

# *Southwest Regional Partnership on Carbon Sequestration*



## **Permian Basin Project Overview**

DE- FC26-05NT42591

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**Pittsburgh, Pennsylvania**



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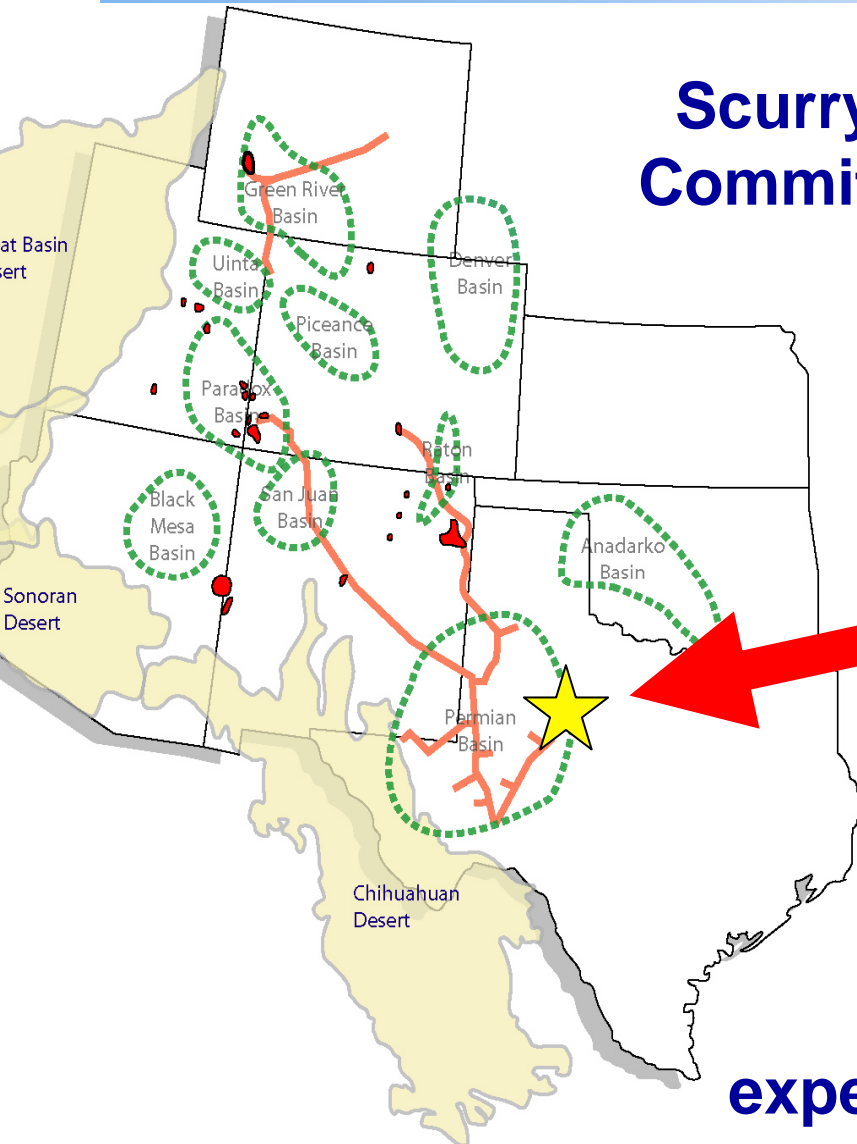


# Acknowledgements

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- Many thanks to the U.S. Department of Energy and NETL for supporting this project
- We also express gratitude to our many industry partners, who have committed a great deal of time, funding, and other general support for these projects
- The work presented today is co-authored by all partners in the Southwest Partnership (SWP)

# SACROC – eastern edge Permian Basin

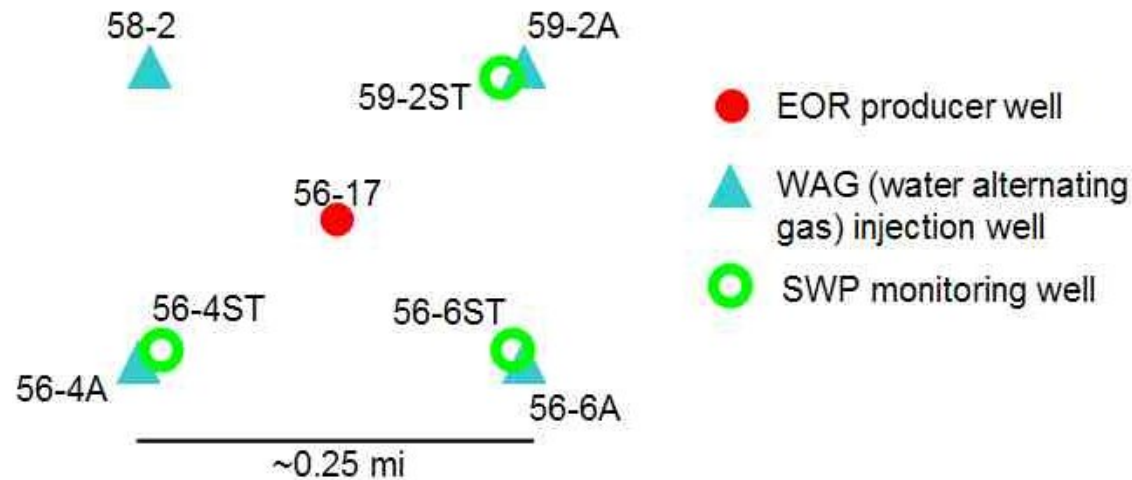


## Scurry Area Canyon Reef Operators Committee (SACROC) unitized oil field

- Ongoing CO<sub>2</sub>-injection since 1972
- Combined enhanced oil recovery (EOR) with CO<sub>2</sub> sequestration
- Depth to Pennsylvanian- Permian reservoir ~6,500 ft

**SACROC site 56-17 injection experiment: September-October, 2008**

# SACROC Injection Monitoring



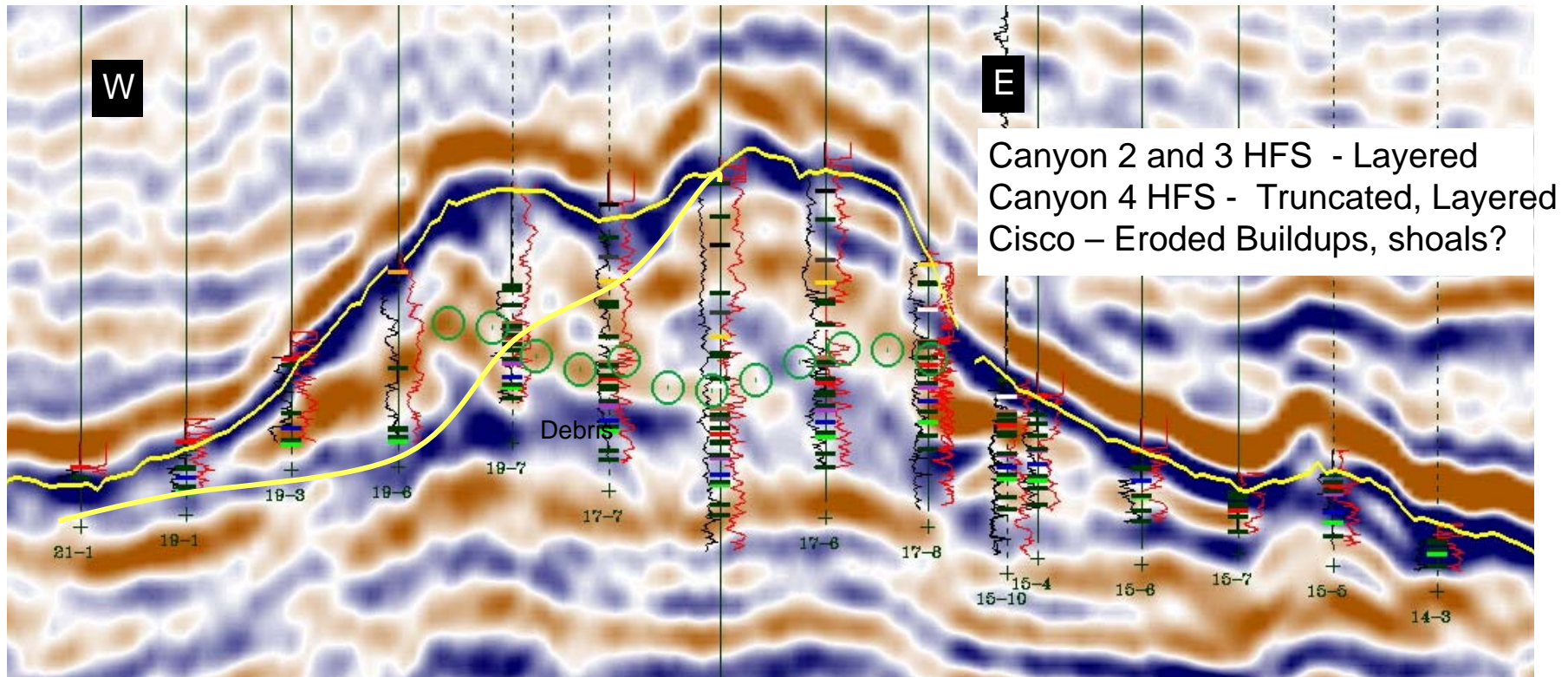
- **2003 and 2008-2009** – 3-D geophysical surveys (**KM, BEG**) used as basis for predictive modeling (**Utah, NMT**) and post-injection seismic surveys in Nov. 08 and Jan. 09 (**UPitt**)
- **March 2006 and June 2008** – CO<sub>2</sub> surface flux surveys; post-injection survey in Jan.-Feb. 09 (**NMT and BEG**)

- **June 2006 through July 2008** – Groundwater monitoring (**BEG**)
- **2007-2008** – Side track drilling of previously existing production wells for conversion to monitoring wells; initial drilling of three new injection wells (**KM**)
- **May-July 2008** – Pre-injection borehole geophysical logging in 56-4ST, 56-6ST, and 59-2ST and 56-4A, 56-6A, and 59-2A; Post injection surveys planned (**KM, SWP, and Schlumberger**)
- **July 2008** – Pre-injection vertical seismic profile (VSP) survey in 59-2ST; post-injection survey in Jan. 09 (**LANL**)

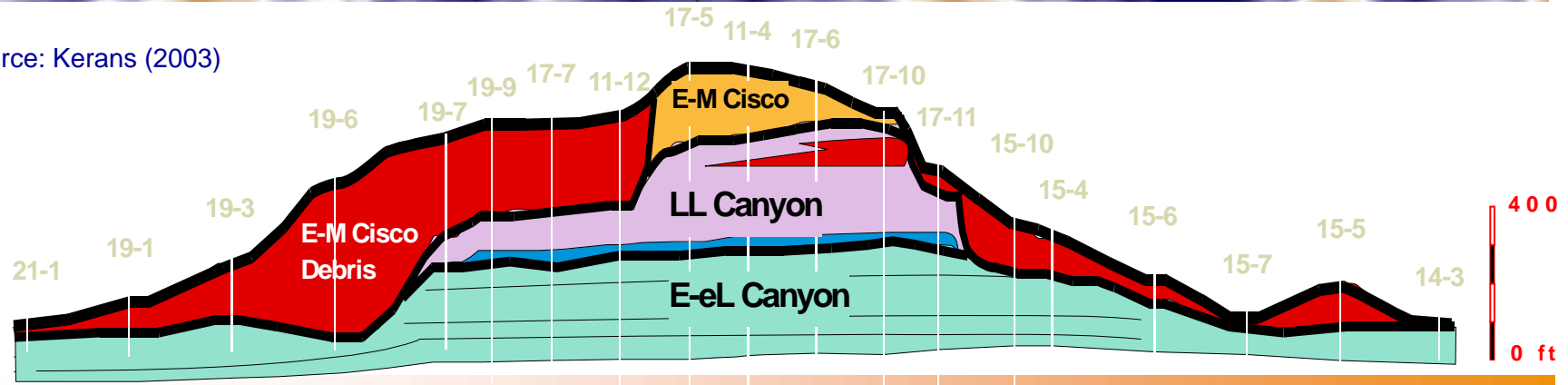
# SACROC Injection Site



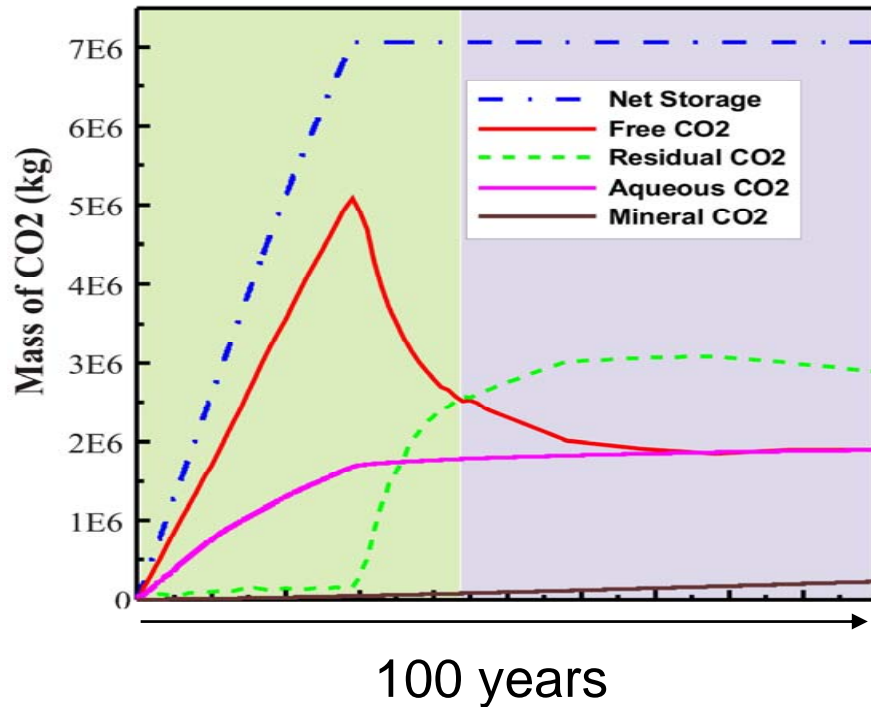
# KM/BEG Seismic Data & Geologic Model



Source: Kerans (2003)

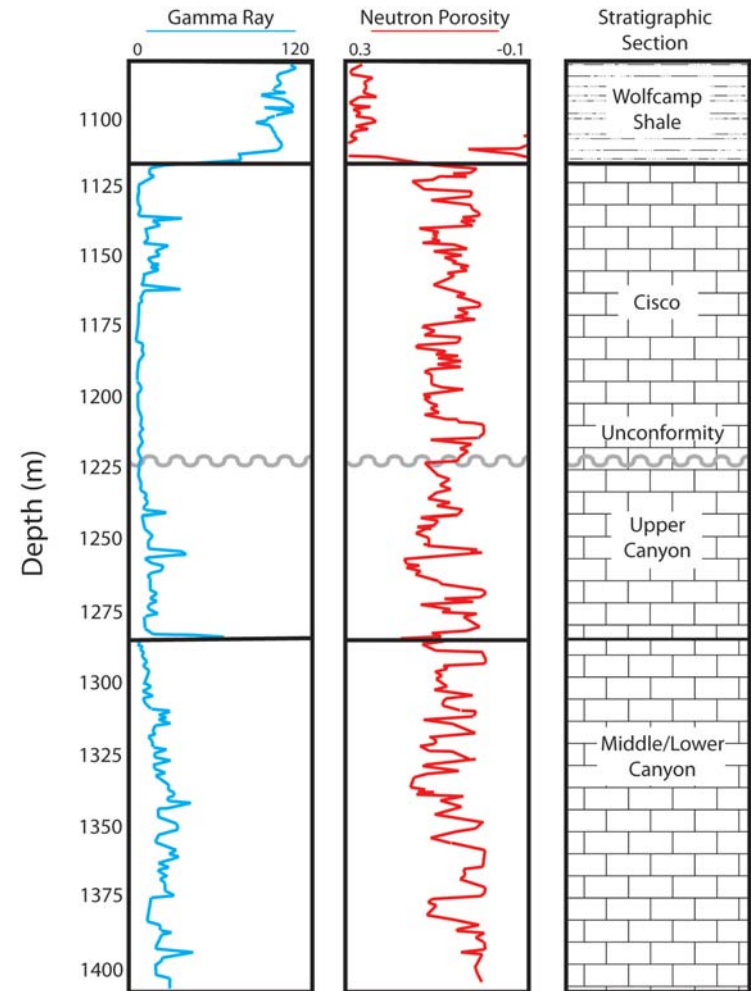


# Han/McPherson Modeling Results

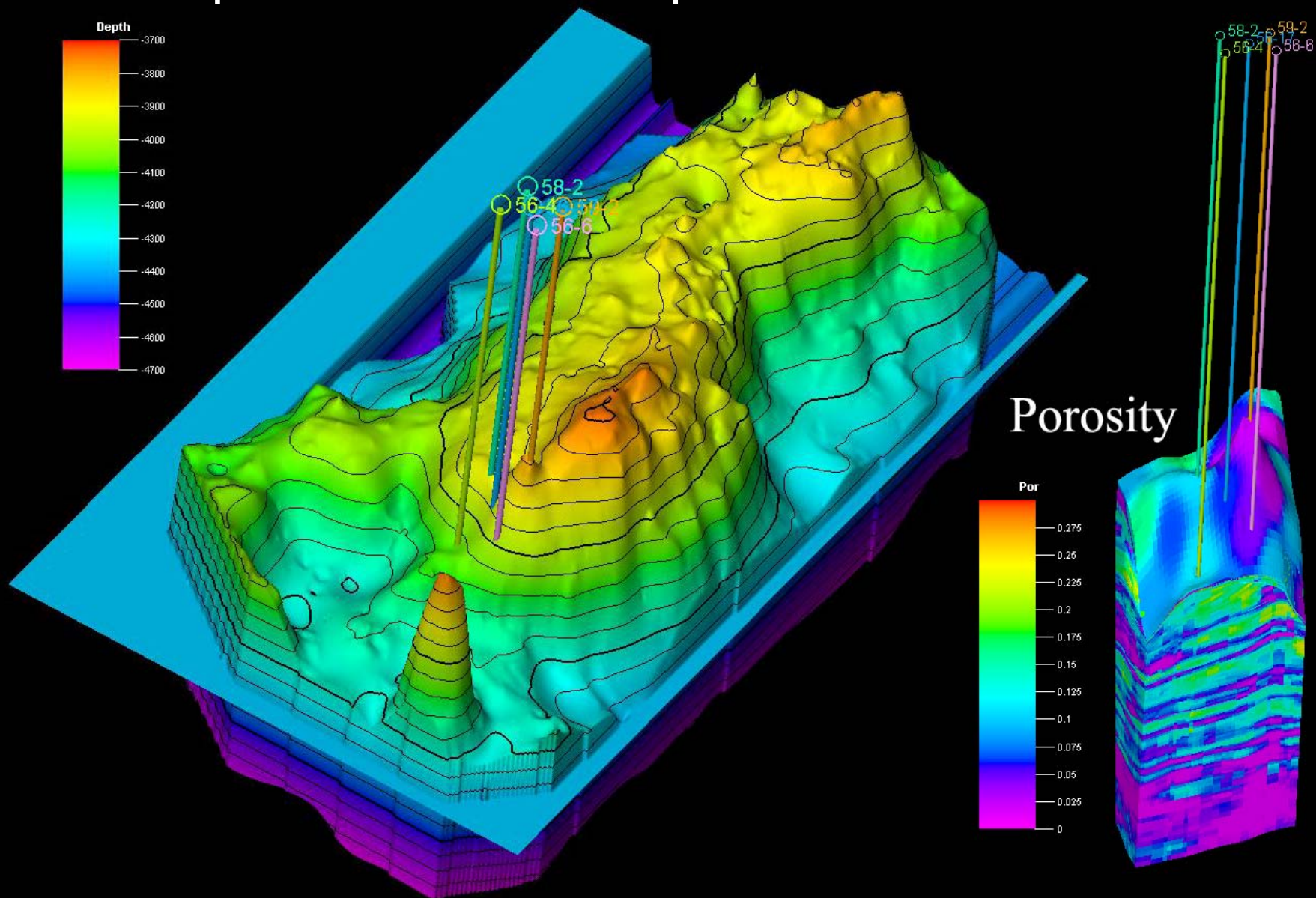


## Summary results:

1. Most CO<sub>2</sub> stored trapped by capillarity (“residual gas trapping”)
2. Injecting in deep saline reservoirs below oil/gas fields is preferred, for many reasons!



# Geologic model describing topography of SACROC northern platform and CO2 pilot site

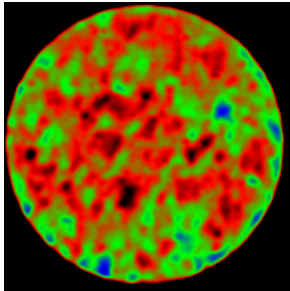




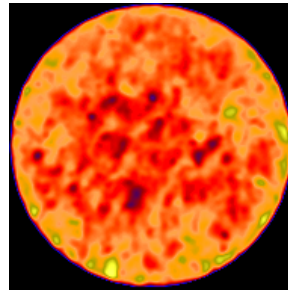
# Harbert (UPitt/NETL) Rock Physics

CT scanner images of SACROC production zone cores  
Dark areas are voids (porosity of material= 19%).

Low energy scan



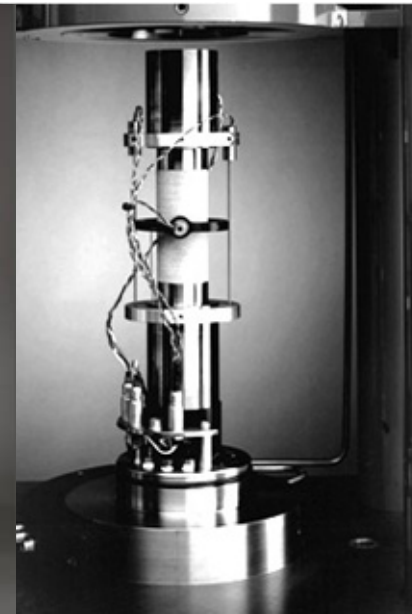
High energy scan



Right: NETL computed tomography (CT) scanner



NER AutoLab 1500 used to replicate in-situ reservoir conditions in rock cores. Coreholders are capable of measuring one compressional and two orthogonally polarized shear waves. The three transducers operate at a frequency of 500 to 700 kHz.

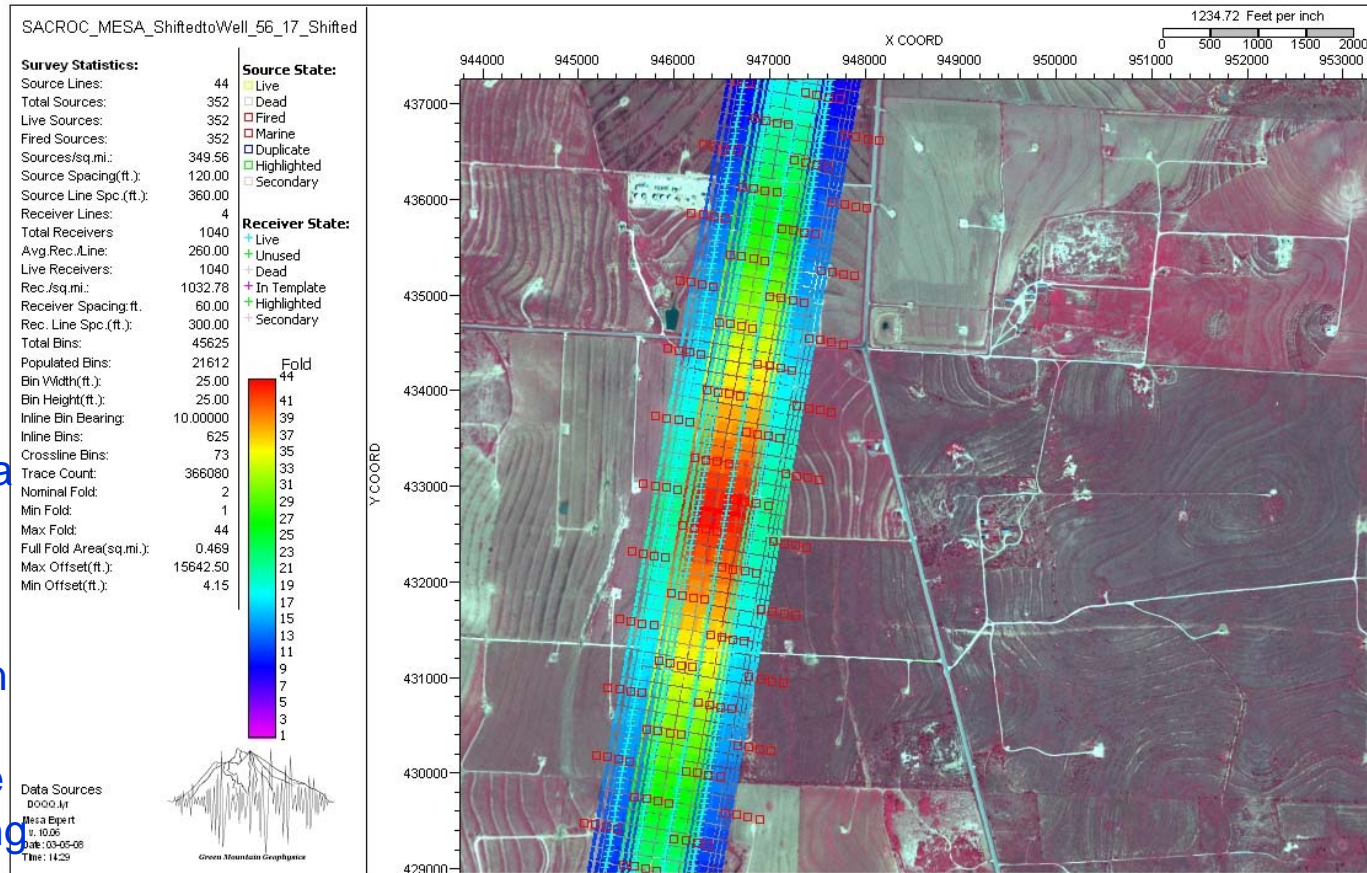


Left: NETL Core Flow Lab equipment

# UPitt/NETL and BEG Seismic Research

Post-injection surface geophysical survey (2-3-D) in injection test area to image CO<sub>2</sub> movement

- Through help of KM and BEG (Hardage), Harbert has obtained pre-stacked, pre-migrated seismic trace gathers from Rock Solid Imaging Co. for amplitude vs. angle (AVA) analysis of KM 2003 dataset
- Purpose: to determine if the amplitude from a specific reflection point on a surface varies as the angle of incidence increases between the source and receiver. This technique can predict reservoir rock type and pore-fluid content if the reservoir and its surrounding media are properly characterized.



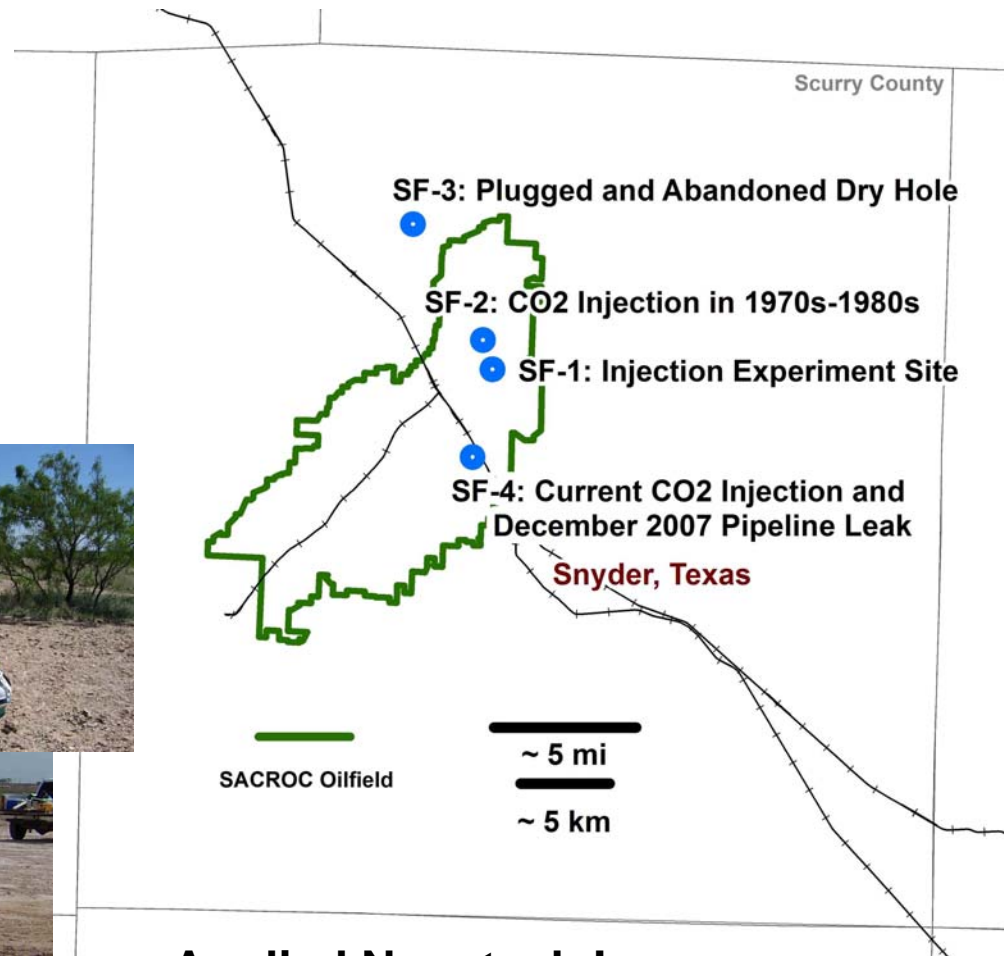
# LANL VSP Geophysical Surveys

- Pre-injection offset and walkaway survey in July 2008
- Post-injection offset and walkaway survey in January 2009



# NMT and BEG SACROC CO<sub>2</sub> Surface Flux Surveys

- Initial survey in March 2006 at Claytonville and SACROC
- SACROC survey in June 2008 at locations shown to right
- Follow up survey will be conducted at same four sites in late January-early February 2009



**Applied Nanotech Inc.  
experimental CO<sub>2</sub> detector will  
be tested at SACROC in Jan. 09**

# BEG Groundwater Sampling

## Geologic Units

Qs = Quaternary  
windblown sand

Qu = Quaternary  
undifferentiated

Eo = Eocene  
Ogallala

TRd = Triassic  
Dockum

## PERMIAN

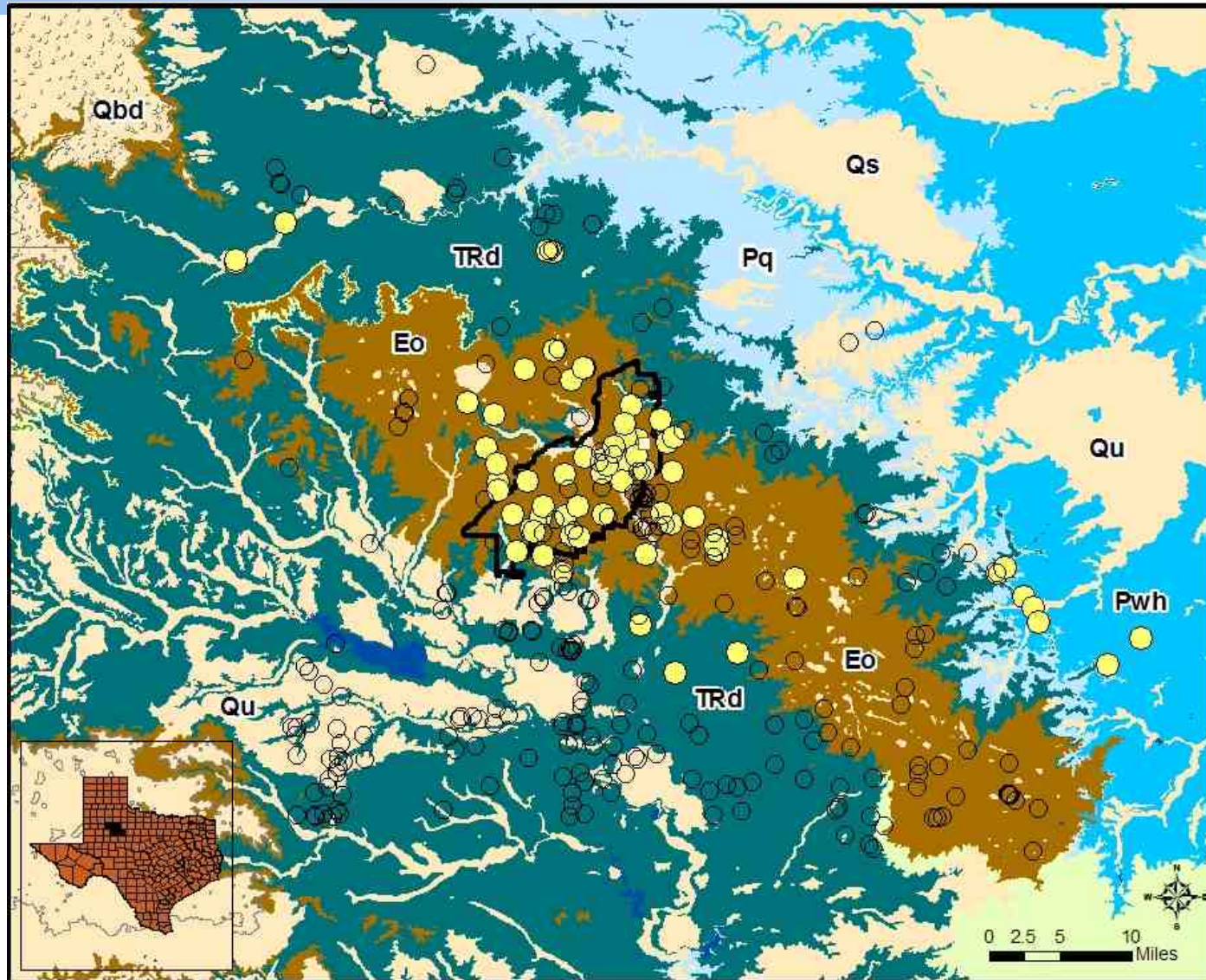
Pq =  
Quartermaster

Pwh = Whitehorse

Pb = Blaine

Ps = San Angelo

Pc = Clearfork



# BEG Water Well Sampling

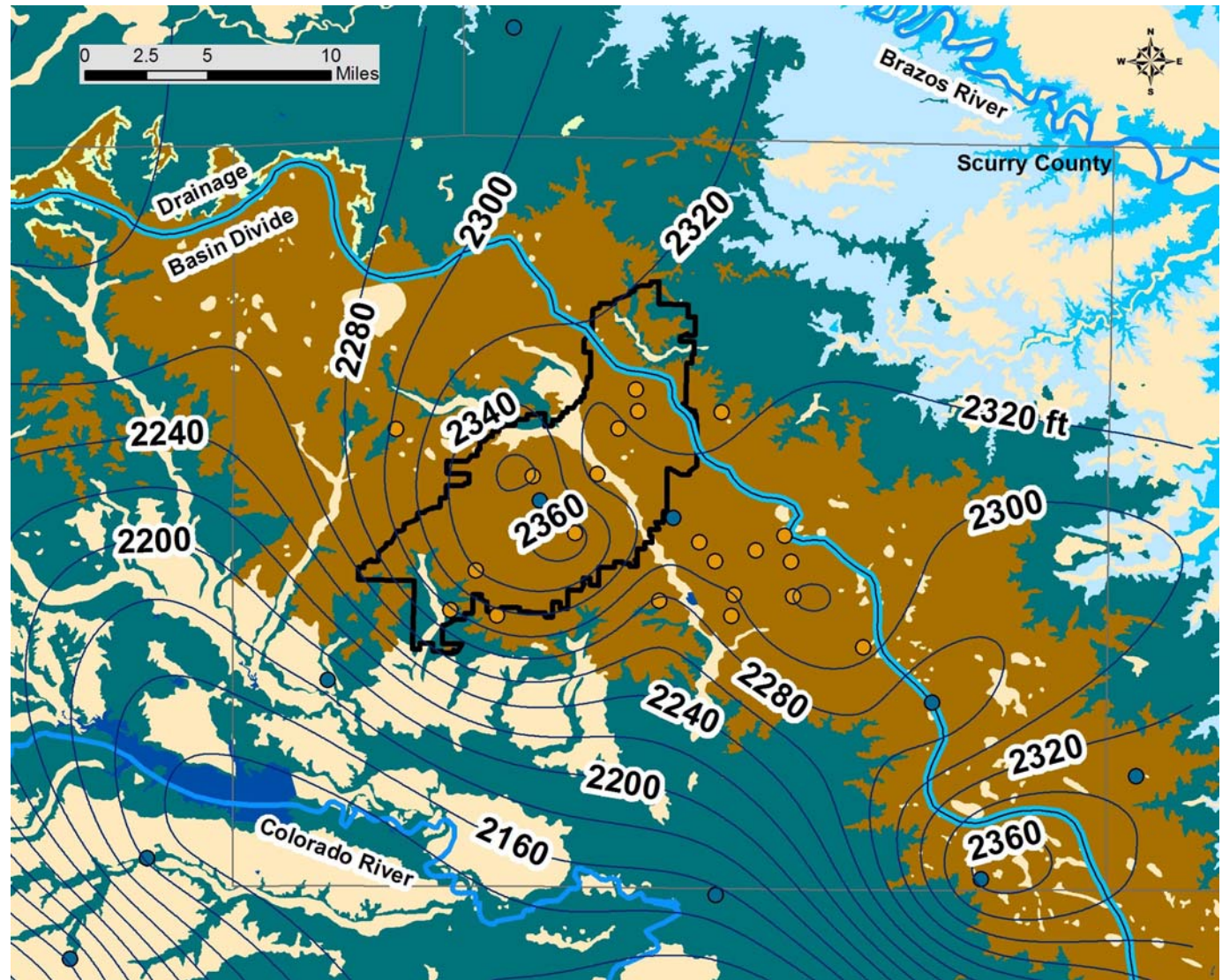
- **Six sampling trips – Claytonville in June 2006; SACROC in July 2007, Nov. 2007, March 2008, July 2008, and Nov. 2008**
- **Total wells sampled – 60 (6 SACROC wells sampled 7/07, 11/07, 3/08, and 7/08)**
- **Total samples sets collected – 123**
- **Laboratory analytes (LANL): Al, Ag, As, B, Ba, Be, Br, Ca, Cd, Cl, Co, CO<sub>3</sub>, Cr, Cs, Cu, d13C, dD, d18O, F, Fe, HCO<sub>3</sub>, Hg, K, Li, Mg, Mn, Mo, Na, Ni, NO<sub>3</sub>, Pb, PO<sub>4</sub>, Rb, Sb, Se, Si, Sn, SO<sub>4</sub>, Sr, TDS, Th, Ti, Tl, U, V, and Zn**
- **Laboratory analytes (UT DGS): DIC, DOC, headspace gases (pCO<sub>2</sub>, CH<sub>4</sub>)**
- **Field parameters: alkalinity, dissolved oxygen, pH, specific conductivity, and temperature**
- **Well information: total depth, water level (where possible), x and y coordinates from GPS, elevation (z) from digital elevation model, stratigraphic unit from BEG-constructed structure contour maps (based on shallow geophysical logs)**

# Water Well Sampling Assistance



# Dockum Santa Rosa Potentiometric Surface Contours on Geology

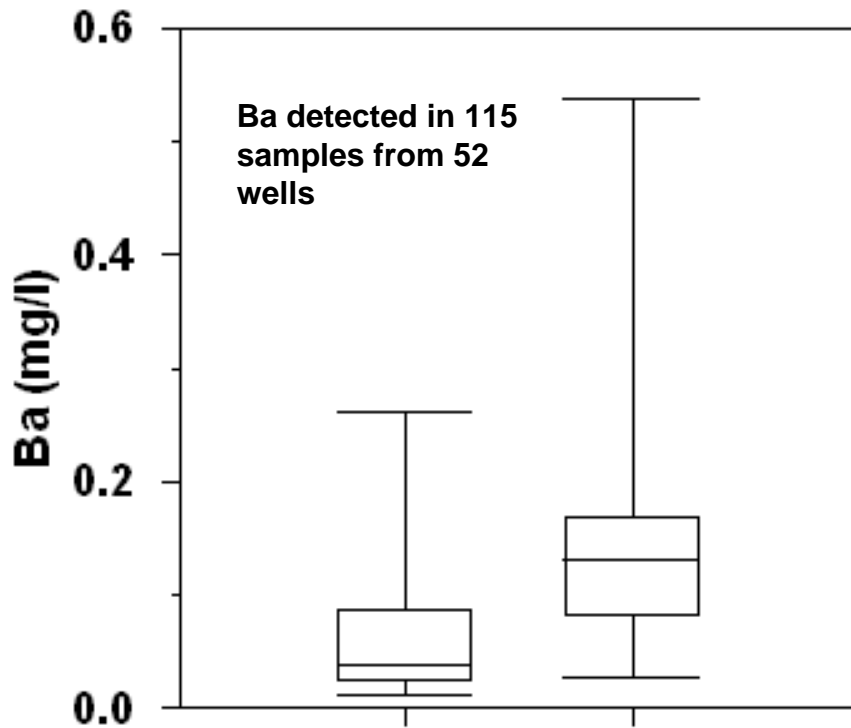
- Water level data from TWDB in 12/07 and 3/08 (blue dots) and BEG in 3/08 and 7/08 (orange dots)
- Contours in feet above sea level
- Possible groundwater mounding over SACROC
- Area-wide water levels to be measured in November 2008





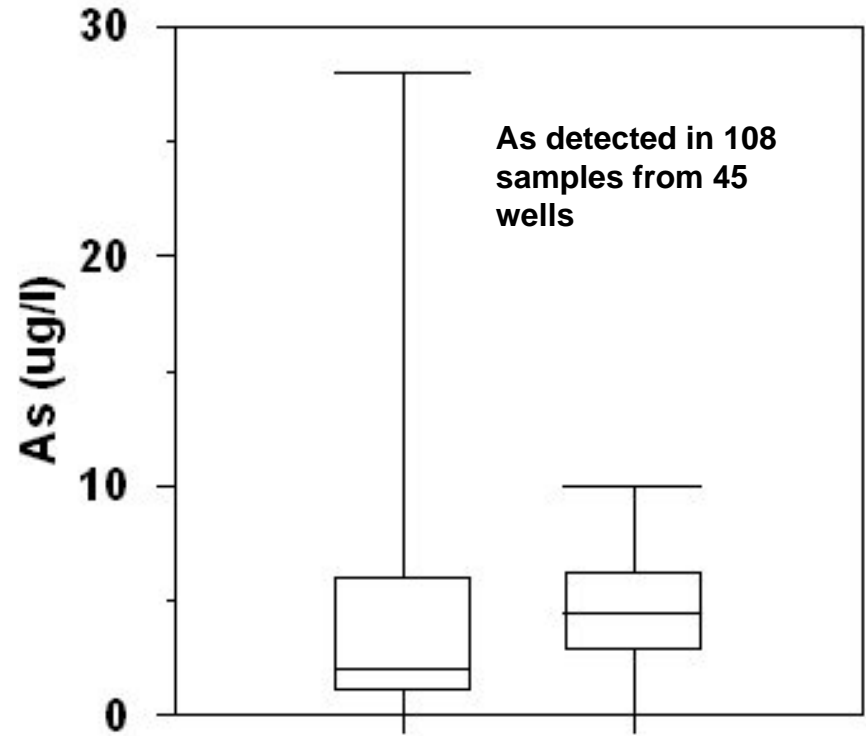
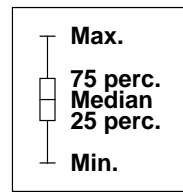
# BEG Water Chemistry Examples

## Box and Whisker Plots



Outside  
SACROC

Inside  
SACROC



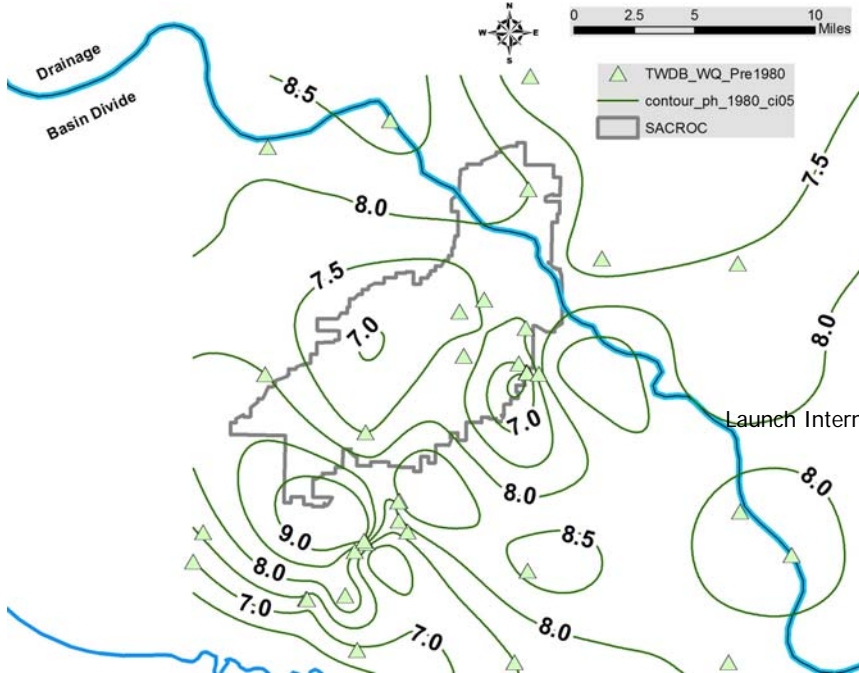
Outside  
SACROC

Inside  
SACROC

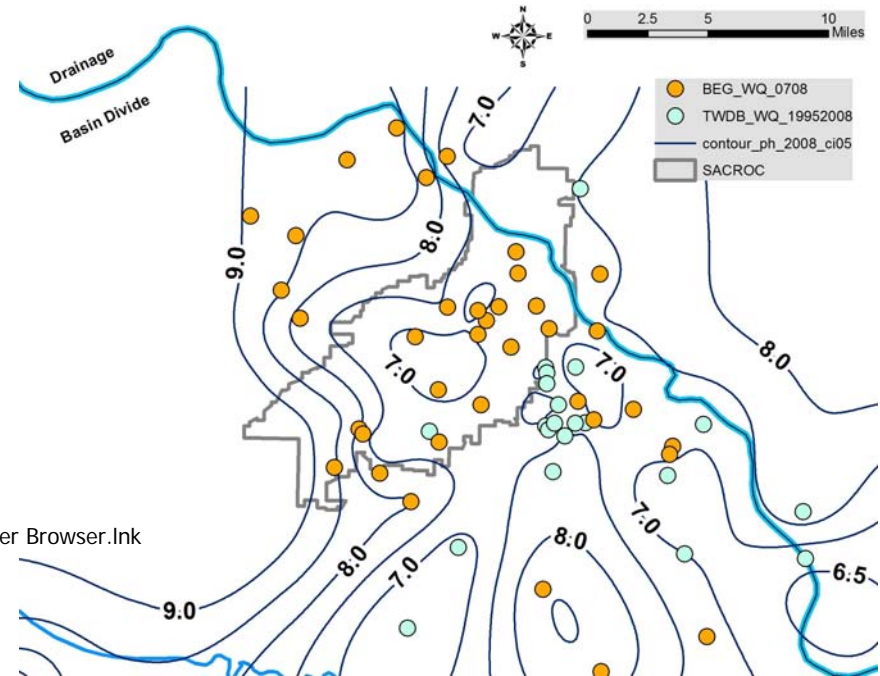
# BEG Water Chemistry Examples

## Temporal-Spatial Relationships

Parameter: pH



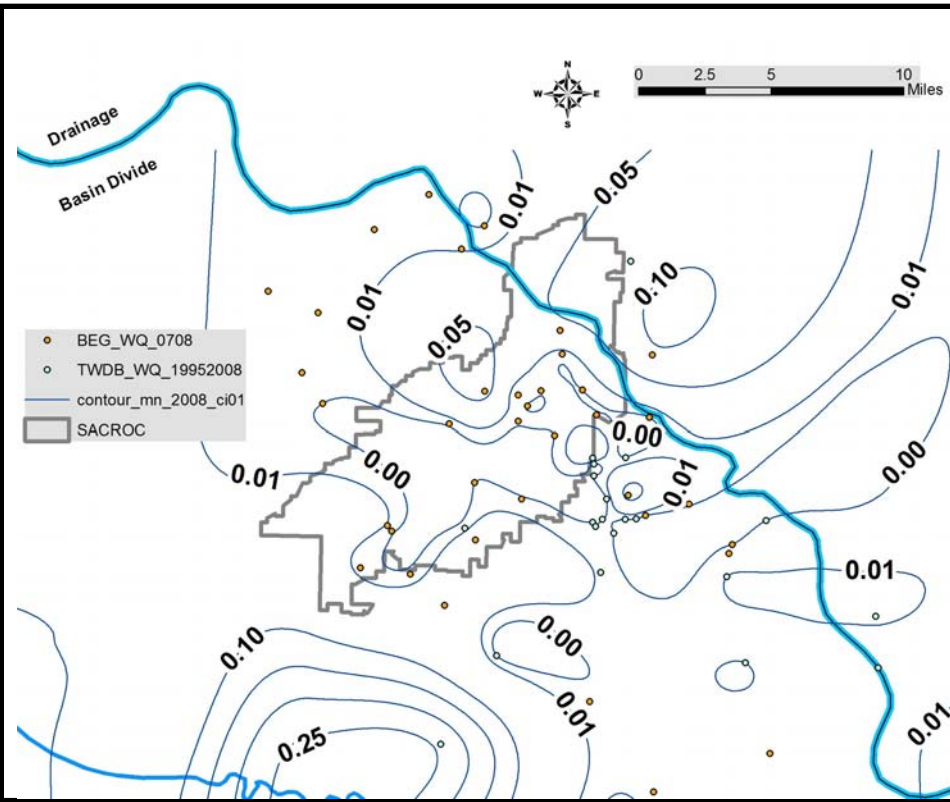
Pre-1980 pH values reported in Texas Water Development Board (TWDB) database for water wells completed in Dockum Santa Rosa



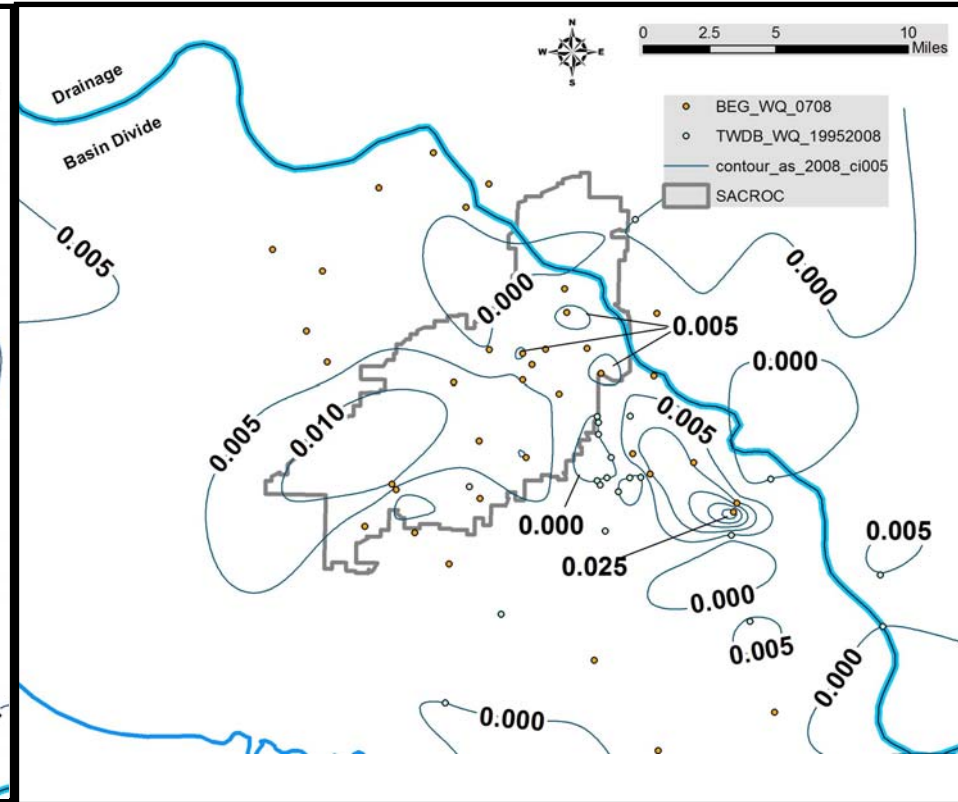
pH values from TWDB (1995 – 2008 samples) and BEG (2007-2008 samples) for water wells completed in Dockum Santa Rosa

# BEG Water Chemistry Examples

## Spatial Relationships

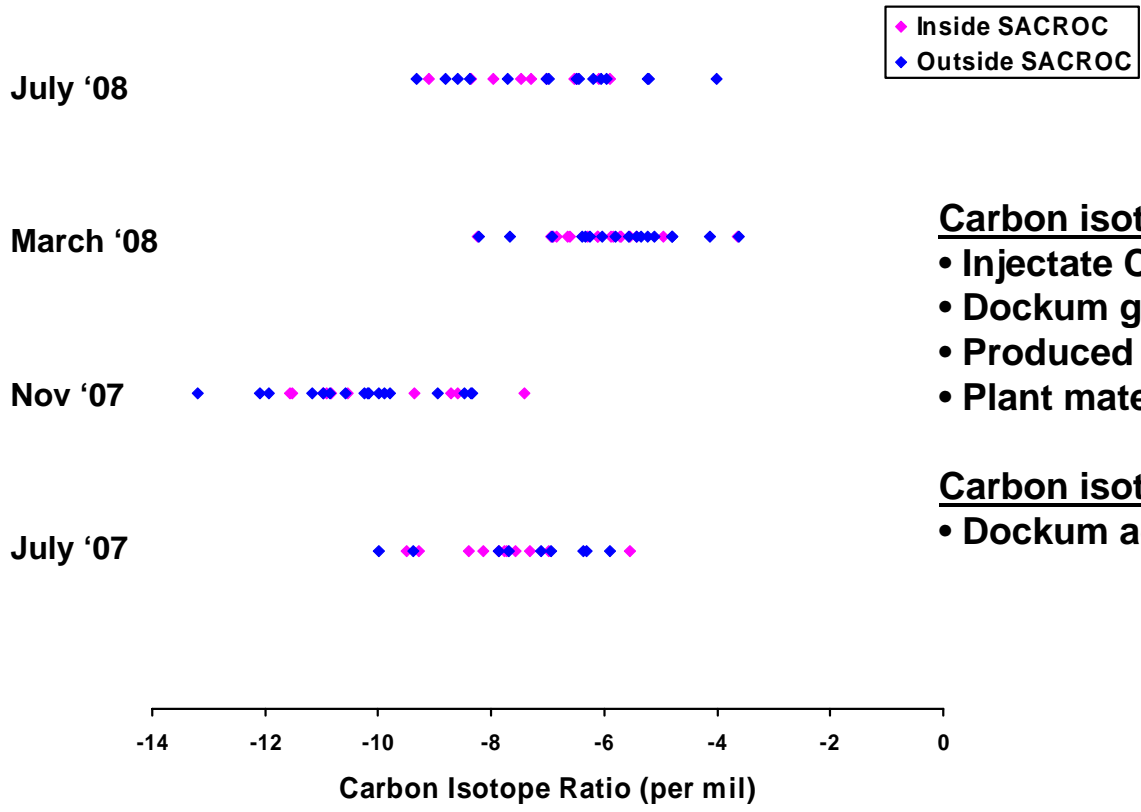


Analyte: Manganese (Mn)



Analyte: Arsenic (As)

# Stable Carbon Isotopic Ratios (d13C)



- Carbon isotope data collected to date:
- Injectate CO2 (-6.1 to - 0.5 per mil)
  - Dockum ground water (-13.2 to -3.6 per mil)
  - Produced water (1.3 to 9.0 per mil)
  - Plant material (-23.5 to -28.8 per mil)

- Carbon isotope data still needed:
- Dockum aquifer carbonate



# Previous O&G Well Drilling

