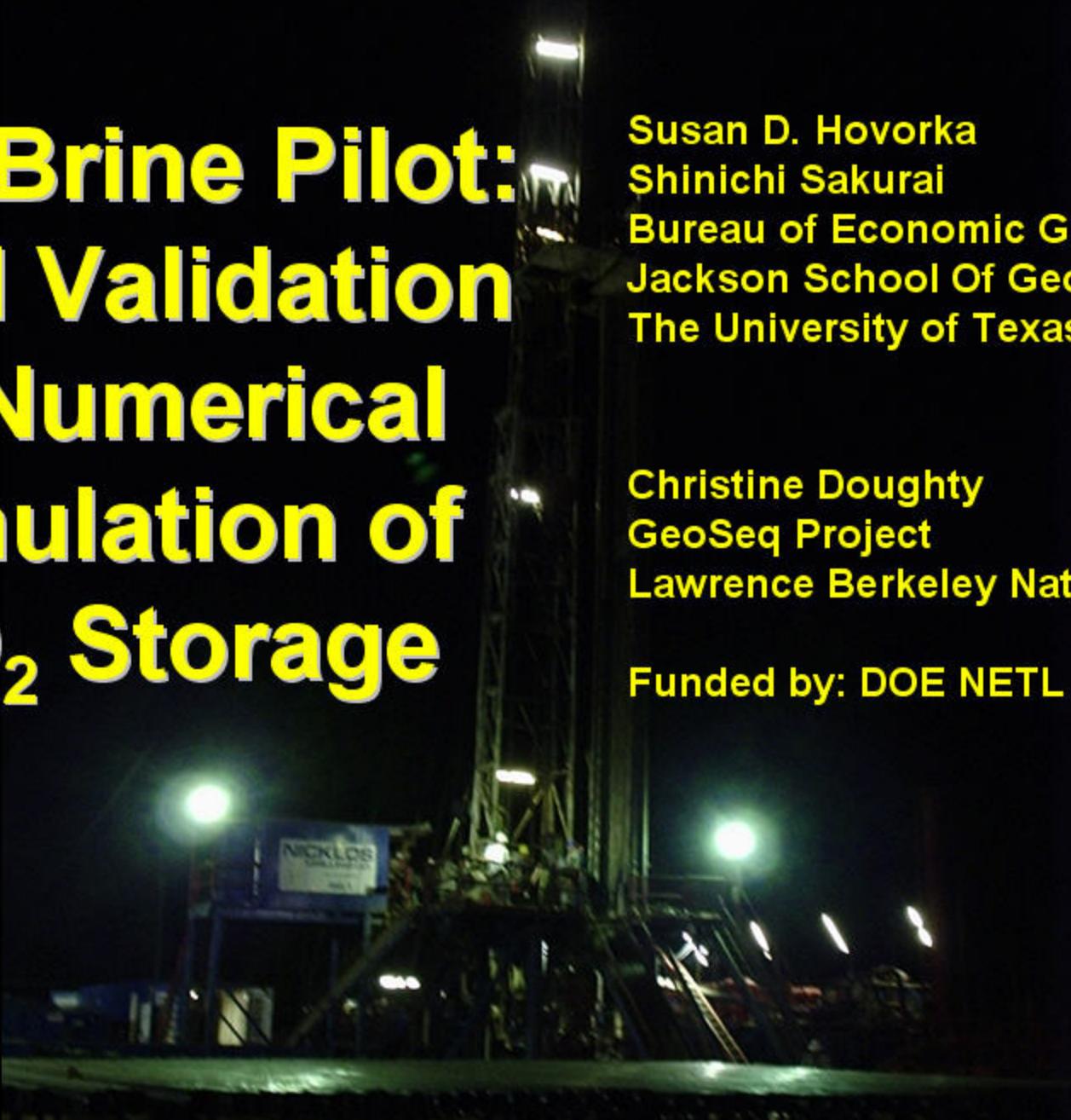


Frio Brine Pilot: Field Validation of Numerical Simulation of CO₂ Storage



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The University of Texas at Austin

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Funded by: DOE NETL

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- Oak Ridge National Lab: Dave Cole, Tommy Phelps, David Riestberg
- Lawrence Livermore National Lab: Kevin Knauss, Jim Johnson
- Alberta Research Council: Bill Gunter, John Robinson, Bernice Kadatz
- Texas American Resources: Don Charbula, David Hargiss
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- Paulsson Geophysical: Bjorn Paulsson
- University of West Virginia: Henry Rausch
- USGS: Yousif Kharaka, Bill Evans, Evangelos Kakauros, Jim Thorsen
- Praxair: Joe Shine, Dan Dalton
- Australian CO2CRC (CSIRO): Kevin Dodds, Don Sherlock
- Core Labs: Paul Martin and others

Frio Experiment: Monitoring CO₂ Storage in Brine-Bearing Formations

Project Goal: Early success in a high-permeability, high-volume sandstone representative of a broad area that is an ultimate target for large-volume sequestration.

- Demonstrate that CO₂ can be injected into a brine formation without adverse health, safety, or environmental effects
- Determine the subsurface distribution of injected CO₂ using diverse monitoring technologies
- Demonstrate validity of conceptual and numerical models
- Develop experience necessary for success of large-scale CO₂ injection experiments

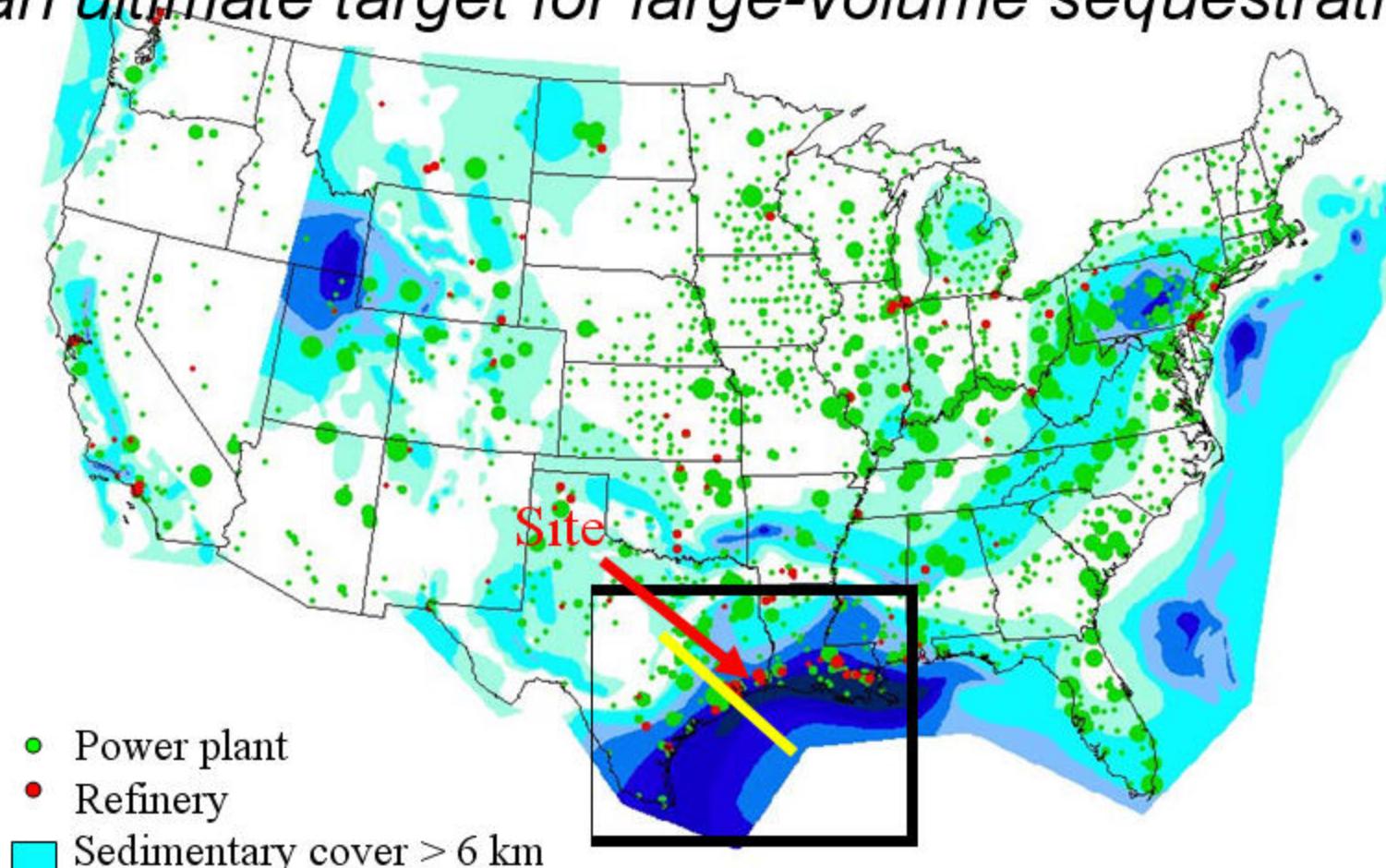
Frio Experiment: Status of Results

1,600 metric tons CO₂ was introduced into a well-characterized, relatively homogenous, high-permeability sandstone system characteristic of the Gulf Coast region of the U.S. and monitored before, during, and after injection

- Vigorous public/industry outreach - favorable response
- Saturation and transport properties measured horizontally, vertically, and through time using multiple tools
- Improved model of conceptual and numerical inputs
- Results to be made available to field projects planned by Regional Sequestration Partnerships and to Carbon Sequestration Leadership Forum projects
- Analysis continues

Initial Step: Site Search

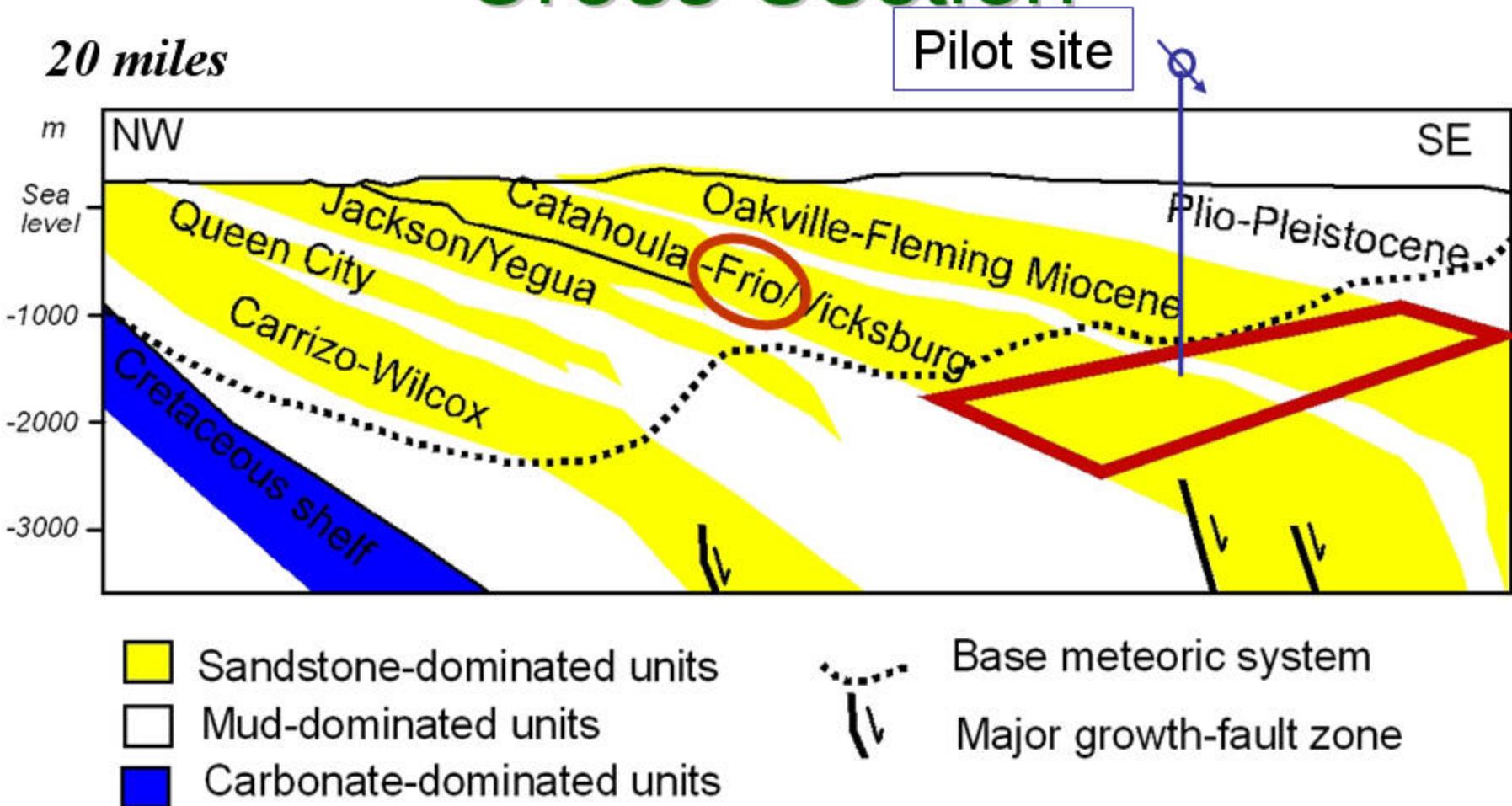
Locating a high-permeability, high-volume sandstone representative of a broad area that is an ultimate target for large-volume sequestration



Sources: USGS, IEA Source database

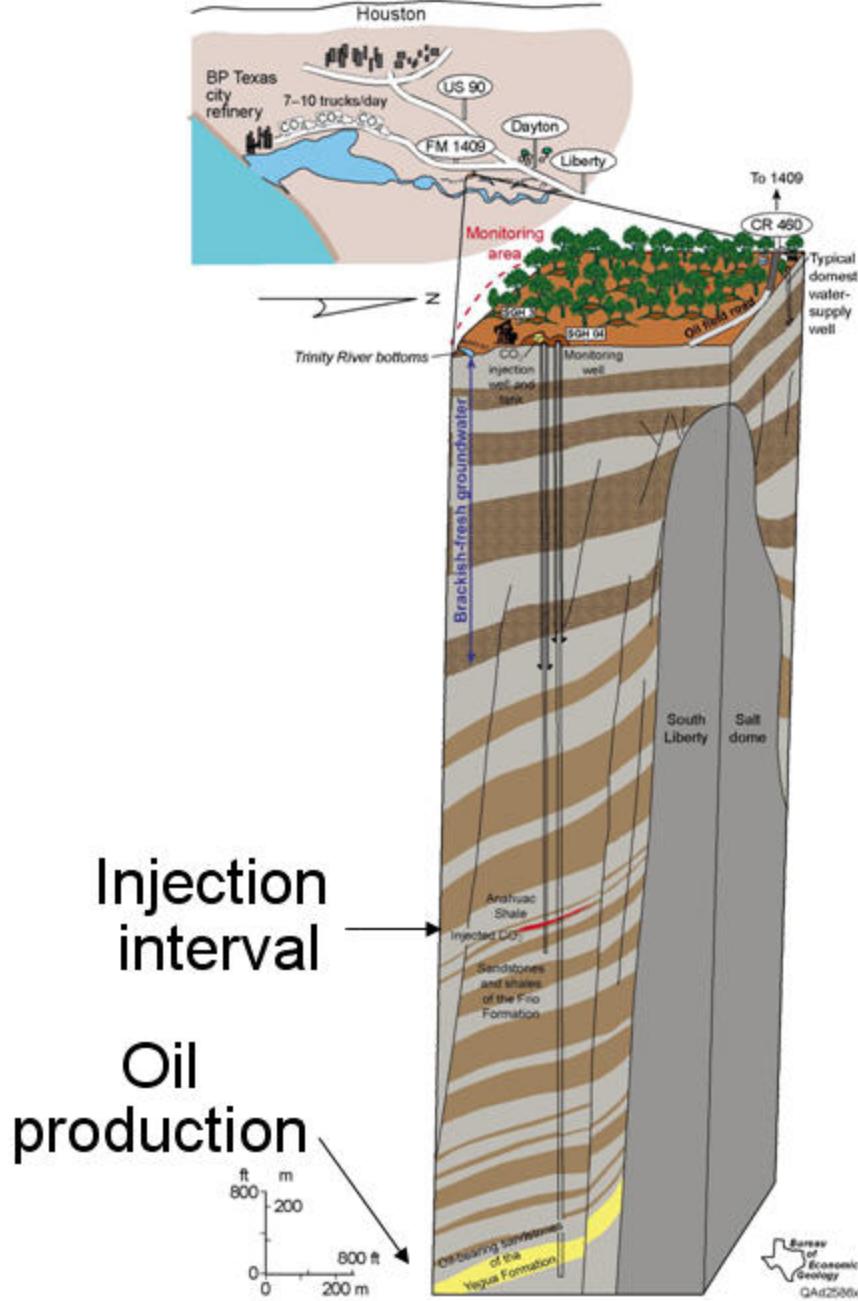
Regional Geologic Setting – Cross Section

20 miles



Modified from Galloway and others, 1982

Frio Brine Pilot Setting

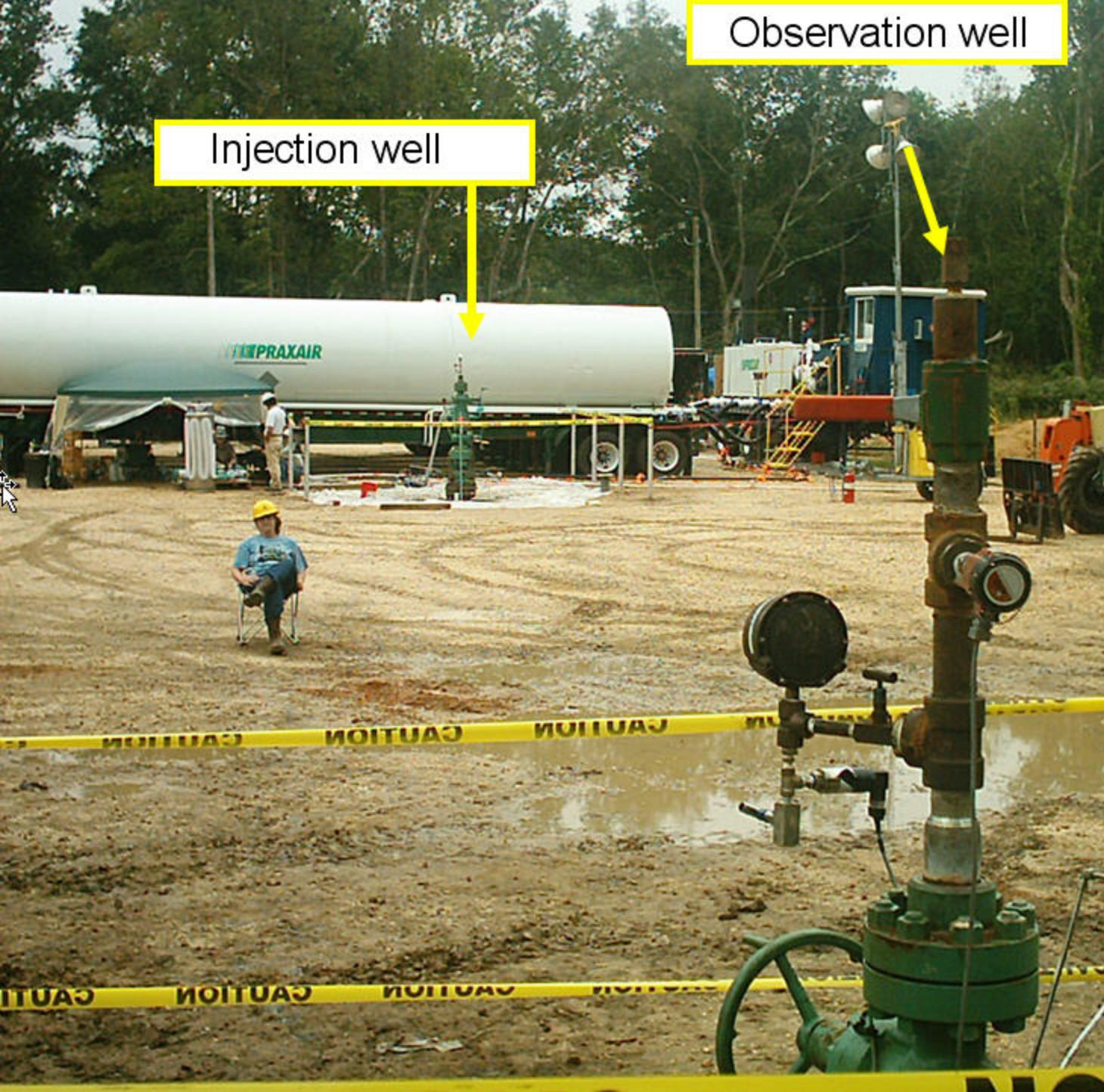


- Injection interval: 24-m-thick, mineralogically complex, Oligocene reworked fluvial sandstone, porosity 24%, permeability 2.3 darcys
- Steeply dipping 18°
- 7-m perforated zone
- Seals – numerous thick shales, small fault block
- Depth 1,500 m
- Brine-rock system, no hydrocarbons
- 150-bar, 53°C, supercritical CO₂

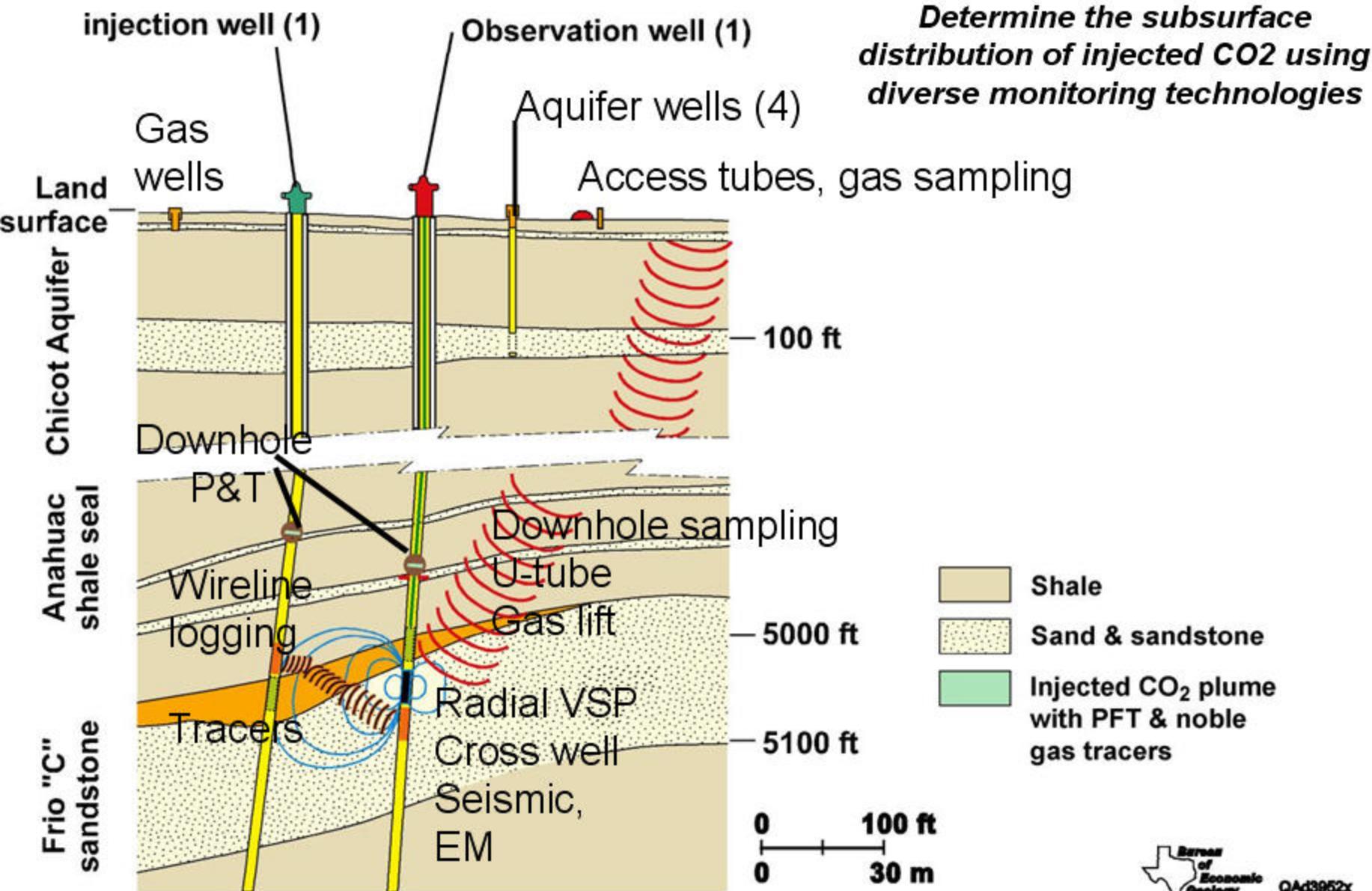
Observation well

Injection well

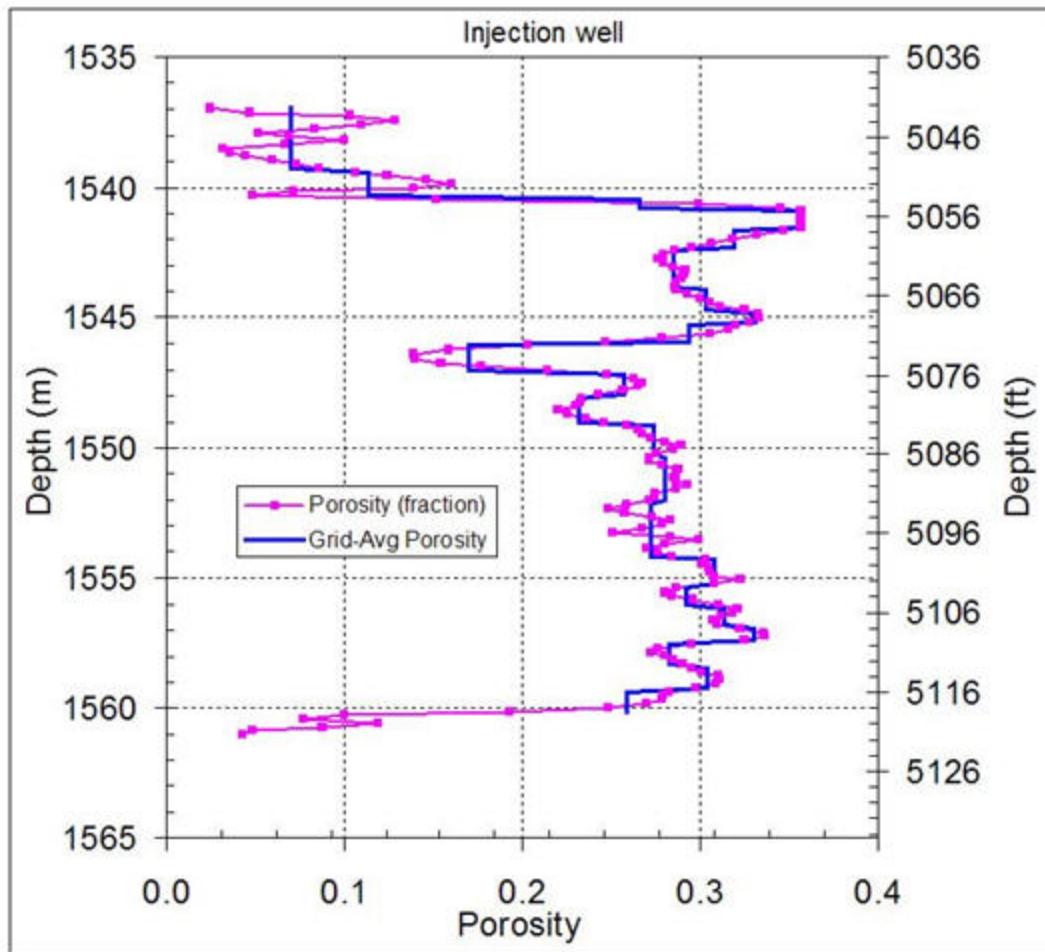
*Closely spaced
measurements
in time and space*



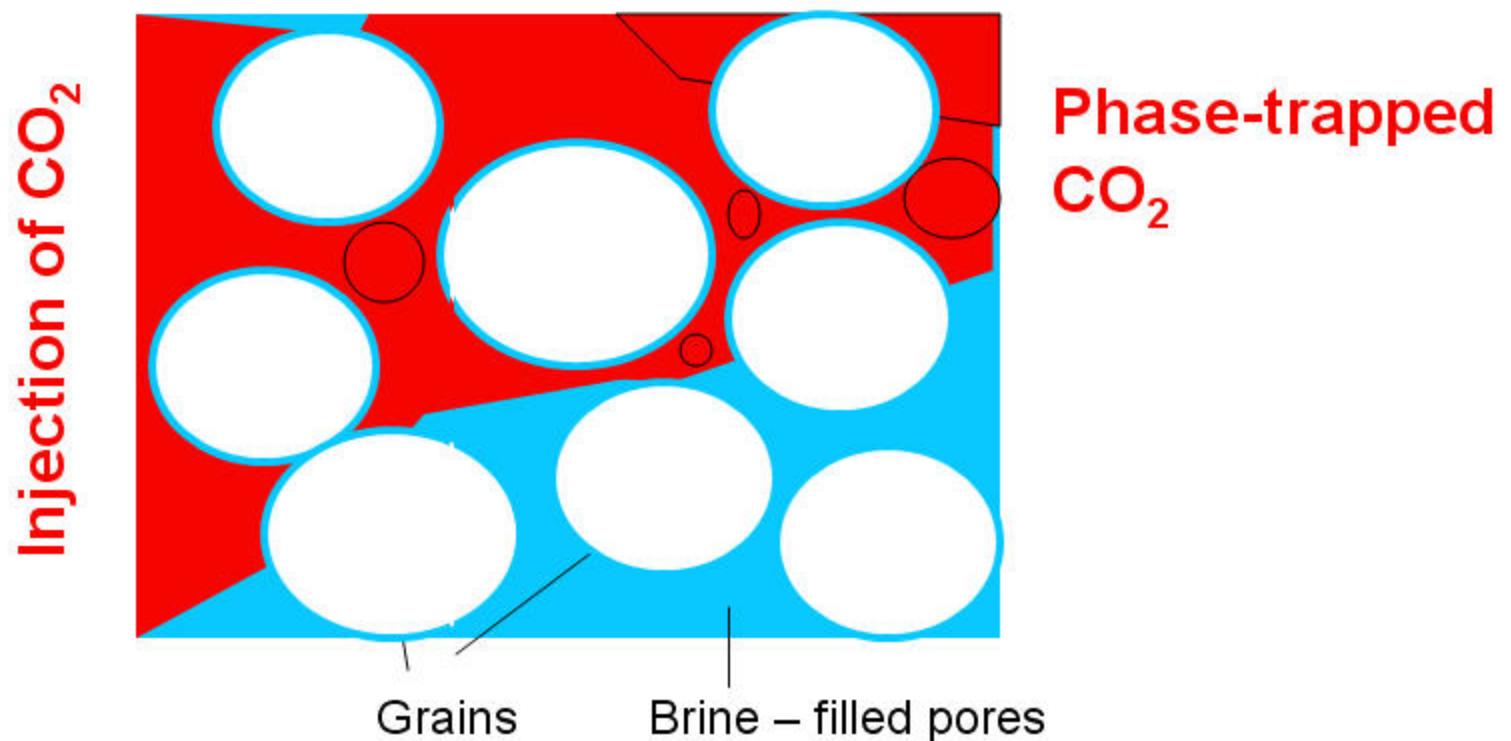
Monitoring at Frio Pilot



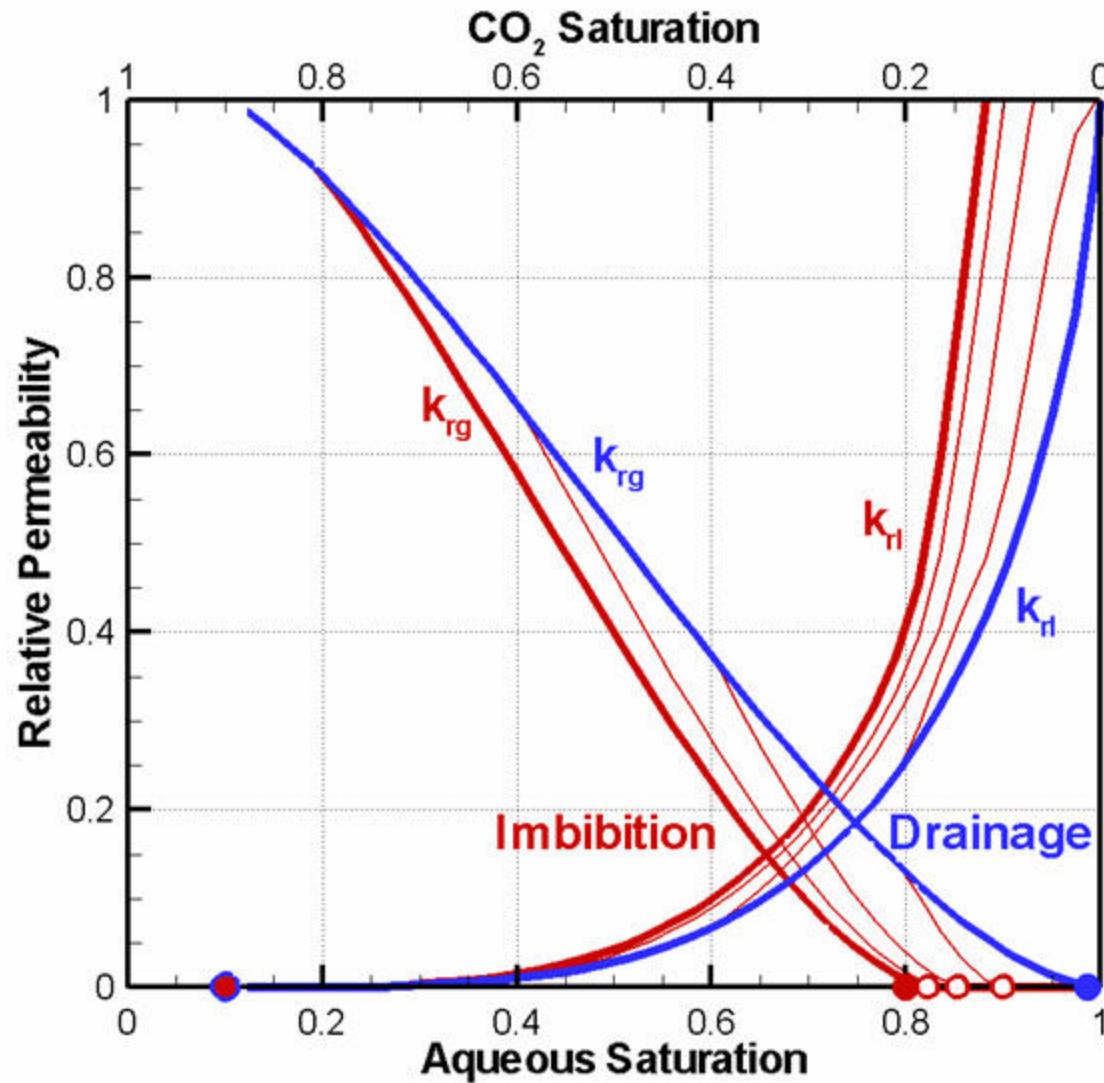
Reservoir Model Input into TOUGH2



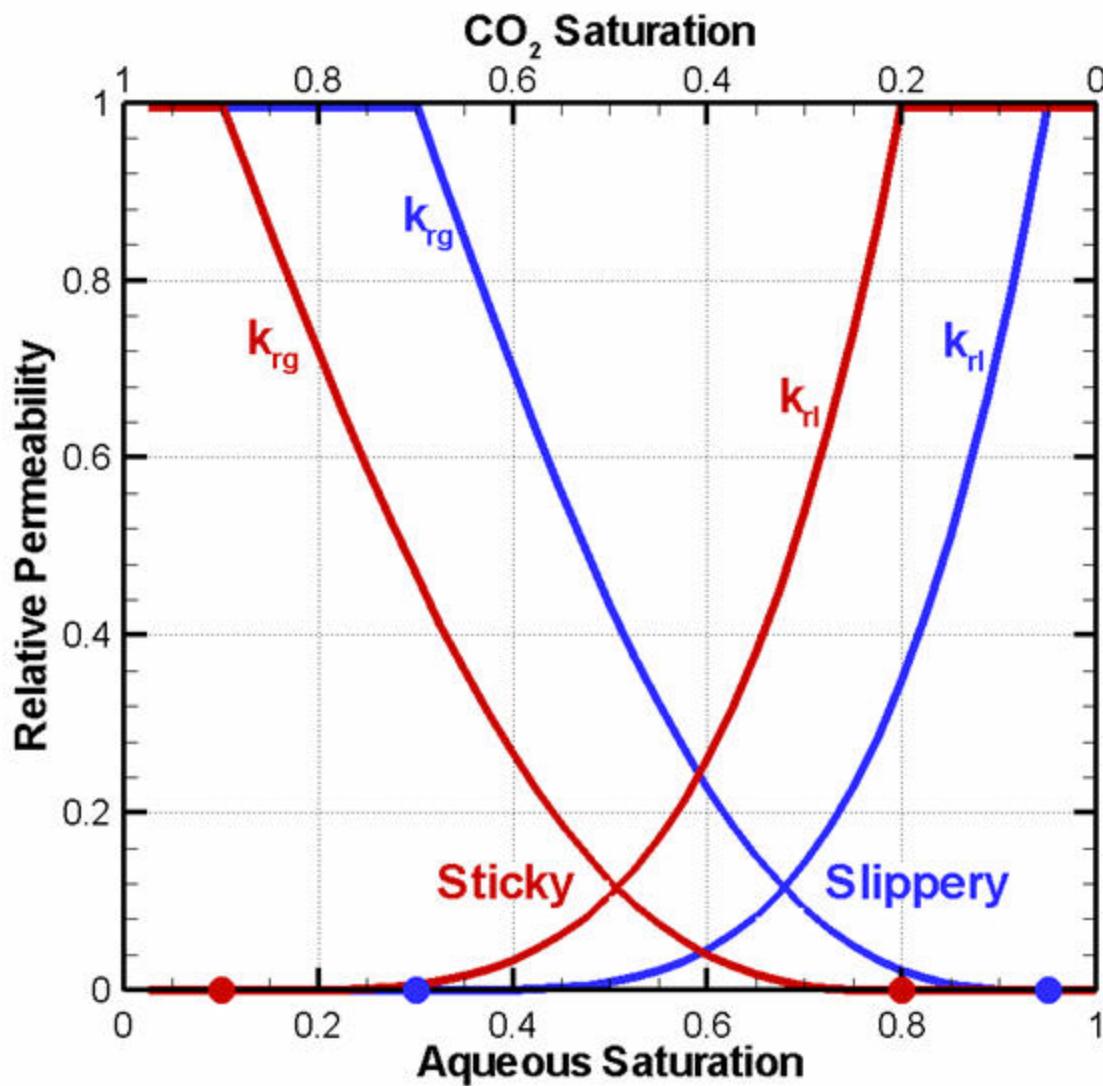
Two-Phase Trapping



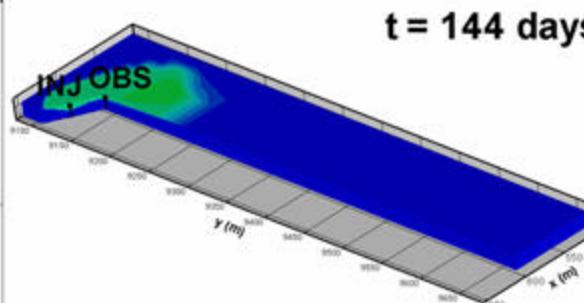
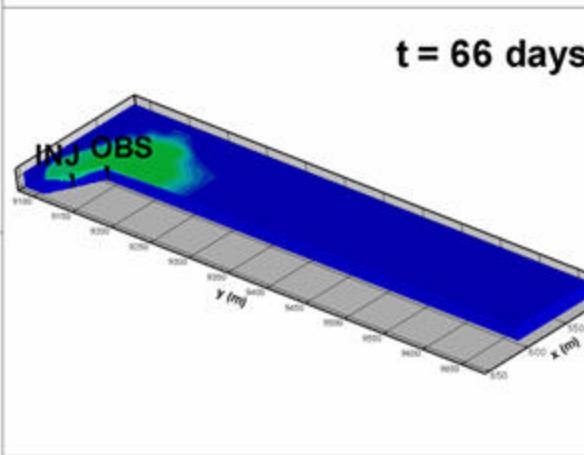
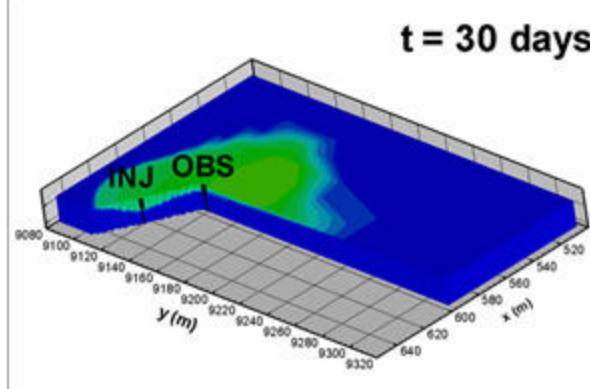
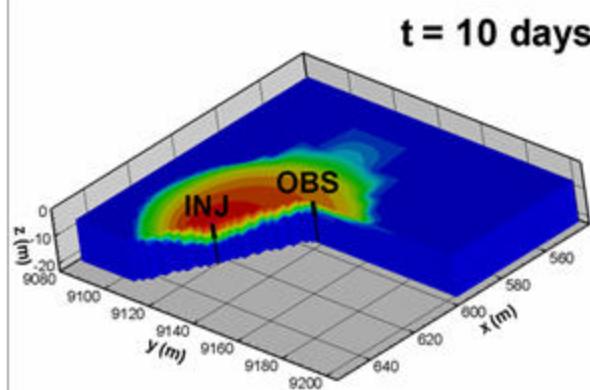
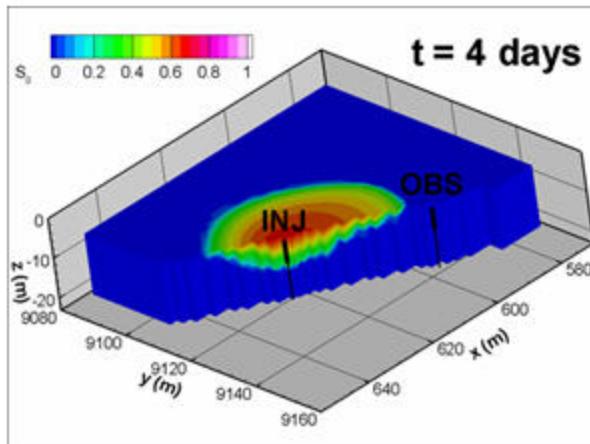
Representative realistic imbibition and drainage curves for two-phase flow



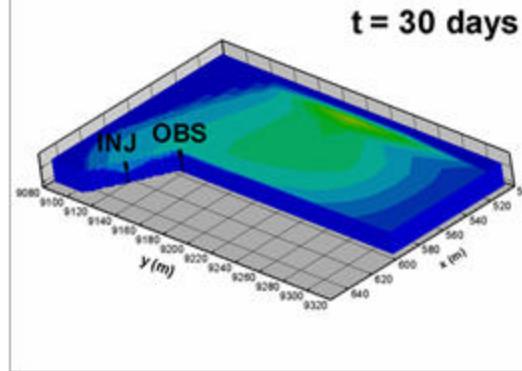
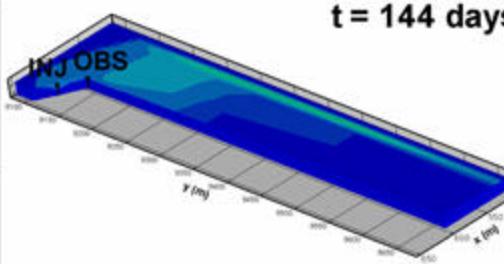
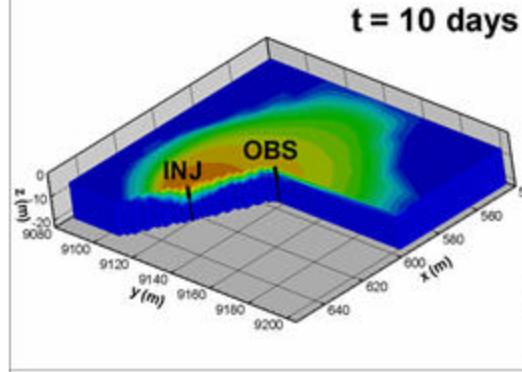
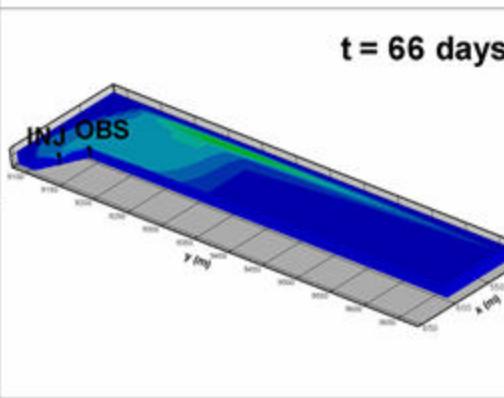
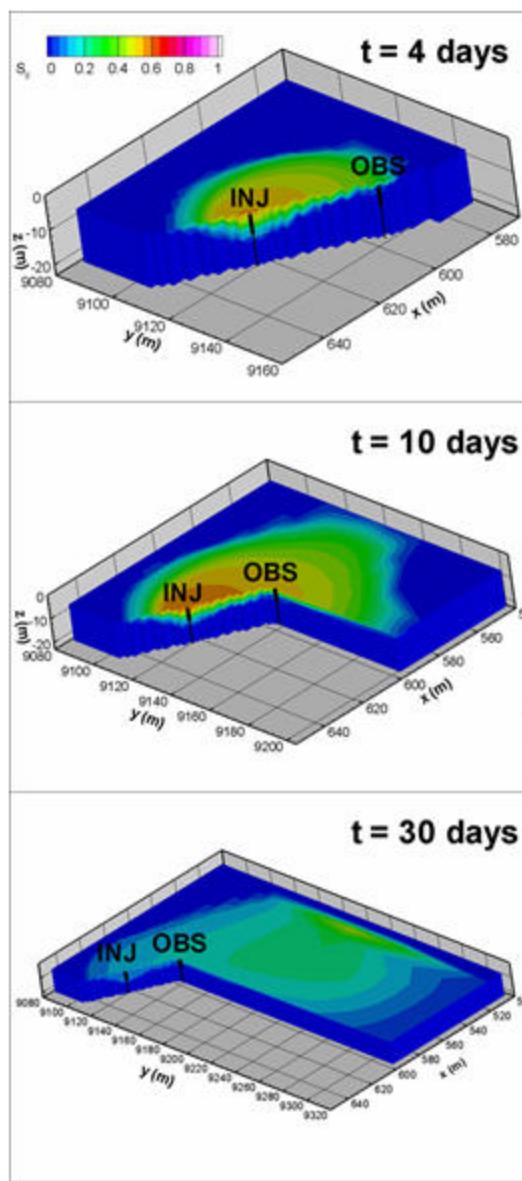
Relative Permeability vs. CO₂ Saturation



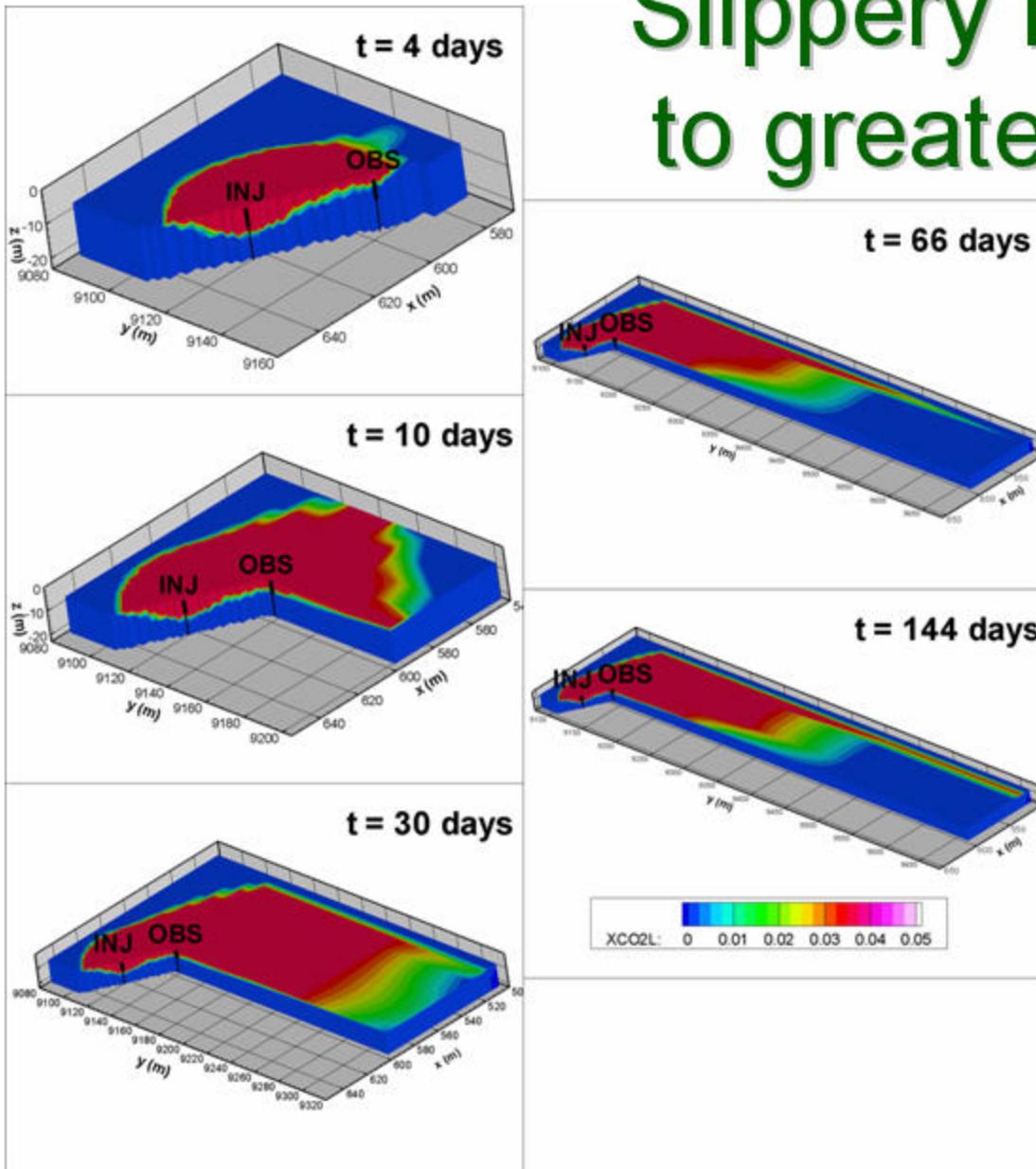
Sticky Plume



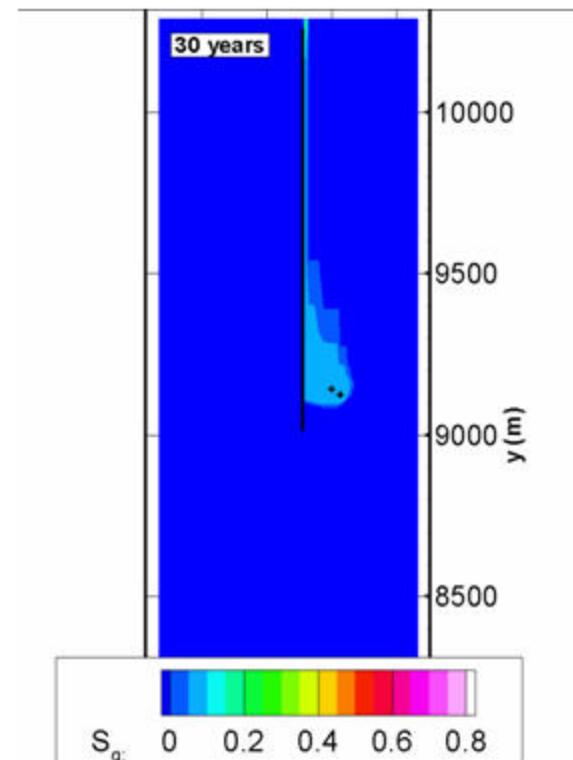
Slippery Plume



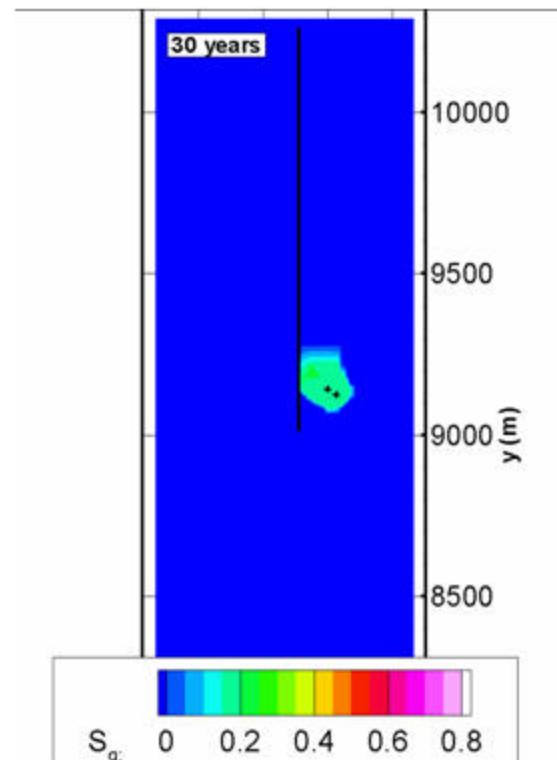
Slippery Plume Leads to greater dissolution



Modeled Fate at 30 Years Is Dependant on Saturation



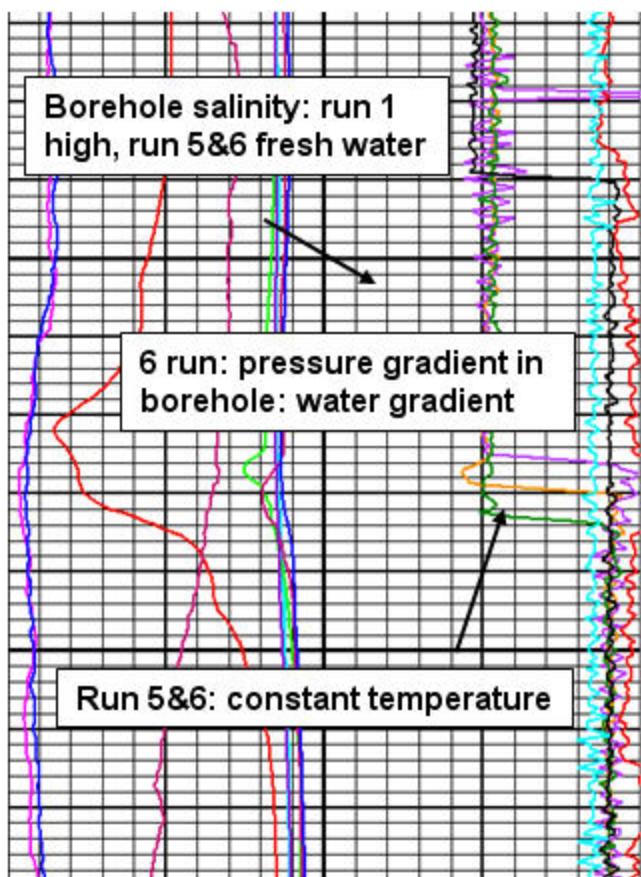
Slippery=Minimal phase trapping



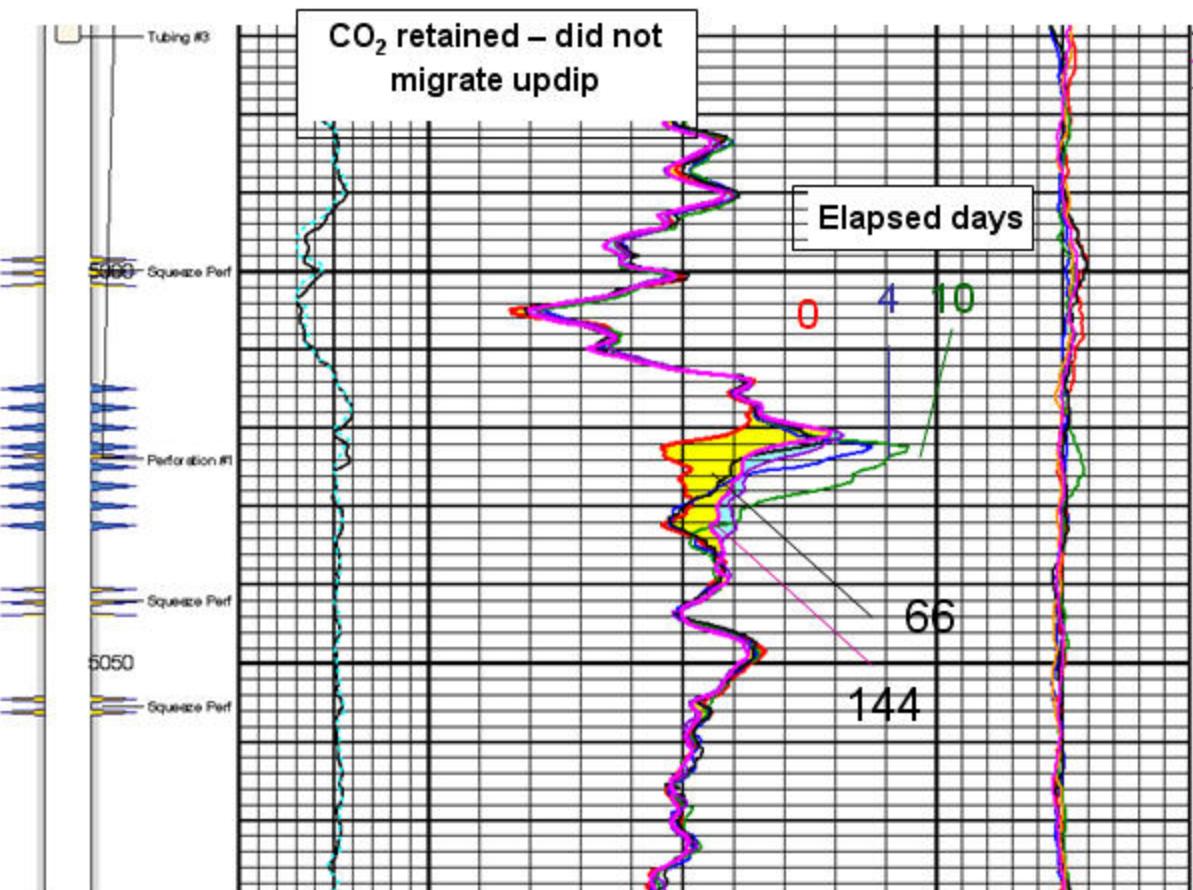
Sticky=Significant phase trapping

Pulsed Neutron Capture Logging

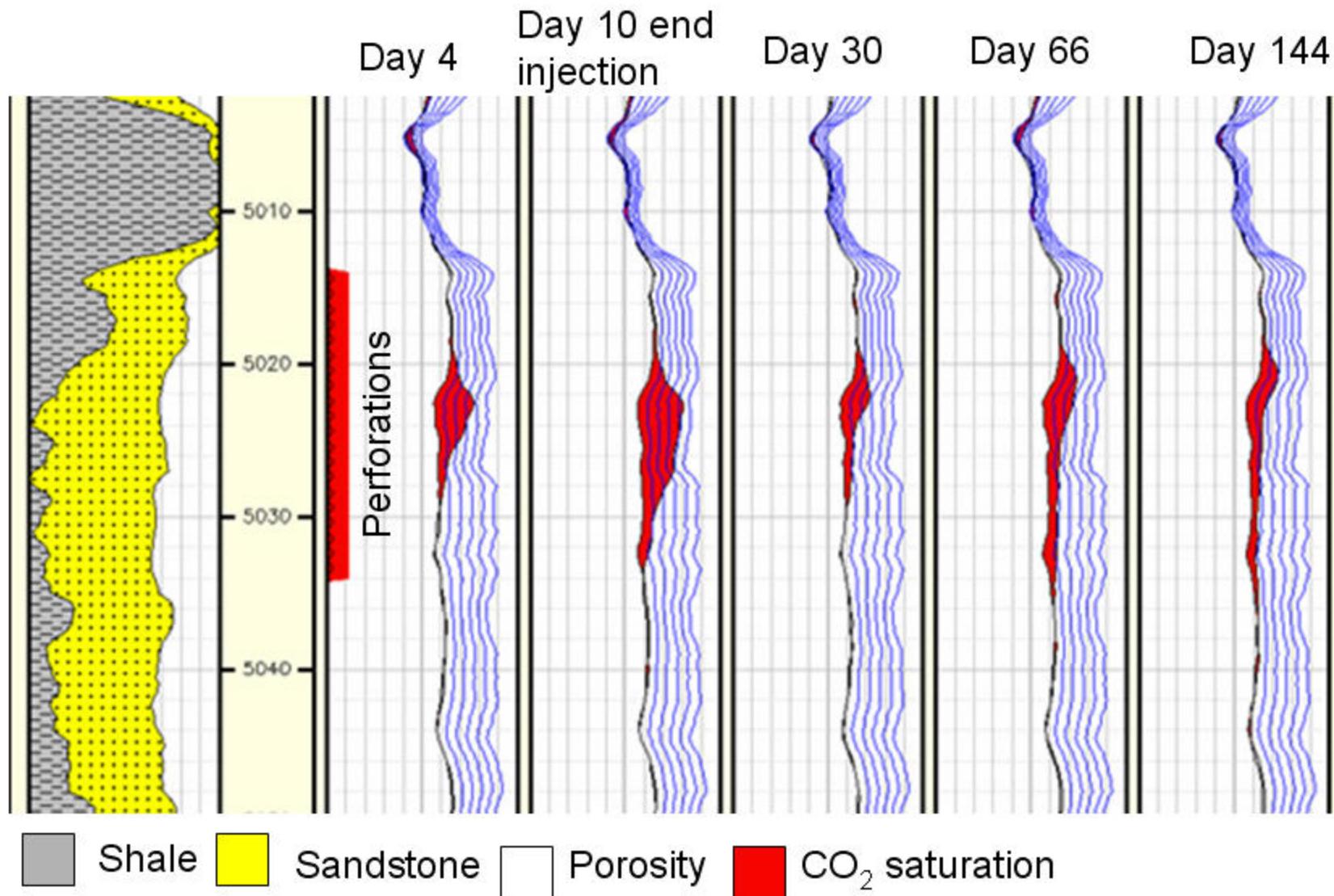
Borehole correction



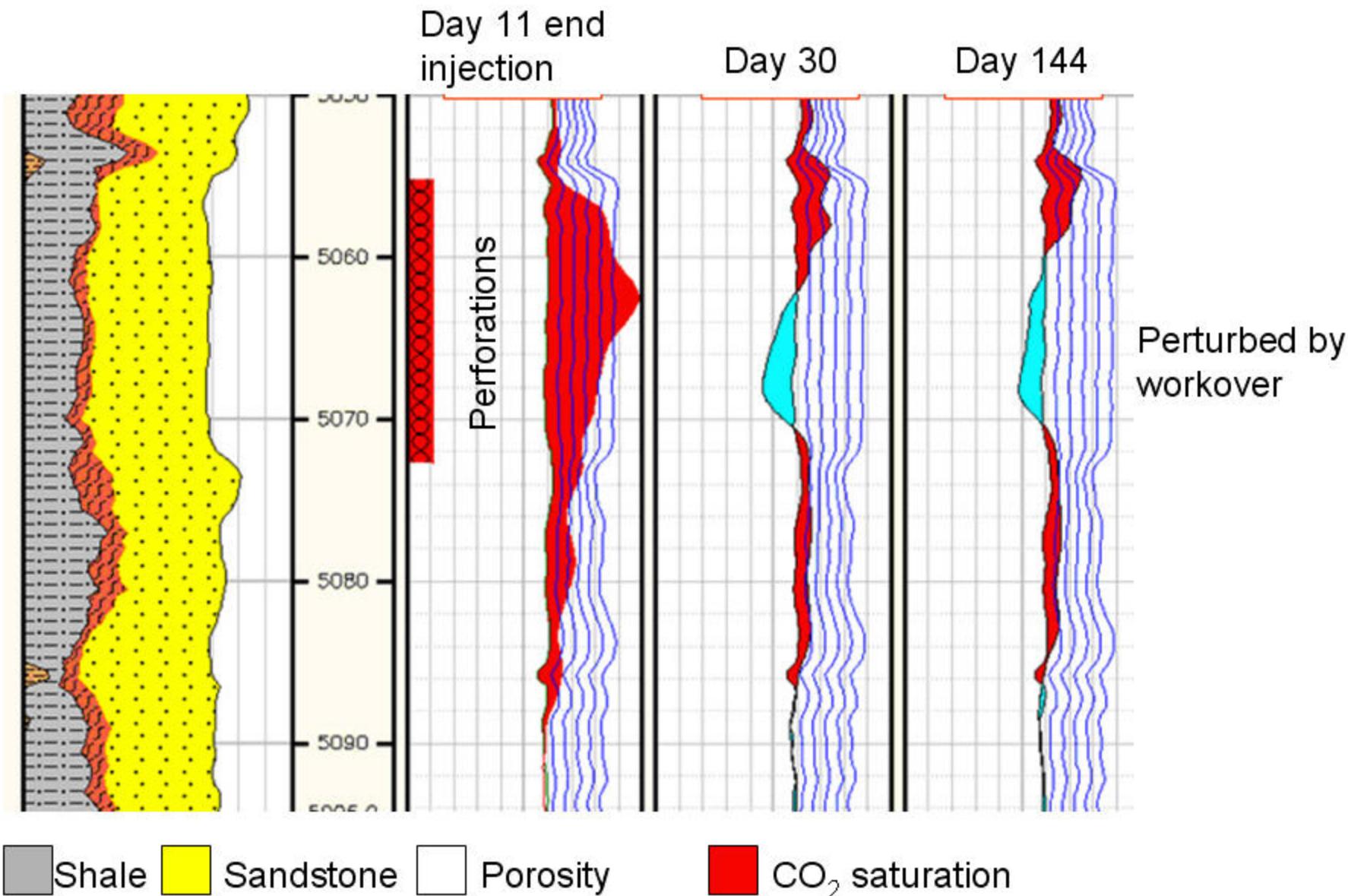
Sigma



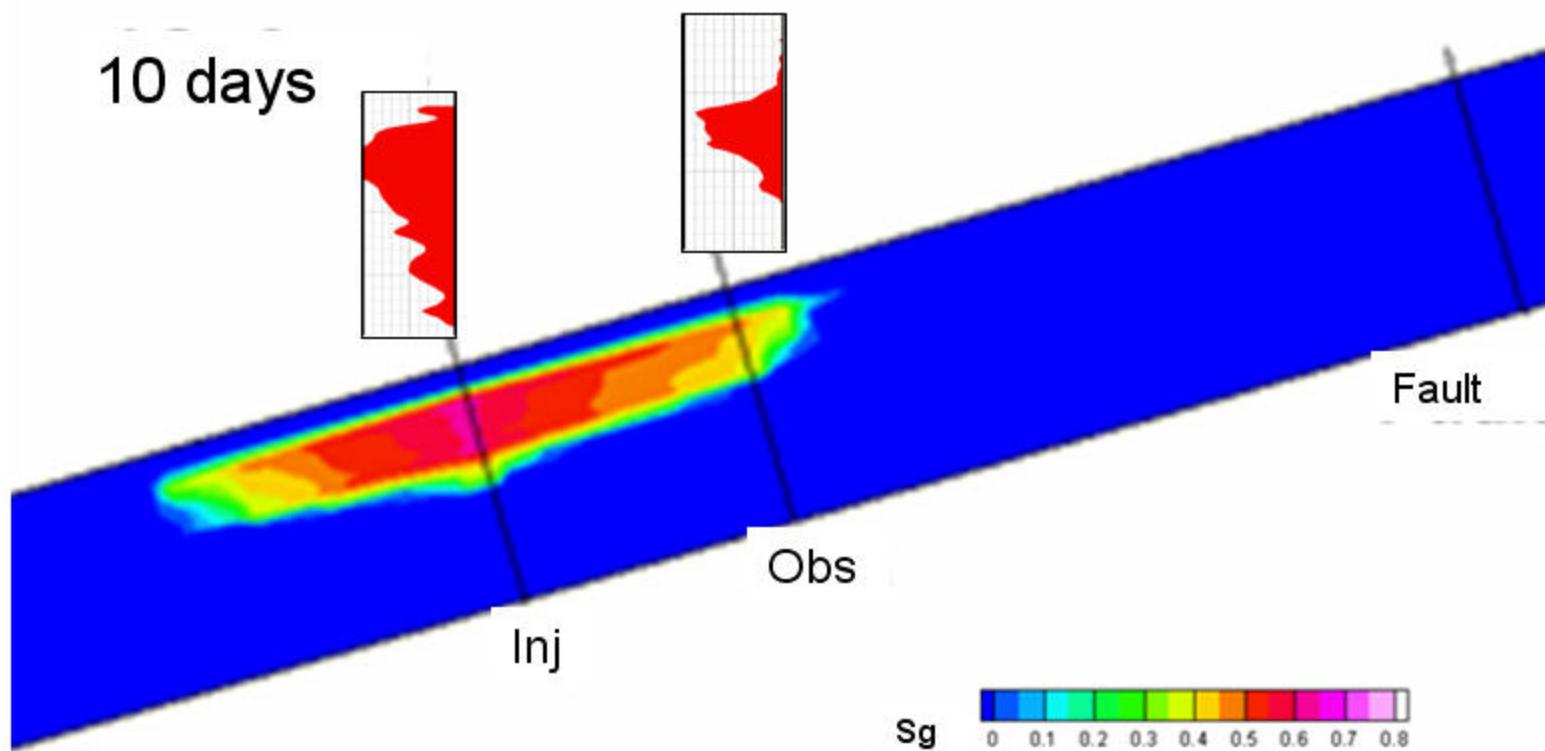
Evolution of CO₂ Saturation: Observation Well



Evolution of CO₂ Saturation: Injection Well

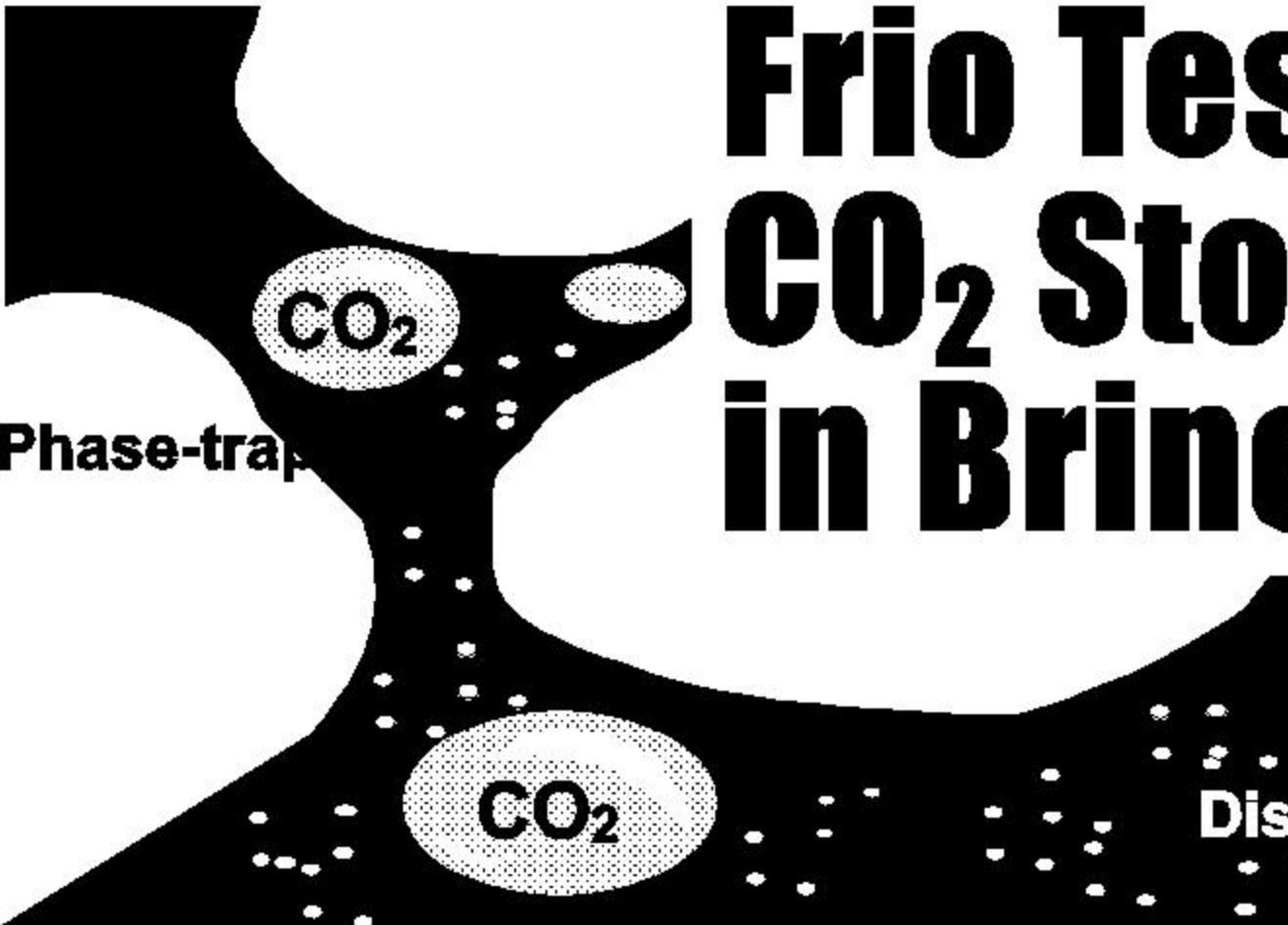


Comparison of Measured and Modeled CO₂ Saturation



Conclusions

- Plume front during injection: 30% faster and thinner than predicted
- Stable plume at 10 days similar to modeled
- Plume evolution during postinjection migration under gravity saturation controlled by decreasing relative permeability to CO₂ as saturation decreases



Frio Test CO₂ Storage in Brine

Phase-trap

Dayton, TX
2004-2005

CO₂

Dissolved

*“The permanence is in
the petrophysics”*