SACROC EOR and Sequestration Demonstration
DE-FC26-05NT42591

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SACROC – Scurry Area Canyon Reef Operators Committee unitized oilfield
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• New Mexico Tech and University of Utah project management
  Robert Lee, Reid Grigg, and Brian McPherson (Principal Investigator)

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    Stephen Boger, Steve Guillot, Mike Hirl, Jeff Kane, Renee Robertson & Merle Steckel in Midland and Houston, TX offices; Kirby Head, Michael Head, Nathan Mathis, and Ricky Thompson in Snyder, TX offices
  Schlumberger
    Dwight Peters and Bob Butsch

• Idea to study groundwater over SACROC
  Susan Hovorka

• The work presented today is co-authored by all research partners in the Southwest Partnership (SWP)
  UT Bureau of Economic Geology; New Mexico Tech; University of Utah; Los Alamos National Laboratory (LANL); University of Pittsburgh
SACROC Previous CO₂ Injection

- 3 TCF (150 million metric tons (MMt)) CO₂ injected for enhanced oil recovery (EOR) since 1972 by multiple operators
- 1.5 TCF (75 MMt) CO₂ recovered as of October 1, 2008
- SWP researchers are among first to test if this CO₂ is trapped in reservoir zones or if it has leaked into overlying strata
- Previous CO₂ injection history provides opportunity for (1) larger scale, inside vs. outside SACROC, and (2) longer time frame soil and groundwater monitoring
- 56-17 reverse 5-spot CO₂ EOR injection pattern is location of the SWP injection experiment test site

KM currently operates SACROC and is providing much assistance with the project
June 2006 through June 2009 – Groundwater monitoring (BEG), sample analysis (BEG and LANL) and data interpretation (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 – surface geophysical survey and geologic model (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)
10/22-23/08 SACROC Presentations

Injection experiment 56-17 site studies
- (1) James Rutledge and Lianjie Huang – LANL
  Pre-injection vertical seismic profiling (VSP) completed in reservoir
- (6) Weon Shik Han – University of Utah
  Modeling to predict fluid movement in reservoir
- (4) Bob Butsch – Schlumberger Carbon Services
  Petrophysical interpretation from borehole logging in reservoir
- (5) Bill Harbert – University of Pittsburgh and DOE/NETL
  Surface geophysics and rock physics

Regional studies
- (3) Lee Harris – New Mexico Tech PRRC
  Surface flux survey inside and outside SACROC
- (2) Katherine Romanak – UT Austin Bureau of Economic Geology (BEG)
  Groundwater geochemistry study inside and outside of SACROC

(1,2,3) – order of presentations
SACROC Injection Site
LANL VSP Geophysical Surveys

- Pre-injection offset and walkaway survey in July 2008
- Post-injection offset and walkaway survey in January 2009
KM/BEG Seismic Data & Geologic Model

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

Source: Kerans (2003)
UPitt/NETL and BEG Seismic Research

Post-injection surface geophysical surveys (2-3-D) in injection test area to image CO$_2$ movement - November 2008 and January 2009

- 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.
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. Core holders are capable of measuring one compressional and two orthogonally polarized shear waves. The three transducers operate at a frequency of 500 to 700 kHz.
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
BEG & TWDB Groundwater Sampling
BEG Water Well Sampling - WQ

- Total wells – 61 wells and 1 spring (+6 SACROC production and brine injection 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, Tl, 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)
Types of power for pumping: solar to portable generator
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
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
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
EPA 2° drinking water standard - 0.05 mg/L

Analyte: Arsenic
EPA Maximum Contaminant Limit – 0.01 mg/L
Gulf Coast Carbon Center (GCCC)

Mission: Global leadership in research and economic implementation of large scale greenhouse gas sequestration.

GCCC Team:
Ian Duncan, Susan Hovorka, Tip Meckel, Becky Smyth, J. P. Nicot, Katherine Romanak, Jeff Paine, Changbing Yang + 3 new post-docs, MA and undergraduate research assistants

Steve Bryant & Gary Rochelle (UT- Chem. Eng.)

Sponsors

bp  Chevron  Schlumberger  Kinder Morgan  Marathon  LCRA  AEP  NRG  Entergy  Praxair  Austin Energy  Jackson School of Geosciences
Questions?
Comments?
Previous O&G Well Drilling
Water Well Sampling Assistance
Low or High Flow Rates from Irrigation Wells

Left: Low discharge rate - less aeration of water hence more accurate insitu groundwater parameters.

Right: High discharge rate - more aeration of water hence less accurate insitu groundwater parameters.