FY02 Annual Technical Report for NCRDS State Cooperative Program

PENNSYLVANIAN BITUMINOUS COAL, NORTH-CENTRAL TEXAS: POTENTIAL FOR COALBED METHANE RESOURCE DEVELOPMENT

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Submitted to
NCRDS State Cooperative Program
U.S. Geological Survey

December 2002

Abstract

Most recent U.S. Geological Survey National Coal Resources Data System (NCRDS) activities completed for the State of Texas by the Bureau of Economic Geology (BEG) focused on Wilcox Group deep coal (lignite) resources, including *Defining coalbed methane exploration fairways in East-Central Texas* (Tyler and Scott, 1999) and *Deep-basin coal (lignite) in Wilcox Group, Sabine Uplift, East Texas: potential for unconventional coalbed methane resource development* (Kim and Ruppel, 2001). The major objectives of these projects were to provide high-quality, organized digital information and interpretations on the location, quality, and quantity of the coal to be mined in the Wilcox Group, Texas Gulf Coast area, during the next several decades to meet the needs of the region and the nation for reliable, low-cost, environmentally compatible energy.

The first commercial coalbed methane field in Texas, the Sacatosa coalbed methane field in Maverick County, was announced in 2001 by The Exploration Company. This field is currently being produced from bituminous coal and carbonaceous shale of the Upper Cretaceous Olmos Formation in the Maverick Basin. Although the Pennsylvanian bituminous coals of North-Central Texas are of higher rank than the Texas Gulf Coast lignites and are comparable to the Olmos bituminous coals, very little current information exists on their occurrence, distribution, geological setting, or future potential for coalbed methane development. More detailed and updated information of the coal resource in this region is essential for inclusion in the NCRDS, utilizing digital databases of available data as well as digitized maps compiled in a Geographic Information System (GIS) platform. Providing updated digital data on the Pennsylvanian bituminous coals of North-Central Texas and assessing their potential for future coalbed methane resource development are the major objectives for this current study. Major accomplishments for FY02 included digitally compiling major background regional data for Pennsylvanian depositional systems and major coal resources such as the Strawn (Thurber) coals, as well as a comparison with current coalbed methane production from Olmos bituminous coals in the Maverick Basin. Future FY03 tasks to be completed include analysis of other coal resources such as the Canyon (Bridgeport) and Cisco (Newcastle) coals, as well as an overall future assessment of the coalbed methane potential of the Pennsylvanian bituminous coals of North-Central Texas.

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Introduction

Adequate energy supplies and efficient use of those supplies are critical to the economic well-being of a country. Affordable and reliable coal supplies are essential to national and local policy. Policy makers require a range of information on the energy supply, as well as the economic and environmental issues associated with that energy source and its use. Formation of an effective national energy policy and development of energy resources require that we understand the geology, distribution, quality, and size of the national energy endowment (U.S. Geological Survey, 2001).

Coal is an energy-producing commodity that is essential to the economic well-being of the world. The major use of coal in the United States is for the production of electricity. Other uses are residential and commercial, including production of coke for the steel industry. The economic viability of a coal deposit depends on several factors, including the overall quality and calorific value of the coal, mining costs, beneficiation costs, transportation to market, and the costs of disposal of the waste products of use. Like any other nonrenewable economic resource, coal deposits are discovered and evaluated, exploited if they are economic, and abandoned once they can no longer be produced at a profit, even though much of the resource may remain in the ground. In a review of world energy resources, M. King Hubbert (1973) estimated that the coal resources of the United States and of the world will be depleted within 300 to 400 years. More recently, the Energy Information Administration (1995) estimated that the United States has enough coal to last 250 years. Clearly, there is a large amount of coal in the United States. However, during the next few centuries, coal production rates will most likely decline as mining of thinner, deeper, and less desirable coal beds becomes necessary. Nevertheless, an overall decline in this Nation's coal production is not anticipated for many years (U.S. Geological Survey, 1996).

Coalbed methane, natural gas production from coals, has received increased interest recently. Once considered an unconventional gas resource with production enabled only through government incentives such as tax credits, coalbed methane has proved to be an economically viable resource even without governmental incentives. It continues to contribute an increasing share to the nation's domestic natural gas production. Interest in coal regions has been renewed as a result of potential coalbed methane resource development.

The U.S. Geological Survey's NCRDS provides a modern versatile inventory of the location, quantity, quality, and availability of coal resources of the United States. The U.S. Geological Survey develops and maintains cooperative projects with the major coal-bearing states to build the NCRDS stratigraphic, geochemical, and petrographic databases. The U.S. Geological Survey has funded approximately 20 to 25 State Geological Surveys, representing 98 percent of U.S. coal production, to collect, evaluate, and correlate drill-hole, mine, and outcrop data; collect coal and related rock samples for analysis; encode and enter geologic and geochemical data into NCRDS; and access NCRDS databases and software to generate new maps, reports, and resource assessments within each state.

Texas ranks sixth in coal production in the United States. Most coal in the region is produced from the Wilcox (Paleocene-Eocene) Group and is used as fuel for mine-mouth electric-power-generating plants. Most recent State of Texas NCRDS activities completed by the Bureau of Economic Geology (BEG) focused on Wilcox Group deep coal (lignite), including *Defining coalbed methane exploration fairways in East-Central Texas* (Tyler and Scott, 1999) and *Deep-basin coal (lignite) in Wilcox Group, Sabine Uplift, East Texas: potential for*

unconventional coalbed methane resource development (Kim and Ruppel, 2001). The major objectives of these projects were to provide high-quality, organized, digital information and interpretations on the location, quality, and quantity of the coal to be mined in the Wilcox Group, Gulf Coast area, during the next several decades to meet the needs of the region and the nation for reliable, low-cost, environmentally compatible energy.

The first commercial coalbed methane field in Texas, the Sacatosa coalbed methane field in Maverick County, was announced in 2001 by The Exploration Company. This field is currently being produced from bituminous coal and carbonaceous shale of the Upper Cretaceous Olmos Formation in the Maverick Basin. Although the Pennsylvanian bituminous coals of North-Central Texas are of higher rank than the Texas Gulf Coast lignites and are comparable to the Olmos bituminous coals, very little current information exists on their occurrence, distribution, geological setting, or future potential for coalbed methane development. More detailed and updated information of the coal resource in this region is essential for inclusion in the NCRDS, utilizing digital databases of available data as well as digitized maps compiled in a digital GIS platform.

Providing updated digital data on the Pennsylvanian bituminous coals of North-Central Texas and assessing their potential for future coalbed methane resource development are the major objectives for this current study. As a multiyear assessment, major accomplishments for FY02 included digitally compiling major background regional data for Pennsylvanian depositional systems and major coal resources, such as the Strawn (Thurber) coals, as well as a comparison with current coalbed methane production from Olmos bituminous coals in the Maverick Basin. Future FY03 tasks to be completed include analysis of other coal resources, such as the Canyon (Bridgeport) and Cisco (Newcastle) coals, as well as an overall future assessment of the coalbed methane potential of the Pennsylvanian bituminous coals of North-Central Texas.

Pennsylvanian Depositional Systems and Coal Resources in North-Central Texas

Pennsylvanian rocks of North-Central Texas are economically important energy resources for coal, oil, and natural gas. Deltaic and fluvial facies in the Strawn, Canyon, and Cisco Group have historically been major coal-producing intervals. Studies with a particular emphasis on coal resources in these intervals were conducted by Mapel (1967) and Evans (1974).Several studies on facies interpretation and regional basin development of the Pennsylvanian in North-Central Texas were conducted by Dumble (1890), Tarr (1890), Cummins (1891), Drake (1893), Plummer and Moore (1921), Lee and others (1938), Cheney and Goss (1952), Turner (1957), Van Siclen (1958), Brown (1969), Wermund and Jenkins (1969, 1970), Galloway and Brown (1972, 1973), and Brown and others, (1973). The geologic history of North-Central Texas is closely tied to the tectonic development of the Fort Worth Basin, the eastern flank of the Midland Basin, and the Red River uplift-southern Oklahoma Mountains. The structural evolution of these basins and associated tectonic elements determined to a great extent the nature and distribution of the principal basin-filling depositional elements of the Pennsylvanian (Brown and others, 1973). Middle and Upper Pennsylvanian rocks were deposited in dip-oriented, fluvial-deltaic facies tracts extending across basin margins onto shallow shelves and into deeper basin-slope environments (Galloway and Brown, 1972; Brown and others, 1973).

Bituminous coal is found in three major regions of Texas: North-Central Texas (west of Fort Worth), South Texas (Eagle Pass and Santo Tomas), and West Texas (Eagle Spring, San Carlos, and Big Bend). These coals are of higher rank than the extensively studied Texas Gulf

Coast lignites and are characterized by relatively thin seams (<3 ft), high sulfur (>2%) and high ash (~15%). Extensive coal mining of these bituminous coals took place from the 1880's through the 1940's. However, with increasing competition from other energy sources such as oil and natural gas, production declined rapidly. Interest has recently been renewed by the search for alternative energy sources, such as coalbed methane, as increased energy demands have constrained domestic energy supplies of oil and natural gas (Evans, 1974).

Coal resources in North-Central Texas are closely related to, and can be predicted by, the depositional fabric of the basin fill. The spatial distribution and internal facies composition of the depositional systems that fill the basins of the region provide an important tool for understanding and predicting coal resources. For example, Strawn Group coals have both embayment and delta-plain origins. The distribution of coals outlines Pennsylvanian fluvial deltaic and associated interdeltaic embayments (Brown and others, 1973). Coal deposits originated on delta plains in swamps and marshes where organic material could grow, die, accumulate, and be preserved, as well as interdeltaic environments, such as lagoons and bays (Evans, 1974).

Pennsylvanian coals in North-Central Texas can be largely divided into Strawn (Thurber), Canyon (Bridgeport), and Cisco (Newcastle). The distribution and estimated resources of major Pennsylvanian coals in North-Central Texas have been calculated by the U.S. Geological Survey (Mapel, 1967). The U.S. Geological Survey's estimates of coal resources in North-Central Texas indicate the presence of 5,371 million short tons of coal in beds 14 or more inches thick and under 3,000 feet or less of overburden. Strawn Group coals are the major Pennsylvanian coals in North-Central Texas in terms of resource, representing more than half (2,800 million short tons) of the total original inferred resources. Cisco Group coals represent another one-third (1,853 million short tons), and Canyon Group coals represent approximately 13 percent (718 million short tons) of the total original inferred resources (Mapel, 1967). Coal-distribution maps in North-Central Texas prepared by A. W. Cleaves in Brown and others (1973) reveal that contradictions exist with the U.S. Geological Survey's coal distribution maps. Reconciliation of such contradictions requires utilization of all available subsurface information and constitutes a useful restudy of the North-Central Texas bituminous coal resources.

The major constraint to potential production of Pennsylvanian coals in North-Central Texas remains in the coal itself. Strawn, Canyon, and Cisco Group coals are generally no more than 30 inches thick, rarely reaching 36 inches in thickness. Poor coal quality characterized by high sulfur content, would prohibit direct combustion. Interest in the coalbed methane potential of these coals has recently increased because the coals have been considered as an alternative energy source as a result of the considerable amounts of higher rank coal that exist as compared with the lower rank lignite resources of the Texas Gulf Coast and also as a result of environmental considerations. Geographic locations of potential coalbed methane areas are also favorable because of low population densities and nearby high-population markets such as Dallas-Fort Worth and Abilene (Evans, 1974).

Bituminous Coals of the Cretaceous Olmos Formation in the Maverick Basin

The first commercial coalbed methane field in Texas, the Sacatosa coalbed methane field in Maverick County, is currently being produced from bituminous coal and carbonaceous shale near the base of the Upper Cretaceous Olmos Formation in the Maverick Basin, at depths less than 3,000 ft from multiple coal beds within the coal zone (20–30 ft). Preliminary data show that the coals are thin (<6 ft), laterally discontinuous, and they host numerous rock and volcanic-ash

partings. The basal coal zone thickens from 20 ft at the outcrop to about 90 ft near the eastern boundary of Maverick County, with maximum net coal thickness approximately 20 ft (Barker and others, 2002). Thickness, depth, and gas contents of the Olmos coals are similar to those of other U.S. productive coalbed methane plays and are compared in Table 1.

Basin	Gas in Place (Tcf)	Avg. Prod. (Mcfd/well)	Coal Rank	Typical Net Coal Thickness (ft)	Typical Gas Content (scf/ton)	Completion Depth (ft)
San Juan	84	2000	Hvb-Lvb	70	430	~2,600
Piceance	99	140		80	768	
Uinta	10	690	Sb-Hvb	24	400	
Powder River	40	250	Sb	75	30	~500
Raton			Hvb-Lvb	<10	200-500	~2,150
Black Warrior	20	100	Hvb-Lvb	25	350	
Central Appalachian	5	120	Hvb-Lvb	11	250	
Cherokee	6	100	Hvb	4	200	
Cook Inlet	230	None	Sb, Hvb-An	100	80 (Sb) 230 (Bit.)	
Central Texas			Sb-Hvb	<10	100-470	500-5,000
Gulf Coast Olmos		10-150	Hvb	7-80	0-300	500-1500

Table 1. Major coal characteristics of U.S. productive coalbed methane plays (modified from Warwick and Barker 2002).

Initial exploration work in the Sacatosa coalbed methane field was a compilation of existing geophysical log data, which illustrate the general continuity and thickness of an upper Olmos coal zone. As an important analog to future coalbed methane resource development in other areas of Texas, similar review of geophysical log data, an essential starting point of any coalbed methane investigation, was undertaken for the Pennsylvanian Bituminous Coals in North-Central Texas. Geophysical logs in Palo Pinto and Stephens County with sonic or density curves were extracted and located from the geophysical log database maintained by the Bureau of Economic Geology. The top and base of the Strawn (Thurber) coal, as well as the coal thickness from a selective grouping of these logs, were compiled. However, only a few sonic/density logs were available regionally, and the major use of this data permitted verification of earlier studies. Preliminary results indicated:

(1) The subsurface depth and downdip distribution of the Strawn (Thurber) coals in Palo Pinto and Stephens County as described in Brown and others (1973) are valid.

(2) Multiple coal seams suitable for coalbed methane potential are limited, most seams less than 3 ft.
(3) Caliper logs indicate that the Strawn (Thurber) underclay and much of the coal are washed-out in most wells, invalidating the use of sonic/density logs for coal-thickness determination.
(4) High ash content of coals is similar to that of Olmos Formation carbonaceous shales that grade laterally into coal.

Digital Maps and Spreadsheets for Inclusion in NCRDS

Modern technology applications and tools, such as digital GIS databases, can enhance the quality and usability of coal resource data. Digital GIS databases allow a wealth of information to be combined and compiled for a comprehensive look not only at the coal resource tonnage but also at coal quality, coal distribution, overburden, land and coal ownership, minability, coalbed methane occurrence, hydrology, and the relationships among these data. All information used is geographically referenced and can be stored, manipulated, and analyzed digitally. The ability to compile many types of spatial data allows an improved understanding of coal occurrence, to make new stratigraphic correlations, and to integrate geologic and resource information (U.S. Geological Survey, 2001).

FY02 NCRDS project's major accomplishments included gathering and compiling digitally regional background data of the Strawn (Thurber) coals, the largest coal resources areally and volumetrically of the Pennsylvanian bituminous coals of North-Central Texas. A variety of previously published studies from Dumble (1890), Plummer and Hornberger (1935), Mapel (1967), Brown and others (1973), Evans (1974), and Cleaves (1975) were mainly utilized. Data available from published studies were incorporated into an Environmental Systems Research Institute, Inc. (ESRI) ArcView GIS format for the user to readily present and analyze the digital mapping data (Figure 1) in separate digital spreadsheets. An advantage of representing spatial data in an ArcView GIS format is the ability to view several themes overlaid atop one another to delineate possible interrelationships among the data. New maps may be created by overlaying different data themes. The data format is also readily available for inclusion in NCRDS and may provide valuable spatial data for delineating future potential coalbed methane production and development fairways.

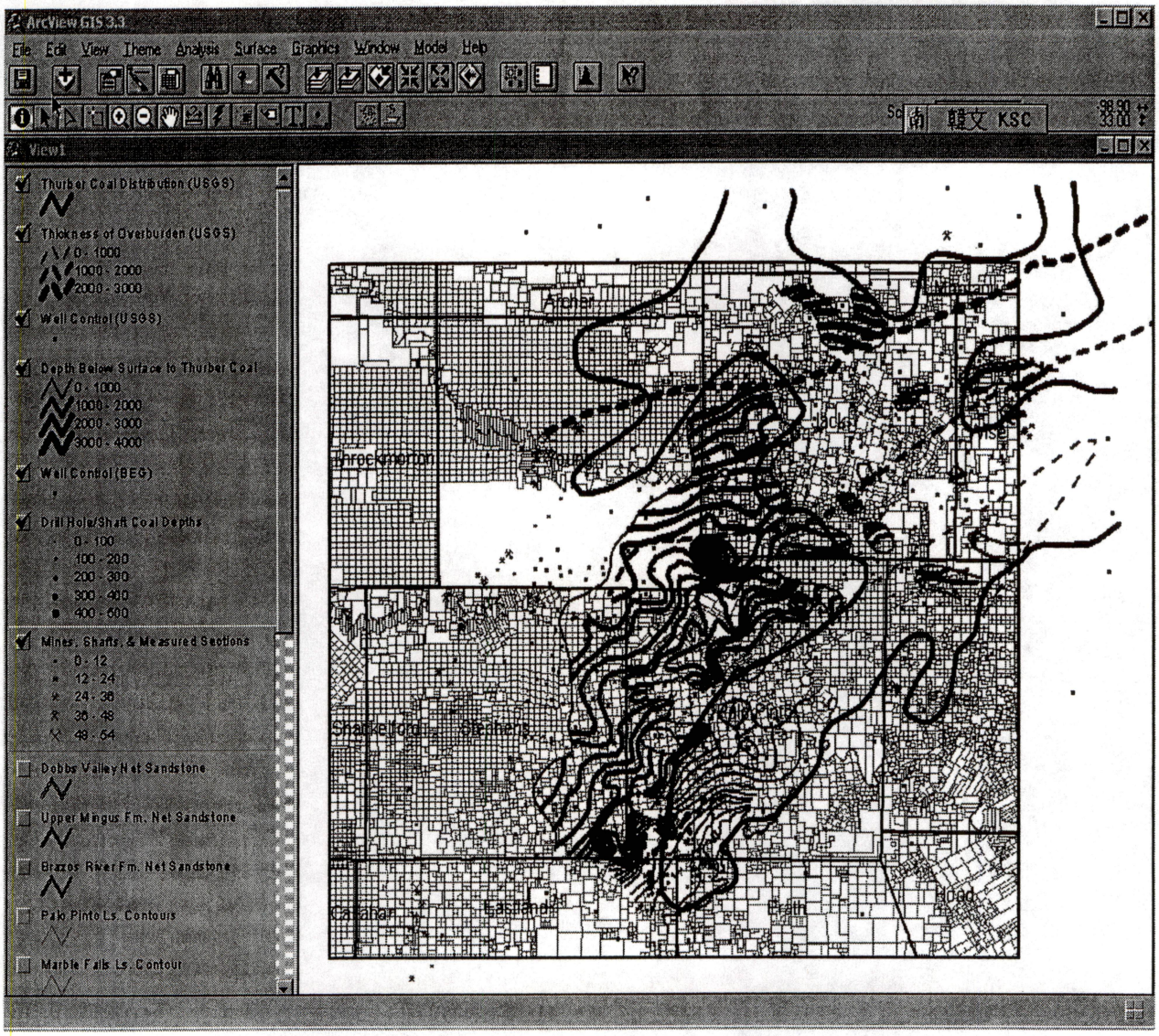

Figure 1. Example of representation of Pennsylvanian bituminous coal data in North-Central Texas utilizing Geographic Information Systems.

FY03 Research Directions

The objective of this cooperative project between the Bureau of Economic Geology and the U.S. Geological Survey is to provide digital data for inclusion in the NCRDS and a preliminary assessment of the coalbed methane potential of the coal-bearing seams of the Pennsylvanian bituminous coals of North-Central Texas. As a multiyear assessment, major accomplishments for FY02 included digital compilation of major background regional data for Pennsylvanian depositional systems and major coal resources, such as the Strawn (Thurber) coals, as well as a comparison with current coalbed methane production from Olmos bituminous coals in the Maverick Basin. Future FY03 tasks to be completed include analysis of other coal resources, such as the Canyon (Bridgeport) and Cisco (Newcastle) coals and subsequent data, as well as an overall future assessment of the coalbed methane potential of the North-Central Pennsylvanian bituminous coals. Deliverables for FY03 include detailed and updated information of the coal resource in this region, utilizing digital spreadsheets of available data, as well as digitized maps compiled in GIS platform. A comprehensive report in pdf document format will also be included in the FY03 Annual Report.

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