Western Kentucky Coalbed Methane Consortium

A Proposed Joint Geologic Study of the Coal-Bearing Strata of the Western Kentucky Coal Field Emphasizing Coalbed Methane Resource Characterization

Kentucky Geological Survey
University of Kentucky

Draft Proposal
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EXECUTIVE SUMMARY

A preliminary analysis of the coalbed methane potential of the Western Kentucky Coal Field has stimulated interest of the coalbed methane industry. Numerous requests for data have been partially met, but most of the data have not been compiled and analyzed in a form useful to the industry. The Kentucky Geological Survey (KGS) is proposing to form an industry-funded consortium to undertake a comprehensive geologic study of Pennsylvanian age coal-bearing rocks in the Western Kentucky Coal Field with a focus on coalbed methane. The study is designed to provide a detailed stratigraphic and structural framework, and coal thickness models that can be used by industry for exploration.

The study will be conducted in two phases, each lasting one year with an interim report and data transfer after the first year. Phase I will consist of map construction including outcrop, mined-out areas, overburden, interburden, coal thicknesses of major coal-producing beds and structure maps. In addition, cumulative coal thicknesses will be calculated using subsurface data. Phase II will consist primarily of stratigraphic data collection, computer database construction, detailed geophysical log correlation within the Pennsylvanian interval, and collection of gas content data. Correlations will be documented with regional structural and stratigraphic cross sections. In addition, boreholes and coal samples of opportunity will be identified for coal quality and gas content analyses. Phase II activities are dependent on companies willing to drill coal tests and contribute the samples for analysis. Data and interpretations resulting from the study will be held confidential for a period of one year from the end of Phase II of the project (until May 31, 2003 under current schedule). Some deliverables include data and products generated under research grants not related to this proposed project; confidentiality cannot be granted for these items. A sample project budget is included. An exact participation cost cannot be calculated until the number of participants and expected products is known. Based on the current budget, with nine or ten companies participating, costs are in the range of $20,000 per company for the two-year project. Project costs will be shared equally by all participants. The greater the number of participants, the lower the per-company cost will be.

KGS has substantial prior experience in conducting proprietary industry-funded research. Since 1990 we have completed a study on the Precambrian East Continent Rift Basin (Cincinnati Arch Consortium), funded by six companies; a study on the Mississippian “Big Lime” in eastern Kentucky, funded by three companies; a study on coal-preparation plants (for reprocessing), funded by one company. After an initial confidentiality period, the results of these studies are now available to industry.

INTRODUCTION

Preliminary indications, such as coal rank, depth, cumulative coal thickness and mining information, suggest that coalbed methane exists in western Kentucky in amounts that should interest the coalbed methane industry (Chesnut and others, 1997).

- Coal-bearing rocks extend to depths greater than 2,500 feet in parts of the coalfield, especially in the Webster and Moorman Synclines (Greb and others, 1992).
- Numerous coals of high-volatile bituminous rank are found throughout this coal-bearing interval.
- Although many of these coals are not of mineable thicknesses, their cumulative thicknesses are probably on the order of several tens of feet.
- Methane explosions in underground mines and mine emission data attest to the presence of methane.

Although preliminary indications for potential coalbed methane production in Kentucky are good, very few data have been compiled that focus on coalbed methane as an energy resource.

The KGS has received a large number of requests from coalbed methane interests for data on the coal-bearing strata in western Kentucky. Requests for structural maps, cumulative coal thickness maps, coal bed isopachs and mined-out areas remain unfilled because these maps are not widely available. To assist industry in their exploration effort the Kentucky Geological Survey (KGS) is proposing to form an industry consortium to conduct a geologic study of the coal-bearing rocks of the Western Kentucky Coal Field. The main objective of this study is to compile and analyze data available at the KGS in the form of boreholes, oil and gas well logs, geologic mapping, deep-mined coal, coal rank, and coal quality. This study will result in a comprehensive geologic data set and model that can be used to improve prospect evaluation.

Data Elements

The following data have been identified as critical to an assessment of coalbed methane potential of Kentucky's coals:

1. Net coal thickness from drill hole data and geophysical logs
2. Regional coal structure maps
3. Cross sections and type geophysical logs to establish stratigraphic framework
4. Catalog of cuttings and cores available
5. Overburden (and interburden) maps
6. Gas content data by direct and indirect (Kim formula) methods
7. MSHA mine ventilation data
8. Cleat direction (face and butt) and density data
9. Coal iso-rank maps
10. Coal quality maps
11. Water production and disposal
12. Gas transportation infrastructure (pipelines, compressor stations, main electrical transmission lines, generators, and substations)

Study Area

The proposed project study area is located in the Western Kentucky Coal Field in the southern part of the Illinois Basin. Figure 1 shows the general location of the study area that is coincident with the areas of fifteen 7.5-minute topographic quadrangles in Union, Webster, and Hopkins Counties. The study area was selected on the basis of the west Kentucky coalbed methane target area delineated by Archer and Kirr (1984) and the area where the overburden to the Springfield (west Kentucky no. 9) coal is at least 1,000 feet thick (Fig. 2). Table 1 shows the generalized stratigraphic nomenclature in use in the Western

Kentucky Coal Fields. Coals in the interval from the Davis to the Baker will be the main focus of the project. Typically, coals below the Davis and above the Baker have limited lateral continuity and are limited in terms of available data.

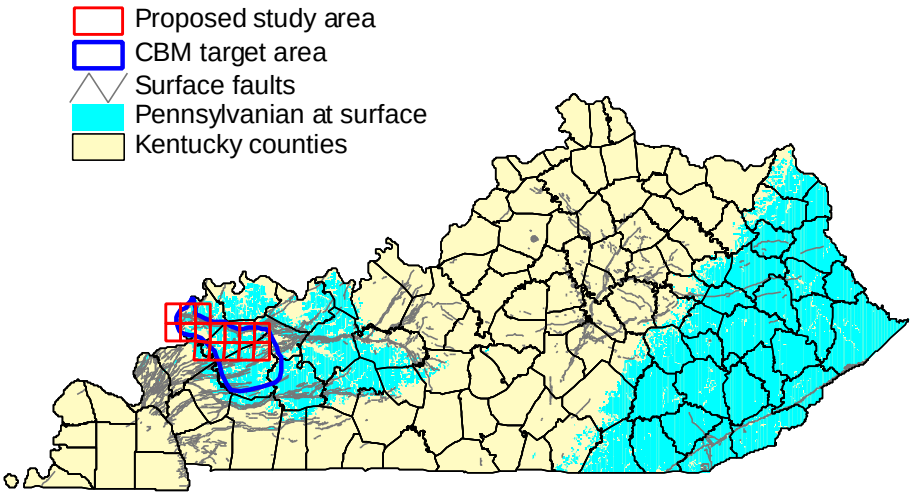

Figure 1. Proposed study area (red outline) showing western Kentucky target area of Archer and Kirr (1984).

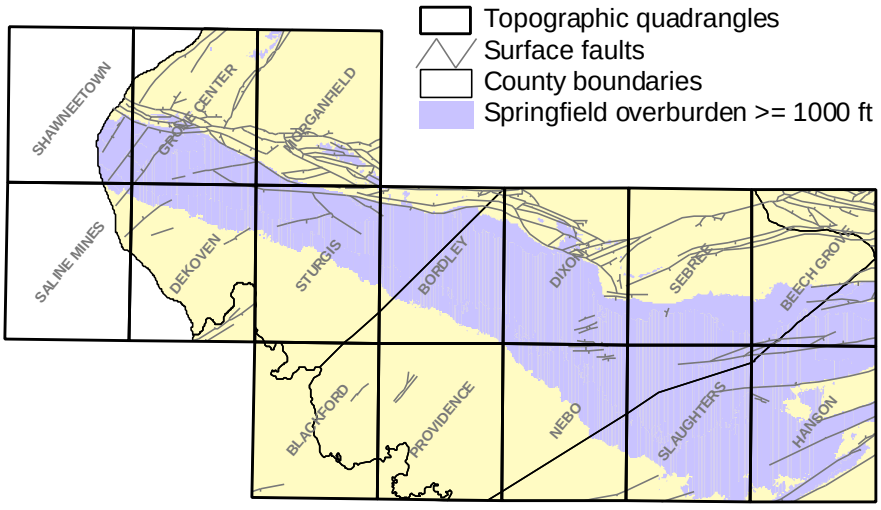

Figure 2. Detail of the proposed study area showing location of area where the Springfield coal overburden thickness is at least 1,000 feet.

PENNSYLVANIAN	Mcleansboro Group	Matoon Fm.	Sulfur Springs coal	
			Mt. Gilead sandstone	
			Vanderburg sandstone	
			Dixon sandstone	
			Geiger Lake coal	
			Livingston limestone	
		Bond Fm.	Lisman coal	
			WKY #18 coal	
			Mt. Carmel sandstone	
			Carthage Limestone Member	
		Patoka Fm.	WKY #17 coal	
			WKY #16 coal	
			WKY #15 coal	
		Shelburn Fm.	WKY #14a coal	
			West Franklin Limestone Mbr.	
			Coiltown (#14) coal	
			Wheatcroft (#13a) coal	
			Baker (#13) coal	
			Providence Limestone Mbr	**Paradise (#12) coal**
				Limestone bed
	Carbondale Fm.		**Herrin (#11) coal**	
			Briar Hill (#10) coal	
			Springfield (#9) coal	
			Houchin Creek (#8b) coal	
			Survant (#8) coal	
			Colchester coal	
			Sebree sandstone	
			Dekoven (#7) coal	
			Davis (#6) coal	
	Raccoon Creek Group	Tradewater Fm.	Yeargins Chapel Limestone	
			Beulah Limestone	
			Curlew Limestone	
			Mannington/Mining City/Lewisport (#4) coals	
			Empire coal	
			Lead Creek Limestone	
			Dunbar coal	
			Elm Lick coal	
			Aberdeen coal and sandstone	
			Amos and Foster coal zone	
			Ice House (#3) coal	
			Finnie and Grindstaff sandstones	
			WKY #2 coal	
			Deanefield coal	
			Hawesville coal	
			Bell (#1b) coal	
		Caseyville Fm.	WKY #1a coal	
			Bee Spring and Pounds sandstones	
			Battery Rock coal	
			Battery Rock sandstone	
			Breckenridge coal	
			Nolin coal	
			Kyrock sandstone	

Table 1. Generalized stratigraphic nomenclature of the coal-bearing rocks of the Western Kentucky Coal Field showing major coal seams in red or bold (after Greb and others, 1992)

Current research and products

The Kentucky Geological Survey is currently engaged in several research efforts to characterize western Kentucky coals. Along with other coal directed research, data are being gathered for available coal resources (Weisenfluh, 1999), deep coals (Williams, 1999), and analysis of coal-bearing rocks to identify coals that are in compliance with the Federal Clean Air Act (Greb, 1999). Each of these on-going efforts is gathering distribution, stratigraphic framework, and coal quality data that are specific to the exploitation of coal resources by mining. However, these data are also fundamental to an assessment of coalbed methane resources and need to be compiled in a unified format to serve the natural gas industry.

	Major Western Kentucky Coals				
	Davis	**Springfield**	**Herrin**	**Paradise**	**Baker**
Product	6	9	11	12	13
Outcrop	Completed	Completed	Completed (includes 12)		Completed
Mined out area	Not Applicable	*Update required*	*Update required (11 and 12 combined)*		*Update required*
Structure	**Proposed**	Completed	Completed	**Proposed**	Completed
Isopach	Not applicable	Completed	Completed	**Proposed**	Completed
Estimated cumulative coal thickness	**Proposed for 6 to 9 interval**	**Proposed for 9 to 13 interval combined**			
Overburden	*	Completed	*		
Interburden	Not applicable	Interval 9-12 completed			*
		NA	Interval 11-13 completed		
Cross sections	**Proposed for the coal-bearing interval**				

Table 2. Products under development by current Kentucky Geological Survey research projects. Some proposed deliverable products for Phase I are shown in red (bold). Asterisk (*) indicates information can be derived mathematically from other available data.

PROJECT OBJECTIVES

The project will be conducted in two phases, with an interim data transfer after the completion of Phase I, and a final report after the completion of Phase II. Quarterly meetings will be held for participants to report progress during the project. These meetings will be held in a location central to the majority of the participants.

Phase I objectives

Phase I will involve developing geographic information systems (GIS) coverages and databases required to make basic gas-in-place assessments. During Phase I, staff will attempt to development an agreement with a coal company in the area to recover and analyze cores of opportunity. Analyses proposed include adsorption/desorption isotherms, proximate analysis, and ultimate analysis as coal samples of opportunity become available. Cumulative thickness of some coals and coal intervals will be estimated using subsurface data in a method described in the following section.

Phase II objectives

The primary emphasis in Phase II will be to develop gas content data in cooperation with the companies identified in Phase 1 willing to contribute access to boreholes of opportunity. A final report synthesizing all results will be provided.

IMPLEMENTATION OF PHASE I MAPPING

Methodology for estimating remaining net coal thickness by depth

Estimates of net coal thickness and depth in the Western Kentucky Coal Field depend on the kinds of information available for different parts of the stratigraphic succession (Table 1). The Springfield Coal and beds immediately above it comprise the principal mineable coals of the region. As such, abundant subsurface drill hole information is available to characterize them. Regional isopach, structure and derivative maps, existing or in preparation, will be used in a quantitative grid-based analysis to identify areas of maximum coal thickness. Stratigraphically lower coals that have insufficient data for quantitative thickness mapping will require different methods of analysis. Existing drill hole records and oil and gas geophysical logs will be utilized to perform a qualitative assessment of the general thickness characteristics for coals between the Davis and Springfield. The products of this analysis will be prepared is such a way that they can be summed to estimate cumulative coal thickness for the interval, but the result will be qualitative in nature. Products of both analyses are summarized in Table 2.

Quantitative analysis of the Springfield to Baker interval

Regional 30-meter cell maps representing total coal thickness, structure, overburden, interburden to adjoining beds and mined-out areas will be prepared for the Springfield, Herrin, Paradise and Baker coals. The best structural datum in the Western Kentucky Coal Field is the Springfield coal because of its continuity and the large amount of subsurface data available for it. Structure and overburden maps for the other beds will be derived from the Springfield using interpolated interburden thickness (see cells with asterisks in Table 2).

Existing mined-out area maps for these beds only contain data current to about 1992. Production data will be used to identify mines with significant expansion since that time. Mine maps on file at the Kentucky Department of Mines and Minerals and the Henderson office of the Kentucky Geological Survey will be used to update the regional coal field maps (area with Pennsylvanian at the surface for western Kentucky shown in Figure 1).

Algebraic grid analysis will be used to sum remaining coal thickness for each of the four beds within specified overburden parameters. The resulting cumulative thickness map will be classified at appropriate intervals.

Qualitative analysis of the Davis to Springfield interval

Significant coal resources exist between the Springfield and Davis coals, but available data are generally insufficient to prepare regional interpolated grids of thickness or structure. There is sufficient drill hole data correlate the coals with some confidence and to classify the region in terms of areas of general thickness. Oil and gas geophysical logs can be utilized to infill areas of sparse data. Individual maps of qualitative coal thickness areas will be prepared for the Davis, Dekoven, Colchester, Survant and Houchin Creek coals in such a way that they can be summed to estimate cumulative coal thickness for the interval.

Coals in the Tradewater and Caseyville Formation

Numerous coal beds occur below the Davis coal, but little data exists to characterize them. Moreover, the interval is very thick relative to the number of coals present and existing date shows that coal correlation and continuity is poor. Analysis of this interval is not proposed for Phase I work. If target areas were identified in Phase I for which more information is required about the lower coal beds, the following methodology would be recommended. Oil and gas geophysical logs can be used to detect the presence of coal beds at depth, but interpretations of coal thickness for these data are qualitative. Presence of organic-

rich black shales that occur above many of the coals in western Kentucky can also be detected. Due to difficulties in correlation in the interval below the Davis only summary statistics will be collected to characterize the numbers of coals, coal-bed spacing and clustering for individual points. An inventory of geophysical logs will be prepared to identify all logs that contain high-quality gamma-density signatures for the stratigraphic interval of interest. These data will be used to prepare geologic cross sections that illustrate the general characteristics of the interval and to assess the continuity of coal beds and zones. Measurements of coal-bed frequency will be derived for fixed intervals below the Davis coal to the base of the Pennsylvanian system.

DELIVERABLES

Project deliverables will be provided in digital format on a CD-ROM. Base map and location data are to be in ArcView shape file format with geodetic coordinates in decimal latitude and longitude (NAD83/WGS84). Documents and cross sections will be in Adobe Acrobat portable document format (PDF). Proposed deliverables include the following:

Phase I:

An asterisk (*) indicates products developed by current KGS research projects. These maps, charts, and data will be delivered as digital products, but cannot be held confidential. Such existing information will require compilation for delivery as an integrated GIS product. Newly proposed items are highlighted in red (bold).

1. Springfield (#9) to Baker (#13) interval for the extent of the Western Kentucky Coal Field
   - Digital coal outcrop maps
     Springfield*
     Herrin and Paradise combined*
     Baker*
   - Digital coal mined-out area maps (existing maps may require an update)
     Springfield*
     Herrin*
     Baker*
   - Digital coal structure maps of select beds
     Springfield*
     Herrin*
     Paradise
     Baker*
   - Digital coal bed isopach maps of select beds
     Springfield*
     Herrin*
     Paradise
     Baker*
   - **Estimated net cumulative coal thickness (all coals in the interval combined)**
   - Overburden/interburden maps
     Springfield overburden*
     Springfield to Paradise interburden*
     Herrin to Baker interburden*
   - **Compilation of MSHA emissions data (includes possible opportunities for collecting coal gas content data)**

2. Davis (#6) to Springfield (#9) interval for the extent of the Western Kentucky Coal Field
   - Digital coal outcrop map of Davis*
   - **Digital coal structure map of Davis**
   - **Estimated net cumulative coal thickness (all coals in the interval combined)**
3. **Digital infrastructure maps for the extent of the Western Kentucky Coal Field (pipelines, compressor stations, and others)**
4. For the 15 quadrangle study area
   - Point database of stratigraphic* information (coal name, depth, and thickness)
   - Point database of coal quality* information (proximate and ultimate analyses, Kim formula gas contents)
   - Point database of coal petrographic* and vitrinite reflectance* data (R_0)
   - Point database of cleat orientation* data
   - Point database of oil and gas well locations* identifying wells with geophysical logs, **well samples, and cores**
   - Point database of coal borehole locations*
   - **Cross section to establish stratigraphic framework including digital versions (LAS) of the geophysical logs used in the correlations**
5. **Interim report and data handbook**

Phase II:

Completion of this phase is dependent on identifying targets of opportunity for gathering gas content data. It is intended that one or more project participants contribute access to drill holes for logging and coal analyses.

1. **For coal samples recovered by drilling**
   - **Gas content data**
   - **Coal quality information (proximate and ultimate analyses)**
   - **Coal petrographic and vitrinite reflectance (R_0) data**
2. **Set of detailed strike and dip cross sections**
3. **Digitized geophysical log library in LAS format of the wells used in the cross sections**
4. **Final report**

CONFIDENTIALITY

Confidentiality of results and material developed by research performed under this proposed project will be maintained for one year from the completion of Phase II. Data elements and materials compiled from existing products and current on-going, publicly funded research cannot be maintained as confidential and will be released according to their respective contractual obligations.

PERSONNEL

The project will be directed by the KGS, within the Coal and Industrial Minerals Section and the Geologic Mapping and Hydrocarbon Resources Section. Principal investigator will be Brandon C. Nuttall of KGS. James A. Drahovzal and Donald R. Chesnut will be co-principal investigators and administrators. The scope of this project will require that a geologist be hired by KGS for the duration of the project.

PROJECT SCHEDULE

Phase I could begin as early as June 1, 2000, depending on the amount of time necessary to obtain funding. Phase II would follow one year later, with submittal of the final report by May 31, 2002. Confidentiality of all project results will be maintained for one year from the completion of Phase II (May 31, 2003).

Table 3. Project Timetable (assuming June 1, 2000 start-up)

Phase I	Phase II	Confidentiality Period
June 1, 2000 – May 31, 2001	June 1, 2001 – May 31, 2002	June 1, 2000 – May 31, 2003

PROJECT BUDGET

A project budget is included below. Funding for travel is included to cover costs of project meetings and trips required to collect data at various company offices. Costs of the project will be shared equally by all companies. The approximate total cost of the 2-year project is $200,000. Should 10 companies participate in the study, the total cost per participant would be $20,000. If fewer than 10 companies participate, the cost per company would be adjusted accordingly. Participation in Phase I alone will not be permitted. Participants must commit to the full two-year project, but payments may be made on an annual basis if desired.

Table 4. Coalbed Methane Consortium Proposed Budget

Direct Costs	Personnel	**$125,000**
	Travel	**$3,000**
	Equipment	**$10,000**
Indirect Costs		**$58,240**
Total		**$196,240**

RESEARCH OPTIONS

Additional related research that can be done at KGS and may be added as Phase II deliverable products

- Digitizing of additional geophysical logs in the study area (subsurface reference atlas) with tagged coal beds (compile an LAS format digital log library).
- Extending the study to the rest of the Illinois Basin
- Extending the study to the Eastern Kentucky Coal Field.

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