Resource Assessment & Production Testing for Coal Bed Methane in the Illinois Basin

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ABSTRACT

The geological surveys of Illinois, Indiana and Kentucky have completed the initial geologic assessment of their respective parts of the Illinois Basin. Cumulative thickness maps have been generated and target areas for drilling have been selected. The first well in the Illinois area of the Illinois Basin coal bed methane project was drilled in White County, Illinois in October 2003. This well was cored in the major coal interval from the Danville to the Davis Coals and provided a broad spectrum of samples for further analyses. Sixteen coal samples and three black shale samples were taken from these cores for canister desorption tests and were the subject of analyses that were completed over the following months, including desorbed gas volume, gas chemical and isotope composition, coal proximate, calorific content and sulfur analyses. Drilling programs in Indiana and Kentucky are expected to begin shortly.

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The Illinois Basin has over 325 billion tons of remaining coal resources that is estimated to contain 11 trillion cubic feet (Tcf), or more, of coalbed methane (CBM). To date, very limited amounts of this CBM have been produced, mainly because historical data have indicated low, uneconomic, gas contents. However, more recently acquired data suggest that gas contents in certain areas within the basin may be much higher than previously thought. Coal production within the basin continues to decline, mainly because of the high sulfur contents of most of the economic coal beds. CBM may be an effective way to use this vast energy resource to help meet the increasing demand for natural gas. Development of this resource would also contribute to the energy security of the nation, as a whole, and be a source of hydrogen for emerging fuel cell technology. This report summarizes project activities for the first six months.

The geological surveys of Illinois, Indiana and Kentucky have completed the initial geologic assessment of their respective parts of the Illinois Basin. Cumulative thickness maps have been generated and target areas for drilling have been selected. The first well in the Illinois area of the Illinois Basin coal bed methane project was drilled in White County, Illinois in October 2003. This well was cored in the major coal interval from the Danville to the Davis Coals and provided a broad spectrum of samples for further analyses. Sixteen coal samples and three black shale samples were taken from these cores for canister desorption tests and were the subject of analyses that were completed over the following months, including desorbed gas volume, gas chemical and isotope composition, coal proximate, calorific content and sulfur analyses. Drilling programs in Indiana and Kentucky are expected to begin shortly.

Data from the Illinois drilling program indicates a cumulative coal thickness (Danville to Davis) of 24.5 ft, with individual bed thicknesses ranging from 1.4 to 5.0 ft. Ash yields range from 9.2 to 24.3 %, total sulfur contents range from 1.5 to 11.4 %, and calorific values range from 9647 BTU/lb to 12544 BTU/lb. Gas content values were determined for after over four months of canister desorption. Gas contents range from 83.3 scf/ton to 188.7 scf/ton on a dry, mineral matter free basis. Lost gas values for all of the samples are typically very low, reflecting slow desorption rates. Three black shale samples that were analyzed contained moderate gas contents (65.7 to 112.2 scf/ton, as-received basis), and will likely contribute to the overall gas resource.

Gases desorbed from the coal and shale samples were analyzed for their gas species and isotope (hydrogen and carbon) compositions. Gas analysis shows a dominance of methane in most of the samples (typically > 60%), and as high as 85 % in one sample. Heavier gases, in contrast, are poorly represented (typically < 1.5 %). Likewise, CO_2 is a minority gas (< 2 %). One concern with the chemical compositions of gas samples has always been dealing with potential line contamination from the feed lines and from residual air that is in the canister when a sample is sealed, which could contribute to elevated nitrogen values. Theoretically, if nitrogen in the canisters is residual from sealing, it should decline with successive sampling. This was noted in about half of the samples. In some samples, the nitrogen values increased, indicating that the nitrogen is probably coming from the coal.

Hydrogen (deuterium) and Carbon 13 stable isotope compositions are very uniform and are consistent with a microbial to early transitional thermal origin of the methane. In the shallower coals, such as the Danville and Herrin, coal methane isotopes clearly indicate a microbial origin, whereas the deeper coal gases have a slightly higher thermogenic overprint. Isotherm and petrographic analyses of the coal samples are still being performed.

Desorption data for the Springfield and Seeleyville coals in Sullivan and Gibson Counties, Indiana have been obtained from donated core. In this area, the Springfield coal ranges from 42 to 94 scf/ton, and the Seeleyville coal from 80 to 149 scf/ton on an as-received basis. Adsorption isotherm data from selected coal samples show a methane holding capacity that ranges from 102 to 235 scf/ton (average 150 scf/ton). The CO_2 holding capacity for the same set of samples is much higher, ranging from 521 to 788 scf/ton. Additional analyses on these samples are currently underway.

INTRODUCTION

The Illinois Basin has over 325 billion tons of remaining coal resources that is estimated to contain 11 trillion cubic feet (Tcf), or more, of coal bed methane (CBM). To date, very limited amounts of this CBM have been produced, mainly because historical data have indicated low, uneconomic, gas contents. However, more recently acquired data suggest that gas contents in certain areas within the basin may be much higher than previously thought. As coal production within the basin continues to decline, mainly because of the high sulfur contents of most of the coals, production of CBM may be an effective way to use this vast energy resource. Development of this resource would also contribute to the energy security of the nation, as a whole.

The goal of this project is to obtain fundamental CBM content, permeability, and well-completion data for Illinois Basin coals from a selected set of core holes. Six exploration cores will be drilled in selected places in the basin to depths up to 1,500 feet. The well sites will be based on detailed geological analysis to determine the best possible areas for economic CBM. Project results will hopefully encourage and support industry as they attempt to explore for, and develop, this important energy resource.

EXPERIMENTAL

Coal samples collected from the drilling program are degassed in standard CBM desorption canisters for a period of 2 to 4 months, depending on the rate of gas release. Following this, the coal samples are crushed in an air-tight ball mill to obtain residual gas measurements. The crushed coal is then removed from the ball mill and analyzed for a variety of parameters including:

1) proximate analysis (moisture, volatile matter, fixed carbon and ash yield)
2) total sulfur content
3) calorific value
4) petrography (maceral analysis and vitrinite reflectance)
5) methane adsorption capacity (isotherm analysis)

Both in-house and private laboratories are used to perform these analyses.

RESULTS AND DISCUSSION BY STATE

Illinois

The first well in the Illinois area of the Illinois Basin coalbed methane project was drilled in White County, Illinois in October 2003. The well was drilled in the New Harmony Oil Field in an area of low local structural relief (see figure 1). A mile or two east and west of this field lie normal faults of the Wabash Valley Fault system that trend northeast-southwest. The new well, the James Cantrell #9 Hon, was cored in the major coal intervals from the Danville to the Davis Coals and provided a broad spectrum of samples for further analyses. The well was subsequently reamed to 7 7/8"and cased with 5 1/4'" pipe. Sixteen coal samples and three black shale samples were taken from these cores for canister desorption tests and were the subject of analyses that were completed over the following months, including desorbed gas volume, gas chemical and isotope composition, coal proximate, calorific content and sulfur analyses. Many of these key coal analyses were completed in this reporting period and these results are tabulated below. Additional analyses such as coal isotherm determinations and coal petrography are in progress and will be reported later.

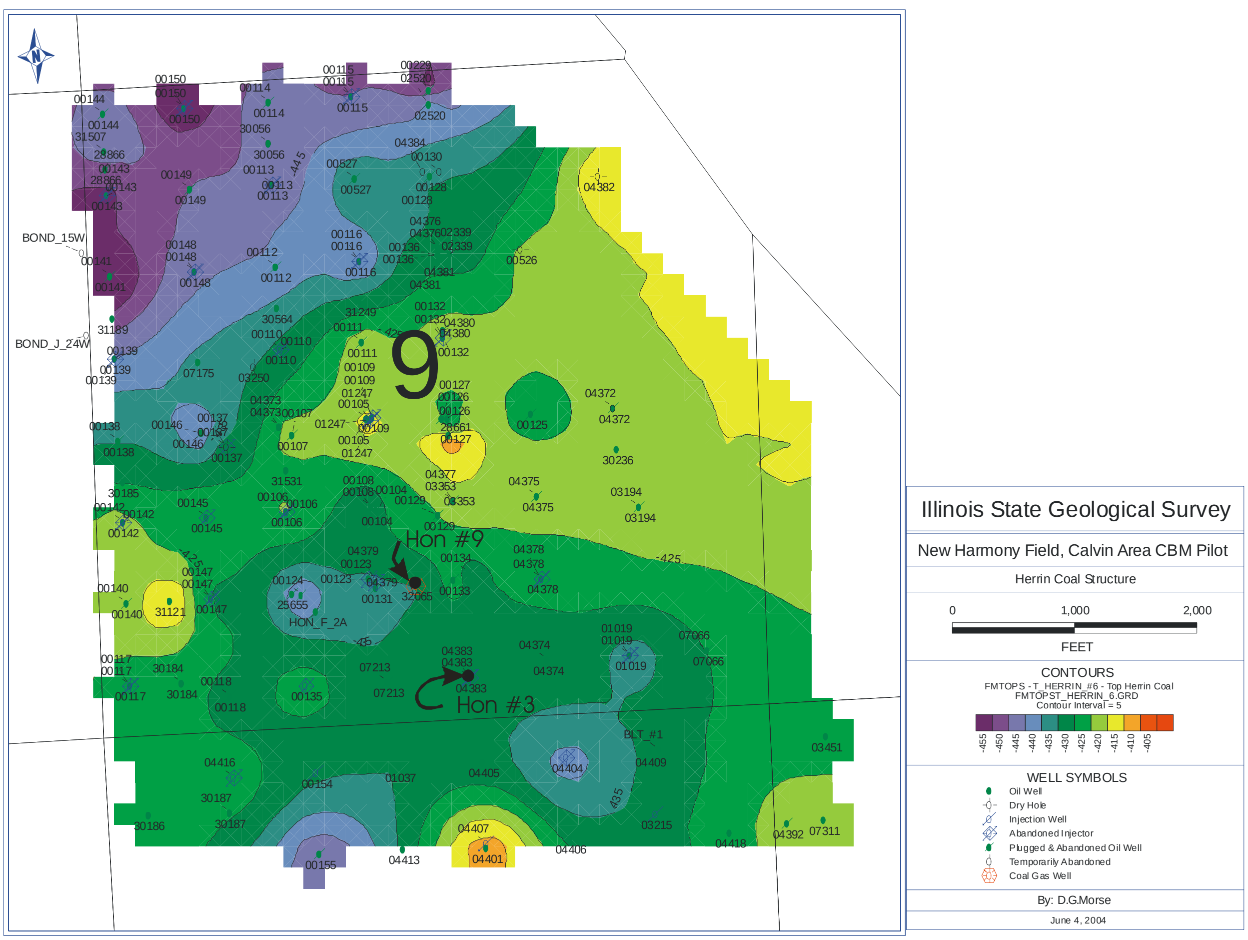

Figure 1. Herrin Structure Map in Pilot area, Sec. 9, T4S, R14W, White County, Illinois

One of the potential dewatering wells in the White County pilot was completed in November, 2003, the #3 Hon. This well is a recompleted old well that formerly produced from a deep Mississippian pay. It had been plugged. Royal Drilling reentered the old borehole, removing the surface plug and washing down the old hole. Although casing was in the hole, it was not cemented across the coals. The old casing was cut off below the coals of interest and new casing was placed in the hole and cemented, thus providing good hole integrity though the coal zones. Correlations to the #9 Hon, which lies about 700 feet to the north-northwest, are shown in figure 2 using the old SP-Resistivity log available from the #3 Hon and the GR-Den log from the #9 Hon.

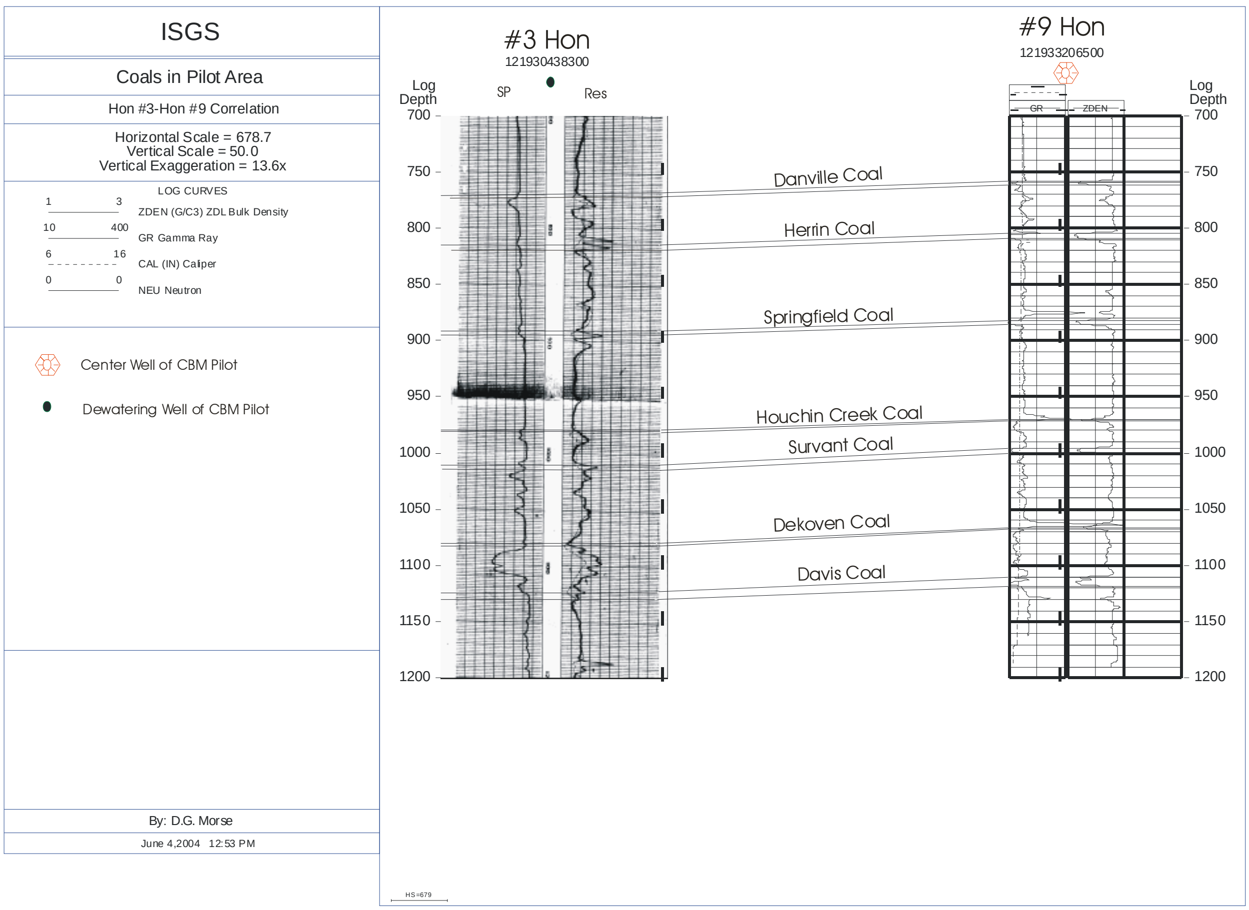

Figure 2. Cross-section from the #3 Hon to the #9 Hon wells in the White County Pilot Project.

Depths and thicknesses for the major coals in the pilot area at #9 Hon are shown in Table 1. These are derived from the GR-Density log in the #9 Hon and are compared to the actual cored coal thickness. The total coal in the pilot area is about 24 feet. The thin Houchin Creek (#4) coal will not be a part of the pilot because it closely overlies a porous water-bearing sandstone that we are unlikely to dewater successfully.

Table 1. Coal Tops from James Cantrell #9 Hon well log and actual coal core thicknesses

Coal	Top (ft)	Base (ft)	Thickness (ft)	Core coal thickness (ft)
Danville	758.0	762.0	4.0	3.6
Herrin #6	806.0	810.0	4.0	5.0
Springfield #5	882.0	886.0	4.0	4.0
Houchin Creek #4	971.0	972.0	1.0	1.5
Survant #3	996.0	1000.0	4.0	4.1
Colchester #2	1066.0	1068.0	2.0	1.6
Davis- upper split	1110.0	1111.5	1.5	1.4
Davis- middle split	1114.0			2.1
Davis- lower split		1118.0	4.0	1.2
Total			25.5	24.5

Note: Between upper and middle split in Davis coal is 1' 3" of carbonaceous shale and siltstone
Between Middle and lower split in Davis coal is 4" of carbonaceous shale with some pyrite partings.

Proximate, heating value, and sulfur analyses were run on all the samples as these values are needed for the gas content calculations. The results are summarized below in Table 2.

Table 2. As-Received Proximate/Btu/S Analyses

Royal Drilling#9 Hon Well

Sample No.	Depth (ft)	Moisture (wt %)	Ash (wt %)	Volatile Matter (wt %)	Fixed Carbon (wt %)	Heating Value (Btu/lb)	Sulfur (wt %)	Coal Rank
D1-Danville Coal	756.2	7.31	10.27	35.48	46.94	11815	4.63	hvBb
D2-Danville Coal	759.7	6.95	24.32	31.16	37.57	9647	2.81	hvBb
D3- Herrin Coal	803.5	7.10	14.34	34.25	44.30	11068	5.07	hvBb
D4-Herrin Coal	805.0	8.66	6.56	34.38	50.40	12221	2.24	hvBb
D5- Herrin Coal	807.0	7.76	10.97	33.91	47.36	11592	2.84	hvBb
E1-Turner Mine Shale	874.0	2.25	66.47	19.79	11.49	4302	2.40	-
E2- Springfield Coal	880.8	6.06	10.58	35.28	48.08	12080	2.83	hvBb
E3-Springfield Coal	882.7	6.65	7.43	37.24	48.68	12384	2.18	hvBb
E4- Springfield Coal	883.7	6.72	10.57	34.75	47.96	12017	1.54	hvBb
E5- Excello Shale	967.4	2.70	71.93	15.20	10.17	3360	2.86	-
C2- Houchin Creek Coal	968.7	4.91	9.57	40.02	45.50	12087	6.46	hvBb
C3- Survant Coal	993.9	5.67	9.17	37.88	47.28	12050	5.28	hvBb
C4- Survant Coal	994.7	5.35	9.54	38.70	46.41	12477	3.91	hvAb
C5- Survant Coal	996.4	5.22	9.18	38.64	46.96	12544	2.48	hvBb

A1- Mecca Quarry Shale	1058.0	3.48	81.50	13.81	1.21	1137	4.67	-
A3- Dekoven Coal	1062.5	4.51	25.24	33.91	36.34	10187	2.85	hvAb
A4-Davis Coal	1107.5	4.47	17.34	35.42	42.77	10977	11.43	hvBb
A5-Davis Coal	1111.3	5.05	10.09	39.40	45.46	12277	4.86	hvBb
B1- Davis Coal	1113.7	4.73	11.45	37.58	46.24	11877	6.88	hvBb

Gas content values were determined for the 16 coal and 3 shale samples after over four months of canister desorption. They are reported below in Table 3 on a dry, mineral-matter-free basis. The values are typical of samples we analyzed in our previous drilling program. The best coal was the Davis Coal. This is equivalent to the Seeleyville Coal that is the reservoir of a coalbed methane operation in Sullivan County, Indiana. Lost gas values are typically very low, reflecting the slow desorption rate of the coals and short lost gas times. Residual gas values were determined by an outside contractor and entered in the total gas computation. Three black shale samples were also analyzed as they will likely contribute to the gas resource. Because of their inherent high mineral matter content, their contents appear to be overly high. The as-received basis values shown at the base of the table put their contents into perspective. A ton of coal in the ground may have 3 to 5 times more gas than a ton of shale. Volumetrically, however, for a 2.00 g/cc carbonaceous shale there are 2715 tons per acre-ft compared to 1800 tons per acre-ft for a 1.324 g/cc coal; even more gas if the shale has some pyrite and is heavy.

Table 3. Gas contents of coal and shale samples from #9 Hon well

Canister	Sample	Gas content (scf/t, dmmf basis) Lost	Desorbed	Residual	Total
D1	Danville 1	2.3	73.2	17.9	**93.4**
D2	Danville 2	2.5	87.3	5.5	**95.3**
D3	Herrin 1	2.0	70.5	13.8	**86.3**
D4	Herrin 2	3.2	74.3	13.7	**91.2**
D5	Herrin 3	2.0	67.9	14.3	**84.2**
E2	Springfield 1	1.0	54.8	20.2	**76.0**
E3	Springfield 2	1.9	66.7	14.7	**83.3**
E4	Springfield 3	2.5	64.3	14.8	**81.6**
C2	Houchin Creek	0.6	53.5	27.4	**81.5**
C3	Survant 1	1.4	71.6	19.4	**92.4**
C4	Survant 2	1.0	72.2	15.1	**88.3**
C5	Survant 3	1.1	72.4	11.5	**85.0**

A3	Dekoven	1.0	71.0	21.3	**93.3**
A4	Davis 1	3.3	94.0	21.4	**118.7**
A5	Davis 2	3.7	87.7	18.6	**110.0**
B1	Davis 3	1.8	68.1	16.5	**86.4***
E1	Turner Mine Sh.**	0.3	72.9	14.7	**87.9**
E5	Excello Sh.**	2.4	112.2	6.3	**120.9**
A1	Mecca Quary Sh.**	0.0	65.7	78.7	**144.4**

* Suspected slight gas leak from the canister during desorption tests
** As-received total gas contents of Turner Mine, Eexcello, and Mecca Quary shales are 21.7, 21.8, and 8.6 scf/t, respectively.

Gases desorbed from the coal and shale samples were analyzed for their chemical and isotope (hydrogen and carbon) compositions. Results are shown in Table 4 below. One concern with the chemical compositions of gas samples has always been dealing with potential line contamination from the feed lines and from residual air that is in the canister when a sample is sealed. These could contribute to the elevated nitrogen values. Multiple samples are obtained from each canister to examine variation with time. Theoretically, if nitrogen in the canisters is residual from sealing, it should decline with successive sampling. This is noted in half of the samples, but there is an equal likelihood for the nitrogen value to increase. Thus, the nitrogen, may indeed be from the coal itself.

Hydrogen (deuterium) and Carbon 13 stable isotope compositions are very uniform and are consistent with a microbial to early transitional thermal origin of the methane (figure 3). In the shallower coals, such as the Danville and Herrin, coal methane isotopes clearly indicate a microbial origin, whereas the deeper coal gases show a slightly more thermogenic origin. This is evident in the C13 isotope vs depth plot shown in figure 4. The quantity of C2+ gases, another thermogenic indicator, also increases with depth.

Table 4. Desorbed Gas Chemical and Isotope Composition, #9 Hon

Gas sample	Coal Depth (ft)	Gas composition, %					CH_4 isotope values	
		N_2	CO_2	CH_4	C_{2+}	$CH_4 + C_{2+}$	d[13]C	d D
HON-D1-A DANVILLE 1(dup. isotopes)	756.2	31.27	1.23	67.50	0.00	67.5	-69.9	-214.1
HON-D1-B DANVILLE 1	756.2	33.20	1.18	65.63	0.00	65.6	-69.2	-214.5
HON-D1-C DANVILLE 1	756.2	21.97	1.33	76.67	0.03	76.7		
HON-D2-A DANVILLE 2	759.7	24.09	1.20	74.71	0.00	74.7	-70.4	-212.1
HON-D2-B DANVILLE 2	759.7	21.84	1.30	76.86	0.00	76.9	-70.2	-215.0
HON-D2-C DANVILLE 2	759.7	13.76	1.23	85.01	0.00	85.0	-69.9	-214.7
HON-D3-A HERRIN 1	803.5	31.96	2.21	65.16	0.67	65.8	-70.8	-215.9
HON-D3-B HERRIN 1	803.5	31.85	2.12	65.29	0.74	66.0	-70.4	-217.2
HON-D3-C HERRIN 1	803.5	23.47	2.11	73.54	0.89	74.4		
HON-D4-A HERRIN 2	805	34.70	1.90	62.64	0.76	63.4	-69.9	-216.4
HON-D4-B HERRIN 2	805	34.30	1.86	62.98	0.86	63.8	-69.8	-218.6
HON-D4-C HERRIN 2	805	22.10	1.93	74.79	1.17	76.0		

HON-D5-A HERRIN 3	807	31.85	1.74	65.61	0.80	66.4	-69.7	-214.7
HON-D5-B HERRIN 3	807	28.86	1.77	68.44	0.92	69.4	-69.9	-217.5
HON-D5-B HERRIN 3 (2nd run)	807	20.71	1.86	76.26	1.17	77.4	-69.9	-218.6
HON-D5-C HERRIN 3	807	20.71	1.86	76.26	1.17	77.4	-69.7	-217.5
HON-E2-A SPRINGFIELD 1	880.8	24.07	1.62	72.89	1.43	74.3	-66.9	-211.1
HON-E2-B SPRINGFIELD 1	880.8	33.34	1.40	63.94	1.32	65.3	-66.1	-210.0
HON-32-C SPRINGFIELD 1	880.8	34.12	1.33	63.21	1.33	64.5		
HON-E3-A SPRINGFIELD 2	882.7	27.60	1.28	69.76	1.37	71.1	-66.9	-211.2
HON-E3-B SPRINGFIELD 2	882.7	25.71	1.40	71.29	1.60	72.9	-66.3	-211.2
HON-E3-C SPRINGFIELD 2	882.7	23.12	1.39	73.64	1.84	75.5		
HON-E4-A SPRINGFIELD 3	883.7	37.24	1.42	60.09	1.25	61.3	-67.2	-209.8
HON-E4-B SPRINGFIELD 3	883.7	37.49	1.32	59.86	1.33	61.2	-67.2	-211.3
HON-E4-C SPRINGFIELD 3	883.7	36.58	1.47	60.24	1.70	61.9	-67.1	-211.9
HON-C2-A HOUCHIN	968.7	21.49	1.87	75.29	1.35	76.6	-66.0	-215.0
HON-C2-B HOUCHIN	968.7	33.99	1.56	63.25	1.20	64.4		
HON-C2-C HOUCHIN CREEK	968.7	29.60	1.74	67.28	1.38	68.7	-65.4	-217.0
HON-C3-A SURVANT 1	993.9	28.18	1.71	69.12	1.00	70.1	-66.9	-219.8
HON-C3-B SURVANT 1	993.9	28.03	1.91	68.96	1.10	70.1	-66.8	-220.1
HON-C3-C SURVANT 1	993.9	21.71	1.94	75.01	1.34	76.4		
HON-C4-A SURVANT 2 (dup. isotopes)	994.9	25.57	1.93	71.47	1.03	72.5	-67.0	-218.8
HON-C4-B SURVANT 2	994.9	27.21	2.06	69.64	1.09	70.7	-67.2	-219.1
HON-C4-C SURVANT 2	994.9	24.55	1.91	72.21	1.33	73.5		
HON-C5-A SURVANT 3	996.4	29.92	1.72	67.41	0.95	68.4	-67.0	-220.1
HON-C5-B SURVANT 3	996.4	32.12	1.68	65.17	1.03	66.2	-67.0	-221.3
HON-C5-C SURVANT 3	996.4	21.94	1.75	74.97	1.34	76.3	-66.8	-222.7
HON-A3-A DEKOVEN	1062.5	22.22	1.76	75.81	0.22	76.0	-65.7	-207.6
HON-A3-B DEKOVEN	1062.5	34.55	1.35	63.93	0.17	64.1	-65.0	-207.9
HON-A3-C DEKOVEN	1062.5	34.44	1.30	64.02	0.25	64.3	-64.5	-212.3
HON-A4-A DAVIS 1	1107.5	29.32	1.22	69.11	0.34	69.5	-65.2	-201.8
HON-A4-B DAVIS 1(dup. isotopes)	1107.5	26.21	1.45	72.04	0.30	72.3	-65.2	-205.8
HON-A4-C DAVIS 1	1107.5	16.42	1.55	81.75	0.28	82.0		
HON-A5-A DAVIS 2	1111.3	27.86	1.19	70.64	0.31	70.9	-66.3	-205.2
HON-A5-B DAVIS 2	1111.3	25.75	1.17	72.75	0.33	73.1	-65.2	-206.9
HON-A5-C DAVIS 2	1111.3	16.56	1.40	81.62	0.41	82.0		
HON-B1-A DAVIS 3	1113.7	31.05	1.37	67.26	0.33	67.6	-64.9	-206.2
HON-B1-B DAVIS 3	1113.7	30.13	1.37	68.17	0.33	68.5	-64.6	-204.7
HON-B1-C DAVIS 3	1113.7	21.46	1.61	76.52	0.41	76.9	-64.4	-207.8
HON-E1-A TURNER	874	51.01	0.37	47.58	1.04	48.6	-66.3	-211.1
HON-E1-A TURNER (2nd GC run)	874	51.20	0.00	47.76	1.04	48.8		
HON-E5-B EXCELLO (dup. isotopes)	967.4	56.20	0.28	42.46	1.06	43.5	-66.5	-215.9
HON-A5-A EXCELLO SHALE	967.4	52.89	0.36	45.61	1.14	46.7	-66.9	-215.6

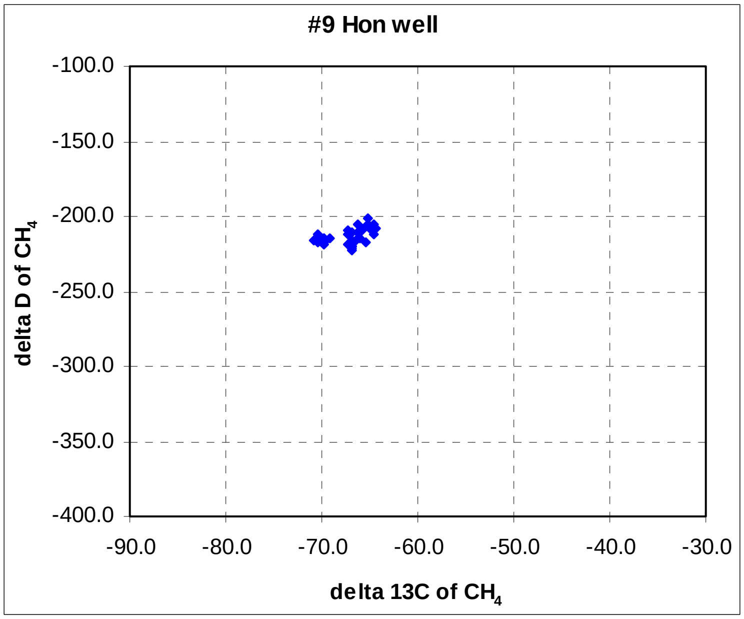

Figure 3. Cross-plot of hydrogen (Deuterium) vs carbon 13 isotope values.

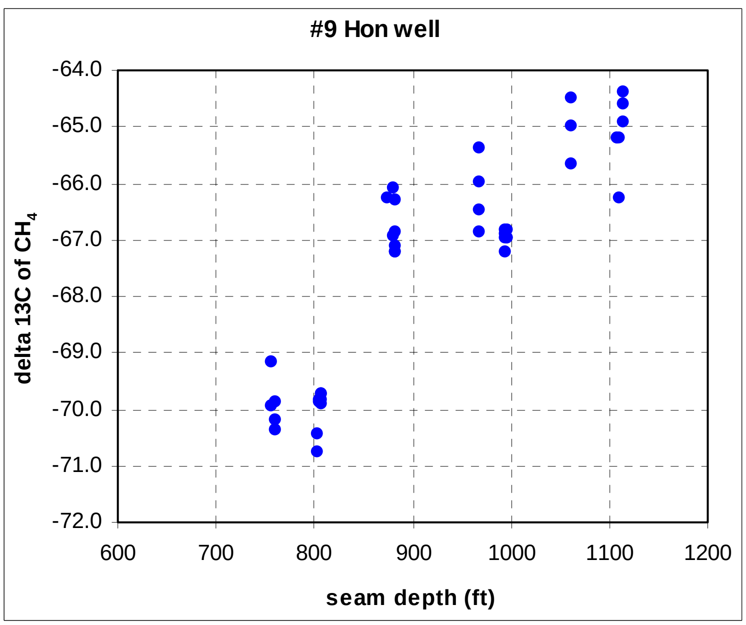

Figure 4. Cross-plot of Carbon 13 isotope values with depth.

Future Work

In the next few months we will receive the results of the isotherm and maceral analyses from the #9 Hon well samples. In May, we will perform pressure transient test measurements to determine the permeability of each coal in the #9 Hon and in two coals in the #3 Hon. These values will be used to design the well stimulation program for the pilot. In June, we anticipate drilling our second test well in the current program in southern White County, an area of the

Illinois Basin where the coal maturity is high. This will be cored through all major coals including two deeper coals not previously analyzed by the Illinois State Geological Survey. The following analyses will be made in this well: gas content, gas chemistry and isotope composition, coal proximate, heating value, equilibrium moisture and sulfur, coal maceral composition, and coal adsorption isotherm determinations.

In the mean time, the #9 Hon will be put on pump for one month to determine its flow characteristics and continuity with the Hon #3. This will be followed with drilling of the other three dewatering wells surrounding the #9 Hon, stimulation of all of these wells, putting them on pump, and monitoring water and gas production.

The final test well in Illinois will be drilled in Jasper County after October 2004. Coals are thick there and found at the deepest levels of the basin, outside of the western Kentucky Rome Trough.

Indiana

In Indiana, project efforts were concentrated on acquiring and systematically processing structural and thickness data for the coal beds that have not been previously examined. For these seams, the croplines as well as maps of the thickness and depth were generated. Coal thickness mapping was done for the following seams: Houchin Creek, Danville, Springfield (Figure 5 and 6), Hymera, and Seelyville. Each map was contoured using the available data. Thickness values smaller than 18 inches were filtered out from the analysis. Mined-out areas were not considered in this initial assessment. A 1 km^2 grid was created for each data set and these grids were added to obtain a cumulative thickness coal map for the area (Figure 7).

In addition, in cooperation with our project partner, Black Beauty Coal Company, coal cores from the Springfield and the Seelyville in Gibson and Sullivan Counties were obtained and have been completely desorbed (Table 5). Adsorption isotherm data has also been obtained for selected coal samples (Table 6).

Table 5 – Desorption data for the Springfield and Seeleyville coal beds from Gibson and Sullivan Counties, Indiana

County	Coal Bed	Sample Depth	Sample Thickness	scf/ton (raw basis)
Gibson	Springfield	596	6.2	81
Gibson	Springfield	628	6.3	76
Gibson	Springfield	326	7.5	46
Gibson	Springfield	241	4.2	42
Gibson	Springfield	364	6.1	61
Gibson	Springfield	232	3	44
Gibson	Springfield	299	6.5	96
Sullivan	Springfield	372	4	94
Sullivan	Springfield	261	5	77
Sullivan	Seelyville	429	3. 4	80
Gibson	Seelyville	508.5	9.9	149
Gibson	Seelyville	462.2	7.6	139
Gibson	Seelyville	449	6.8	100

Using the geothermal data available from the AAPG geothermal Survey of North America, a new interpretation for the geothermal gradient map was produced. Data points that seemed anomalous (too high or too low) were filtered out by examination of nearby data points.

Table 6 – Adsorption isotherm data for selected Indiana coal samples.

Sample	Coal	County	depth (feet)	Adsorption of gases (scf/ton, daf basis)					
				CO2 at 300 psi	CO2 at 400 psi	CH4 at 300 psi	CH4 at 400 psi	CO2/CH4 at 300 psi	CO2/CH4 at 400 psi
Dan C1	Danville	Vigo	surface mine	625	700	170	202	3.7	3.5

Dan A3	Danville	Knox	undergr. mine	715	788	147	175	4.9	4.5
Vic-1	Springfield	Sullivan	373	540	640	195	225	2.8	2.8
Spr Cy	Springfield	Warrick	surface mine	619	727	115	142	5.4	5.1
Wabash	Springfield	Gibson	undergr. mine	680	785	157	188	4.3	4.2
Vic-1	Seelyville	Sullivan	556	521	602	175	215	3.0	2.8
Seel SDH	Seelyville	Posey	901	577	681	102	128	5.7	5.3
33-H8 448.7	Seelyville	Gibson	448.7	684	770	196	234	3.5	3.3
33-H8 452.5	Seelyville	Gibson	475.3	655	740	200	235	3.3	3.1
UB B1	Upper Block	Parke	surface mine	523	561	102	128	5.1	4.4
UB B2	Upper Block	Parke	surface mine	572	624	134	160	4.3	3.9
UB I5	Upper Block	Daviess	234	nd	nd	123	150	nd	nd
LB I5	Lower Block	Daviess	251	nd	nd	127	150	nd	nd

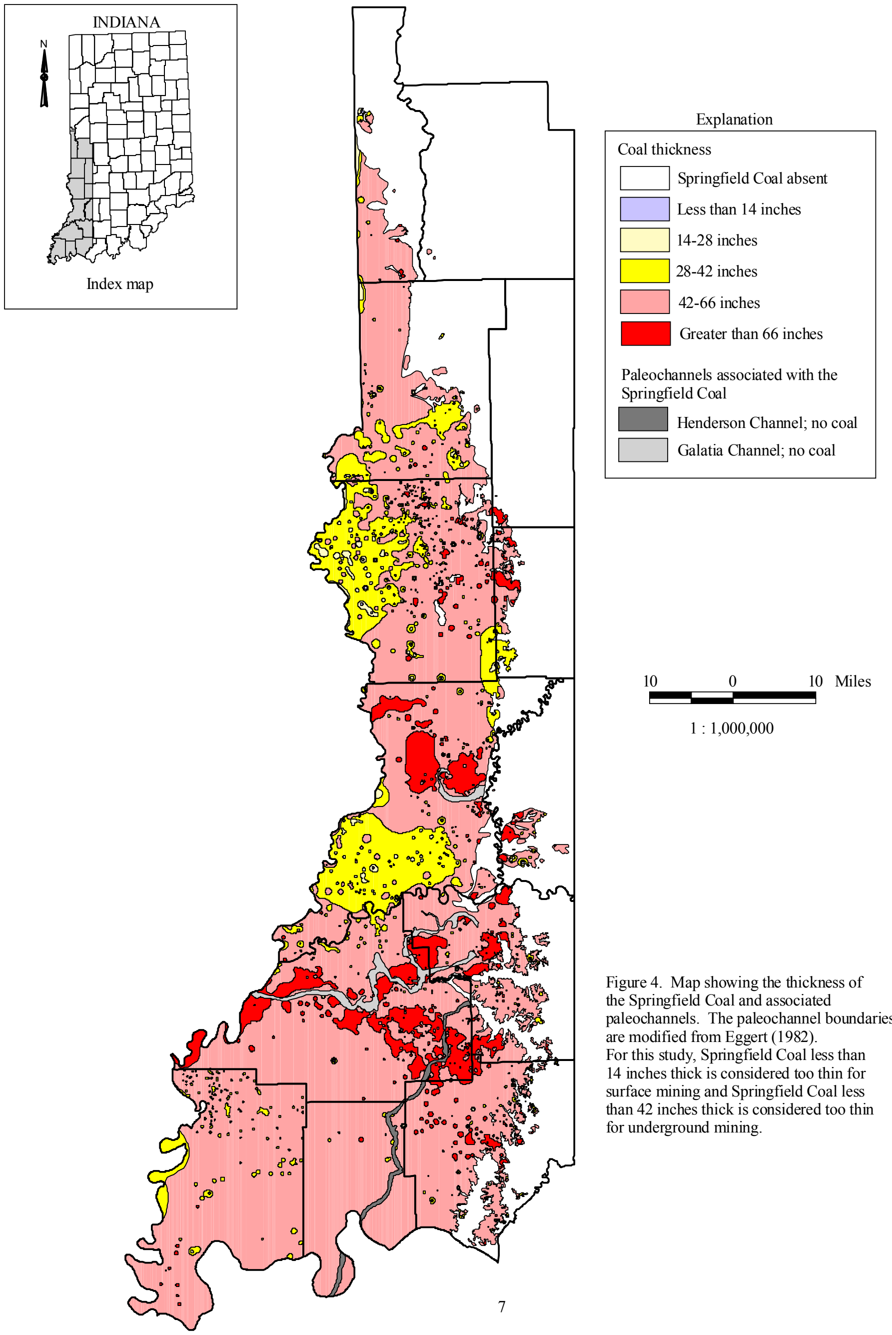

Figure 5 – Thickness of the Springfield coal bed in Indiana.

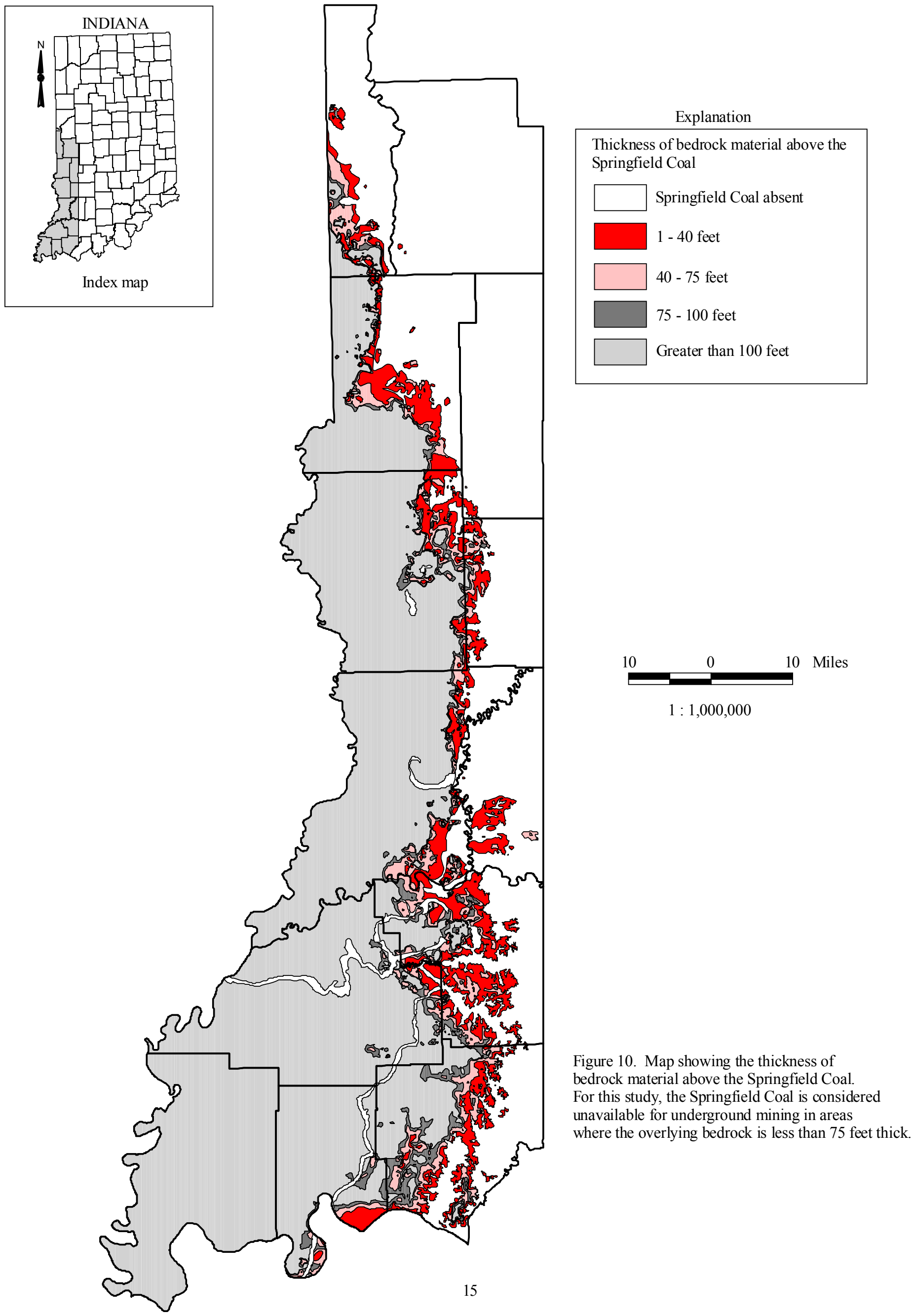

Figure 6 - Overburden thickness on the Springfield coal bed in Indiana.

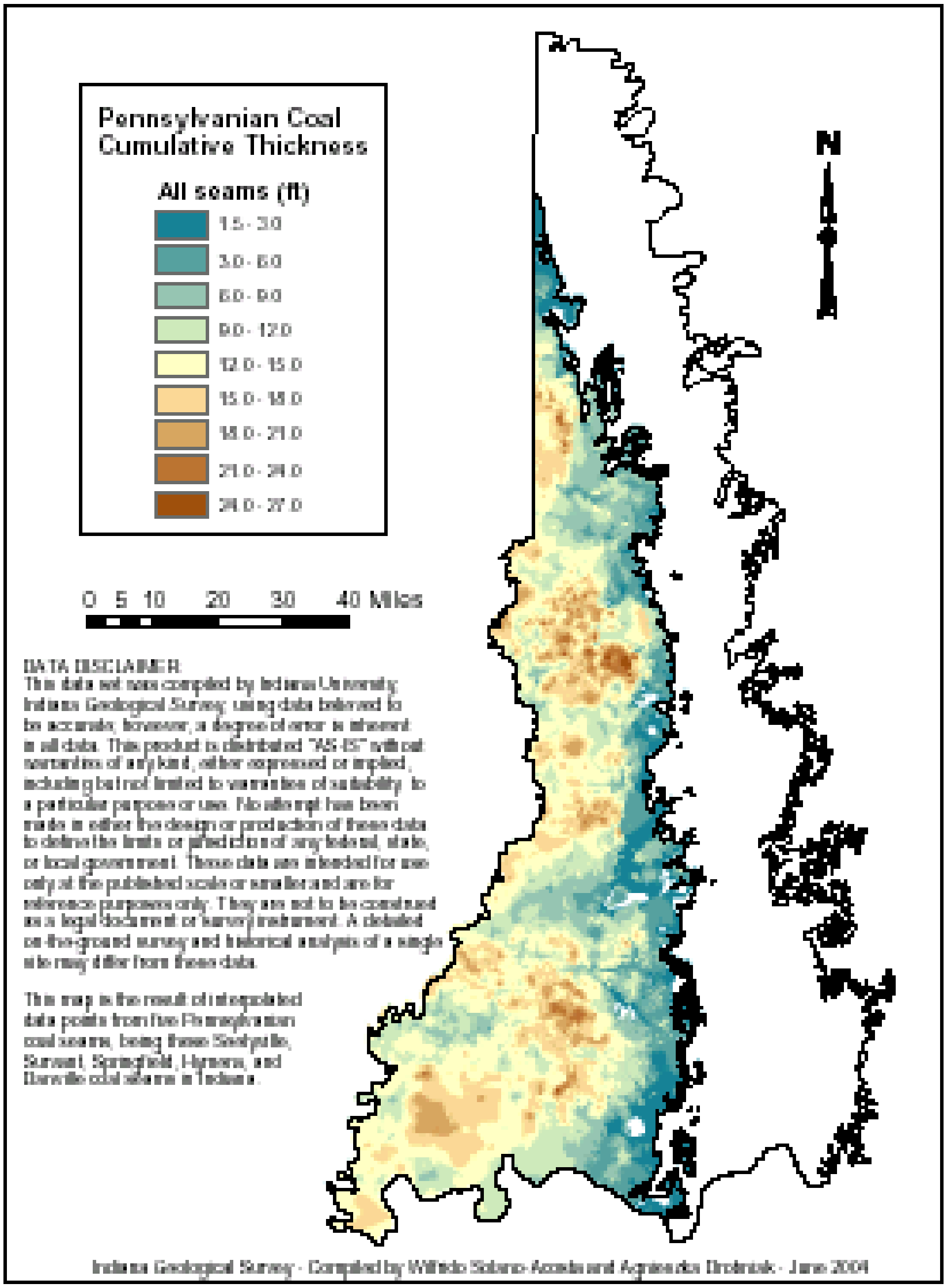

Figure 7 - Cumulative coal thickness (all coal beds) in Indiana.

Kentucky – In Kentucky, efforts have concentrated on developing GIS coverages to identify the most promising areas in the western Kentucky Coal Field for drilling. Using borehole, outcrop and mine data and geophysical records, thickness maps were constructed for the following coal beds: Davis, DeKoven, Springfield, Herrin, Paradise and Baker. An example using the Springfield coal bed is shown in Figure 8. An overburden thickness map was also constructed using the Springfield coal bed as a datum (Figure 9). The Springfield coal was used as it is the thickest and most extensive coal bed in western Kentucky. Digital files that show the mined out areas of the Springfield, Herrin, Paradise and Baker (little, if any, underground mining has occurred in the Davis and DeKoven) were obtained from the Kentucky Department of Mines and Minerals, and assembled into an additional GIS coverage. Another coverage showing the position of known faults in the Western Kentucky Coal Field was assembled using information from geologically-mapped 7½ minute quadrangles (Figure 10).

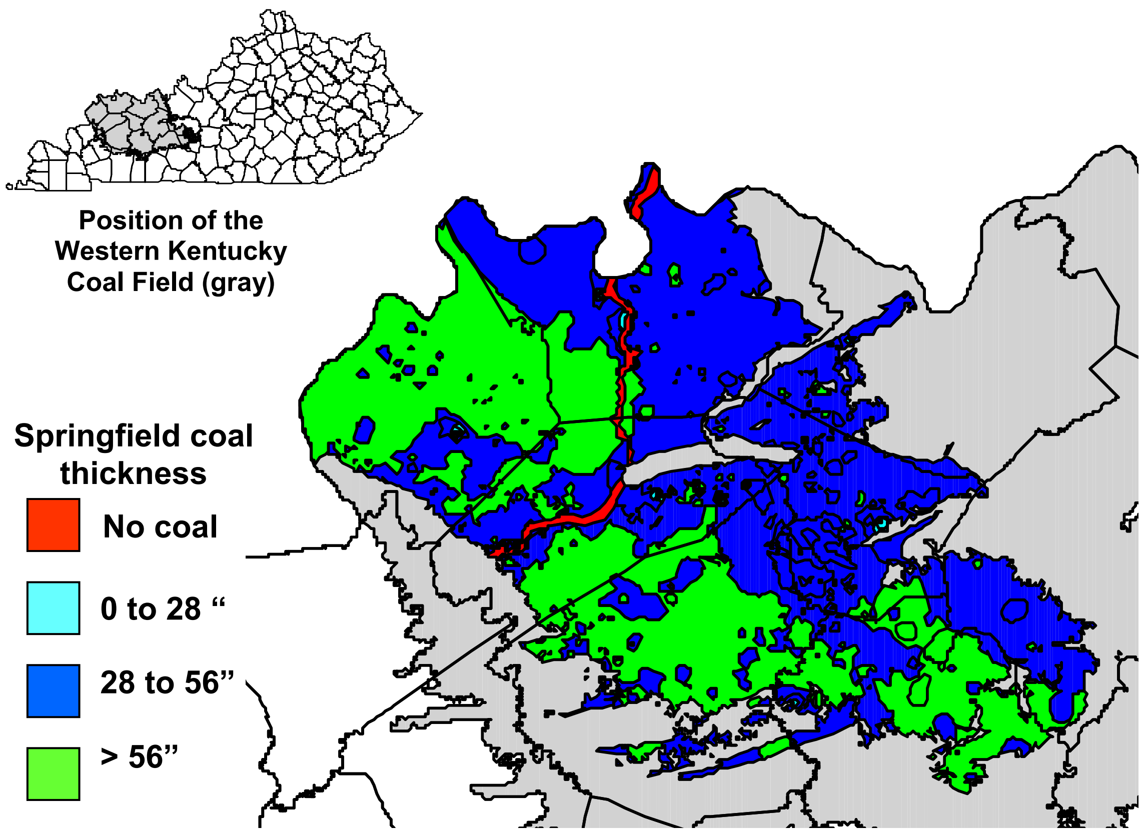

Figure 8 – Thickness of the Springfield coal bed in western Kentucky.

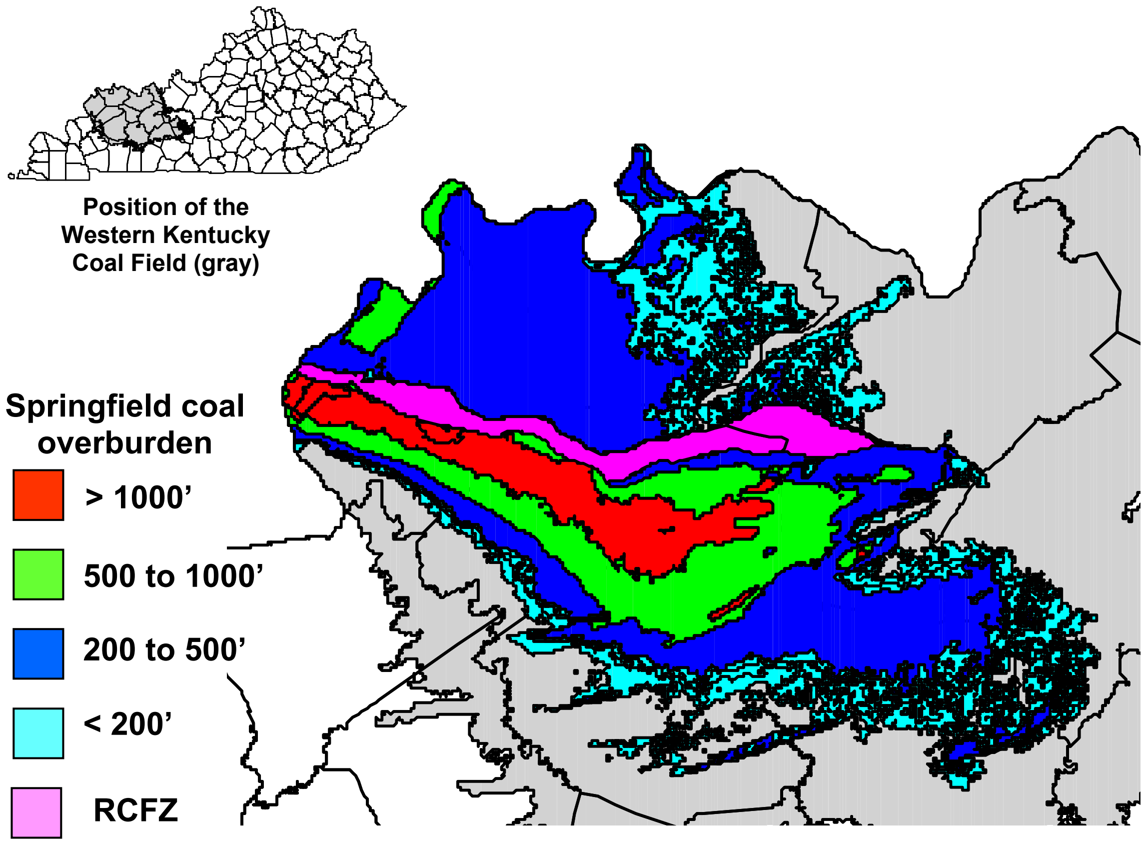

Figure 9 – Overburden thickness on the Springfield coal bed in western Kentucky. The most deeply-buried coal exists south of the Rough Creek Fault Zone (RCFZ).

All of the coverages were then combined to form a derivative map that displays the areas with the greatest cumulative thickness of coal, depth of cover to the Springfield coal, mined out areas, and position of known faults. This map is shown below (Figure 11). Areas of yellow indicate a cumulative coal thickness of more than 15 feet, with the different shades of yellow indicating varying depth of cover. Areas of green indicate cumulative thickness of less than 15 feet, regardless of overburden depth. Areas of purple indicate mined out areas, with different shades representing mining in different coal beds. Using this map as a guide, the site for our year 1 drill hole was selected (Figure 11, drill hole 2). Drilling should commence in late June or early July.

In April, a core of Springfield coal was obtained from a location in Ohio County, which is located on the edge of the coal field (Figure 11, drill hole 1). The coal at this location is 45 inches thick, and has minimal overburden (135 ft). Desorption data are still being collected, as are gas species and isotope data. One early isotope analysis has indicated a dominant biogenic origin for the gas.

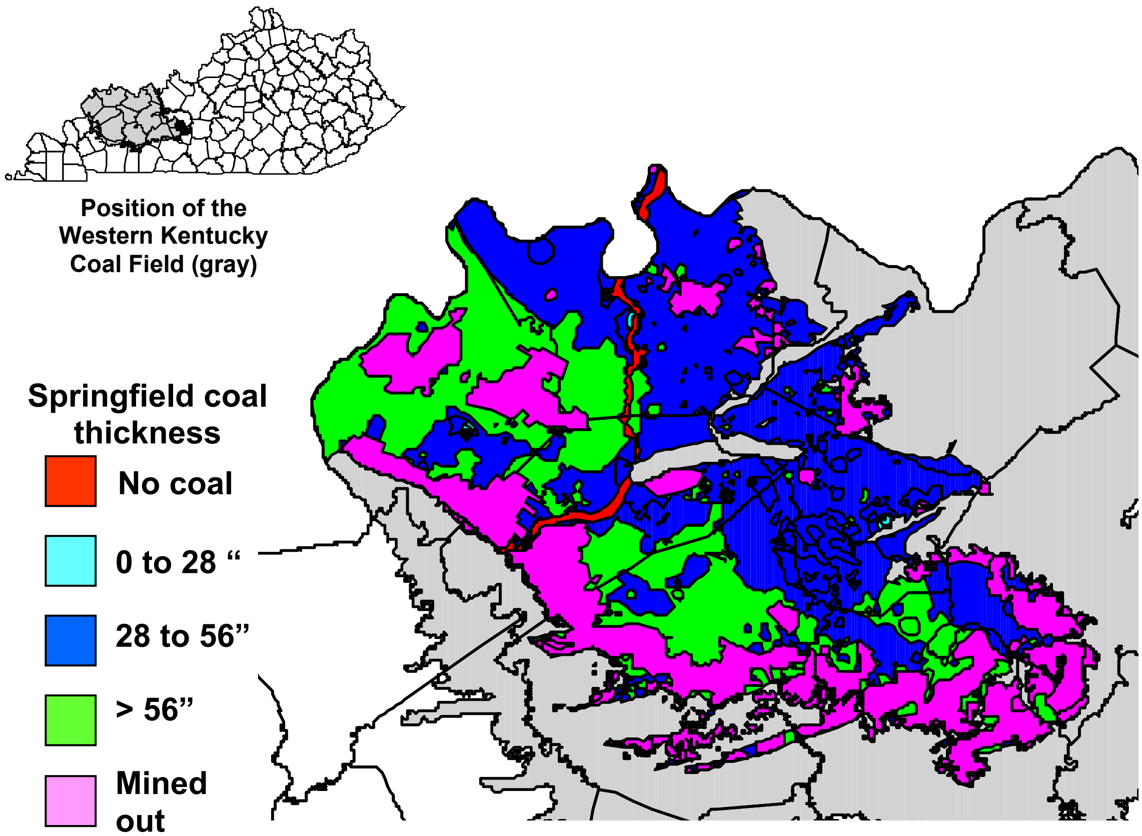

Figure 10 – Mined out areas of the Springfield coal bed in western Kentucky.

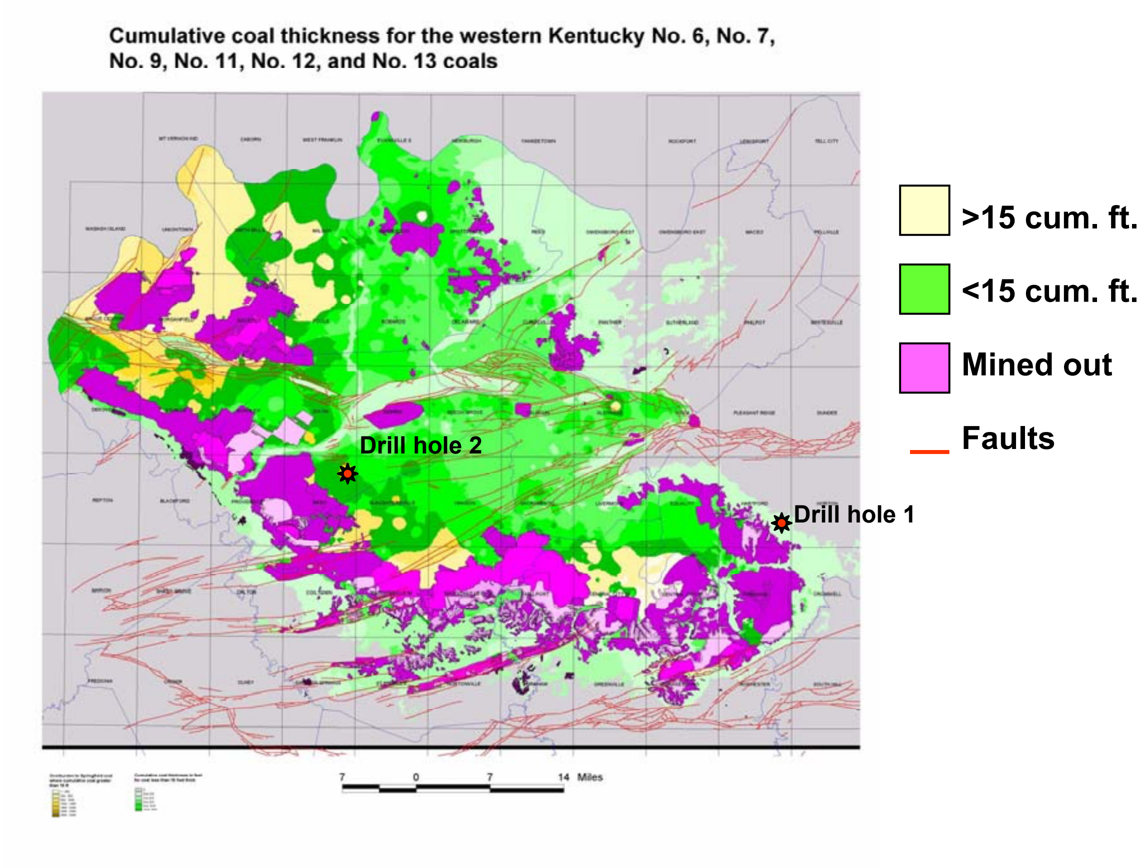

Figure 11 – Derivative map for the Western Kentucky Coal Field showing cumulative coal thickness of the Davis (WKY # 6) through Baker (WKY # 13) coal interval, mined out areas, and position of known faults.

CONCLUSION

A geologic assessment of the Illinois Basin has resulted in the generation of individual coal thickness, cumulative coal thickness, and coal overburden maps. Critical analysis of these maps has allowed for the identification of the most promising areas that may yield economic coal bed methane. Drill sites have been established, and one core hole in Illinois has already been drilled. Drill holes in Indiana and Kentucky are expected to begin shortly.

Desorption data from the Illinois core hole indicate gas contents that range from 83.3 scf/ton to 188.7 scf/ton on a dry, mineral matter free basis for the Danville to Davis coal interval. Lost gas values typically are low, reflecting slow desorption rates. Black shale roof rock samples that were analyzed contained moderate gas contents (65.7 to 112.2 scf/ton, as-received basis), and will likely contribute to the overall gas resource. Gas analysis shows a dominance of methane in most of the samples (typically > 60%), the origin of which is primarily biogenic.

Similar desorption data from donated core samples of the Springfield and Seeleyville coal beds in Indiana show desorption rates that range from 42 to 94 scf/ton for the Springfield coal, and 80 to 149 scf/ton for the Seeleyville coal (both ranges on an as-received basis). Adsorption isotherm data show the methane holding capacity of selected coal samples to range from 102 to 235 scf/ton (average 150 scf/ton). The CO_2 holding capacity for these samples is much higher, ranging from 521 to 788 scf/ton.

The effects of well completion techniques on produced gas content will help us better understand what is needed to produce economic CBM in the Illinois Basin. Pressure transient test measurements to determine the permeability of coals from the Illinois core samples will be performed soon, and subsequently used to design a well stimulation program for a pilot production test well. Additional data from the forthcoming Indiana and Kentucky drilling programs will also provide us with a better understanding of the range of gas contents in the Illinois Basin.