

CO₂ Injection into Illinois Coals

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Outline

- Illinois Basin Geology and Site Selection
- DOE Phase II CO₂ Injection Plans
- CO₂ Injection COMET3 Modeling for Well Spacing Design

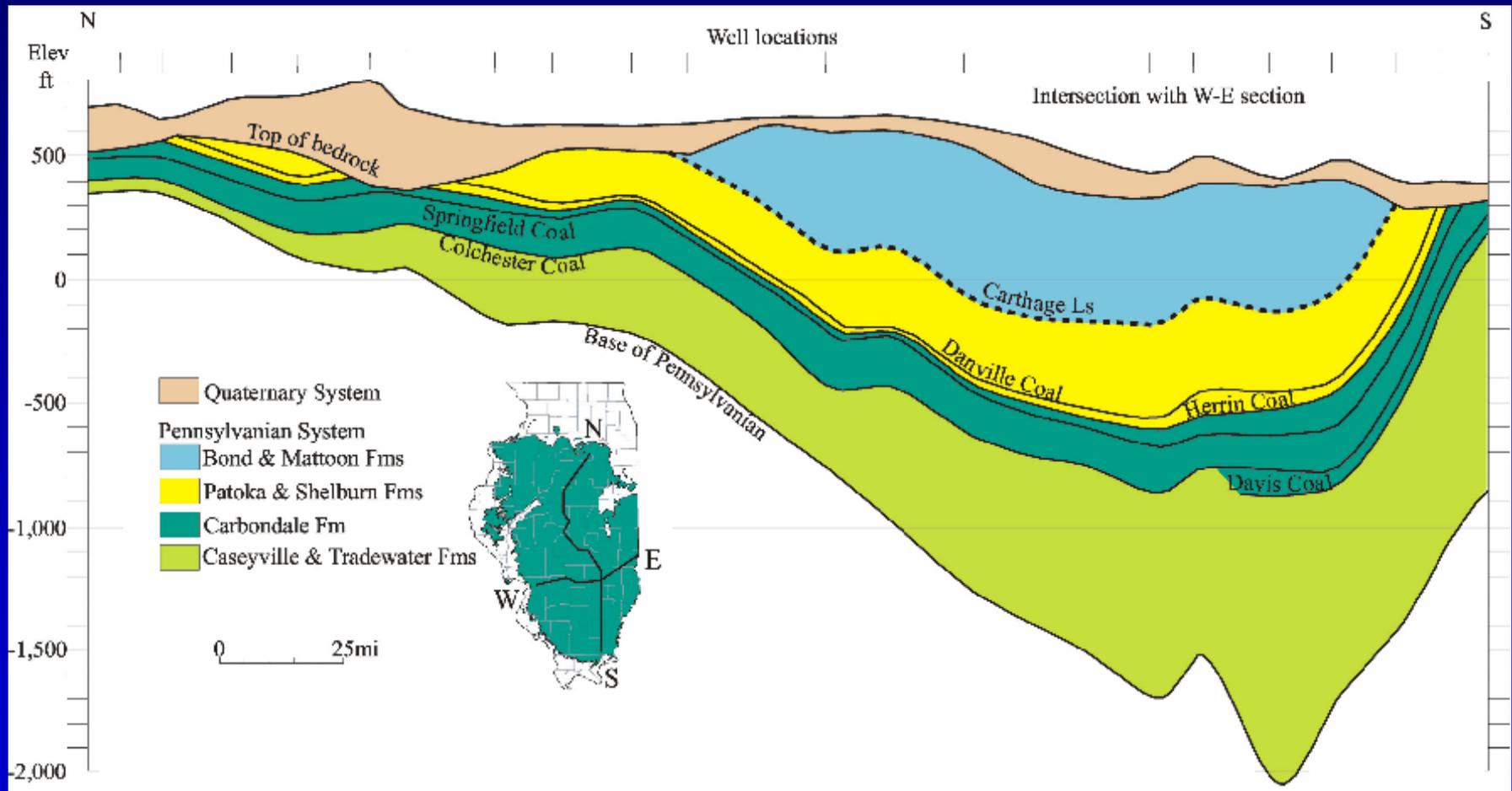
Illinois Basin Geology

How much coal?

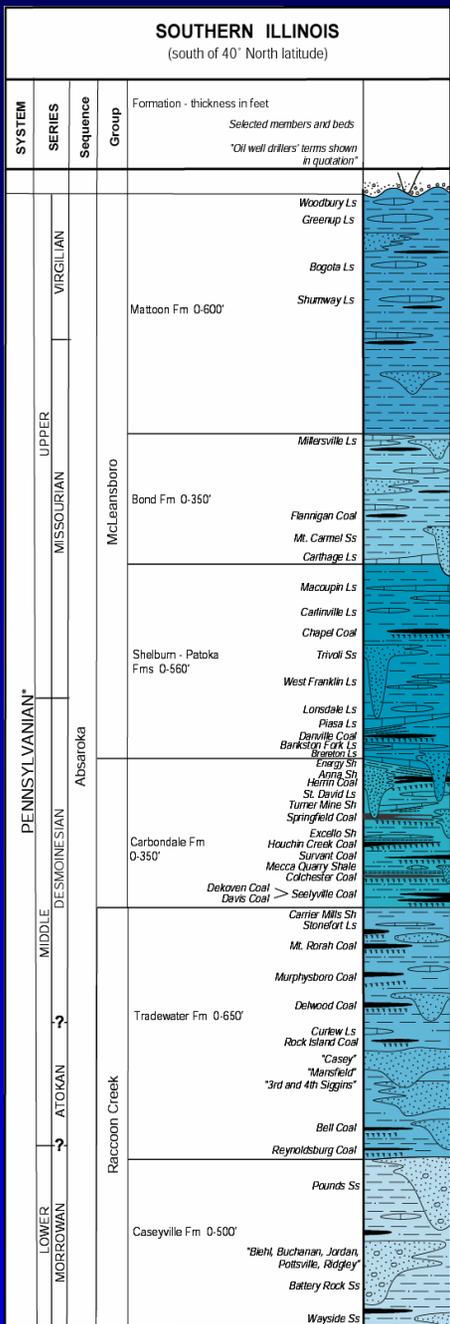


- Illinois 211 billion tons
- Indiana 59 billion tons
- W KY 39 billion tons
- IL Basin 309 billion tons, the largest bituminous coal reserve in the Nation

N-S Cross Section of Coal-bearing Strata in Illinois



By Christopher Korose, Jamie McBeth, and Colin Treworgy, ISGS

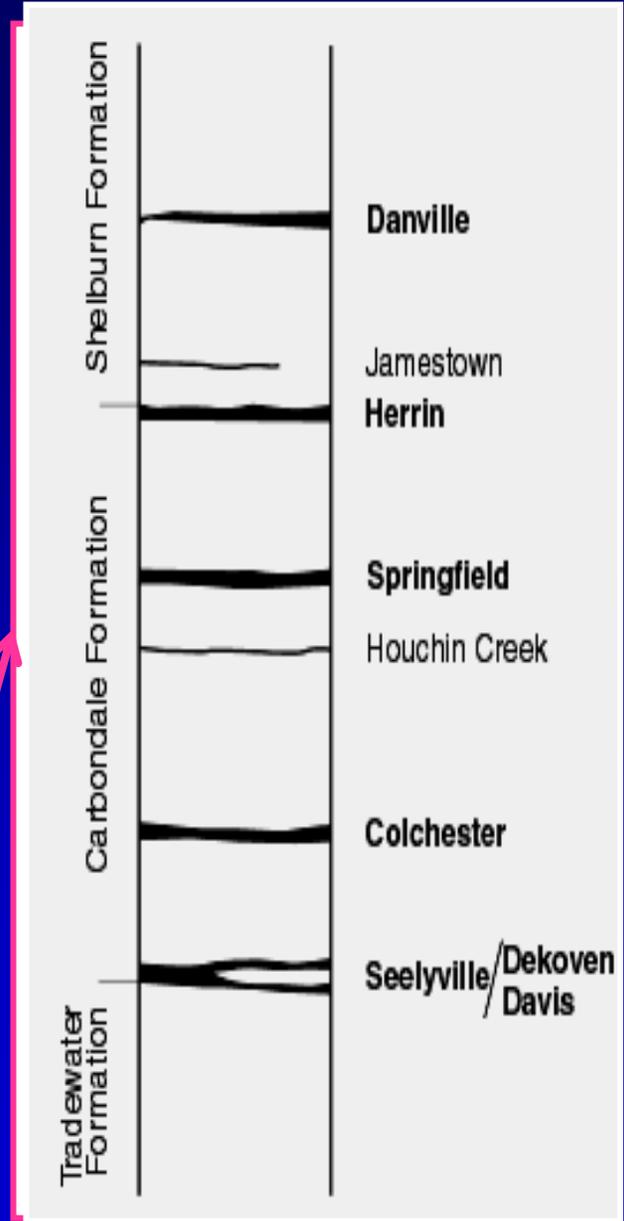


Illinois Pennsylvanian Rocks

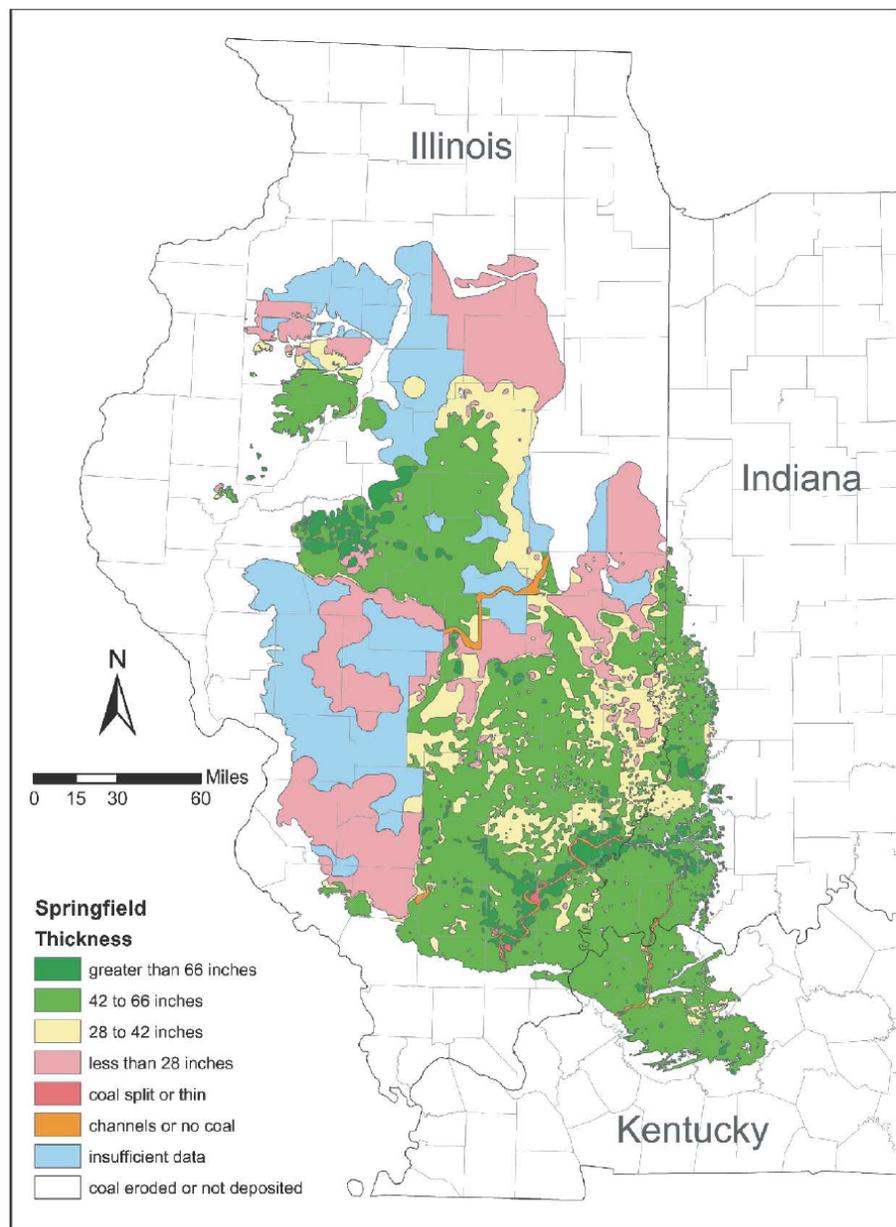
Shale Seals
Throughout

Principal
Coal
Gas
Targets

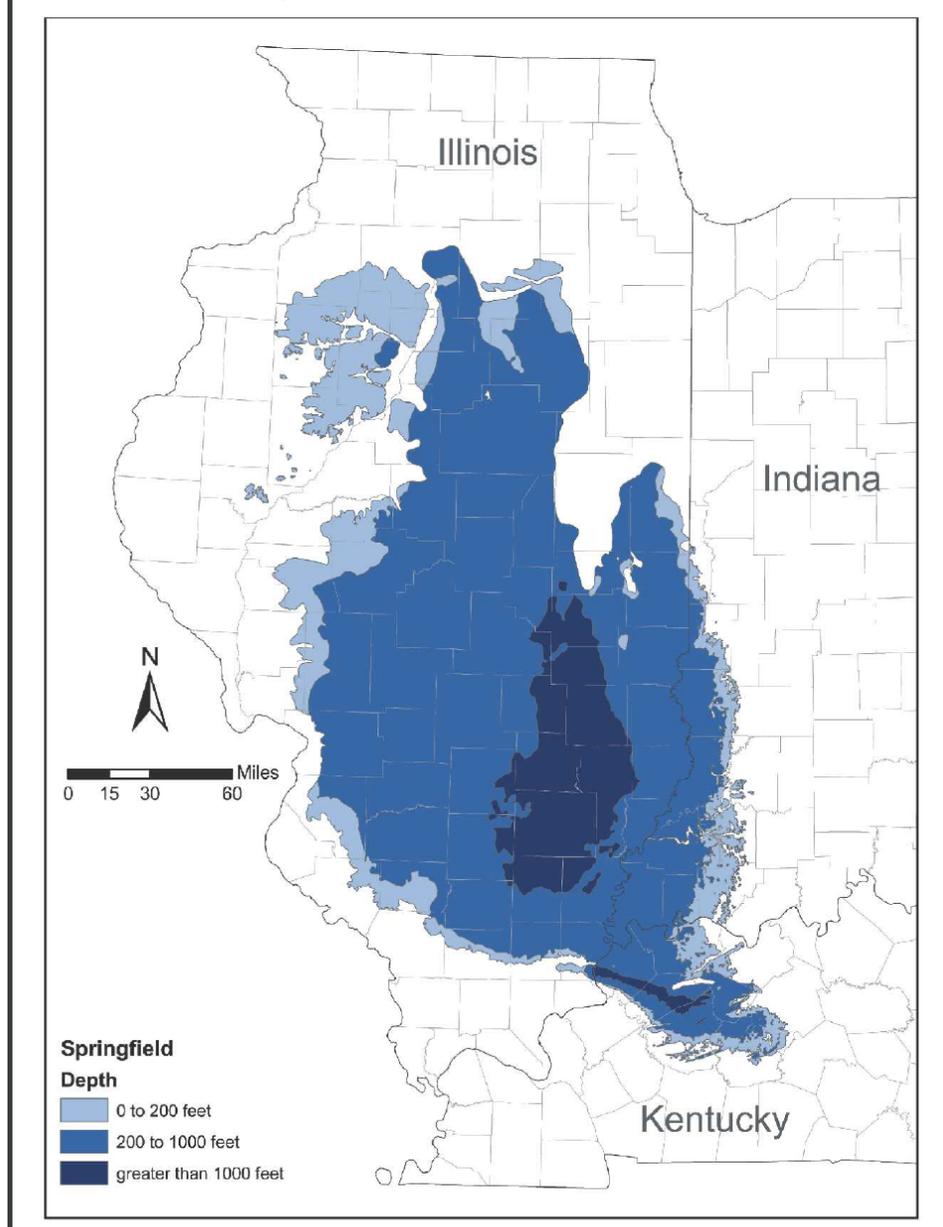
Major Coal
Gas/CO₂ Injection
Targets



Thickness of the Springfield Coal



Depth of the Springfield Coal



Coalbed Methane Site Selection

- Defining ideal target coal as > 1000 ft depth
- COMET modeling to define
 - Well spacing
 - Surface injection equipment specifications
 - On-site storage
 - Injection volume
 - Injection rate and duration

CO₂ Injection into One Coal

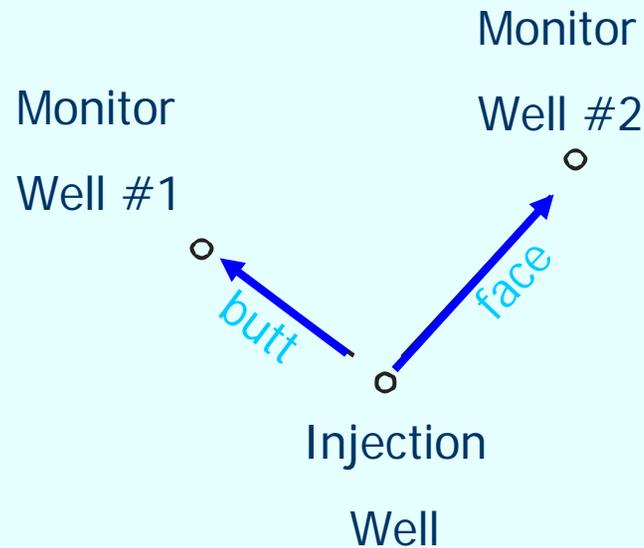
Purpose: To determine the CO₂ injection and storage capability, and the ECBM recovery potential of Illinois Basin coal

- Water Injection PT Test
- Small Nitrogen Injection Test
- Small CO₂ Injection Test
- 30-Day CO₂ Test- Injection of up to 700 tons of CO₂ with 60 day soak

Coal Injection Test Design

Coal Data Before Injection:

- Geology and Logs
- Desorption
- Adsorption
- Coal Gas Chem



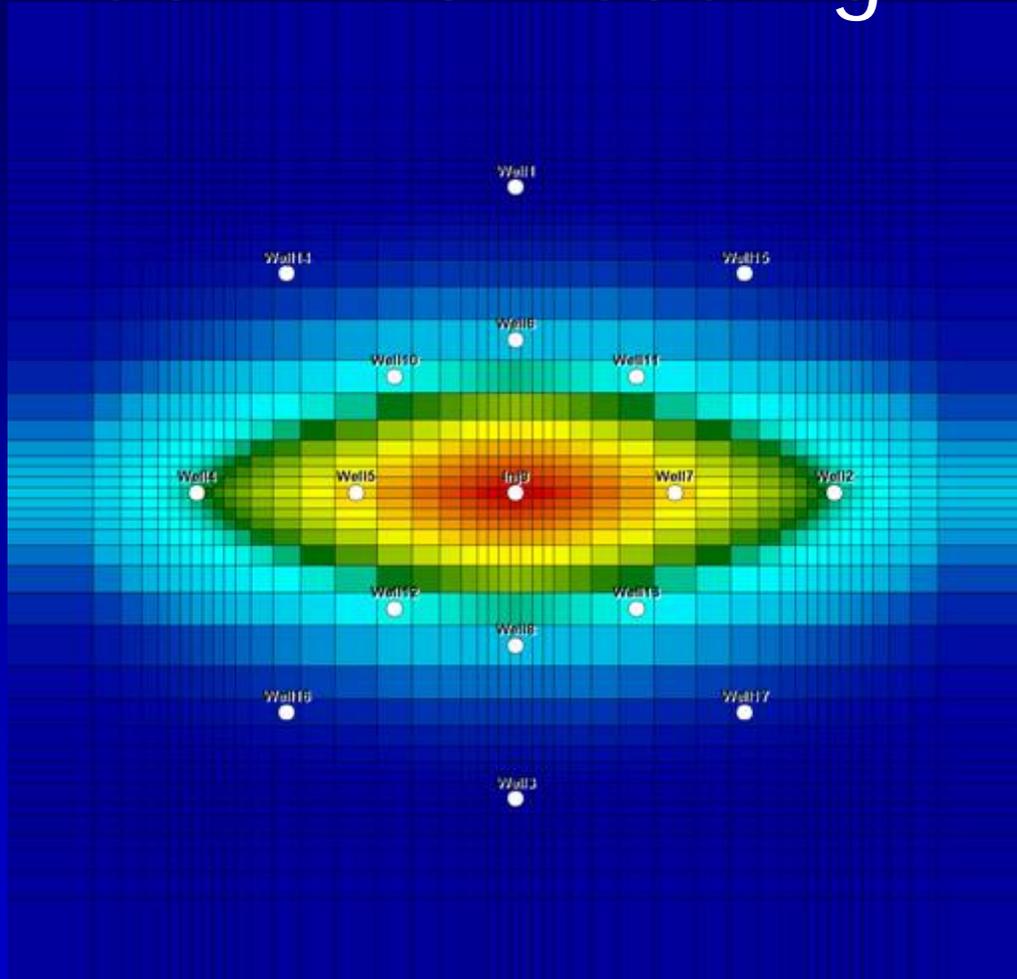
600-700 Ton CO₂ Injection

- Measure Pressure Transients to Calculate Changes in Permeability
- Measure Injected and Recovered Gas Volumes and Pressures
- Measure Recovered Gas Chemistry

MMV Program:

- soil (vadose) gas
- Groundwater gas
- Atmospheric gas
- Pressure and fluid analyses in two deep observation wells
- Hi-Res Air Photos

COMET 3 Modeling



COMET Modeling Study to Determine Well Spacing for ECBM Pilot:

Well spacing criteria:

- quantifiable response at observation/production wells:
 - within 30 days
 - pressure: 1.0 psi; gas saturation: 10%
- observation wells oriented orthogonal to CO₂ injector
 - observation wells equidistant from injector
 - relatively close spacing to ensure response
- cleat orientation:
 - Face = x direction
 - Butt = y direction

Pilot:

- 1 injector, 2 observation/production wells

COMET Modeling Study to Determine Well Spacing for ECBM Pilot:

Reservoir model:

- Area: ~ 21 acres
- Grid: single layer (Herrin coal, 4.0'), hybrid grid
- Infinite flow boundary at outer edge of model.
- Wells:
 - 16 observation/production with 150' and 300' spacing
 - observation/production wells oriented along x and y axis and 45° diagonal

Reservoir Parameters:

- Most likely values obtained from DST, core data from recently tested area wells, and regional data
- Data is extracted from raw COMET output using a data parsing program written at ISGS for graphic presentation and continuous data analysis

COMET Modeling Study to Determine Well Spacing for ECBM Pilot:

Variables in study:

matrix & pore compressibility, cleat spacing, initial gas concentration, stress dependent permeability, porosity, skin, matrix swelling, CH₄ & CO₂ sorption time, differential permeability (K_x/K_y) = {2-8}, CH₄ Langmuir constants, and relative permeability.

Tested 36 scenarios revolving around our most likely values

Total gas saturation recorded for:

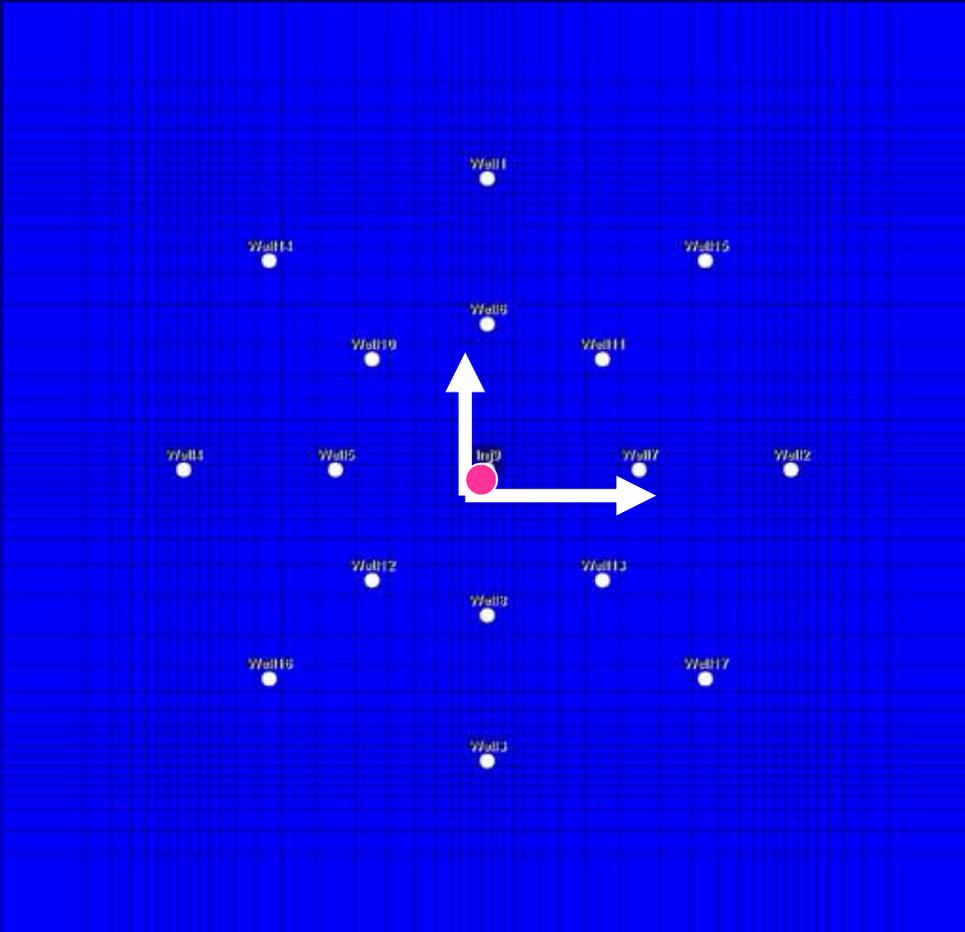
- 150' wells: x, y, 45 degree diagonal
- 300' wells: x, y, 45 degree diagonal

Breakthrough was defined at total gas saturation equal to 1, 10, and 25%.

Sensitivity Study Example: K differential = 8

- Plotted Parameter: total gas saturation in cleats
- Methane Langmuir Constants: $V_L = 12.86$ scf, $P_L = 513.6$ psia
- Initial gas content = $(G_c)_{ini} = 2.94$ scf/cu ft (undersaturated)
- Radial Equivalent Permeability = 50 md
- $K_x/K_y=8$; $K_x= 141.4$ md, $K_y= 17.7$ md

Modeled Area

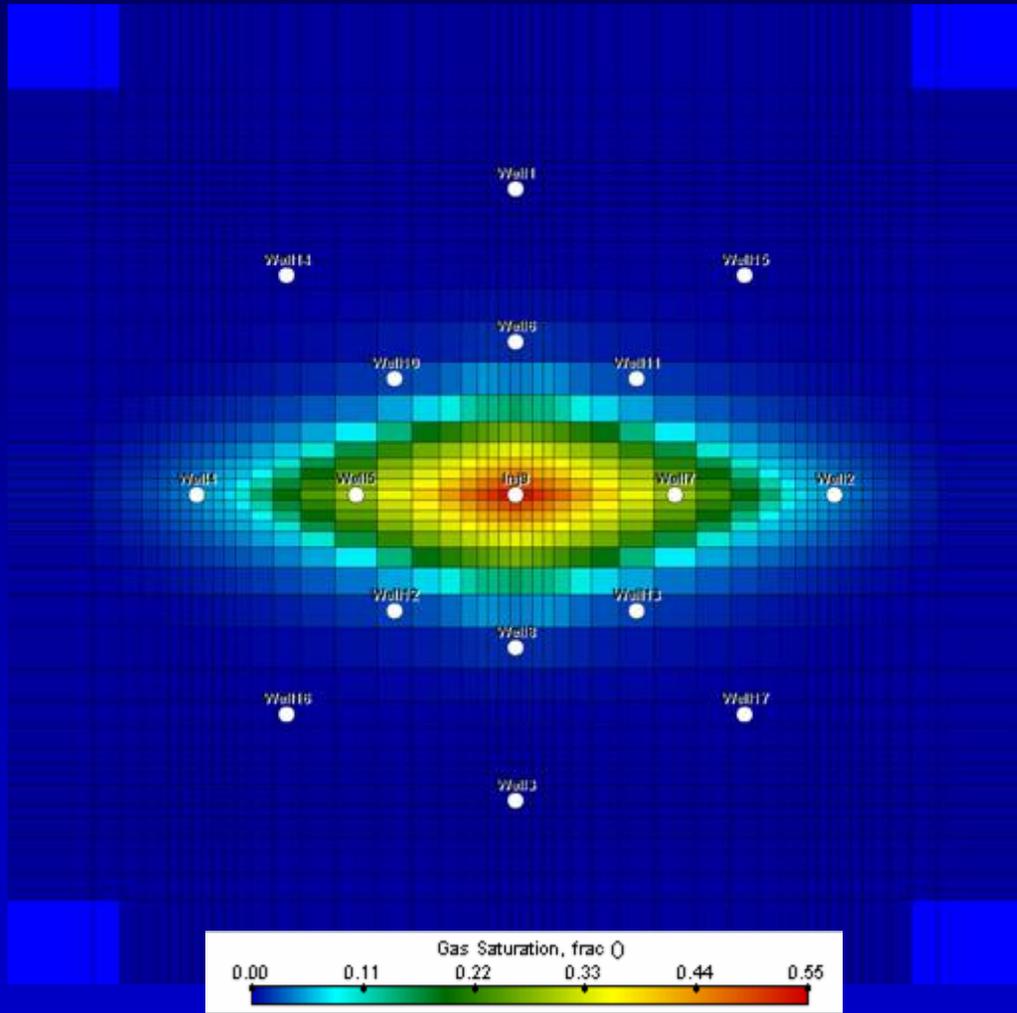


16 observation/
production wells
surrounding central
injector 150 ft & 300 ft
from injector

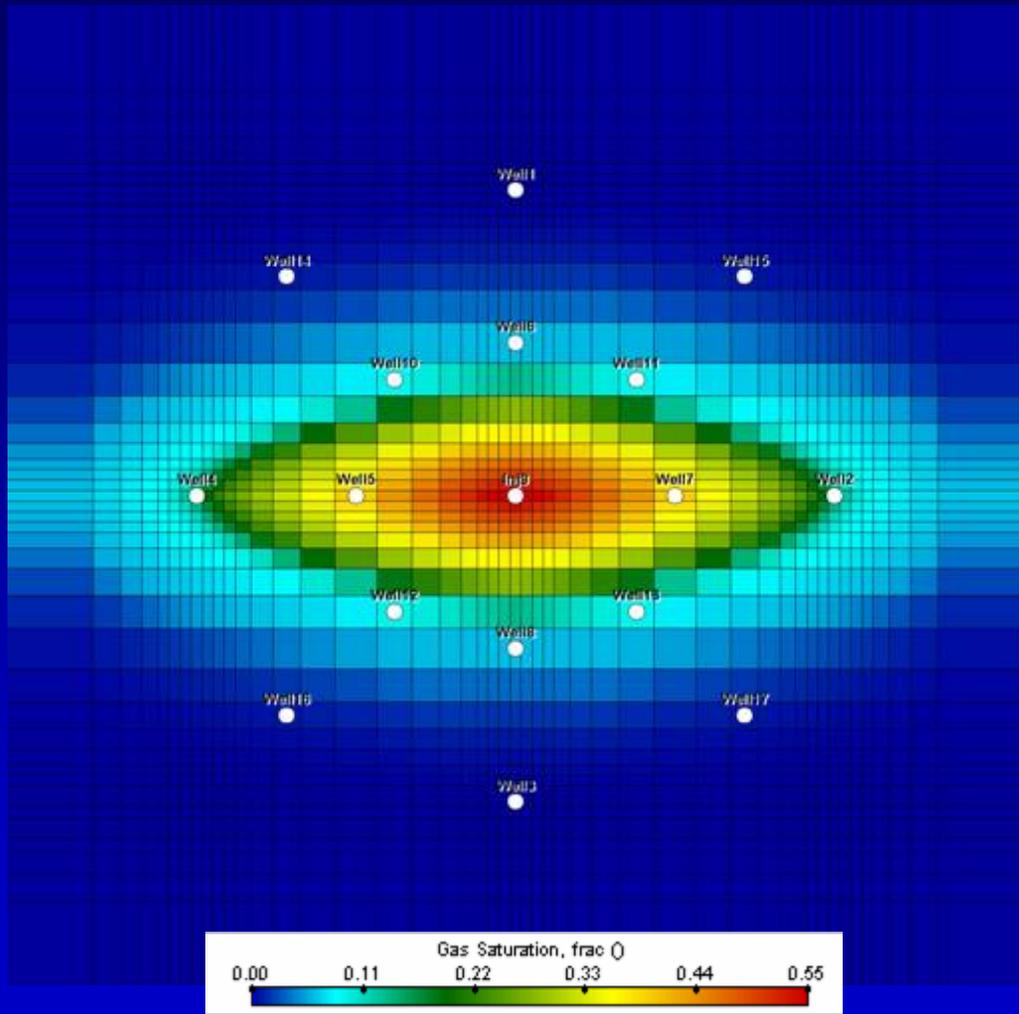
-X-dir (high k) = face cleat
-Y-dir (low k) = butt cleat

Time = 0 days

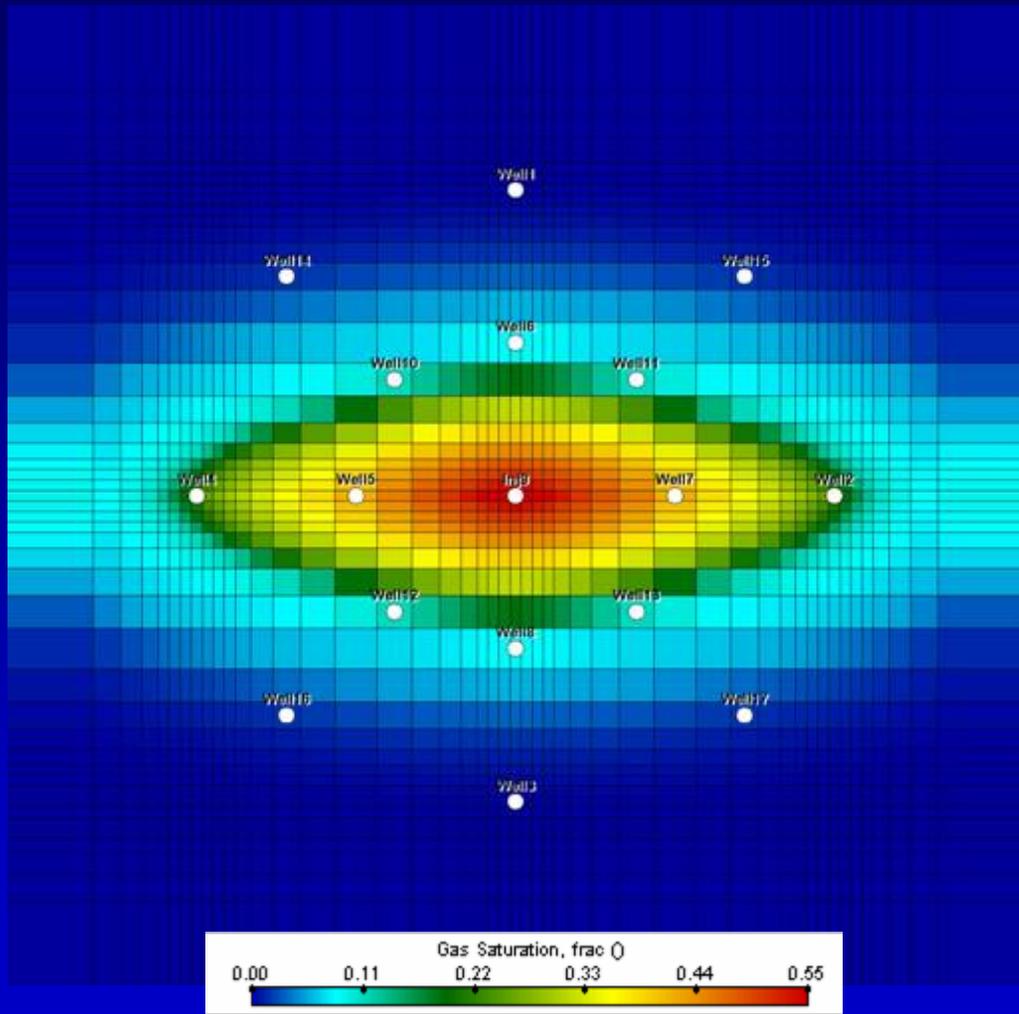
Total Gas Saturation in Cleat System



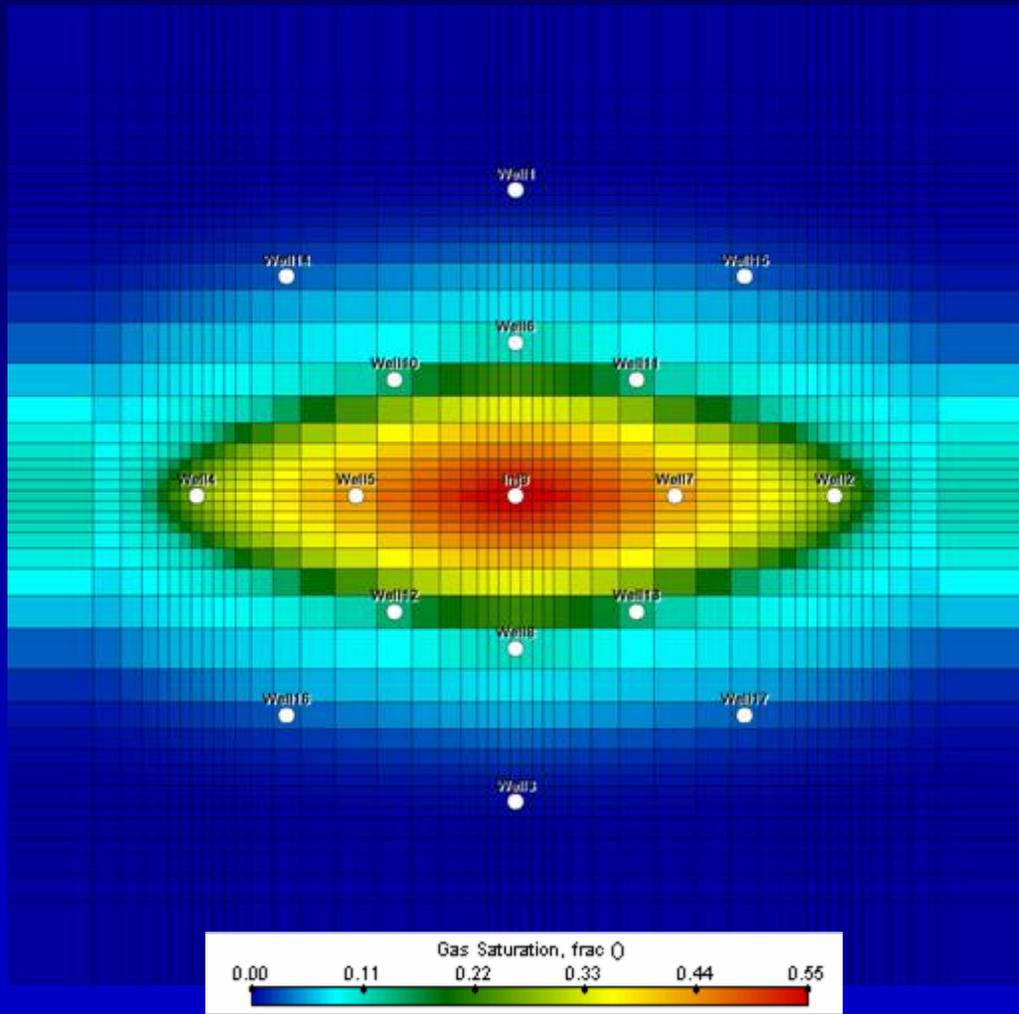
$t = 5$ days



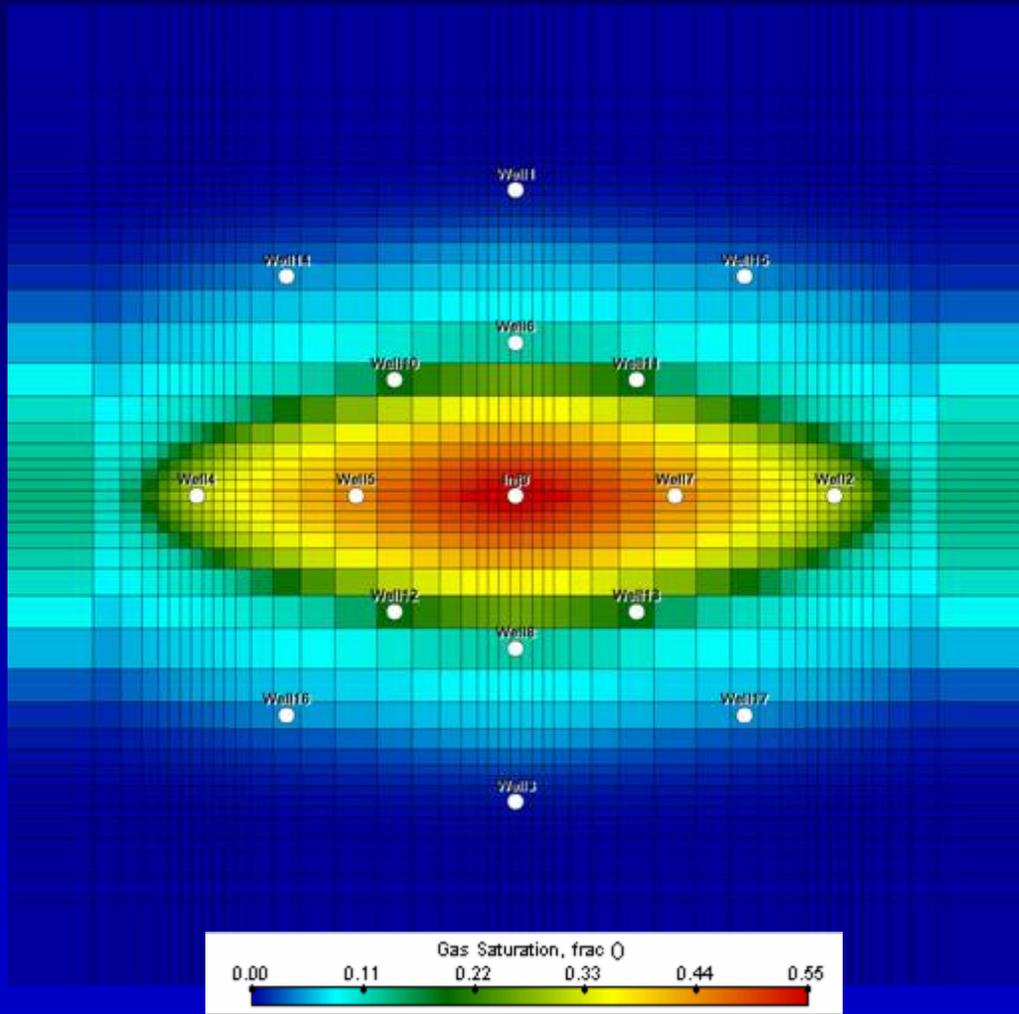
$t = 15$ days



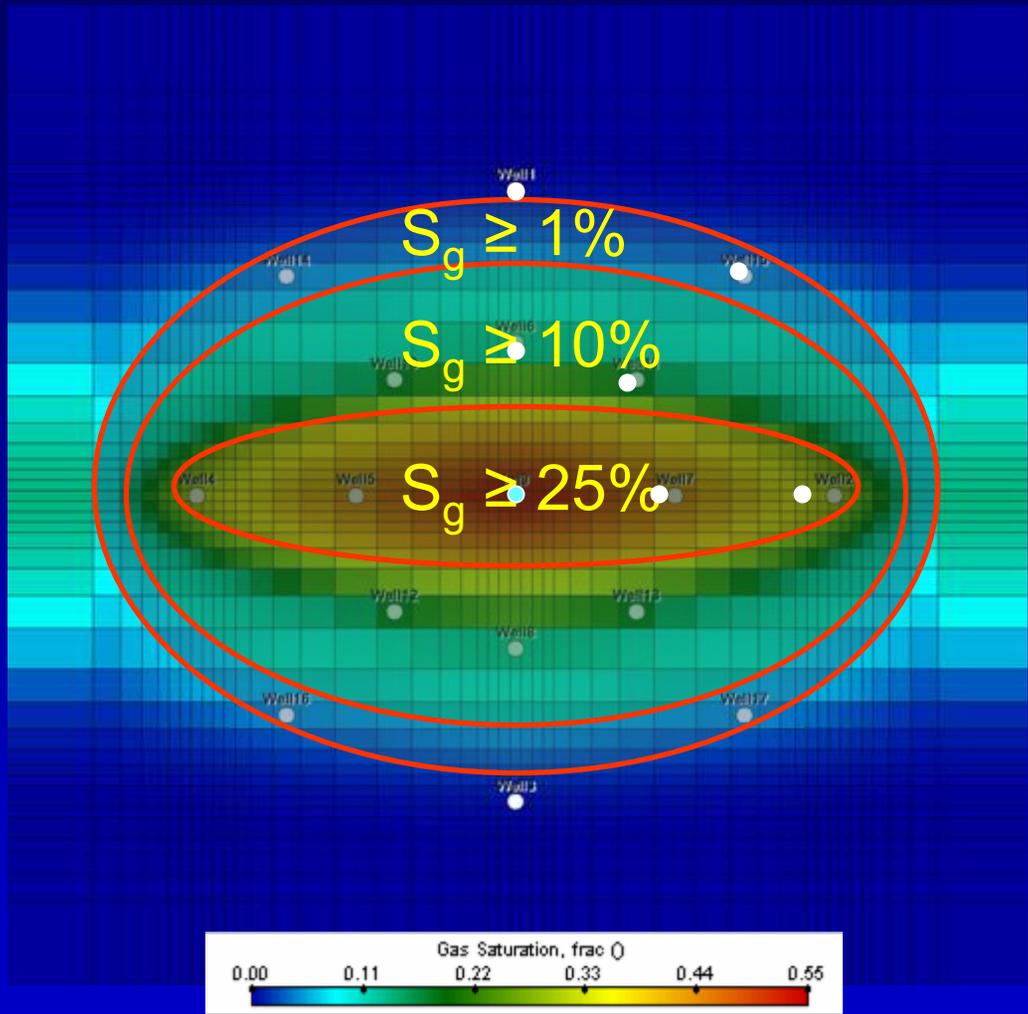
t = 20 days



t = 25 days



$t = 30$ days



$t = 30$ days

ECBM Pilot Conclusions:

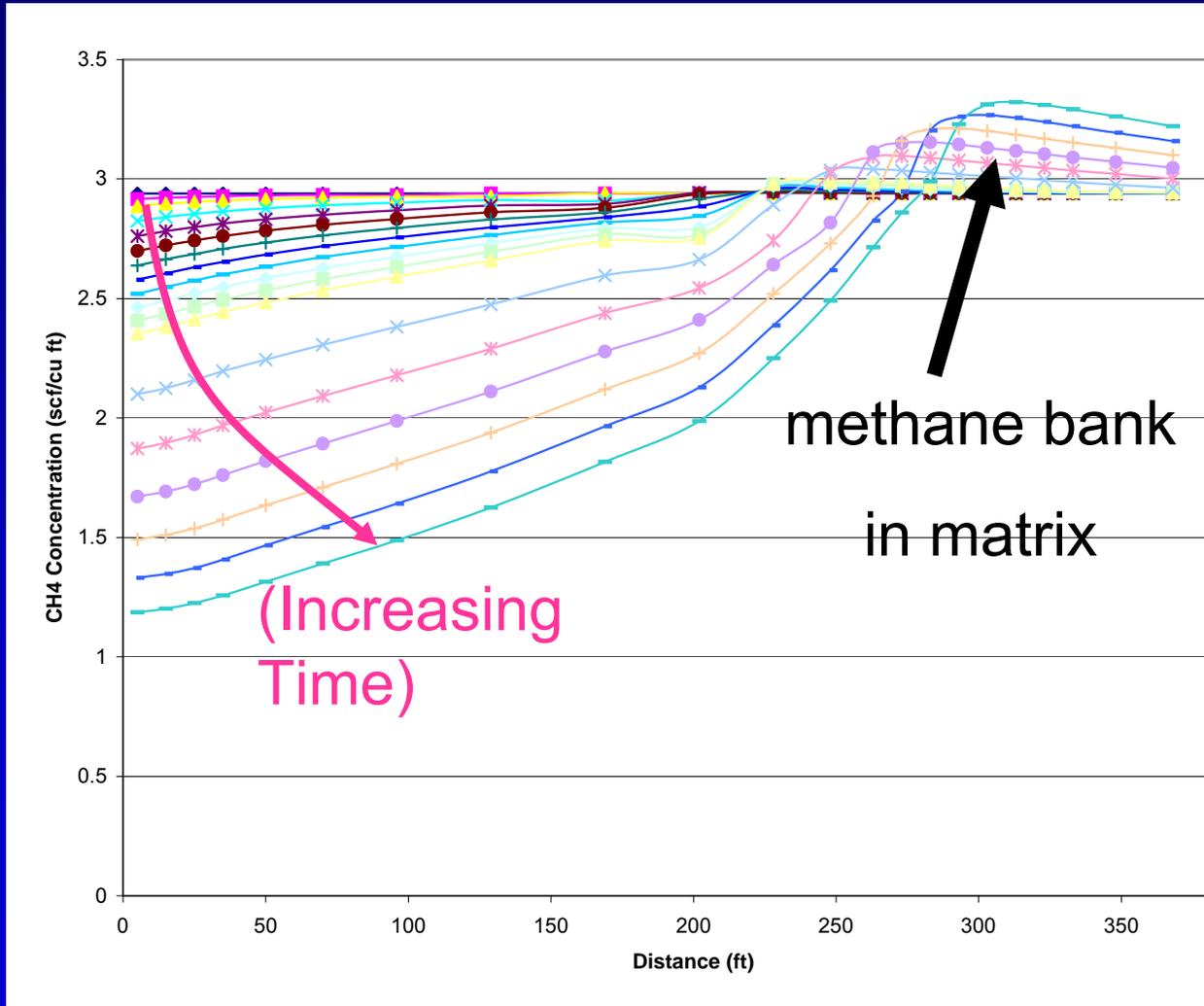
Percent of 36 simulations in which breakthrough occurs

		Sg = 1%	Sg = 10%	Sg = 25%
150' wells	X-dir:	100	100	97
	Y-dir	100	100	84
	Diag:	100	100	97
300' wells	X-dir:	100	100	22
	Y-dir	0	0	0
	Diag:	3	0	0

(X-dir = high perm, Y-dir = low perm, Diag = intermediate)

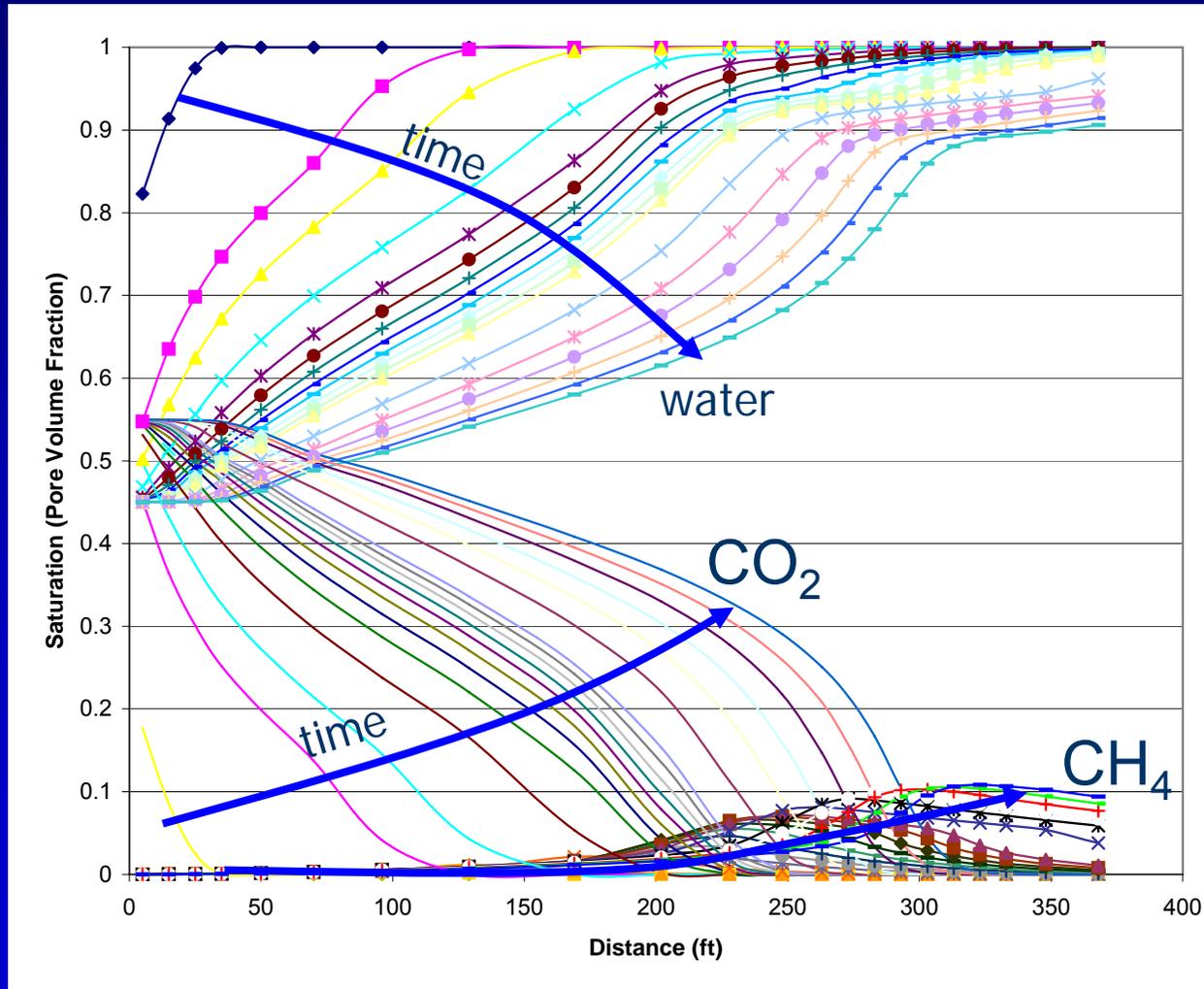
- **150' wells: In the lowest permeability direction (pessimistic case) breakthrough at Sg = 25% occurs 84% of cases.**
- **300' wells: breakthrough only significant in high permeability direction.**
- **Indicates appropriate spacing of about 150 feet.**

Adsorbed CH₄ Concentration vs. Distance as CO₂ is Injected (for most likely scenario)



CO₂, CH₄, Water Sat. in Cleats vs. Distance as CO₂ is Injected

(for most likely scenario)



Summary

Purpose: To determine the CO₂ injection and storage capability, and the ECBM recovery potential of Illinois Basin coal

- Modeling supports well spacing of about 150 feet
- Field Test Schedule
 - Site Selection- by Feb. 07
 - MMV begins- Feb. 07
 - Drilling begins- April 07
 - CO₂ Injection begins- May 08



Midwest Geological
Sequestration Consortium
www.sequestration.org