.1 billion
- GE gasification technology
- Online in 2012



The image shows a map of Illinois divided into its 102 counties. A blue callout box with a white border and a blue arrow points to the county of Madison. The text inside the box is 'ERORA-Tenaska' in white, bold, sans-serif font. The map uses a color gradient from light yellow in the north to dark red in the south, with various shades of orange, brown, and green in between. County names are printed in black on each county.

ERORA-Tenaska

Multiple New Coal Gasification Projects In Progress to Use Illinois Coal

- Power Holdings LLC developing a 50 bcf/yr synthetic natural gas facility
- Will use ~4 million tons coal per year (new mine) with GE gasification technology
- \$1.3 billion project
- Gas output 100% subscribed under 20-year contracts
- ~17,000 tons/day CO₂ available



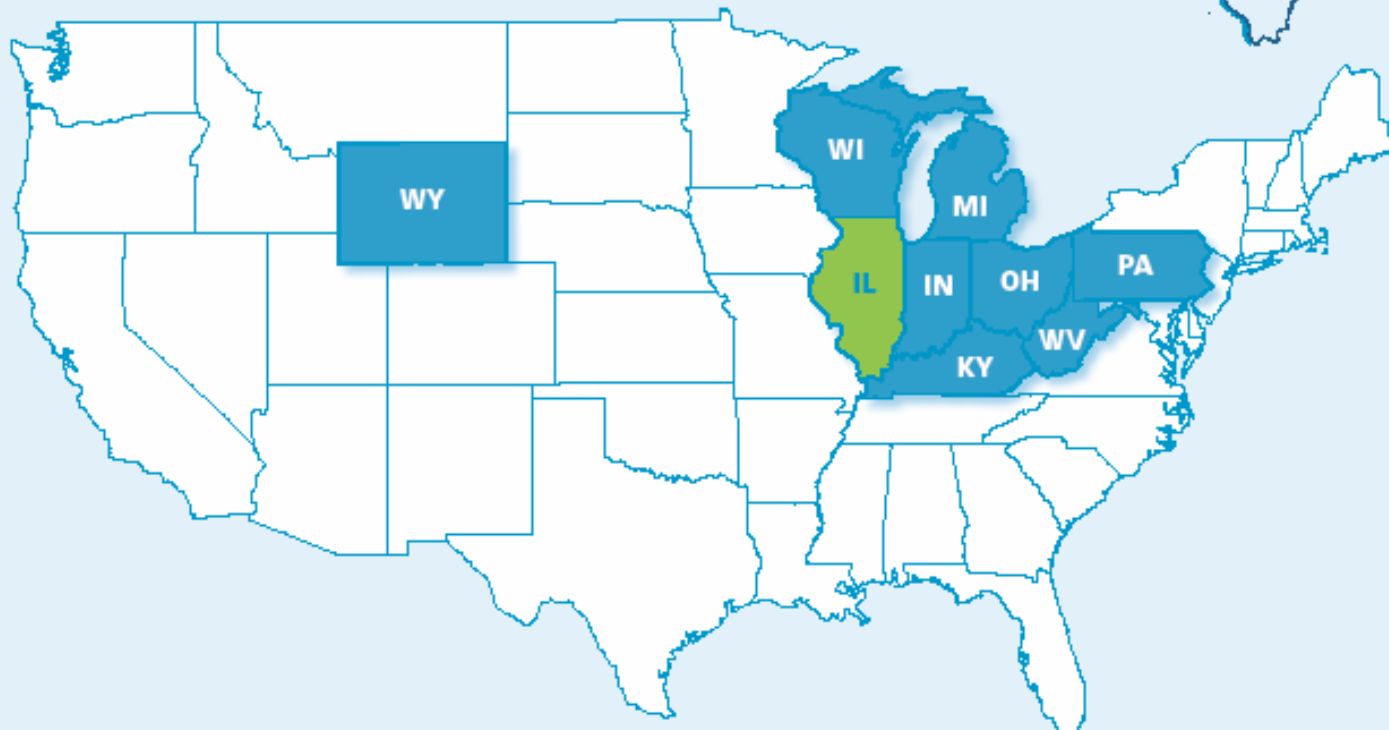
A map of Illinois showing its 102 counties. A blue callout box with a white border and a pointer is located in the bottom-left corner, pointing to the Perry county area. The callout box contains the text 'Power Holdings' in white. The map itself is color-coded by county, with various shades of brown, orange, yellow, and green.

Power Holdings

Illinois Seeking FutureGen and Facilitating IGCC, Carbon Sequestration, and CO₂ EOR

- Illinois Office of Coal Development leading Illinois' FutureGen team; eight states formally endorse Illinois sites
- IL SB 1704 provides liability protection for the Alliance and establishes monitoring responsibility at ISGS
- Illinois Office of Coal Development supporting IGCC projects with grants, bonding, and cofunding Midwest Geological Sequestration Consortium, a DOE regional sequestration partnership
- Illinois working across state agencies to attract more IGCC projects that use abundant Illinois coal and are optimized for carbon sequestration
- Illinois seeking public-private partnership to develop a CO₂ pipeline backbone to deliver CO₂ from these projects to Illinois oil fields

FutureGen for Illinois Coalition



COALITION SUPPORT

Indiana	Pennsylvania
Kentucky	Wisconsin
Michigan	West Virginia
Ohio	Wyoming



U.S. COAL PRODUCTION

More than 3/4 of U.S. coal production comes from the 9 states in the Illinois Coalition



U.S. COAL-FIRED ELECTRICITY

More than 40% of coal-fired electricity is produced from the 9 states in the Illinois Coalition

SOURCE: Energy Information Administration, Official Energy Statistics from the U.S. Government, 2006 Data



U.S. COAL RESERVES

The states in the Illinois Coalition are home to 59% of U.S. coal reserves, while just 2.5% of coal reserves are in Texas.



www.futuregenforillinois.com



www.isgs.uiuc.edu



www.sequestration.org