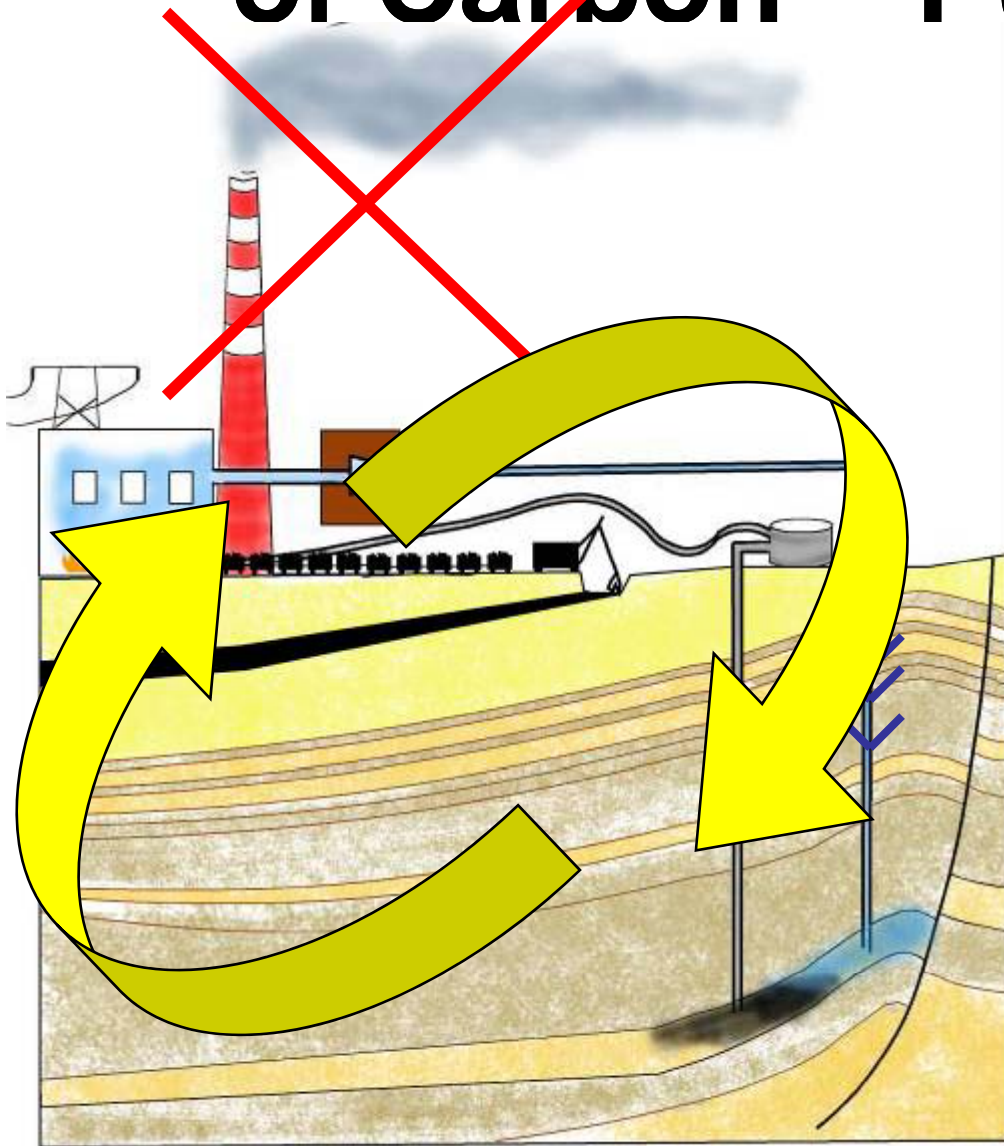


Testing Geologic Sequestration of Carbon – Put it back



Carbon extracted
from coal or other
fossil fuel...

Returned into the earth
where it came from

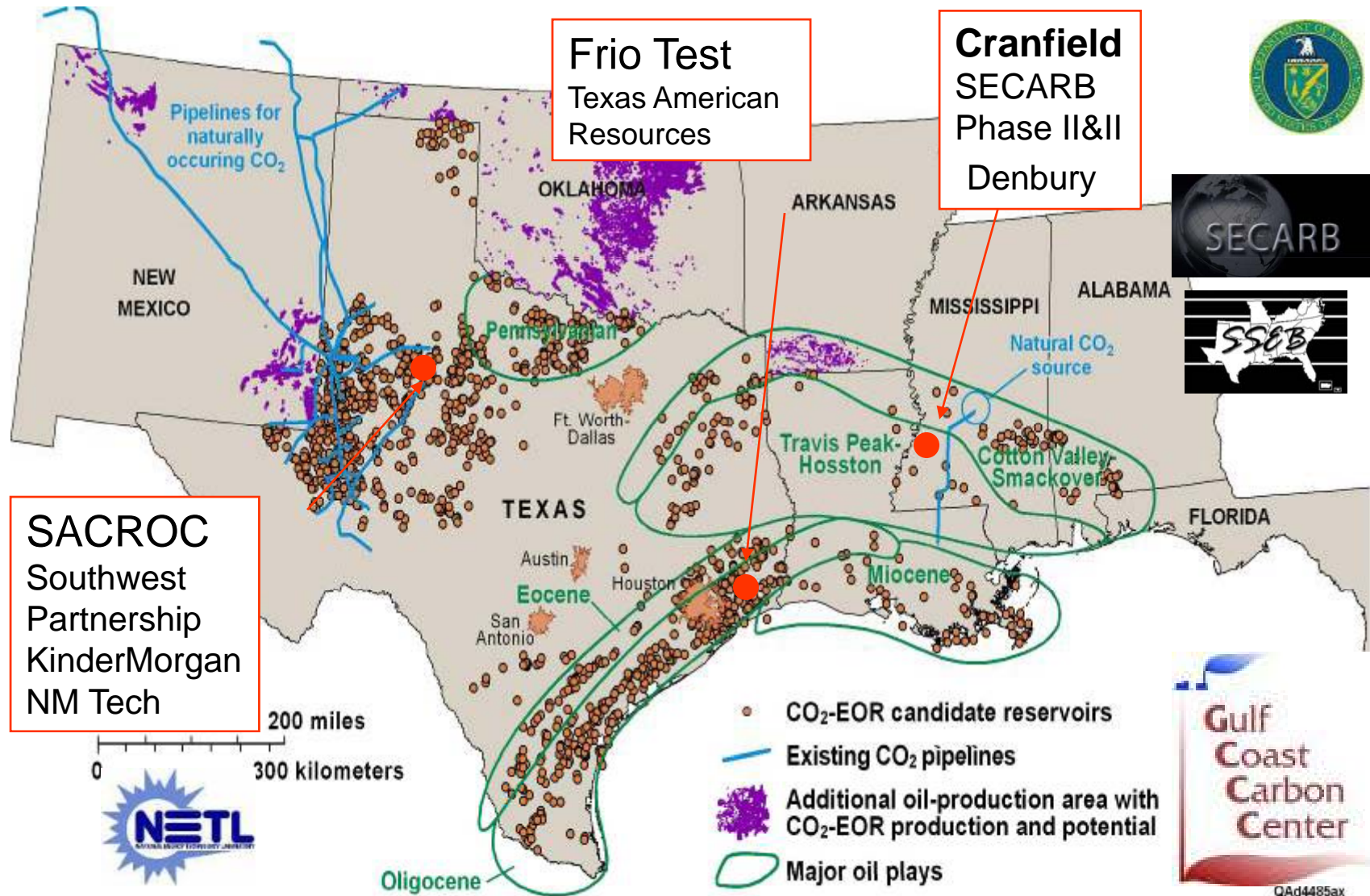
An elegant solution - will it work?

susan.hovorka@beg.utexas.edu
www.gulfcoastcarbon.org

Bureau of Economic
Geology
Jackson School
University of Texas
at Austin



Ongoing GCCC Field Tests for Monitoring and Verification Technologies - DOE-NETL and Industry Hosts



Field Research Teams

Frio Test

Bureau of Economic Geology
Lawrence Berkeley National Lab
Schlumberger:
Oak Ridge National Lab
Lawrence Livermore National Lab
Alberta Research Council
Texas American Resources
Sandia Technologies
BP
National Energy Technology Lab
Paulsson Geophysical
University of West Virginia
USGS
Praxair
Australian CO2CRC (CSIRO)
Core Labs

SACROC

Bureau of Economic Geology
New Mexico Tech
University of Utah
University of Pittsburg
Kinder Morgan
Los Alamos National Labs
Sandia National Labs

Cranfield

Bureau of Economic Geology
University of Mississippi
Mississippi State university
Schlumberger
Sandia Technologies
Denbury Resources



Experimental Questions

Can we measure the change resulting from putting CO₂ underground?

Can we predict the change over time?

Is the CO₂ stored safely underground?

Monitoring



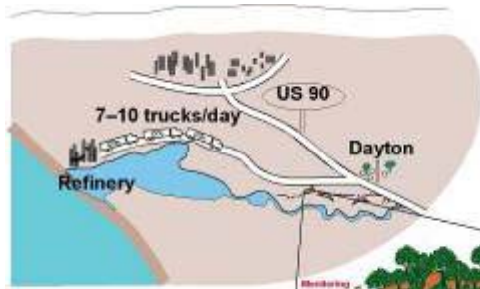
Verification

Modeling

Provide useful information to next tests and deployments

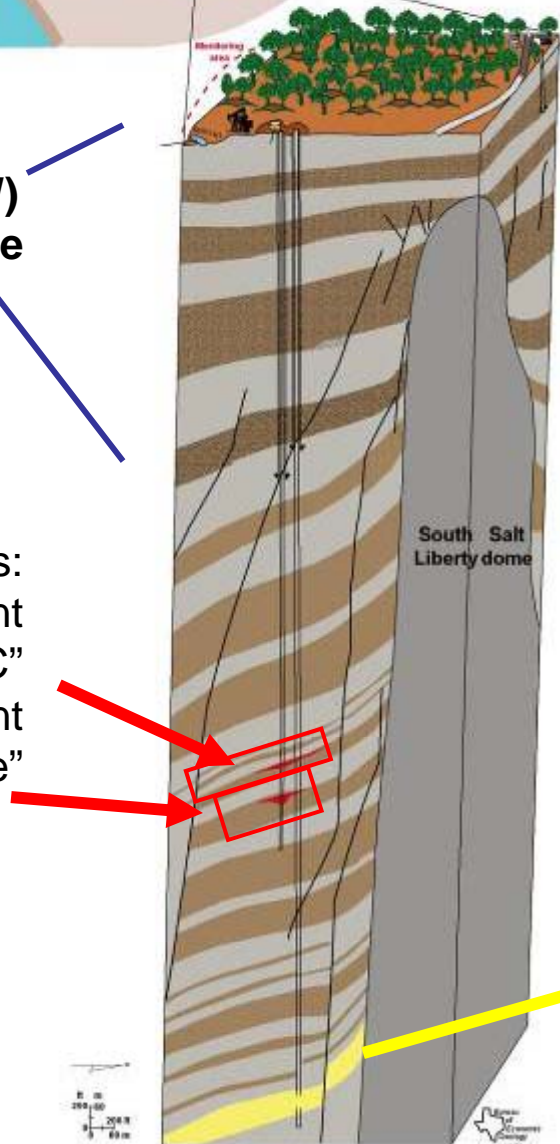
Frio Brine Pilot Test

Food grade CO₂
Shipped by truck



Fresh water (USDW)
protected by surface
casing

Injection zones:
First experiment
2004: Frio "C"
Second experiment
2006 Frio "Blue"

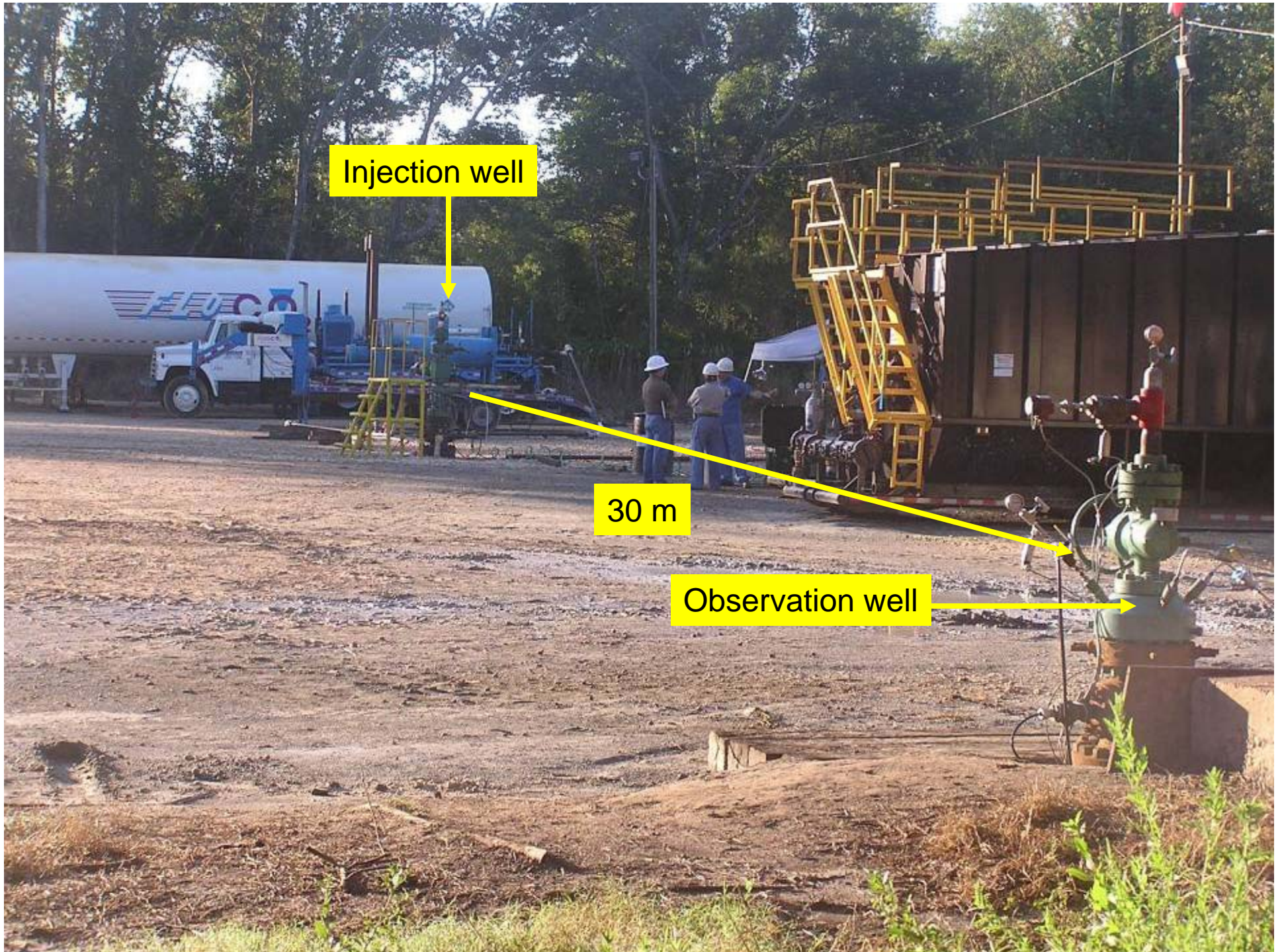


Depth 5034
and 5450 ft

Steeply dipping- high permeability
sandstone

Fluid is brine 100 ppt NaCl
100 -110 degrees F

Oil production



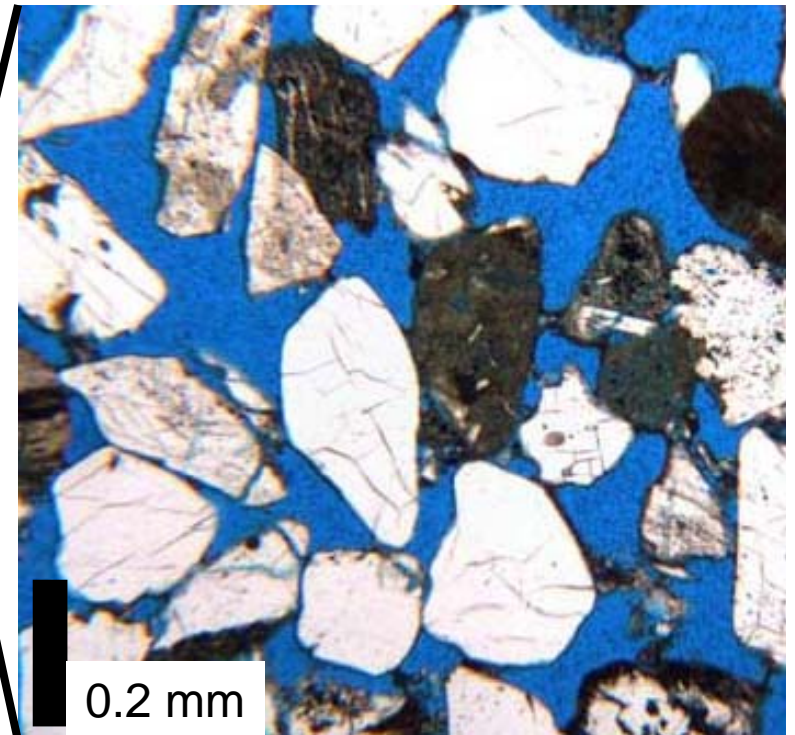
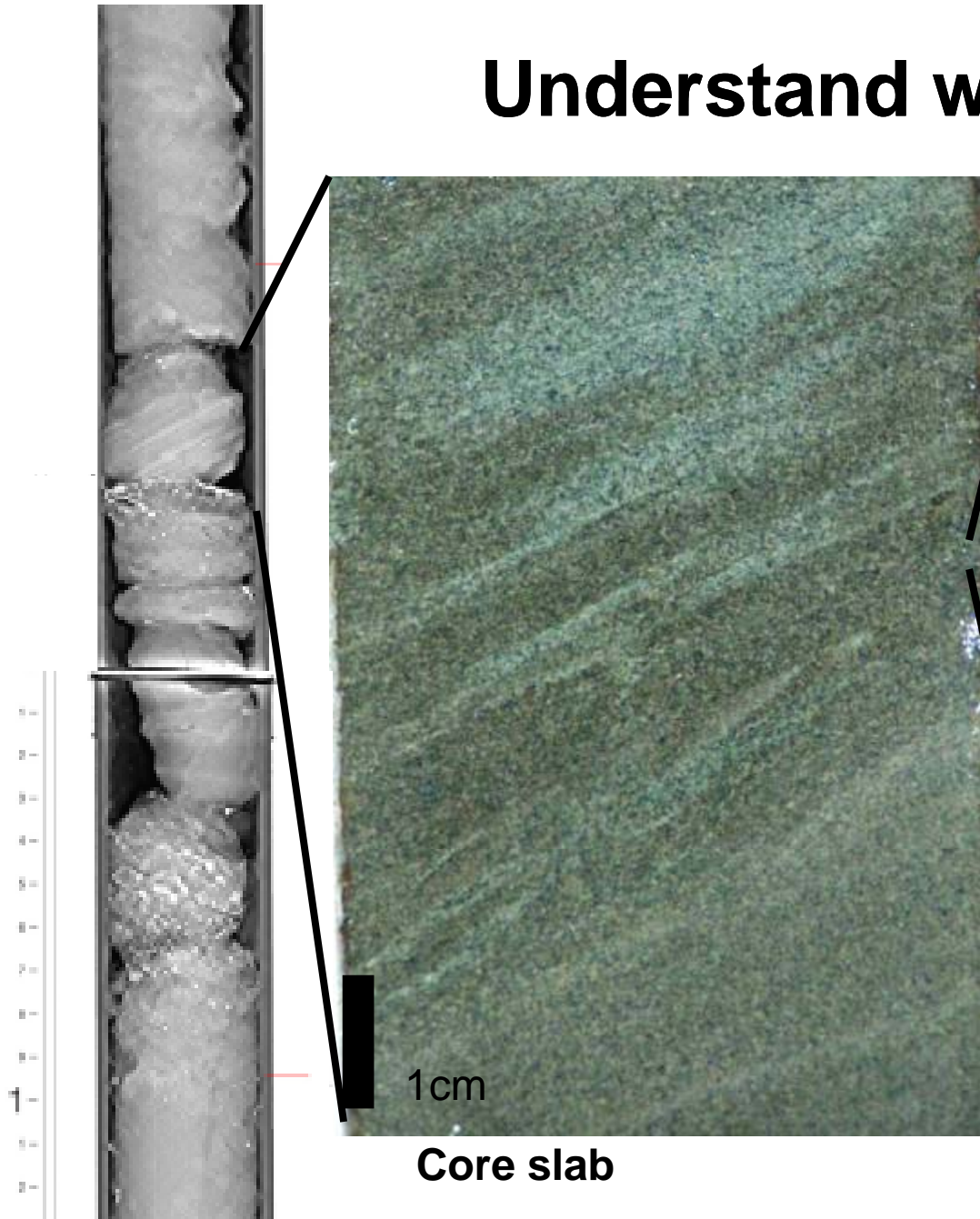
Injection well

30 m

Observation well

CT Scan

Understand what you inject into

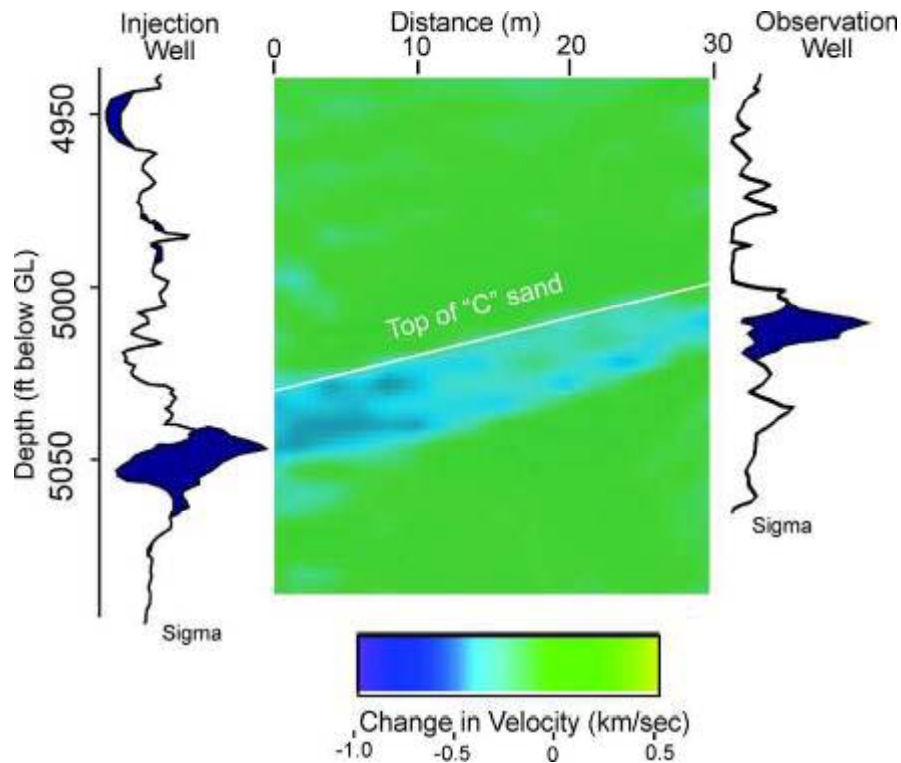


Rock slice "thin section"
microscope view

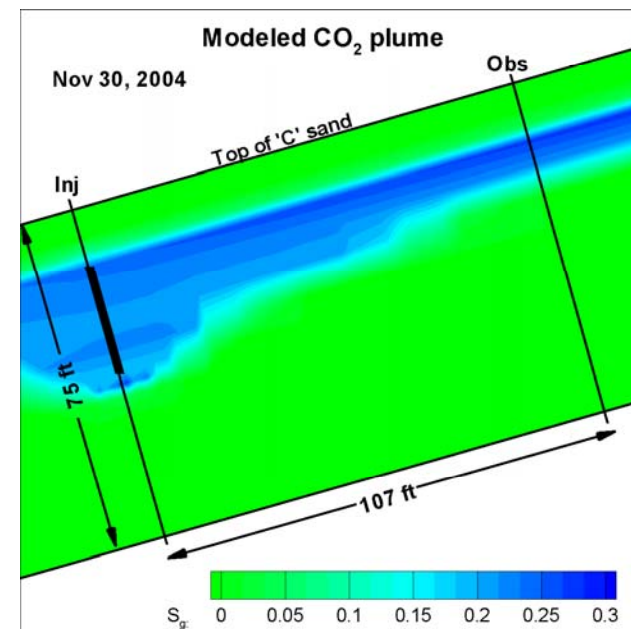
Core slab

Yes, we can predict and measure where the CO₂ moves underground

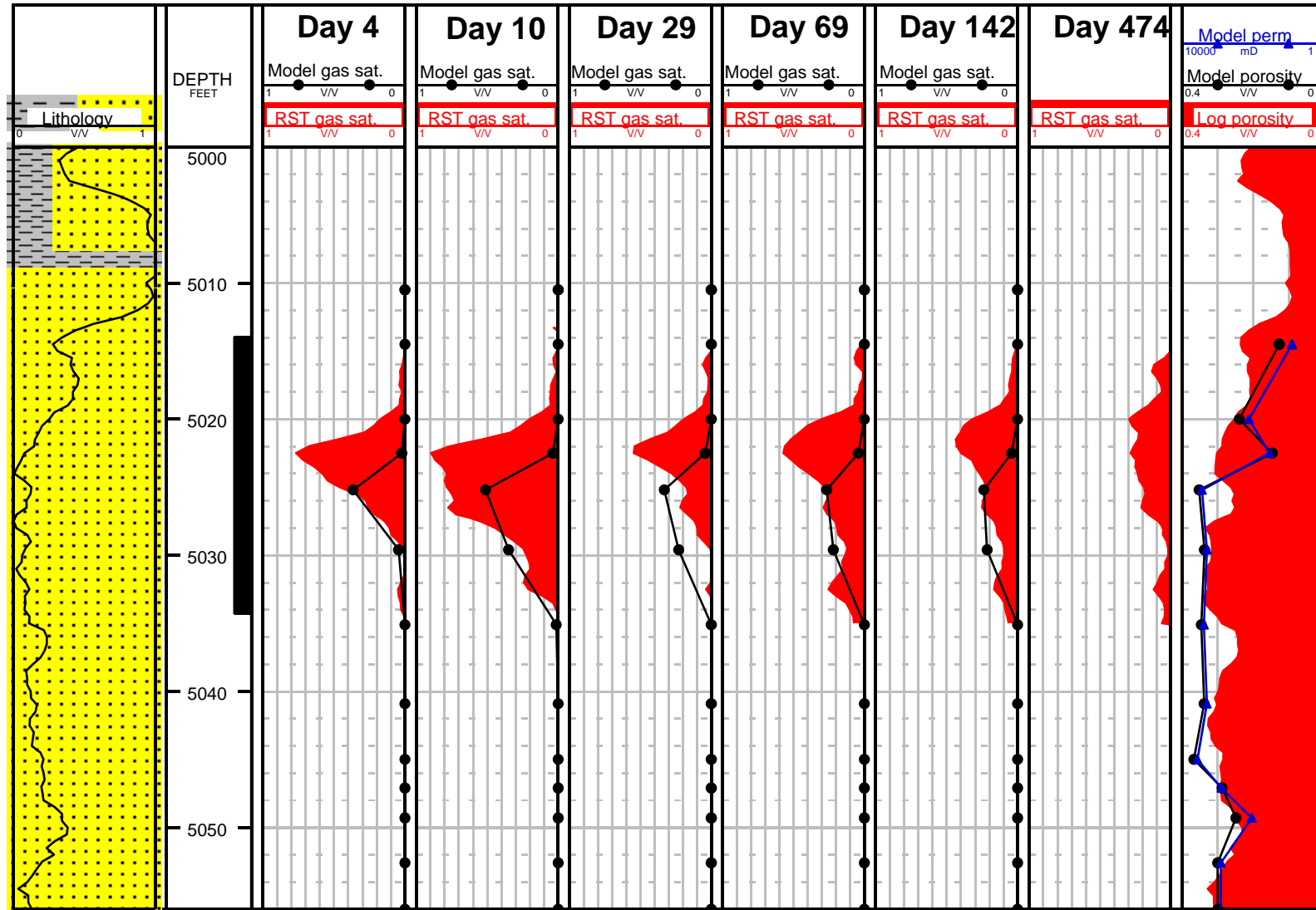
Measured with cross-well tomography and wireline logs



Predicted with computer model TOUGH2

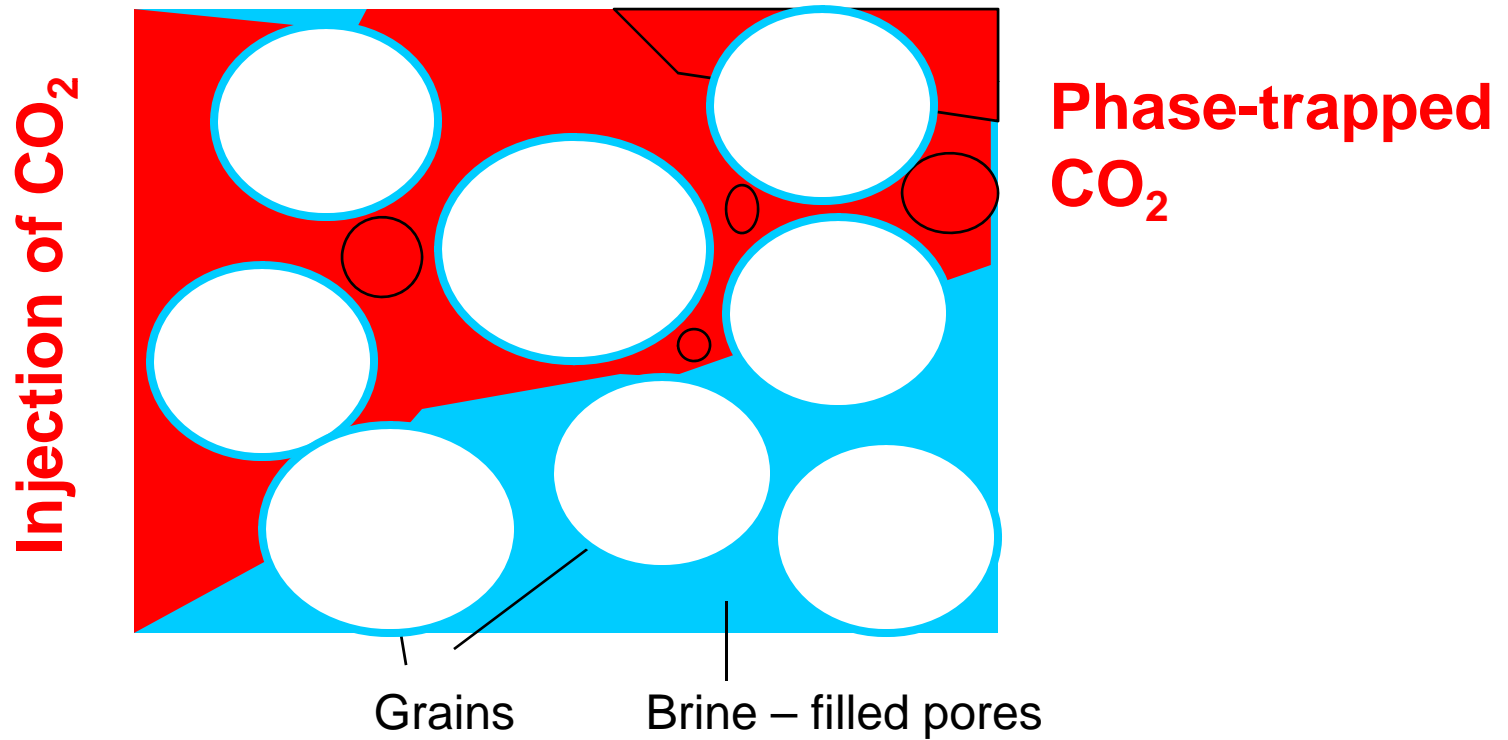


Measurement at a Well: Saturation logging (RST) Observation well to measure changes in CO₂ saturation – match to model



Shinichi Sakurai, Jeff Kane, Christine Doughty

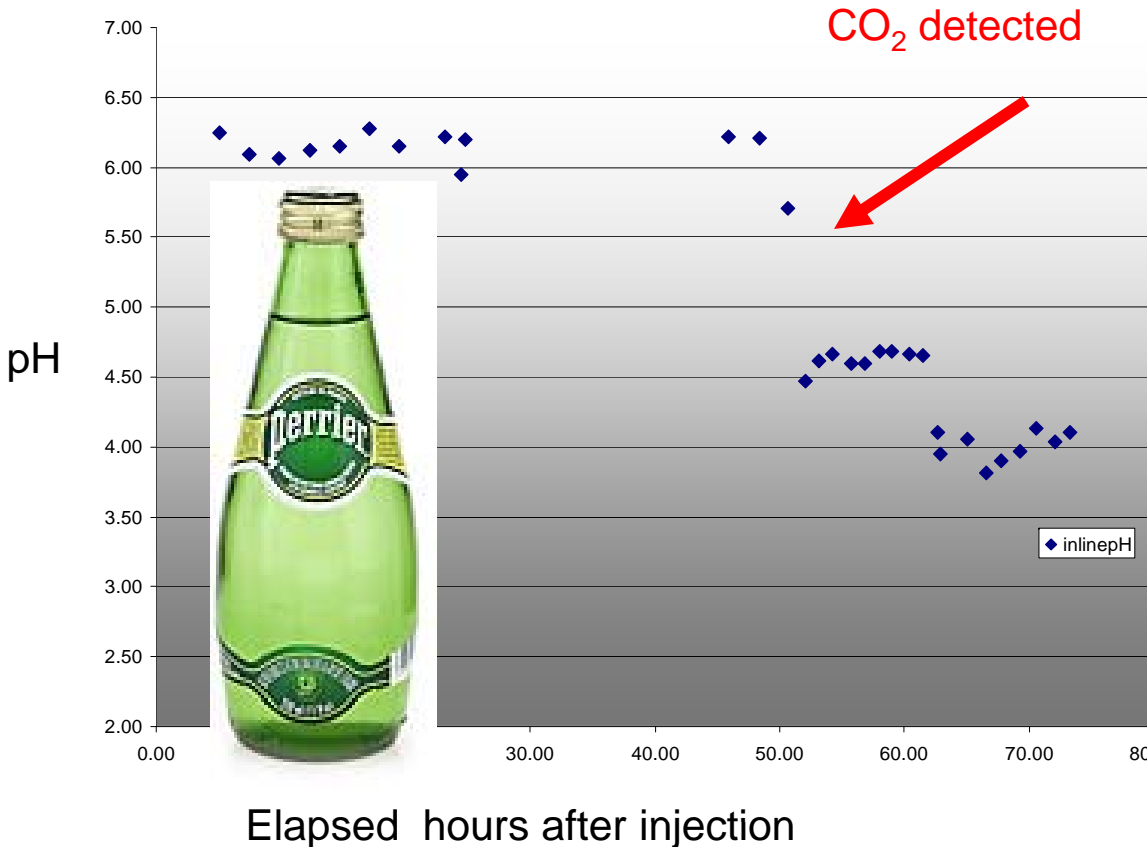
Phase Trapping – the power of capillary pressure





January 2006, attempting to produce the CO₂ back – no success. CO₂ is underground but cannot be produced

Chemical Changes During Injection

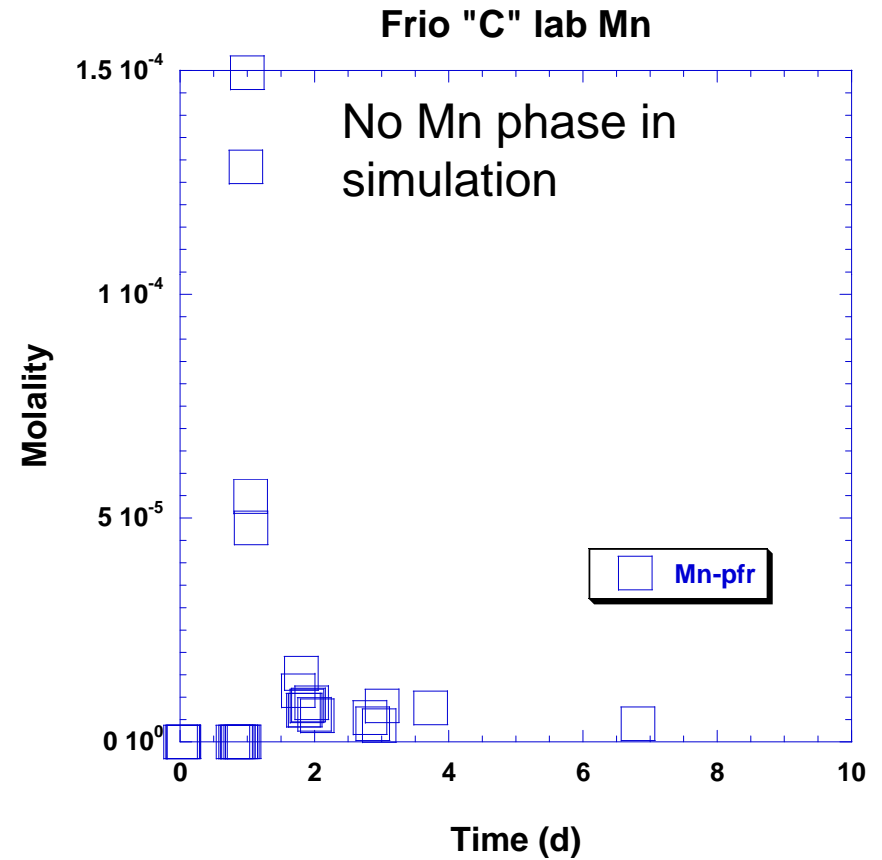
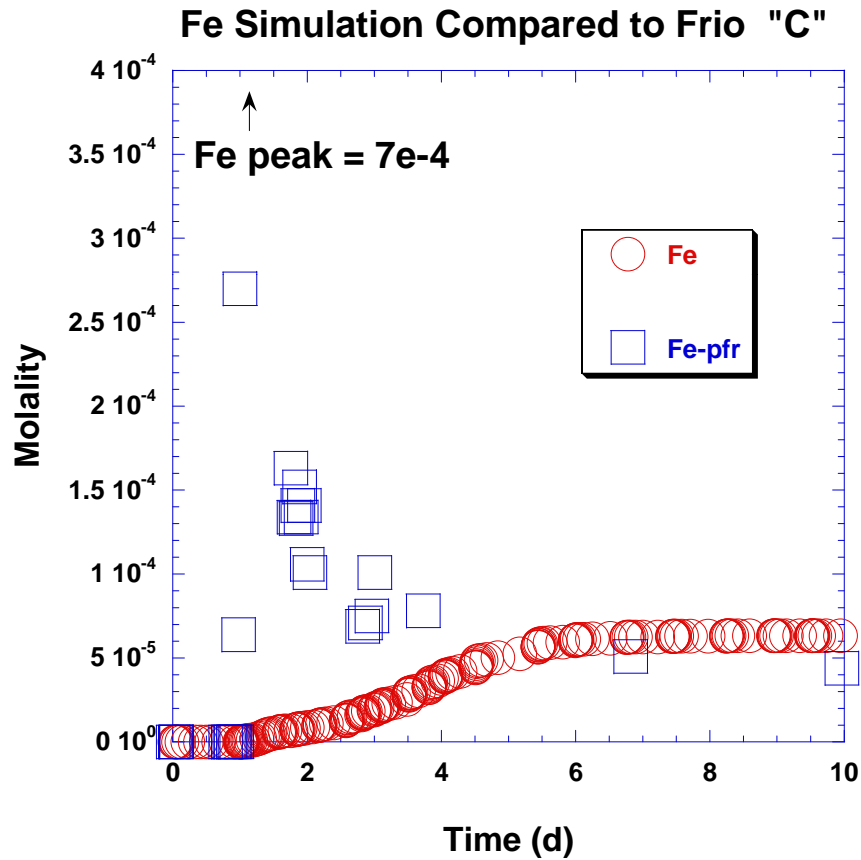


Analysis underway by USGS
Alkalinity, metals, DOC, DIC, VOC

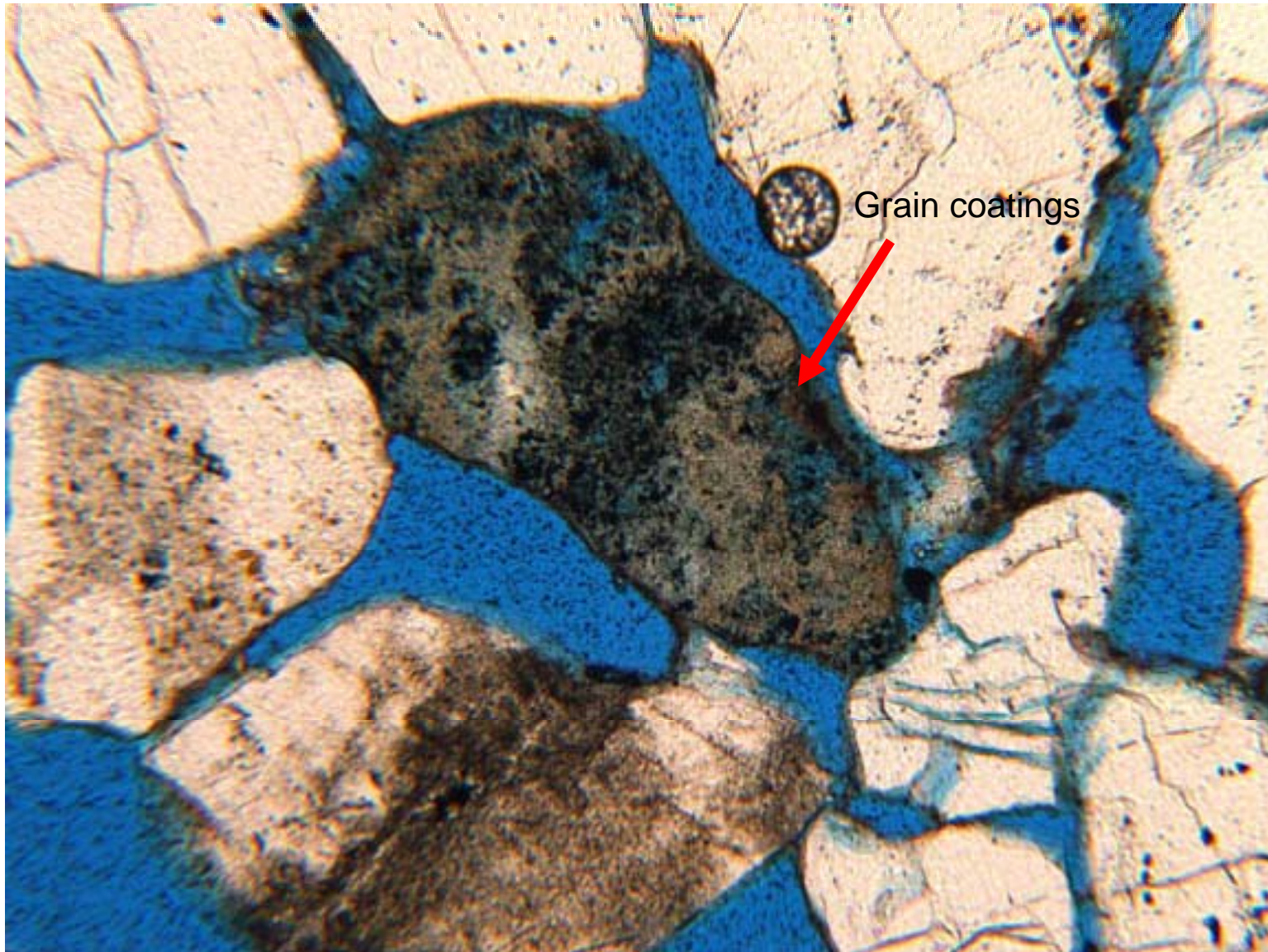
Unexpected result – extra iron and manganese in brine



Geochemical Simulation vs. Lab data

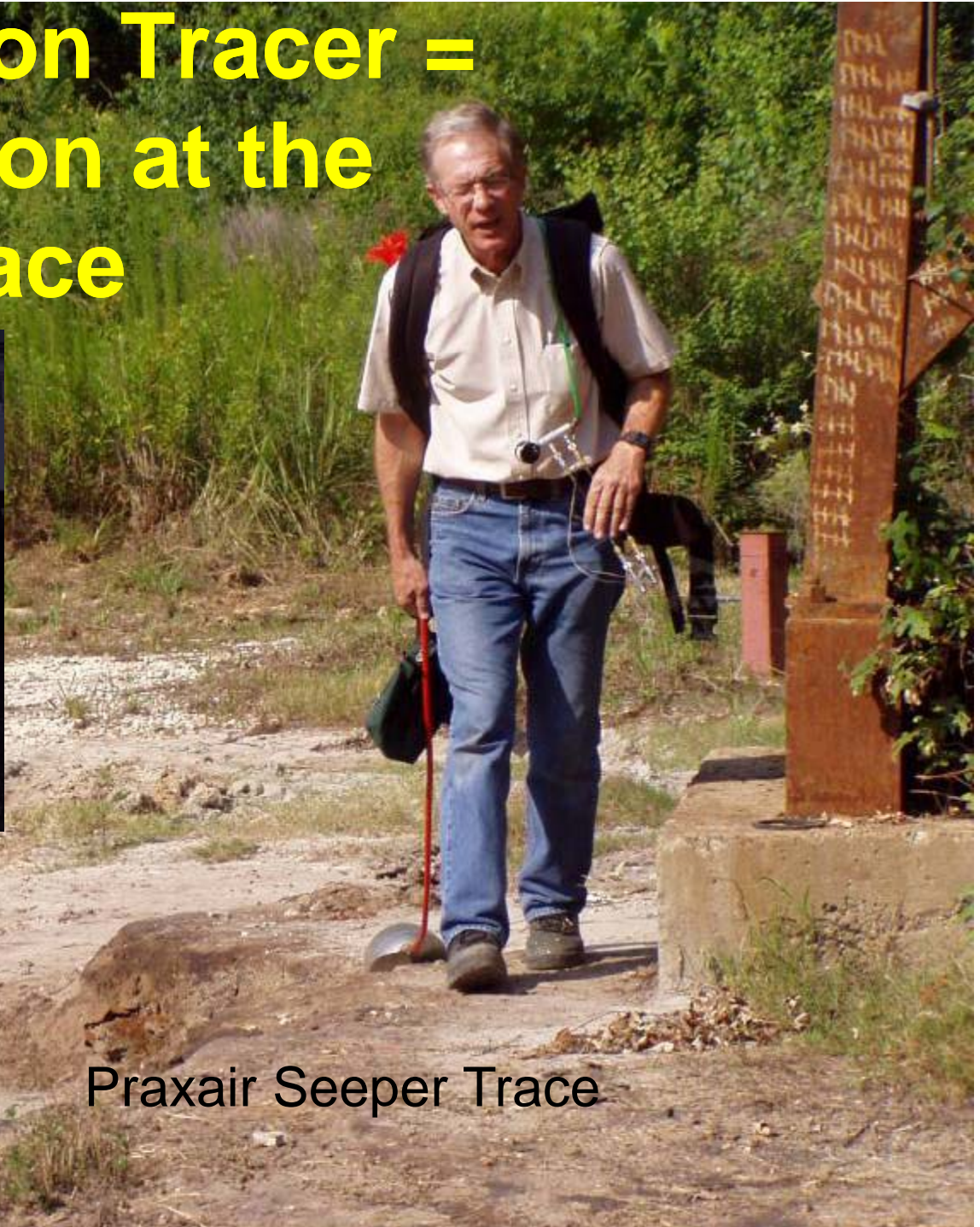
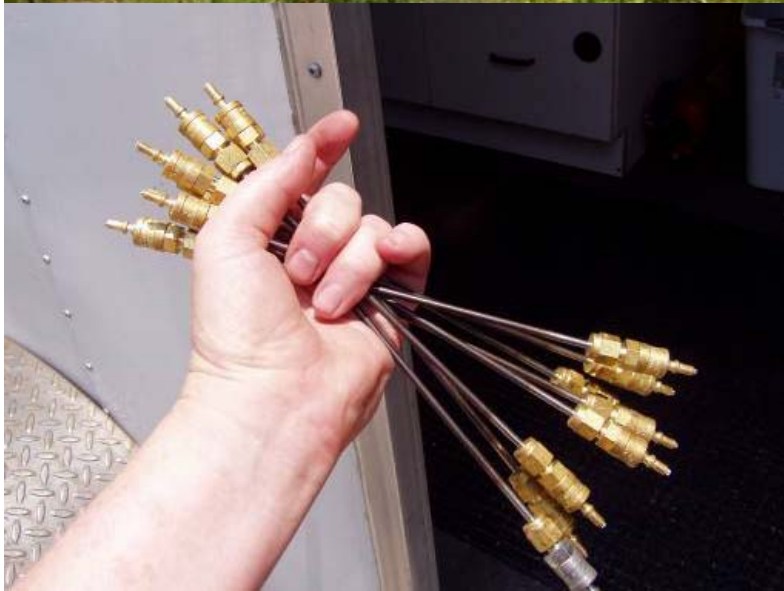


Grain coatings – early actors in geochemistry



5mm

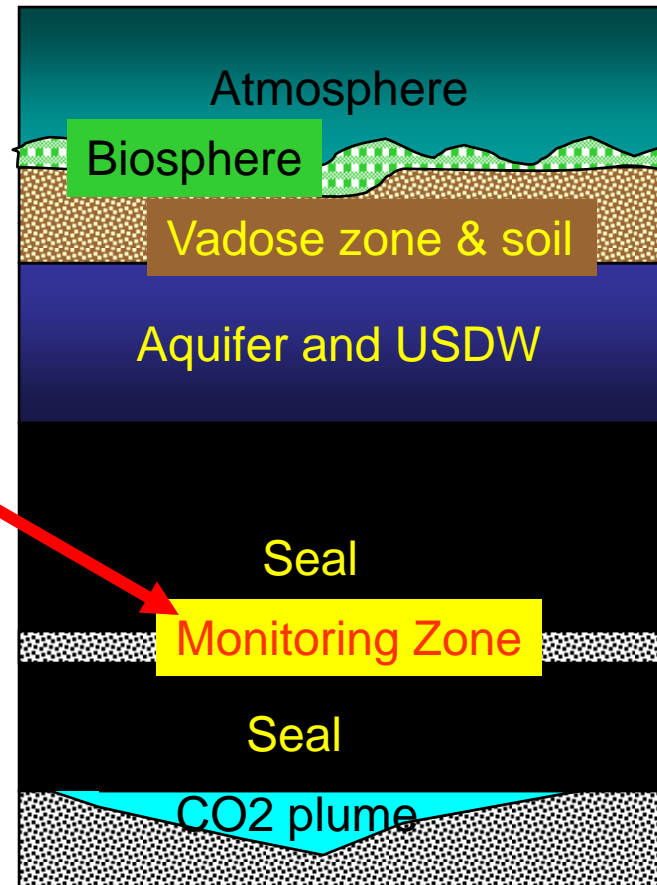
Perfluorocarbon Tracer = No Detection at the Surface



Praxair Seeper Trace

Cranfield test: Subsurface Monitoring Above Injection Zone

- Close to perturbation
- Quiescent relative to the surface
- High signal to noise ratio



Real-time Pressure monitoring at Cranfield



Time	BHT Monitor Intvl	BHP Injection	BHT Injection
20	251.44	5,595.7790	260.19
10	251.44	5,595.8070	260.19
30	251.44	5,595.8270	260.19
20	251.44	5,595.8440	260.19
10	251.44	5,595.8650	260.19
70	251.44	5,595.8680	260.19
10	251.44	5,595.8880	260.19
2009-01-13 14:19	852.82	187.73	14.72
2009-01-13 14:09	852.83	187.22	14.73
2009-01-13 13:59	853.83	186.68	14.73
2009-01-13 13:49	853.39	187.97	14.73

Surface & downhole data collected every minute and uploaded every 10 minutes to website.

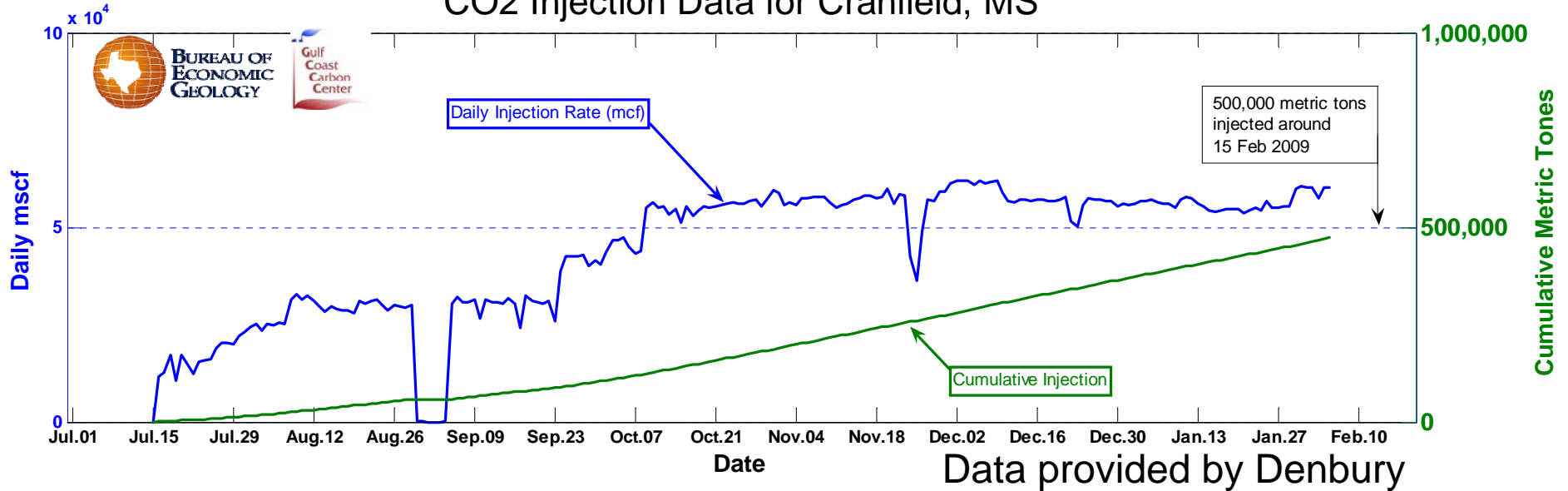
Time: 1 2 7 15 30 60 90 365

Scale: Auto Max/Min StDev High/Low HHigh/LLow

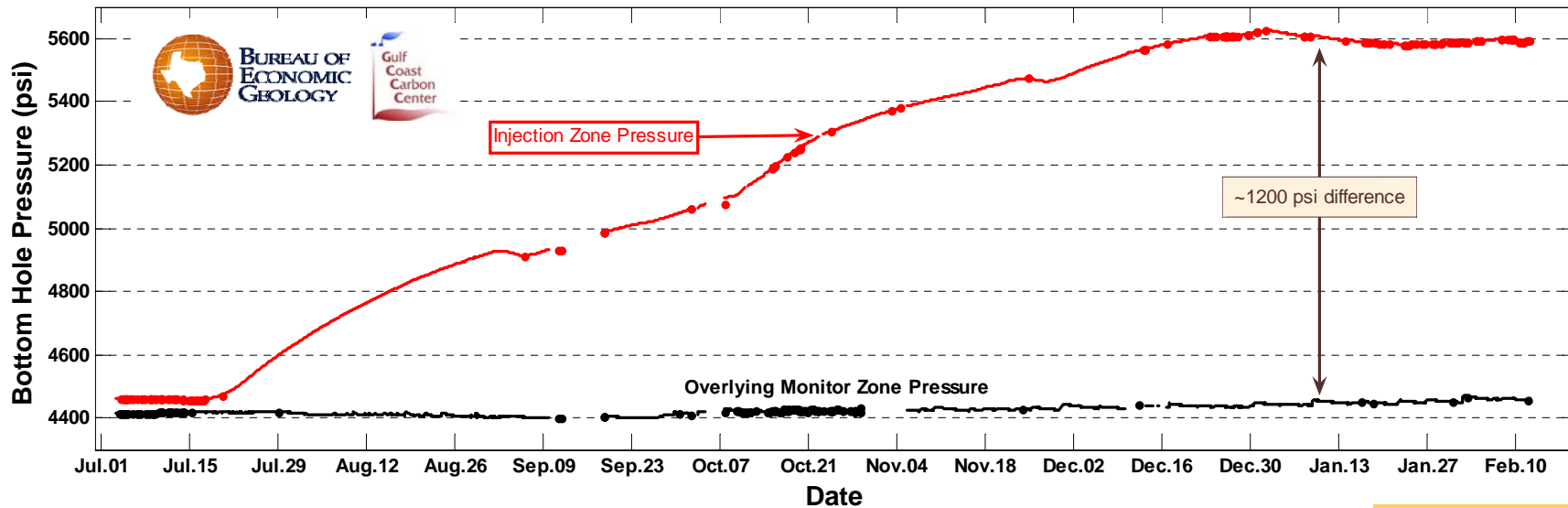
Show Extras View by: Log values

Continuous field data from dedicated monitoring well

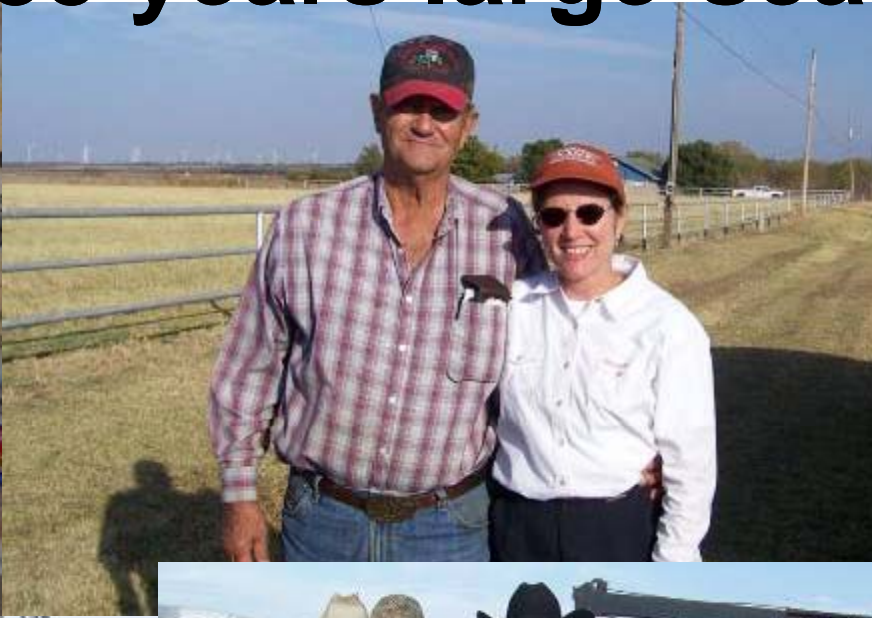
CO2 Injection Data for Cranfield, MS



Continuous Pressure Data from EGL #7 Monitor Well

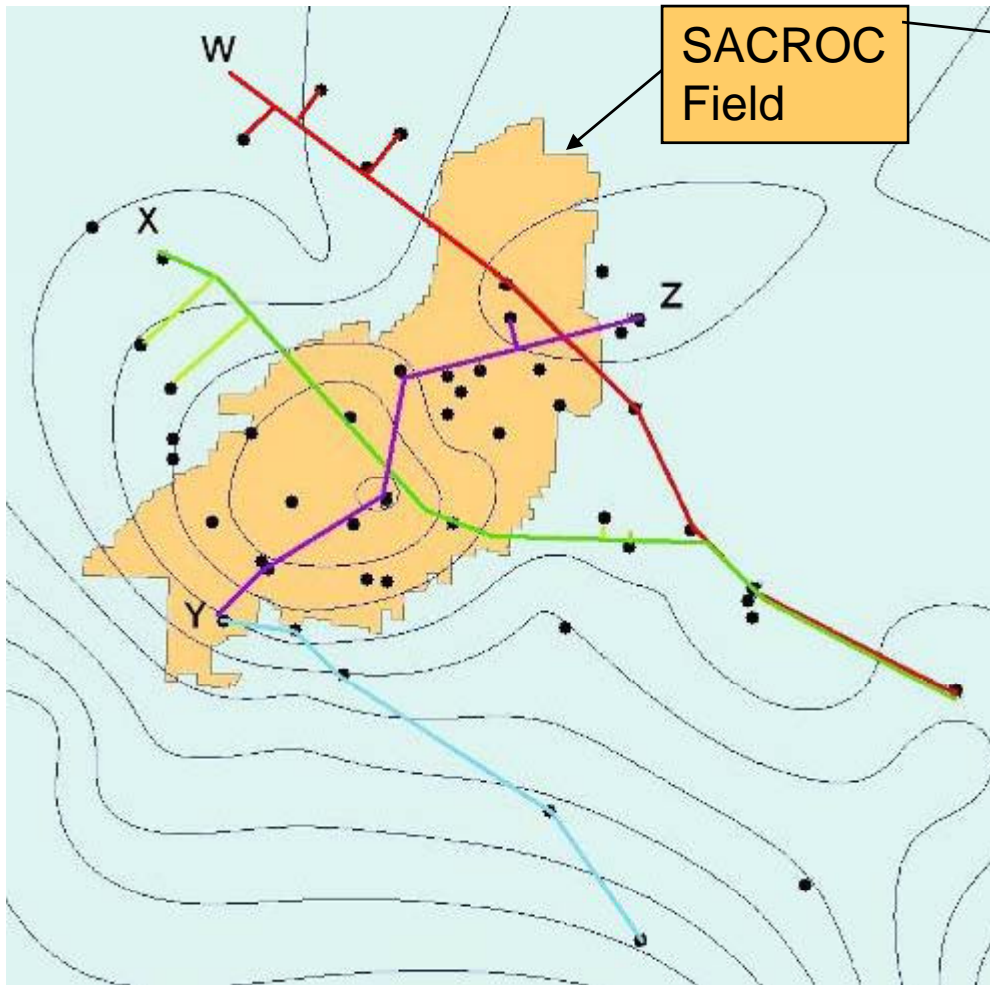


SACROC- testing fresh water after 35 years large-scale injection

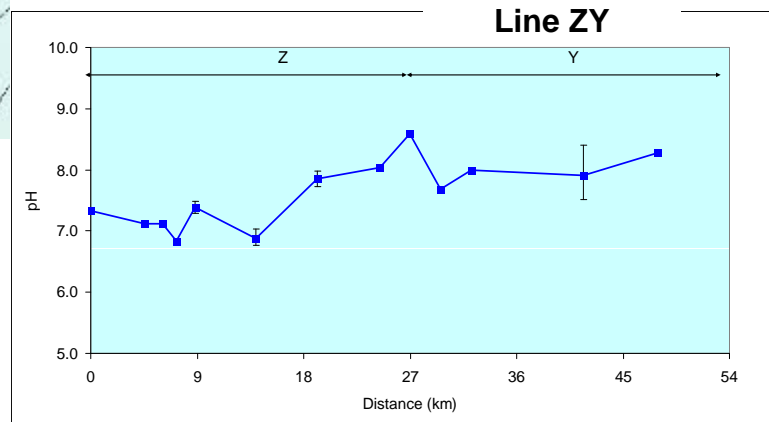
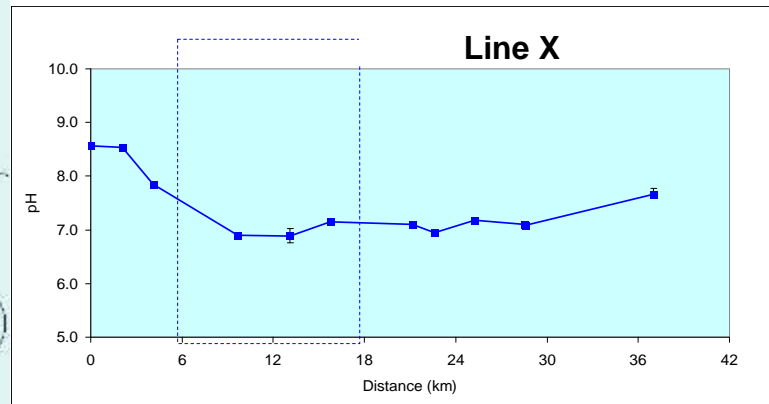
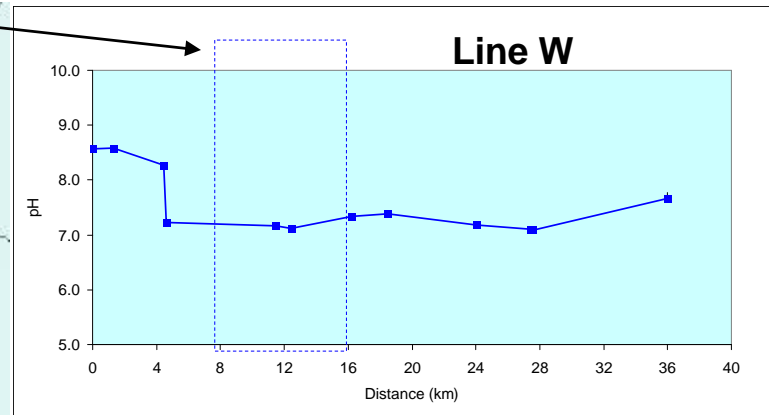


Smyth, BEG 2009

pH Along Transects Across SACROC field



SACROC Field



Wells completed through Ogallala aquifer with TD in Dockum Santa Rosa Aquifer

Romanak, Yang, Smyth BEG 2009

What can we say from these tests about “Is CO₂ safely Stored?”

- **Permanence of trapping – phase trapping limits movement of CO₂**
- **Wells are weak points – but in two areas studied this year with many wells, no evidence that leakage has occurred**

Conclusions

Can we measure the change resulting from putting CO₂ underground?

Yes, the tools tested have worked better than expected, confidence is increased.

Can we predict the change over time?

Yes, numerical models have worked correctly, confidence is increased.

Is the CO₂ stored safely underground?

So far yes, becomes more rigorous as we test larger scale over longer periods.

Work so far has helped prepare for next larger, longer tests, which are underway