FACTSHEET FOR PARTNERSHIP FIELD VALIDATION TEST

Partnership Name	Southwest Regional Partnership on Carbon Sequestration
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Field Test Information: Field Test Name	Permian Basin, Texas: SACROC EOR-Sequestration Test
Test Location	Near Snyder, Texas
Amount and Source of CO_2	Tons / Source 350,000 tons/year for 2 years; CO2 sourced from McElmo Dome, CO
Field Test Partners (Primary Sponsors)	KinderMorgan CO2 Company, L.P.

<u>Summary of Field Test Site and Operations</u>

General Geology and Target Reservoirs: The SACROC oil field unit produces from Pennsylvanian-age strata. The SACROC oil field unit, the main part of Kelly-Snyder field, lies along a trend of fields described by Galloway et al. (1983) as the Horseshoe Atoll Play (Fig. 1). It produces from Strawn- and Canyon-age carbonate reefs. The SACROC unit represents an isolated platform depositional environment. Target reservoirs include the producing Pennsylvanian carbonates (e.g., Cisco-Canyon formations, Fig. 2), draped by thick Wolfcamp shales (Fig. 2) that act as seals.

Seal Strata: The section overlying the productive oil zone is Permian-age strata, Triassic age Dockum formation, and Paloecene/Eocene Ogallala Formation (Fig. 2). Permian strata include cyclic shallow-water ramp carbonates sequences bracketed by cycle-base shales, and evaporate tops. The carbonate mudstones and evaporite beds are tight. Immediately overlying the injection zone, the Wolfcamp formation within the Wichita-Albany Group is a high-stand sea level rise flooding surface composed of marine shales. Thus, there are both primary and secondary seals between the injection zone and the potable water zone.

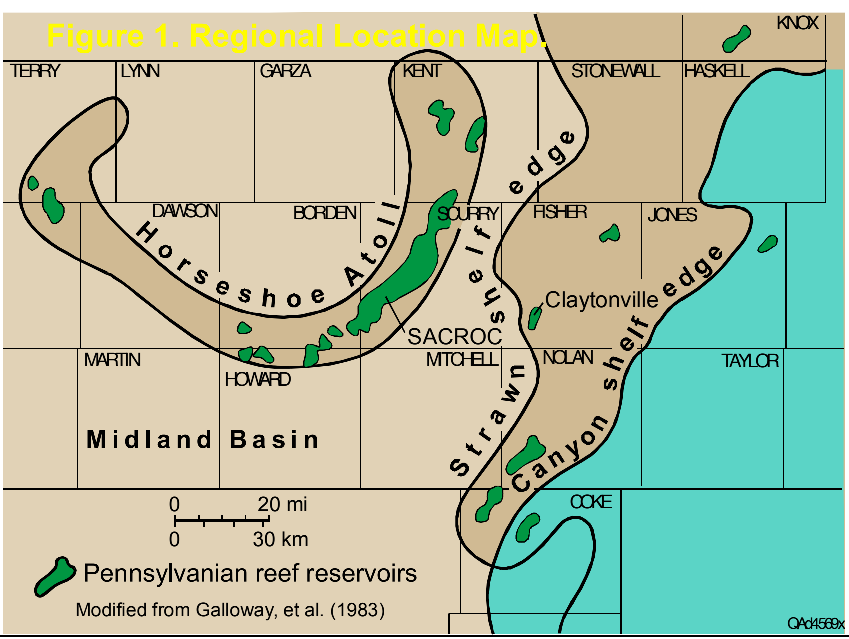


Figure 1. Regional Location Map.

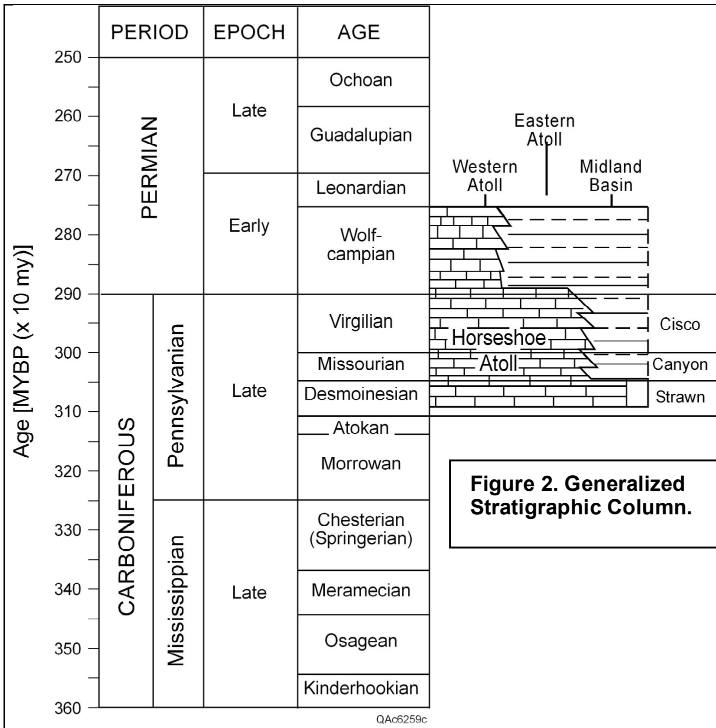


Figure 2. Generalized Stratigraphic Column.

Potential Leakage Areas: The Pennsylvanian Reef strata in West Texas (Fig. 2) have low leakage potential. The structural closure is not formed by faulting and no faults have been mapped in either field or on other fields within the Horseshoe and Pennsylvanian Reef plays. Fracturing is prevalent within the injection zone but is confined to the injection zone. Fractures are a result of paleo low stand exposures that formed variable sized karsts. Because the fracture origin is non tectonic, the fracture are confined to the injection zone and do not result in potential leakage paths. Both fields are highly developed, containing numerous wellbores. Potential leakage from wellbores is a field management issue that can be addressed by engineering practices. Well-drilling in these fields is documented and indicate little potential for unknown wellbores.

Reservoir Properties:

The oil residing in the field is of high quality. Oil API gravity is 42. At an original reservoir pressure of 2,335 psi, the oil was slightly undersaturated, so there was no original gas cap. Some free gas was most likely released into the reservoir during initial production, as seen by increasing producing gas-oil ratios. After water injection and possible bottom water drive stopped pressure depletion in the 1960's, these gas-oil ratios dropped and stabilized. A possible secondary gas cap is thought to have developed in the northeast structural high. Oil reservoir porosity and permeability are relatively low. In the target Pennsylvanian Cisco-Canyon reservoirs (Fig. 2), porosity averages five percent, and permeability is in the 10-md range. Pore types include vugs, interparticle, intercrystalline, and fractures. Because the relationship between porosity and permeability is dependent on the pore type, it can be quite variable. Although storage and flow capacity is low, the reservoir has been interpreted to be in fairly good vertical and horizontal communication, based on the consistency of bottom-hole pressure measurements.

In sum, the target reservoir physical properties and character of its oil makes Pennsylvanian carbonates (Fig. 2) a good candidate for CO_2 enhanced oil recovery as well as concomitant storage of CO_2. Good injectivity is also implied, and among our goals is to elucidate potential injectivity reduction following CO_2 injection.

Data Quality:_Formation characterization is ongoing at SACROC. The field was discovered in the early 1950's and quickly developed. Thus, much of the well data and wireline logs are quite old. Newly acquired data have increased the quality of subsurface characterization. A 3-D seismic survey was finished at SACROC in early 2006.

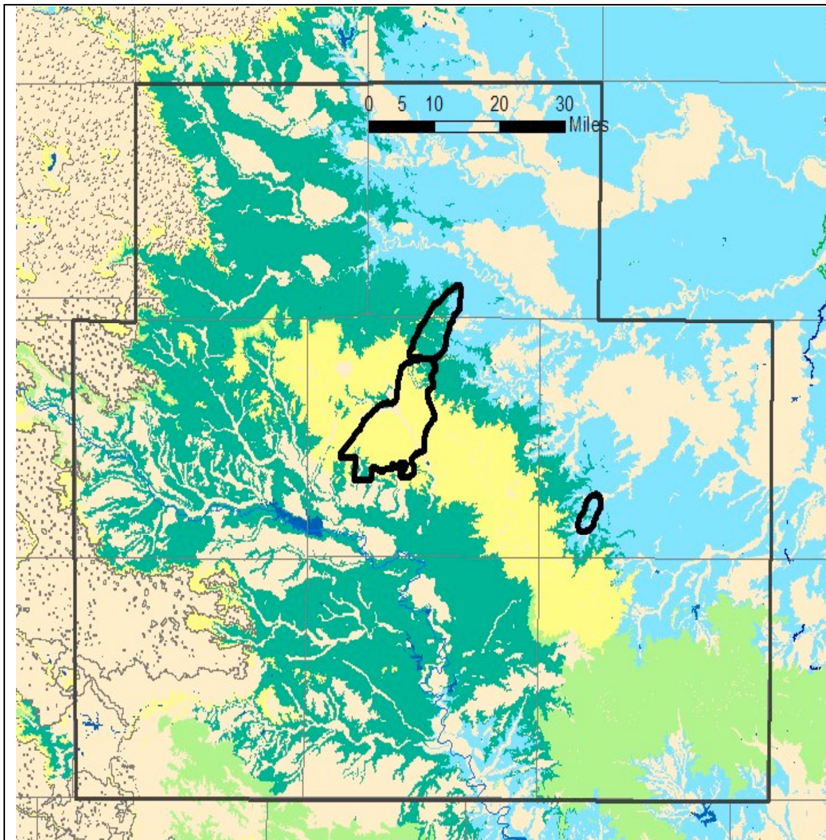


Figure 3. GAT sheets showing SACROC unit (big to left) and Claytonville (small to right) fields in Scurry and Fisher counties, respectively. SWCarb groundwater study area is outlined in black. Key to geologic units: beige = Quaternary units grouped; yellow = Ogallala Fm.; dark green = Dockum Fm.; light green = Cretaceous units grouped; light blue = Permian units grouped.

Surface Description and Land Use: Figure 3 illustrates the location of the SACROC field in Scurry and Fisher Counties, Texas. Also shown in Figure 3 is the location of the Claytonville field, a potential future sequestration-EOR site. The Ogallala Formation (Fig. 3, yellow) is present at the surface over most of the SACROC unit. This is an outlier of Ogallala that is not part of the TWDB-defined major aquifer unit. Presence of Ogallala overlying Dockum Formation (Fig. 3, dark green) results in slightly different chemistry of Dockum groundwater because in this case, precipitation seeps downward through Ogallala before recharging the Dockum. Outliers of Dockum deposits and the Permian units, Quartermaster Formation, Whitehorse Sandstone, and Cloud Chief Gypsum, are present at the surface over the SACROC field. The Permian units (Fig. 3, light blue) have been grouped in ArcGIS project for simplicity of presentation. A surface water divide exists almost bisecting the Ogallala relict outcrop. Regional groundwater analyses indicate a possible groundwater divide at the same location. This is another complication for analysis of regional groundwater variability because there are likely changes in groundwater chemistry along flow-paths to the northeast toward the Double Mountain Fork of the Brazos River and to the southwest toward the Colorado River.

Surface topography is relatively flat compared to other SWP pilot areas, with only gentle hills and mild terraces associated with surface water erosion. As such, land-usage in the area is dominated by farming, both corporate-owned and privately-owned, with some commercial and residential areas.

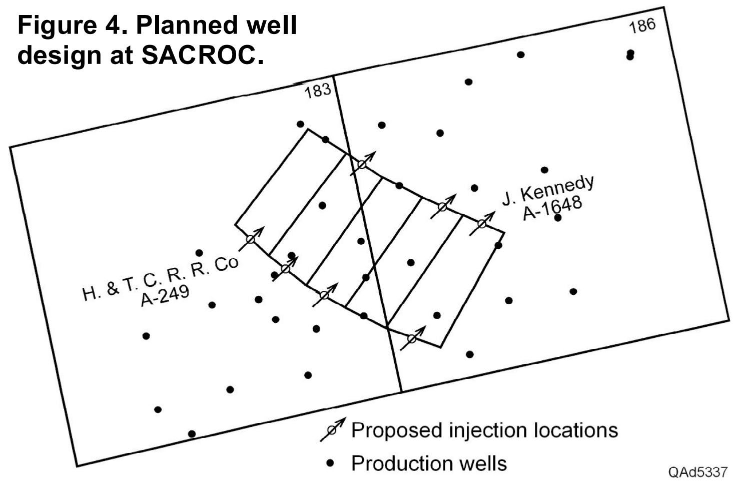
Nearest Underground Drinking Water Source: Drinking water over this area is relatively shallow. The Dockum and Ogallala formations are the primary drinking water sources in this area (Figs. 2 and 3). Where these formations are absent shallow Permian drinking water lies at relatively shallow depths. Most of the water wells over SACROC and in Scurry County are defined as producing from the Dockum Formation but they are likely also completed in the Ogallala formation. Water wells in Fisher County are completed in Permian units (Blaine and other aquifers), Triassic Dockum, or Quaternary Seymour units.

Injection Operation: Injection of CO_2 is currently occurring in the SACROC Unit. The injection rate is forecasted to exceed 16 MMCF a day based in five injectors (Fig. 4), translating to approach 350,000 tons per year. Injection will last 2 years; this includes a WAG (water alternating with gas) period where CO_2 injection will be partially offset by water.

Research Objectives

The SACROC Unit in the Texas Permian Basin is the oldest CO_2-EOR operation in the United States, with CO_2 injection dating from 1972—only one CO_2-EOR project in Hungary is older, dating from ~1969. SACROC continues to be flooded by the current owner/operator, Kinder Morgan CO_2 Company, L.P. (KinderMorgan). Current operations inject ~13.5 $MtCO_2$/yr and withdraw/recycle ~7 $MtCO_2$/yr, for a net storage of ~6.5 $MtCO_2$/yr. In total, the site has accumulated more than 55 $MtCO_2$.

Figure 4. Planned well design at SACROC.



Our first effort at SACROC will be an intensive post-audit modeling analysis to understand the fate of the CO_2 injected over 30 years time. KinderMorgan maintains a vast database of CO_2 injection/production data to facilitate an effective analysis. We are also beginning extensive MMV studies at SACROC during its ongoing injection operations.

EOR-Sequestration Testing: The CO_2 at SACROC is sourced from the McElmo Dome. It is proposed to inject CO_2 at the site for a period of several years and to intensely monitor CO_2 movement for 18 months. Lower-intensity monitoring will be performed for the remaining period of the four-year SWP Validation Phase program. Injection will commence in early 2008. State-of-the-art reservoir modeling will be used to simulate flow and chemical processes and forecast ultimate CO_2 storage capacities. Given the historical success of EOR in this and other southern U.S. basins, our primary research objective of the EOR-sequestration test is to evaluate and maximize efficacy of CO_2 subsurface monitoring technologies, and to improve our ability to track the fate of injected CO_2 and to calculate ultimate storage capacity. A particular focus will be efficacy of 2-D and 3-D seismic imaging methods and investigation of ways to optimize interpretation using other geophysical data. Finally, another major goal is to develop a rigorous risk assessment framework that will help identify optimum storage sites in this and other similar oilfield reservoirs located throughout the southwestern U.S.

Summary of Modeling and MMV Efforts:

Table 1 below summarizes our ongoing and future monitoring activities for the SACROC EOR-sequestration testing. Data from these monitoring activities are being used to parameterize state-of-the-art basin reservoir models that include coupling of multiphase CO_2-groundwater flow with rock deformation and chemical reactions. These models are being used to conduct the post-audit (history match) at SACROC and to evaluate ranges of residence times, migration rates and patterns. We are also examining the effects of CO_2 injection on fluid pressures and rock strain (e.g., potential reactivation of fracture permeability). Model simulations are being conducted to examine potential reservoir diagenesis to follow CO_2 injection, including variations in solubility, dissolution, and precipitation. Using newly acquired seismic data from surveys conducted in early 2006, we are also developing state-of-the-art seismic models. These models are helping us evaluate different seismic methods for imaging CO_2 in the subsurface, including 3-D reflection, vertical seismic profiling, and passive seismic monitoring.

Table 1. Measurement Technologies Employed at SACROC, Texas Test Site

Measurement technique	Measurement parameters	Applications
Introduced and natural tracers	- Travel time - Partitioning of CO_2 in brine/ oil - Identification sources of CO_2 - CO_2, HCO_3, CO_3^{2-}	- Tracing movement of CO_2 - Quantifying solubility trapping - Tracing leakage - Quantifying solubility & mineral trapping
Water composition	- Major ions - Trace elements - Salinity	- Quantifying CO_2-water-rock interactions - Detecting leakage into shallow groundwater aquifers
Subsurface pressure	- Formation pressure - Annulus pressure - Groundwater aquifer pressure	- Control of formation pressure below fracture gradient - Wellbore and injection tubing condition - Leakage out of the storage formation
Well logs	- Brine salinity - Sonic velocity - CO_2 saturation	- Tracking CO_2 movement in and above storage formation - Tracking migration of brine into shallow aquifers - Calibrating seismic velocities for 2-D seismic surveys
Time-lapse 2-D seismic imaging	- P and S wave velocity - Reflection horizons - Seismic amplitude attenuation	- Tracking CO_2 movement in and above storage formation
Vertical seismic profiling	- P and S wave velocity - Reflection horizons - Seismic amplitude attenuation	- Detecting detailed distribution of CO_2 in the storage formation - Detection leakage through faults and fractures
Passive seismic monitoring	- Location, magnitude and source characteristics of seismic events	- Development of microfractures in formation or caprock - CO_2 migration pathways
Electrical techniques	- Formation conductivity	- Tracking movement of CO_2 in and above the storage formation - Detecting migration of brine into shallow aquifers
Time-lapse microgravity techniques	- Density changes caused by fluid displacement	- Detect CO_2 movement in or above storage formation - CO_2 mass balance in the subsurface
Visible and infrared imaging from satellite	- Hyperspectral imaging of land surface	- Detect vegetative stress
CO_2 land surface flux monitoring using flux chambers or eddycovariance	- CO_2 fluxes between the land surface and atmosphere Atmosphere	- Detect, locate and quantify CO_2 releases
Soil gas sampling	- Soil gas composition Isotopic analysis of CO_2	- Detect elevated levels of CO_2 - Identify source of elevated soil gas CO_2 - Evaluate ecosystem impacts

Accomplishments to Date

- Baseline surface fluxes measured
- Baseline reservoir groundwater (brine) compositions assessed
- 3-D reservoir model grids assembled
- surface and subsurface geologic maps and cross-sections refined through new mapping
- 3-D reflection seismic survey completed
- 2-D vertical seismic profile (VSP) completed

Summary of Target Sink Storage Opportunities and Benefits to the Region

- The SACROC pilot will be an initial high resolution analysis of the potential for CO_2 storage in the broader carbonate "Horseshoe Atoll" system, a huge (area and volume) system with potentially enormous CO_2 capacity (Fig. 1). Given that most of the western side of the atoll is below the oil-water contact, it is particularly appealing for large-scale sequestration, as suggested by our Characterization Phase analysis of the region.
- The SACROC field is also representative of many oil/gas fields throughout the southwestern U.S., and results will be applicable to many such fields.
- Typically, EOR with CO_2 is carried out with an objective to maximize re-production and recycling of CO_2 for further EOR. Among the SWP goals is to maximize sequestration, or leaving CO_2 in the ground rather than recycling, while not compromising efficacy of EOR.

Cost:

Total Field Project Cost: Approximately $5.5M

DOE Share: Approximately $4.4 or 80%

Non-Doe Share: Approximately $1.1 or 20%

Field Project Key Dates:

Baseline Completed: March, 2008

Drilling Operations Begin: October, 2007

Injection Operations Begin: March, 2008

MMV Events: March, 2008

Field Test Schedule and Milestones (Gantt Chart):

Major field operations at SACROC have been underway since the start of the project in late 2005. Safety training, initial reservoir model grids, and other essential SWP activities also began during this past year. First injection was originally schedule for March 2007, but was rescheduled to March 2008, because of insufficient data for necessary reservoir engineering design. A general summary of the SWP's schedule is provided in the Gantt chart below.