Permian Basin Project Overview
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• 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)
SACROCU – eastern edge Permian Basin

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

- Ongoing CO₂-injection since 1972
- Combined enhanced oil recovery (EOR) with CO₂ sequestration
- Depth to Pennsylvanian-Permian reservoir ~6,500 ft

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

- **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)

- **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** – CO₂ surface flux surveys; post-injection survey in Jan.-Feb. 09 (NMT and BEG)
SACROC Injection Site
KM/BEG Seismic Data & Geologic Model

Canyon 2 and 3 HFS - Layered
Canyon 4 HFS - Truncated, Layered
Cisco – Eroded Buildups, shoals?

Source: Kerans (2003)
Summary results:
1. Most CO$_2$ 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%).

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.
UPitt/NETL and BEG Seismic Research

Post-injection surface geophysical survey (2-3-D) in injection test area to image CO₂ 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$_2$ 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$_2$ 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

- 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, CO3, Cr, Cs, Cu, d13C, dD, d18O, F, Fe, HCO3, Hg, K, Li, Mg, Mn, Mo, Na, Ni, NO3, Pb, PO4, Rb, Sb, Se, Si, Sn, SO4, Sr, TDS, Th, Ti, U, V, and Zn
- Laboratory analytes (UT DGS): DIC, DOC, headspace gases (pCO2, CH4)
- 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

Ba detected in 115 samples from 52 wells

As detected in 108 samples from 45 wells
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
THE END
Previous O&G Well Drilling