CO_2 Sequestration Potential Of Texas Low-Rank Coals

Quarterly Technical Progress Report

Reporting Period Start Date: April 1, 2003
Reporting Period End Date: June 30, 2003

By:

Duane A. McVay
Walter B. Ayers, Jr.
Jerry L. Jensen

July 2003

DE-FC26-02NT41588

Texas Engineering Experiment Station
3000 TAMU
332 Wisenbaker Engineering Research Center
College Station, Texas 77843-3000

DISCLAIMER

ABSTRACT

The objective of this project is to evaluate the feasibility of carbon dioxide (CO_2) sequestration in Texas low-rank coals and to determine the potential for enhanced coalbed methane (CBM) recovery as an added benefit of sequestration.

The main objectives for this reporting period were to further characterize the three areas selected as potential test sites, to begin assessing regional attributes of natural coal fractures (cleats), which control coalbed permeability, and to interview laboratories for coal sample testing. An additional objective was to initiate discussions with an operating company that has interests in Texas coalbed gas production and CO_2 sequestration potential, to determine their interest in participation and cost sharing in this project.

Well-log data are critical for defining depth, thickness, number, and grouping of coal seams at the proposed sequestration sites. Therefore, we purchased 15 well logs from a commercial source to make coal-occurrence maps and cross sections. Log suites included gamma ray (GR), self potential (SP), resistivity, sonic, and density curves. Other properties of the coals in the selected areas were collected from published literature. To assess cleat properties and describe coal characteristics, we made field trips to a Jackson coal outcrop and visited Wilcox coal exposures at the Sandow surface mine. Coal samples at the Sandow mine were collected for CO_2 and methane sorption analyses. We contacted several laboratories that specialize in analyzing coals and selected a laboratory, submitting the Sandow Wilcox coals for analysis. To address the issue of cost sharing, we had fruitful initial discussions with a petroleum corporation in Houston. We reviewed the objectives and status of this project, discussed data that they have already collected, and explored the potential for cooperative data acquisition and exchange in the future. We are pursuing a cooperative agreement with them.

TABLE OF CONTENTS

INTRODUCTION

The overall objectives of this project are to determine the feasibility of CO_2 sequestration in Texas low-rank coals and the potential for enhanced coalbed methane (CBM) recovery as an added benefit of sequestration. The main objectives for this reporting period were to further characterize the three areas selected as potential test sites, to begin assessing regional attributes of natural coal fractures (cleats), which control coalbed permeability, and to interview laboratories for coal sample testing. An additional objective was to initiate discussions with an operating company that has interest in Texas coalbed gas production and CO_2 sequestration potential, to determine their interest in participation and cost sharing in this project.

Characterization of the three areas selected for CO_2 sequestration is crucial for accurately evaluating the technical and economic feasibility of CO_2 sequestration and enhanced coalbed methane production. Also, knowledge of the properties of natural fractures is essential for planning exploration and development because of their influence on recovery of methane. Fresh coal samples are needed from the regions of interest in order to effectively characterize the coal. Well log data are critical in defining depth, thickness and number of coal seams at the proposed sequestration areas.

EXPERIMENTAL

None.

RESULTS AND DISCUSSION

Coal Properties at Outcrops and Mines

Fractures occur in nearly all coal beds. Knowledge of the natural fractures properties of coal is essential for planning both CO_2 injection and methane production. Coal permeability depends on the abundance, aperture, and connectivity of natural fractures, and commonly, the fracture orientation imposes flow anisotropy. Therefore, we are describing coal fracture characteristics at outcrop and in mines in east-central Texas. We searched online sites of core and cuttings repositories and found that there are few samples available from the proposed sequestration areas, and most samples are cuttings. Also, we concluded that archived cores are not suitable for testing adsorption / desorption properties because of coal oxidation. To gather fresh samples for coal reservoir property characterization and to describe fractures, we visited outcrops and mines in east-central Texas.

Coals of the Whitsett and Manning Formations (Jackson Group) were studied near Lake Somerville (Fig. 1b). We used a GPS device to determine site locations and altitudes and recorded fracture properties. Generally, Jackson face cleats strike N60ºE, and butt cleats strike N150ºE (Table 1 and Fig. 1). Face cleat orientation in the Jackson coal seams (Fig. 2) parallel the orientation of fractures in adjacent sandstones. Cleats are not uniformly spaced, and they terminate vertically at coalbed margins. Due to the friable nature of coal at Lake Somerville, we were unable to describe cleat spacing, or fracture density (fractures/unit distance).

At Alcoa's Sandow Mine located near Rockdale, Texas, we planned to measure cleat spacing and density on a clean, fresh coal surface. However, a freshly stripped coal surface was unavailable, so we described highwall coal exposures. At Sandow, an 8-ft thick Calvert Bluff Formation (upper Wilcox Group) lignite is exposed in the 80-ft highwall that is comprised predominately of sand and mudstone (Fig. 3). We described Wilcox coal in two Sandow pits located about 7 miles apart (Fig. 1). At the first pit, face cleats trends averaged N60ºE, and butt cleats trends averaged N145ºE. Fractures at the first pit are not uniformly spaced, and they terminate within bedding intervals. Face cleats spacing measured at highwalls (Fig. 4) ranged between 2 and 7 inches. At the second stop, the cleat orientations were very similar to the first. The face cleat orientations ranged from N 60º E to N67 ºE, and the distance between the face cleats ranged between 4 and 8 inches. The orientation of the butt cleats was a little more variable with values ranging from N172ºE to N162ºE. The distance between the butt cleats ranged between 4.7 and 7 inches.

In general, the intensity and openness of fractures control coalbed permeability, and structural setting is the major control on fracture intensity. Figure 1 schematically illustrates the orientation of coal cleats at the Lake Somerville outcrop and Sandow Mine, and the orientation of major fault zones of East-Central Texas. Face cleat trends measured in this study are consistent with the dominant fracture strike (N65ºE) in Austin Chalk of Giddings field of Washington and Austin counties in Central Texas (Drake and others, 2001). Thus, the consistent face cleat orientation of the area studied supports the concept of regional fracture sets that resulted from far-field stresses. This fracture orientation may result in permeability anisotropy and impart a northeast-elongate pattern to fluid movement in injection or production projects. We plan two more field trips to coal mines in East Texas and the Sabine Uplift area to confirm regional fracture orientations and to further characterize fracture characteristics.

Analysis of Samples

We sent three coal samples from Sandow mine to TerraTek Laboratories located in Salt Lake City, Utah for proximate analysis, coal petrography, vitrinite reflectance, and CO_2 and methane sorption isotherms. For some analyses, the coals must be at equilibrium moisture, which may take approximately a month to accomplish. The samples had been exposed by overburden removal for less than 24 hours.

Analysis of Well Logs

To characterize coal occurrence for CO_2 sequestration, detailed coal description is required for each of the 3 proposed areas. We needed at least 3 well logs from each of the areas for this task to make maps and cross sections. Therefore, we purchased 15 well logs from Fayette (4 wells), Grimes (4 wells), San Augustine (3 wells), Rusk (3 wells), and Brazos (1 well) Counties. These well logs include a gamma ray, self potential, resistivity, sonic, and density curves. Locations of acquired well logs are shown in Fig. 5.

As stated in the previous quarterly report, coal occurrence information had been input into our mapping software. The next steps are to interpret coal occurrences using the newly obtained well log data, to construct fence diagrams for each site, and to incorporate the results to available coal occurrence maps. We will use these maps and cross sections to build models for reservoir simulation. Figures 6 through 8 show the coal occurrences in small sections of the Wilcox Group.

Coal Property Database Compilation

For the Wilcox, Yegua, and Jackson coals, we collected published coal-property data (Kaiser et al., 1980; Tewalt, 1986) pertinent to reservoir behavior. These data comprise summary tables of proximate analyses (as received and moisture-free/dry basis) that include volatile matter, fixed carbon, ash, sulfur, btu/lb, and equilibrium moisture content values. Ultimate analysis summary data (as received and dry basis) were collected and are comprised of values of carbon, hydrogen, nitrogen, chlorine, sulfur and oxygen content of both near-surface (20 to 200 ft deep) and deep-basin (200 to 2,000 ft deep) lignites. Also, trace element analysis, major-oxide analysis data of ash and ash characteristics, forms of sulfur analysis data, mineral matter content and organic parameters are available. The 200-ft data limit conforms to depth limit of surface mining, whereas the 2,000-ft depth was the depth limit imposed in earlier investigations of in-situ gasification. Because the maximum depth of the published data is less than 2000 ft depth, characteristics of Wilcox lignites in Grimes and Fayette counties are unavailable.

Earlier studies revealed stratigraphic and geographic variations and trends in Texas early Tertiary coal quality (Tewalt, 1986). For example, ash-oxide data vary greatly within Wilcox and Jackson Group coals. Average trace element concentrations in Texas coals are similar to those in other U.S. lignites on a whole-core basis. Near-surface and deep-basin seams in Texas are similar in quality. Quality disparity is greatest between deep-basin and near-surface seams in the Sabine Uplift area, mainly because of lower ash content in the deep seams.

Data Acquisition

Initially, we intended to use a Texas A&M University drilling rig to drill three wells core holes to obtain samples for coal characterization, gas content and composition analyses, CO_2 and N_2 adsorptive capacity, and fracture descriptions. We planned to log the core holes to measure in-situ coalbed properties and to perform a well test to measure flow capacity and determine coalbed permeability. However, our available equipment limit drilling to depths less than 1,000 ft. Therefore, we are exploring the possibility of cooperative drilling, testing, and data exchange with an operator who is interested in Texas coalbed gas potential. This quarter, we initiated discussions with a petroleum corporation, which is very active in the areas of our selected sites and is interested in a cooperative study. Data already collected by them, and that which we would collect in cooperatives efforts with them, would provide the framework necessary to characterize the coal and to model CO_2 injection and enhanced coalbed gas production from Texas low-rank coals at the depths of our proposed sites. They have has provided us with the list of data they have collected from 5 wells near a proposed CO_2 sequestration area.

Presently, we are working on a confidentiality agreement and reviewing opportunities for future cooperative research and cost sharing.

CONCLUSION

1. Face cleat orientations were measured at 3 locations (2 Wilcox and 1 Jackson) in east-central Texas. Generally, face cleats trend N60°-65°E, consistent with regional fracture patterns in the Austin Chalk, a fractured hydrocarbon-bearing unit that underlies Tertiary age coals. Acquired well logs at proposed areas
2. Butt cleats are orthogonal to face cleat but are poorly developed.
3. Face cleat spacing in Wilcox coals at Sandow mine ranges between 2 and 8 inches
4. Face cleat spacing in highly weathered Jackson coals at the Lake Somerville outcrop is 1-5 to 2.5 inches
5. Some fractures at Sandow mine appear to be mineralized.
6. Published data provide a framework for evaluating stratigraphic and geographic coal quality variations in Texas.

REFERENCES

Drake G.E., Daniels J.L., Steinle A.S., and Williams S.P., 2001, Horizontal drilling in the Cretaceous Austin Chalk Formation - case studies (Abs.), AAPG Bulletin, Vol. 85, No. 13. (Supplement).

Hovorka S.D., 1998, Facies and diagenesis of the Austin Chalk and controls on fracture intensity - a case study from North-Central Texas: The University of Texas at Austin, Bureau of Economic Geology, Geological Circular 98-2, 47 pages.

Kaiser W.R., Ayers W.B., and La Brie L.W., 1980, Lignite Resources in Texas: The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations No.104, 52 pages.

Tewalt S.J., 1986, Chemical characterization of Texas lignite: The University of Texas at Austin, Bureau of Economic Geology, Geological Circular 86-1, 54 pages.

Table 1. Orientation and Spacing of Coal Cleats in Lake Somerville and Sandow Mine.

Sandow Mine : Upper Wilcox- Coal thickness --8 ft							
STOP-1: Location: N30°27.855' W 97°07.112' Altitude: 316 ft				**STOP-2: Location: N30°33.013' W 97°03.148' Altitude: 317 ft**			
Fracture orientation				Fracture orientation			
Face Cleat	Distance between face cleats	Butt Cleat	Distance between butt cleats	Face Cleat	Distance between face cleats	Butt Cleat	Distance between butt cleats
N60°E	6.7 inch	N145°E	6.0 inch	N60°E		N165°E	
N60°E	2.6 inch	N160°E	3.15 inch	N65°E	4 inch	N172°E	4.7 inch
N60°E	2.8 inch	N150°E	6.0 inch	N67°E	7.9 inch	N162°E	7.1 inch
N60°E	2.0 inch	N160°E	3.54 inch				

Lake Somerville: Jackson-Manning				Jackson-Whitsett			
Location: N30°19.017' W 96°31.048' Altitude: 269 ft				**Location: N30°19.08' W 96'31.019' Altitude: 287 ft**			
Fracture orientation				Fracture orientation			
Face Cleat	Distance between face cleats	Butt Cleat	Distance between butt cleats	Face Cleat	Distance between face cleats	Butt Cleat	Distance between butt cleats
N65°E		N155°E		N60°E		N150°E	

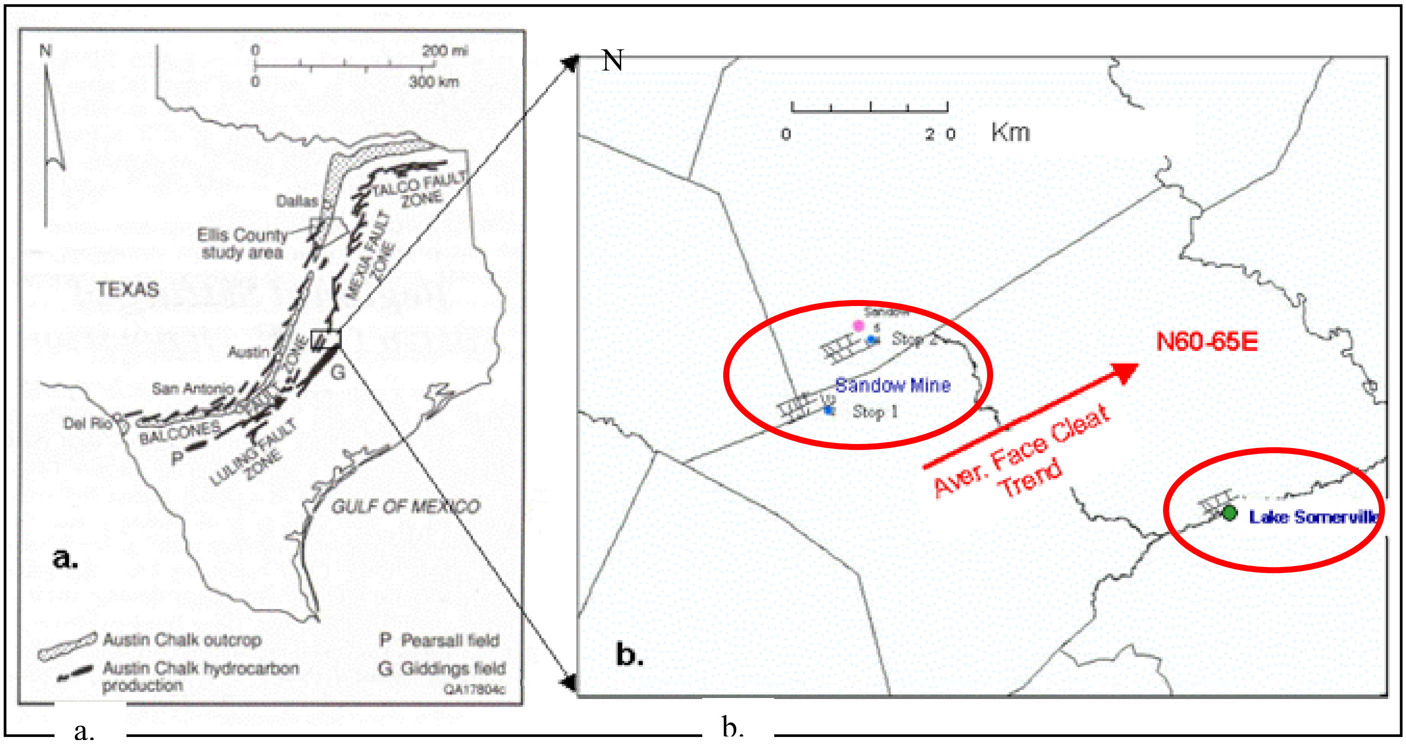

Figure 1. Sandow Mine and Lake Somerville fracture orientation and their relation to major East-Central Texas Faults trends and fields producing from the fractured Austin Chalk.

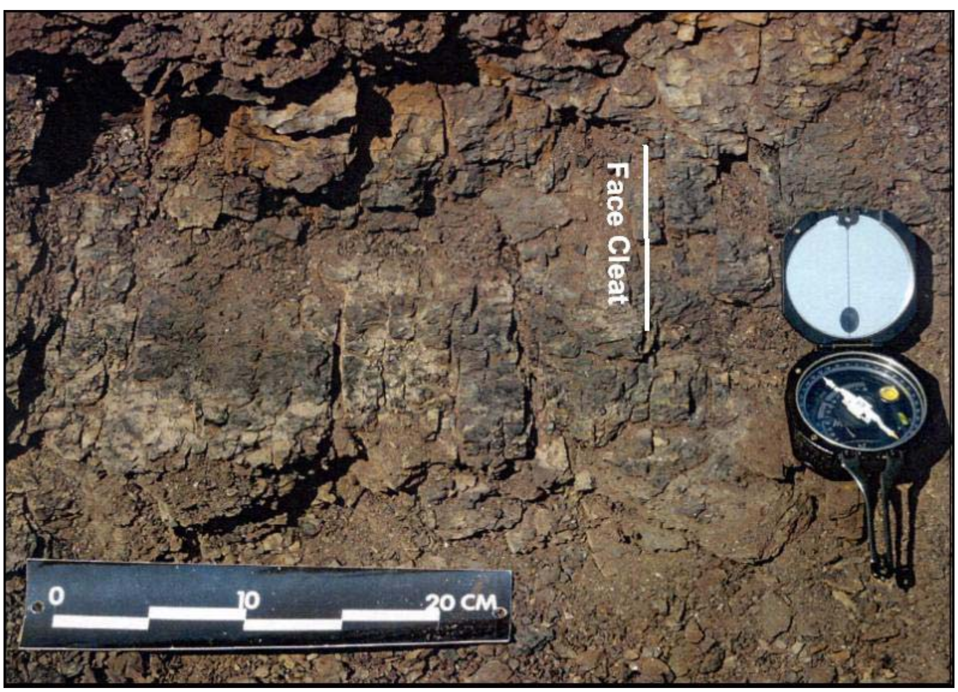

Figure 2. Lake Somerville coal cleat.

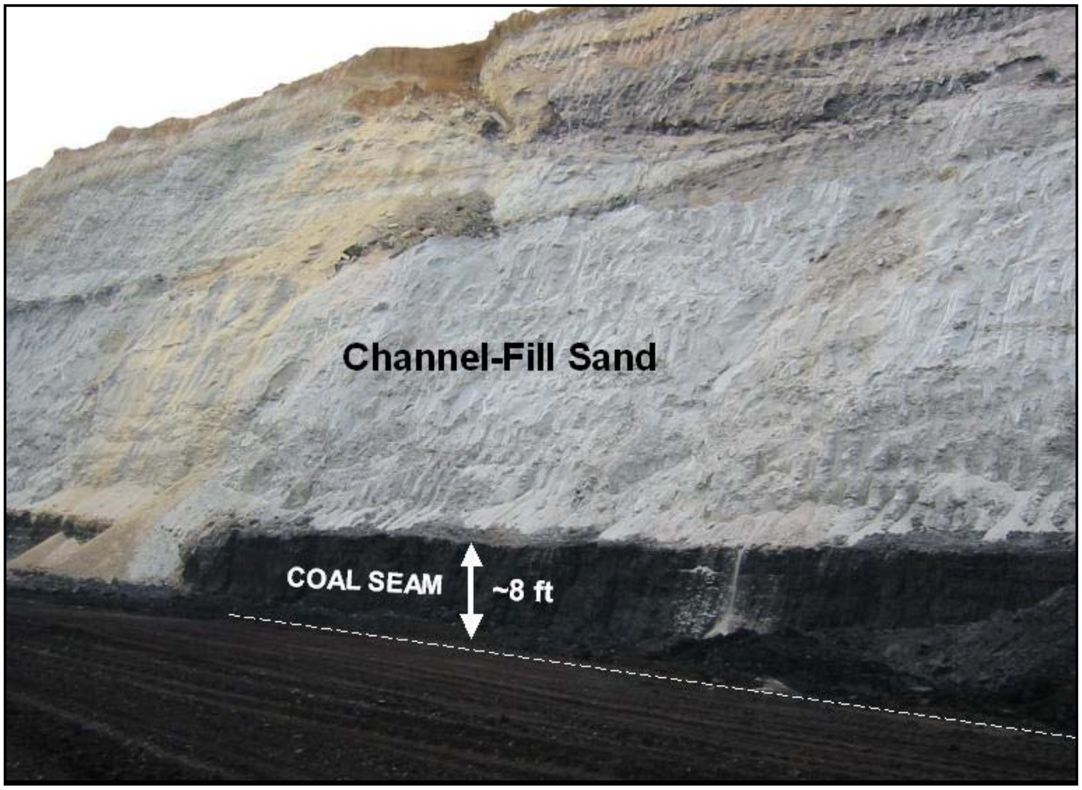

Figure 3. Wilcox coal exposed in highwall of Sandow Mine, east-central Texas.

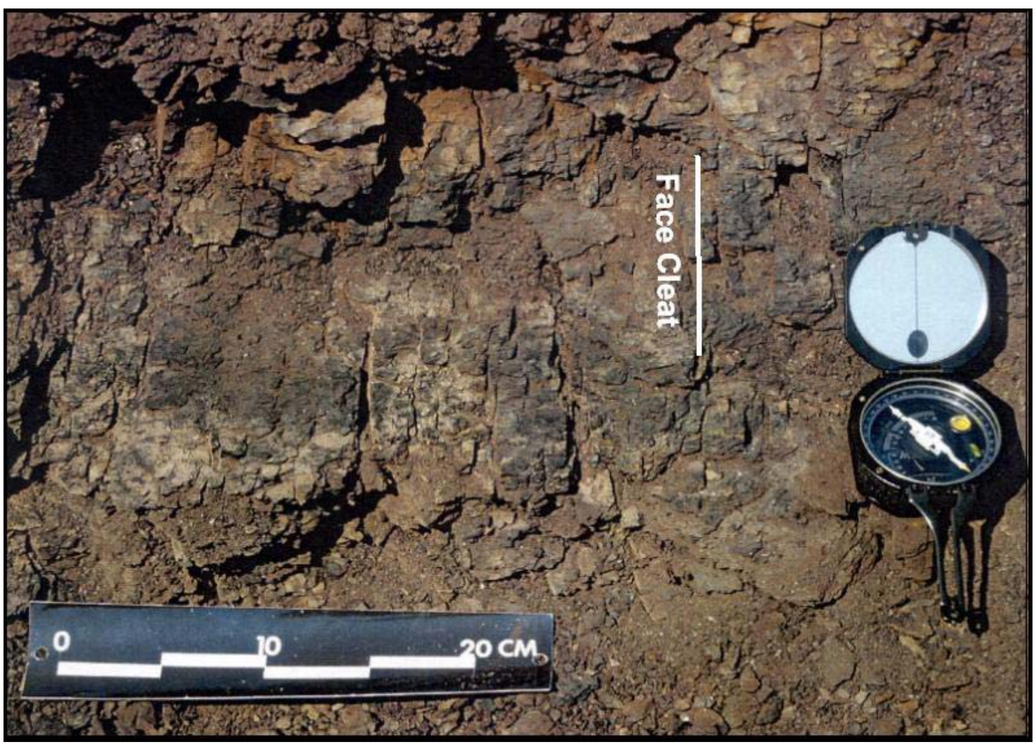

Figure 4. Wilcox cleats in Sandow Mine, east-central Texas.

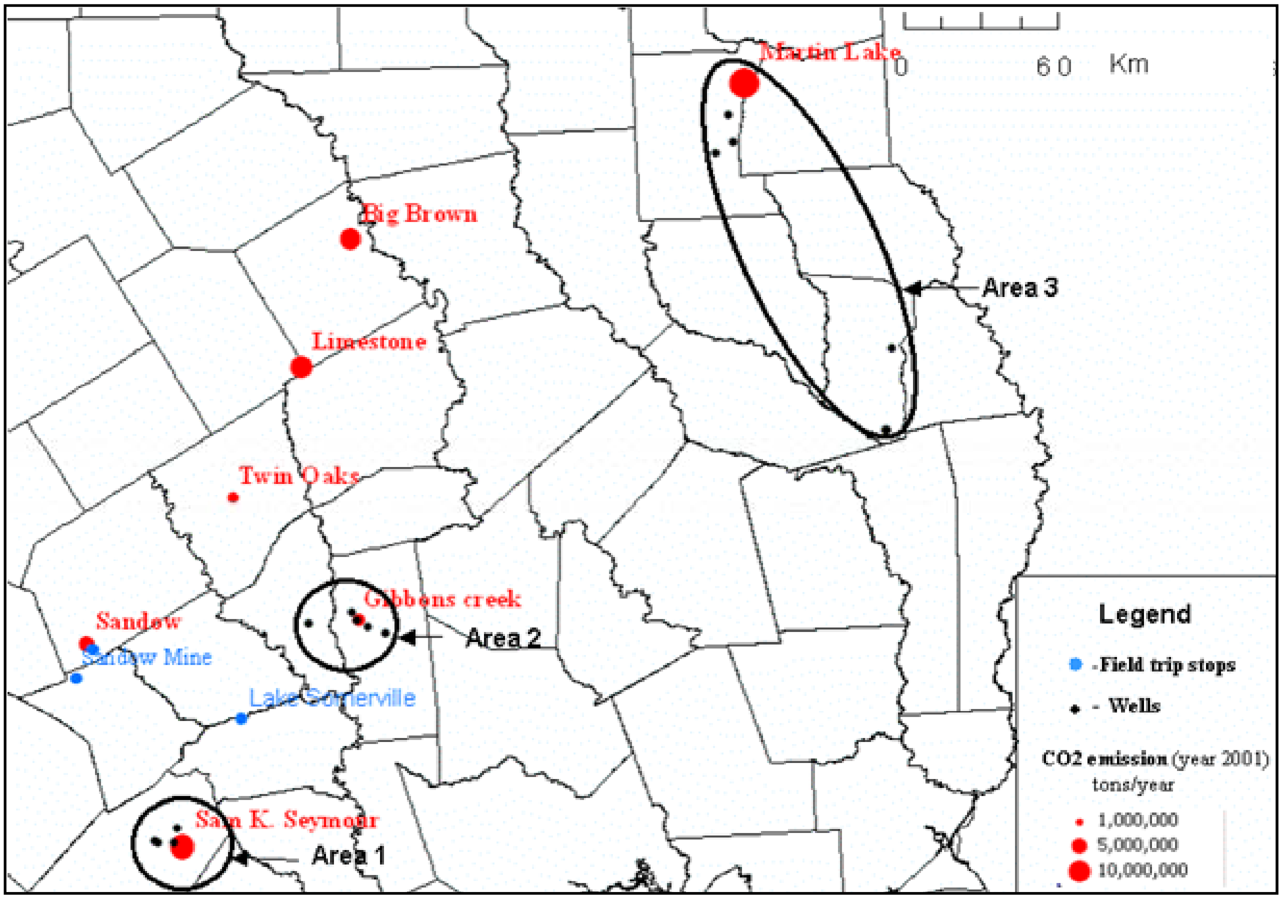

Figure 5. Locations of proposed sequestration characterization sites and locations of acquired well-logs, east-central Texas.

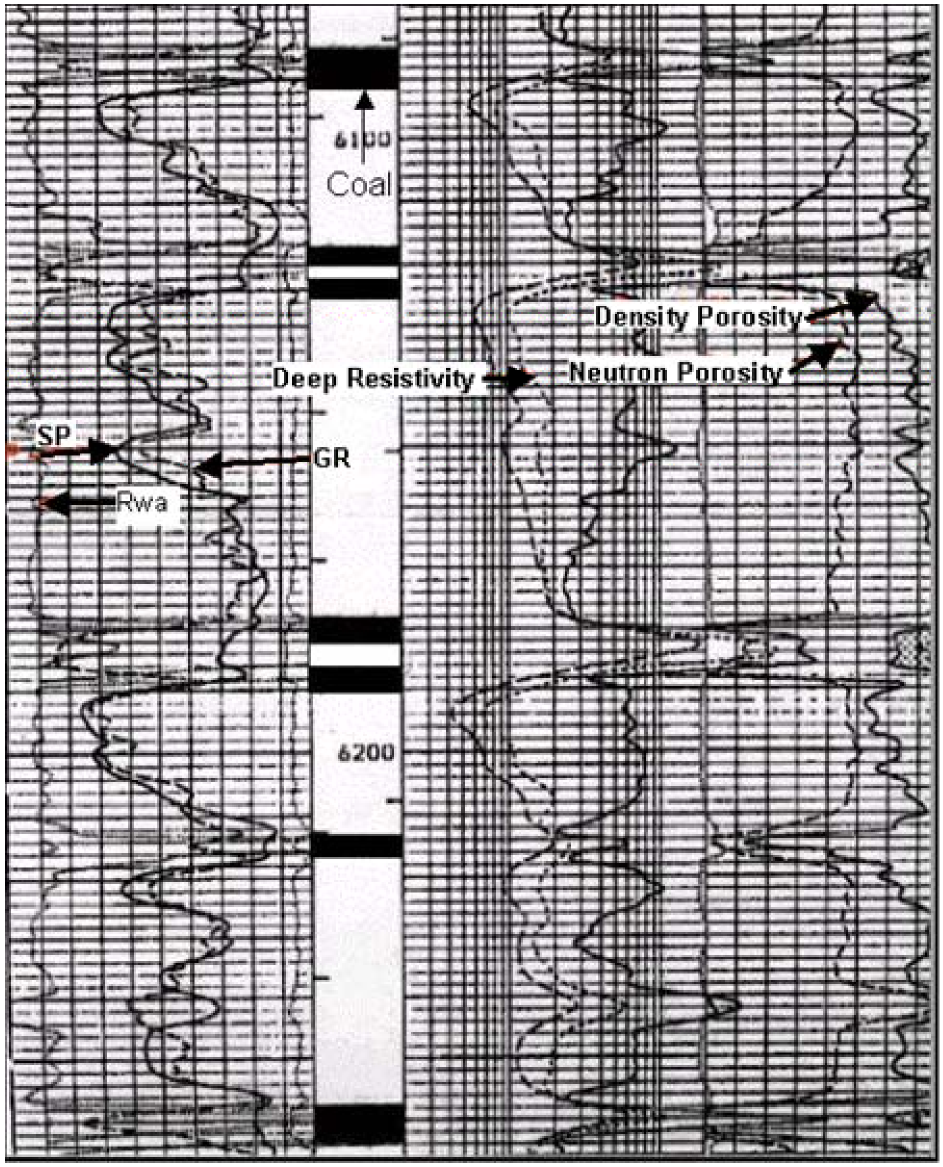

Figure 6. Lignite occurrence in Fayette County Well API (4214932832). Only small section of Wilcox interval is shown).

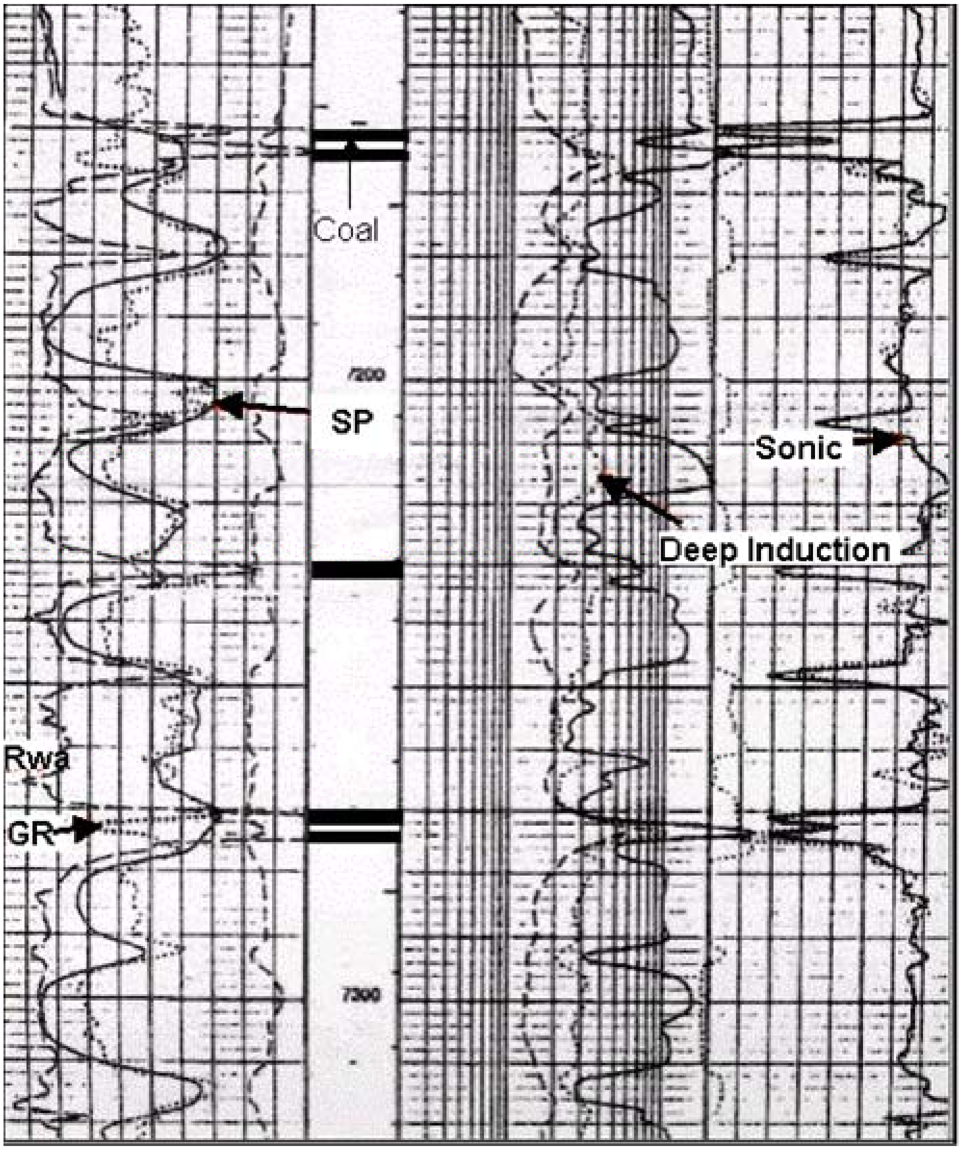

Figure 7. Lignite occurrence in a Grimes County Well (API 4218530568). Only small section of Wilcox interval is shown.

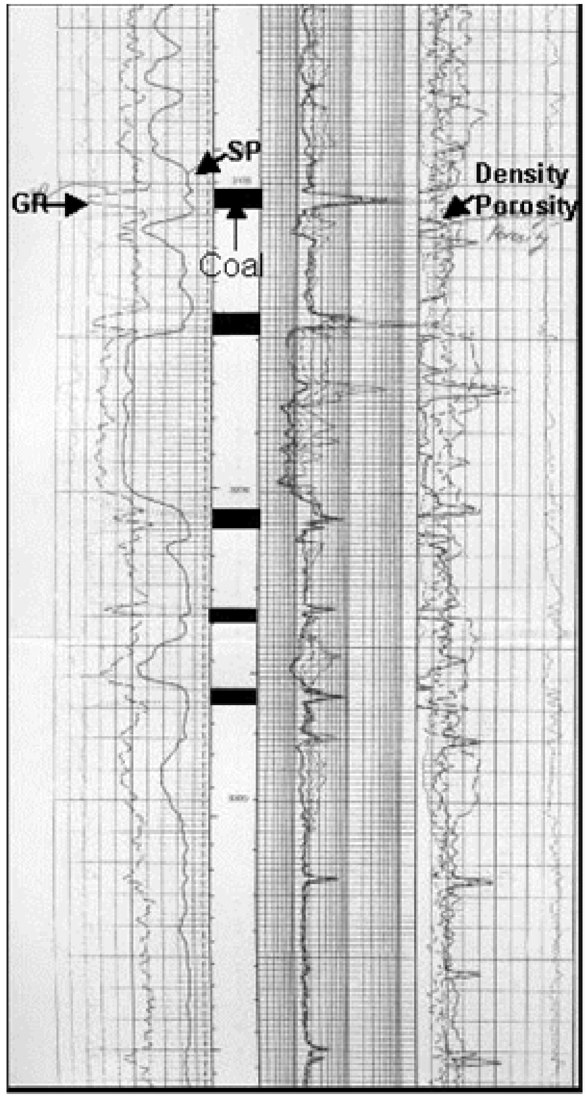

Figure 8. Lignite occurrence in a San Augustine County Well (API 240530176). Only small section of Wilcox interval is shown.