

Amos and Foster Coals: Low-Ash and Low-Sulfur Coals of Western Kentucky

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KENTUCKY GEOLOGICAL SURVEY

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COVER PHOTO

The screened photograph on the cover is a view of the Okefenokee Swamp in southeastern Georgia. The study of peat formation in modern swamp environments such as the Okefenokee Swamp, where peat accumulations reach a thickness of more than 10 feet, provides insight into the origin of ancient coal deposits.

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***The Amos coal has the highest
quality of any coal analyzed in
western Kentucky.***

AMOS AND FOSTER COALS: LOW-ASH AND LOW-SULFUR COALS OF WESTERN KENTUCKY

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ABSTRACT

The Amos and overlying Foster are low- to medium-sulfur coal beds of Atokan age (Middle Pennsylvanian) that crop out in Butler County, Kentucky. The Amos coal bed averages 3.9 percent ash and 1.2 percent sulfur (dry basis). It is the more consistent of the two coals in both quality and thickness. Both beds were formed in protected-swamp environments with very low to moderate detrital influences; the Amos coal seems to have been affected by detritus only late in its development. The low sulfur content of the Amos coal bed is attributed to the accumulation of peat under predominantly fresh-water conditions.

The Foster coal bed averages 7.7 percent ash and 2.7 percent sulfur (dry basis). The higher ash content of the Foster coal bed is attributed to detrital influx during peat accumulation. The higher and more variable sulfur content of the Foster is attributed to sulfate-bearing waters that invaded parts of the Foster swamp.

Petrographic analyses show the Amos and Foster coals to have high vitrinite content and extremely low fusinite/semifusinite content. The miospore *Lycospora pusilla* dominated all samples examined in this study. *Punctatosporites minutus* was secondary in importance, and the abundance of this form was roughly inverse to the abundance of *Lycospora pusilla*, possibly reflecting differences in the "wetness" of the peat-forming environments. Interpretation of the age of the Amos and Foster coal beds is based on comparisons of ranges of miospores from Illinois, Great Britain, and Western Europe. The miospores of the Amos and Foster coal beds indicate that these beds correlate with coal beds of the Abbott Formation of Illinois.

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INTRODUCTION

The coal beds of the Western Kentucky Coal Field are important energy sources for generating electrical power in the midwestern and southeastern United States. The coal field contains thick, continuous beds that are readily accessible to both surface and underground mining. Coal beds of this region typically average greater than 3 percent sulfur, and as such are considered to be high-sulfur coal. The enactment of more stringent air-quality standards for electrical-power-generating stations has caused a shift away from the use of western Kentucky coal to other Appalachian and western United States coals that are lower in sulfur. This shift has caused economic hardship in the mining industry of western Kentucky, and has also increased the price of electrical power produced in this region because of increased coal-transportation costs. For these reasons it is important to identify and evaluate any low-sulfur coal beds in the Western Kentucky Coal Field to determine if they can be developed economically.

The Amos coal bed, and in some areas the Foster coal bed, are unusually low in ash and sulfur compared to most other coal beds in the Western Kentucky Coal Field. The Amos and Foster coal beds crop out in Butler County, Kentucky, in the Riverside, Welch Creek, Reedyville, Flener, and probably the Ready and Spring Lick 7.5-minute quadrangles (Fig. 1). In addition, the Foster coal has been identified in the South Hill Quadrangle at two localities.

It is the purpose of this study to characterize the stratigraphy, environments of deposition, and coal constituents of the Amos and Foster coal beds, and to determine the relationships of coal quality to the general geology of the coals. By understanding the geological factors that influenced lower sulfur coals in western Kentucky, it is hoped that coal deposits of similar quality will be discovered and developed.

Previous Workers

Crider (1915) published the first comprehensive geologic study of the area that included the Amos and Foster coal beds. He named the Amos and Foster coal beds, by adopting the names of the mines in which the coals were being worked.

Mullins and others (1963) made reserve estimates for the Amos and Foster coal beds. They considered the Gidcomb and Amos to be the same coal bed. Mullins and others (1963) reported 26,790,000 tons of coal in place for the Foster, and 10,602,000 tons of coal for the Amos-Gidcomb.

The Foster coal bed was tentatively identified by Shawe (1966) on the Reedyville 7.5-minute geologic quadrangle map. In the geologic column, he identified the uppermost unnamed coal bed as the Foster, but mapped it as an unnamed bed. Shawe (1968) identified and mapped the Amos and Foster coal beds in the Riverside Quadrangle. Gildersleeve (1972) mapped the Foster coal bed in the Flener Quadrangle. Moore (1974) identified the Foster coal bed at two localities in the South Hill Quadrangle. Gildersleeve (1976) mapped the Amos and Foster coal beds in the Welch Creek Quadrangle. Smith and Brant (1980) published resource estimates and outcrop maps for the Amos and Foster coal beds, estimating 23,206,000 tons of remaining coal resources.

Methods

During the present study, 102 outcrop and mine sections were described, and additional information was obtained from 250 drillhole descriptions. From these data, isopach maps were prepared for the sandstones and coal beds that occur within the study area. Cross sections were prepared and used for correlations and to determine facies relationships. The 53 coal samples collected during this study were analyzed to determine their chemical, mineralogical, petrographic, and palynologic properties.

The petrographic investigations were done with Leitz microscopes equipped for quantitative reflectance measurements. Geochemistry (X-ray fluorescence) was carried out using fused-glass pellets on a Phillips AXS system. Mineralogical investigations (X-ray diffraction) of the low-temperature ash (LTA) were performed using a Phillips XRD unit.

Splits of the coal samples were analyzed for palynologic constituents (miospores). Standard investigative procedures were used, and results are reported by range of abundance using the methods of Smith and Butterworth (1967). Miospore identifications are generally based on the taxonomic descriptions provided by Smith and Butterworth (1967).

Stratigraphy

The Amos and Foster coal beds are part of the Middle Pennsylvanian Tradewater Formation of western Kentucky (Fig. 2). The oldest named coal bed in the Tradewater Formation in the study area is the Gidcomb coal, which occurs approximately 380 feet above the Caseyville Formation. The Amos coal bed is 20 to 50 feet above the Gidcomb coal bed. The Foster coal bed is 15 feet above the Amos coal where the intervening strata between the coals is shale. Where the intervening strata

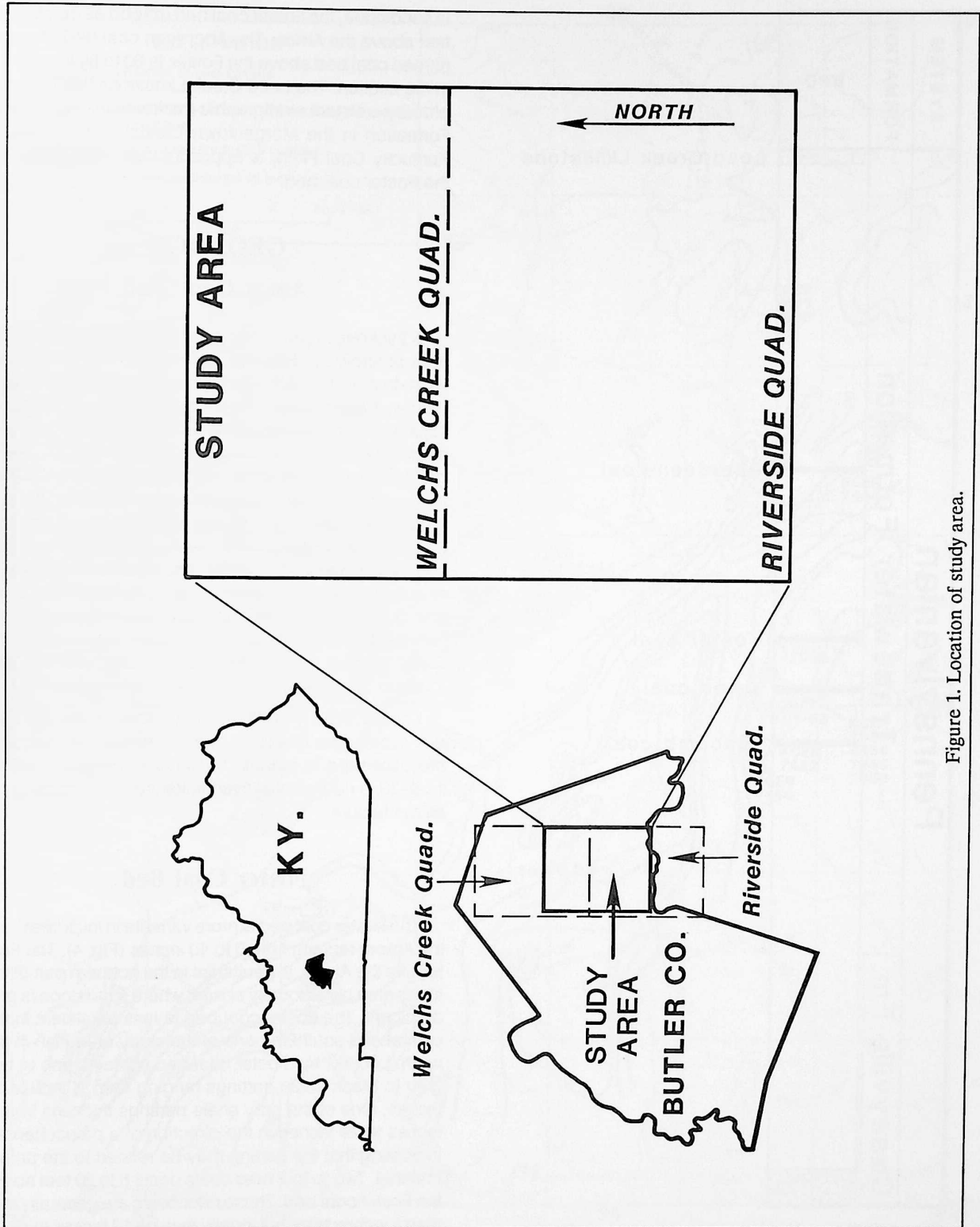


Figure 1. Location of study area.

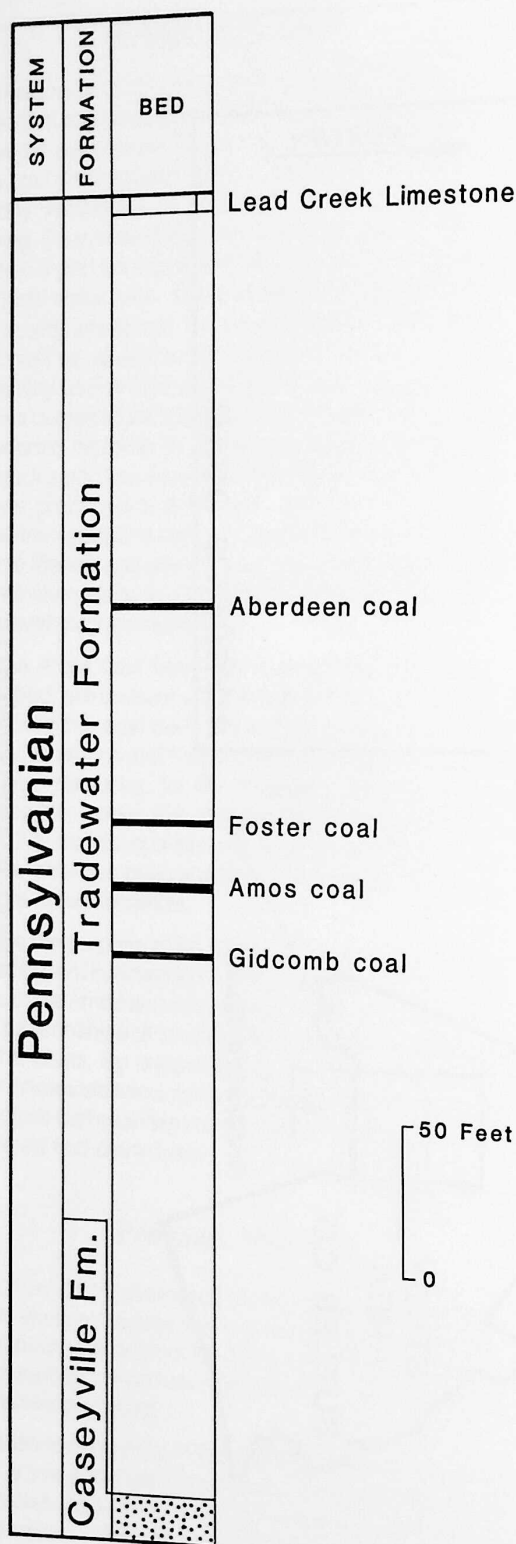


Figure 2. Generalized stratigraphic section showing position of the Amos and Foster coal beds.

is sandstone, the Foster coal bed may be as much as 40 feet above the Amos. The Aberdeen coal bed, the next named coal bed above the Foster, is 60 to 80 feet higher in the section. The Lead Creek Limestone, which is the oldest persistent stratigraphic marker in the Tradewater Formation in the Morgantown District of the Western Kentucky Coal Field, is approximately 200 feet above the Foster coal bed.

GEOLOGY

Amos Coal Bed

A thickness map of the Amos coal bed in the study area is shown in Figure 3. The coal occurs as southwest-trending lobate deposits separated by sinuous, narrow, barren areas. The Amos coal bed ranges in thickness from 0 to 30 inches, but averages about 14 inches. The thicker deposits of the Amos coal, those greater than 20 inches, are limited to lenses within the lobes. The coal bed is generally present within the central and northern parts of the study area, but locally has been removed by paleochannel erosion. The Amos coal normally contains no partings, although in Carter coordinate sections 9-I-36 and 5-I-36, a black-shale parting from 0.2 to 0.13 foot thick was measured. The Amos coal is most commonly absent in the south-central part of the study area. In the southern area, a seat rock is often found at the Amos horizon, but no coal is present.

Locally, from 5 to 20 feet above the Amos coal are one or two rider coals not more than 8 inches thick that are cannelloid in places. In Carter coordinate section 15-I-36, a rider coal is overthickened by a small paleo-slump feature.

Foster Coal Bed

The Foster coal bed is more variable in thickness than the Amos, ranging from 0 to 40 inches (Fig. 4). The Foster, like the Amos, is persistent in the northern part of the study area but is locally absent where sandstone is predominant. The Foster coal bed is less persistent in the central and southern parts of the study area than in the north. Locally, the Foster coal bed contains one or two gray to black shale partings ranging from $\frac{1}{4}$ inch to 24 inches. One of the gray shale partings thickens from 2 inches to 24 inches in the direction of a paleochannel, indicating that the parting may be related to the paleochannel. Two to four rider coals occur 5 to 20 feet above the Foster coal bed. These rider coals are generally less than 6 inches thick but locally may be 12 inches thick. At some localities the rider coals are cannelloid.

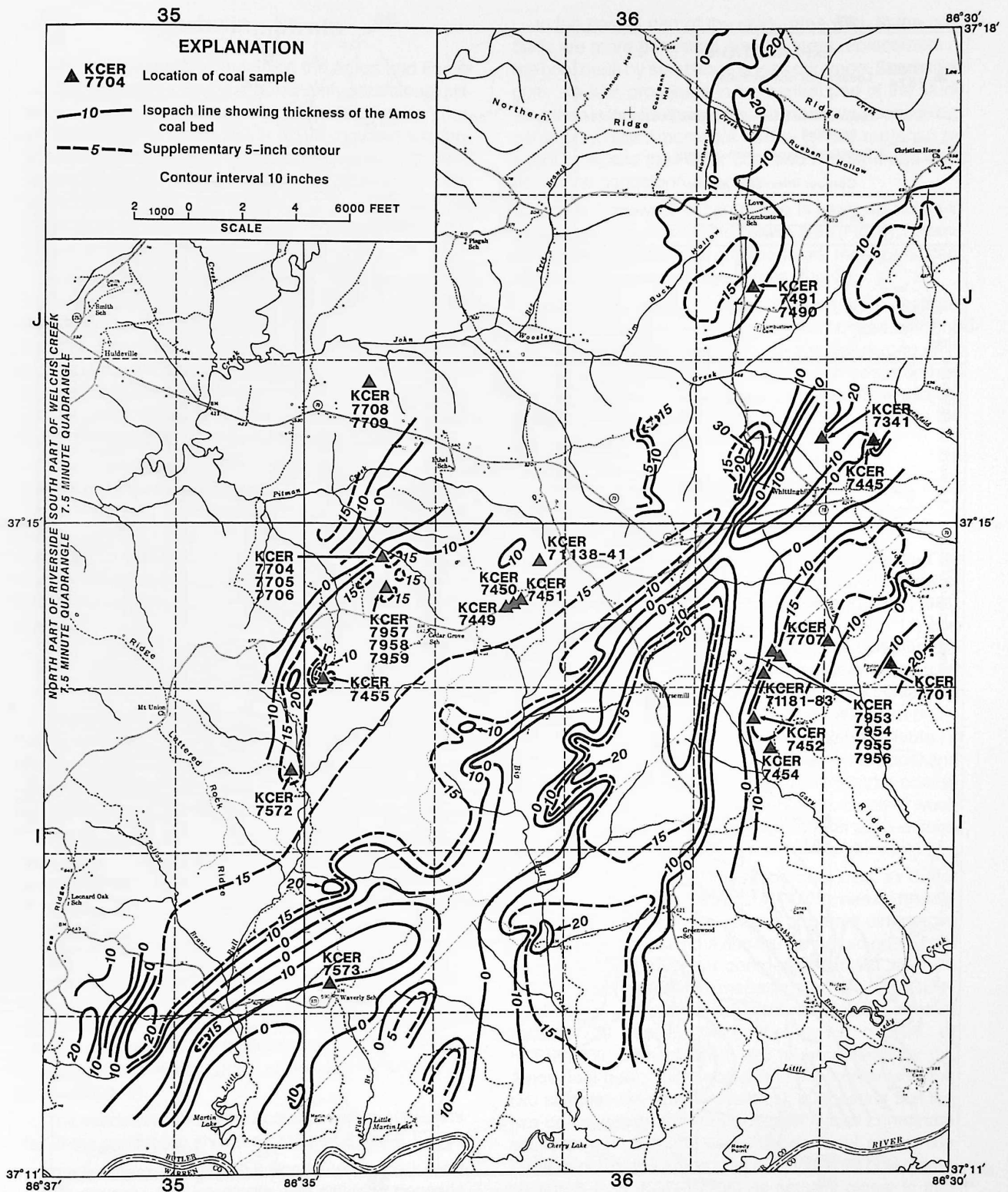


Figure 3. Isopach map of the Amos coal bed.

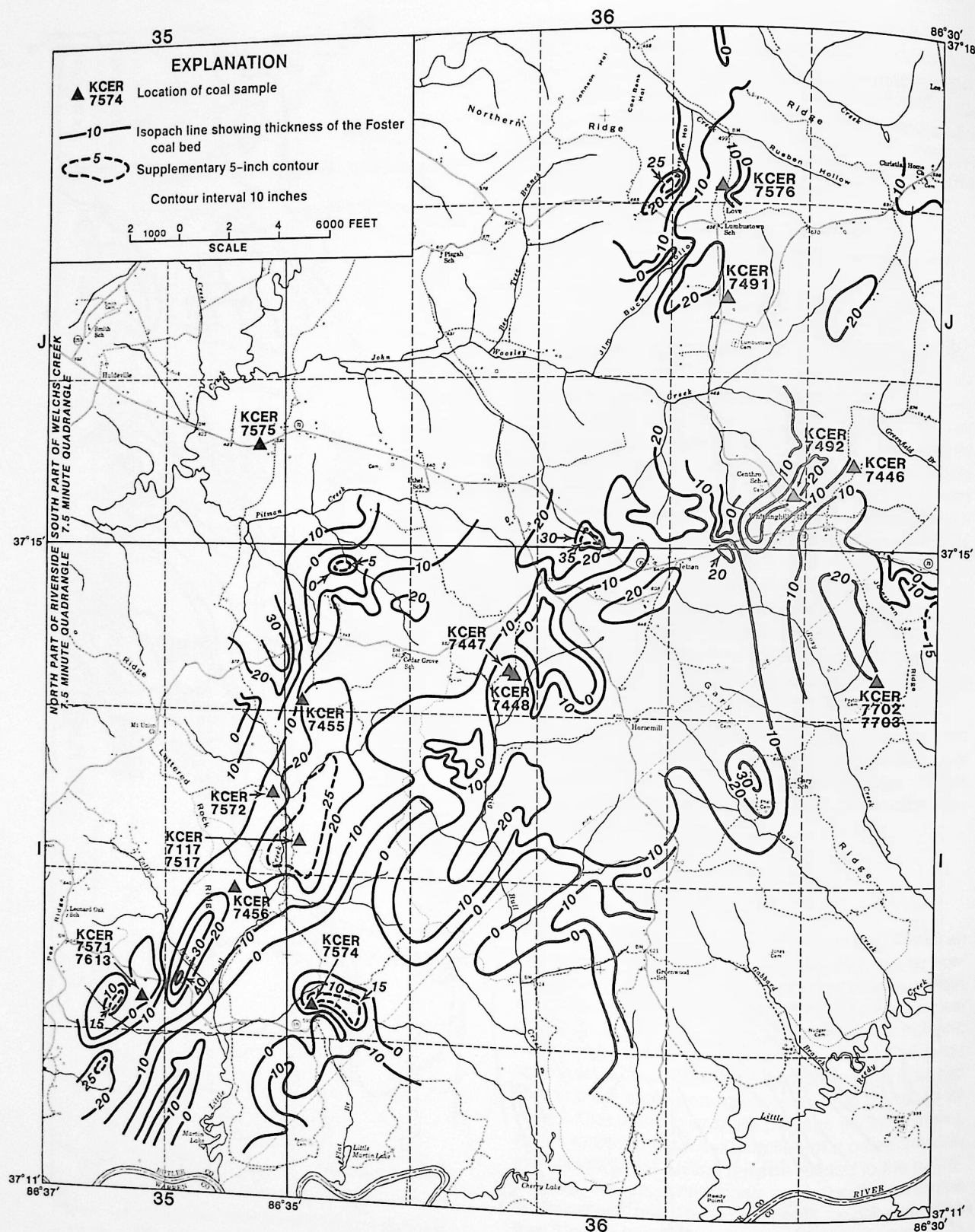


Figure 4. Isopach map of the Foster coal bed.

Enclosing Strata

The rock sequence containing the Amos and Foster coals in the study area is predominantly sandstone, siltstone, and shale, with minor amounts of claystone, coal, and black shale. Figures 5 through 7 show the relationship of these lithologies in the study area. Although limestone was reported in some drillers' logs, it was not observed at outcrops or in mines. The majority of rock sequences above each coal coarsened upward from claystones or shales to sandstones.

The sandstone units are generally light gray and fine to medium grained, although coarse-grained beds with lag conglomerate occur locally. The gross lithologic sequence above each coal generally coarsens upward, but many of the sandstone units are massive to thick bedded, and grade upward to become thin bedded with low-angle crossbedding and flaser bedding, and have sharp basal contacts, suggesting channel deposition.

The siltstones are light to medium gray and thin bedded. The shales are medium to dark gray, silty, lenticular bedded, and contain siderite nodules. Black shales, when present, usually occur above the coal beds, but locally occur as discrete beds. Most of the claystone occurs as seat rock beneath the coal beds, but lenticular deposits of claystone without coal are also present.

Geometry of the Sandstones

Sandstone is not the predominant lithology in the study area, but it is important for interpreting the depositional environments of the coals. The sandstone deposits are chiefly lenticular in cross section (see Figs. 5-7), with sharp erosional bases.

The sandstone deposits beneath the Amos coal are elongated pods oriented in southwest-northeast sub-parallel trends (Fig. 8). The elongate pods are 500 to 750 feet wide, and can be traced for several thousand feet where data permit. The longer trends are somewhat sinuous and bifurcating.

The sandstone deposits between the Amos and Foster coals are also lenticular in cross section, with a maximum width of several thousand feet and a maximum thickness of 90 feet. The thick sandstone deposits trend northeast-southwest, and apparently bifurcate in places (Fig. 9).

The sandstone above the Foster coal (Fig. 10) is similar to the sandstone shown on Figures 8 and 9.

The southern area (Fig. 5) is dominated by thick sandstone deposits that interfinger with siltstone deposits. The coal beds are thin and truncated.

In the central part of the study area (Fig. 6) the coal beds are more persistent and the local replacement of the coal beds by sandstone is less common. Sandstone units are less prominent in the central part of the study area than in the southern area. Siltstone also occurs less commonly. The Amos coal bed is locally replaced by sandstone, and the Foster coal bed overlaps and thins above the sandstone deposits.

Figure 7 shows that sandstone is more abundant in the northern area than in the central area (Fig. 6); however, the Amos and Foster coal beds are more persistent than they are in the southern area (Fig. 5).

The cross sections also illustrate thin, wedge-shaped sandstone units that are associated with the thick sandstone deposits. The thinner sandstone units are connected to the thicker sandstone deposits and extend laterally into the surrounding shales. These thin deposits are flat bottomed in cross section, whereas the thick deposits are more V-shaped.

PETROGRAPHY

Amos Coal Bed

The total vitrinite content of the Amos coal bed resembles that of other high-vitrinite coal beds typical of western Kentucky (Table 1); see Hower and Wild (1981, 1982) for summaries of the Herrin (W. Ky. No. 11) and Springfield (W. Ky. No. 9) coal beds. Total vitrinite decreases slightly to the southeast, but otherwise the total vitrinite content is uniform. The very small percentage of fusinite plus semi-fusinite in the Amos coal bed is unusual, even for an extremely high-vitrinite coal (Table 1); a 2.8-cm fusain (KCER-71140) separates the upper and lower benches of the Amos coal bed in Carter coordinate section 4-I-36. At the present time, no other western Kentucky coal bed is known to exhibit such uniform maceral composition.

The upper bench of the Amos coal bed, in Carter coordinate section 5-I-36 (KCER-7705), has no fusinite or semifusinite. The most readily apparent differences between the latter sample and the canneloid rider of the Amos coal bed in Carter coordinate section 25-J-36 (KCER-7709) are in the megascopic texture (KCER-7705 being a banded coal) and in the sulfur content (KCER-7709 having twice the sulfur content of KCER-7705, both of which are high contents for the Amos coal bed). The maceral and ash contents of the two samples are virtually identical, suggesting that the two coals, which are from adjacent Carter coordinate sections, represent the same depositional event. The lower bench of the Amos coal bed, in Carter coordinate section 5-I-36 (KCER-7706), is actually closer in ash and sulfur percentages to other Amos coal bed samples

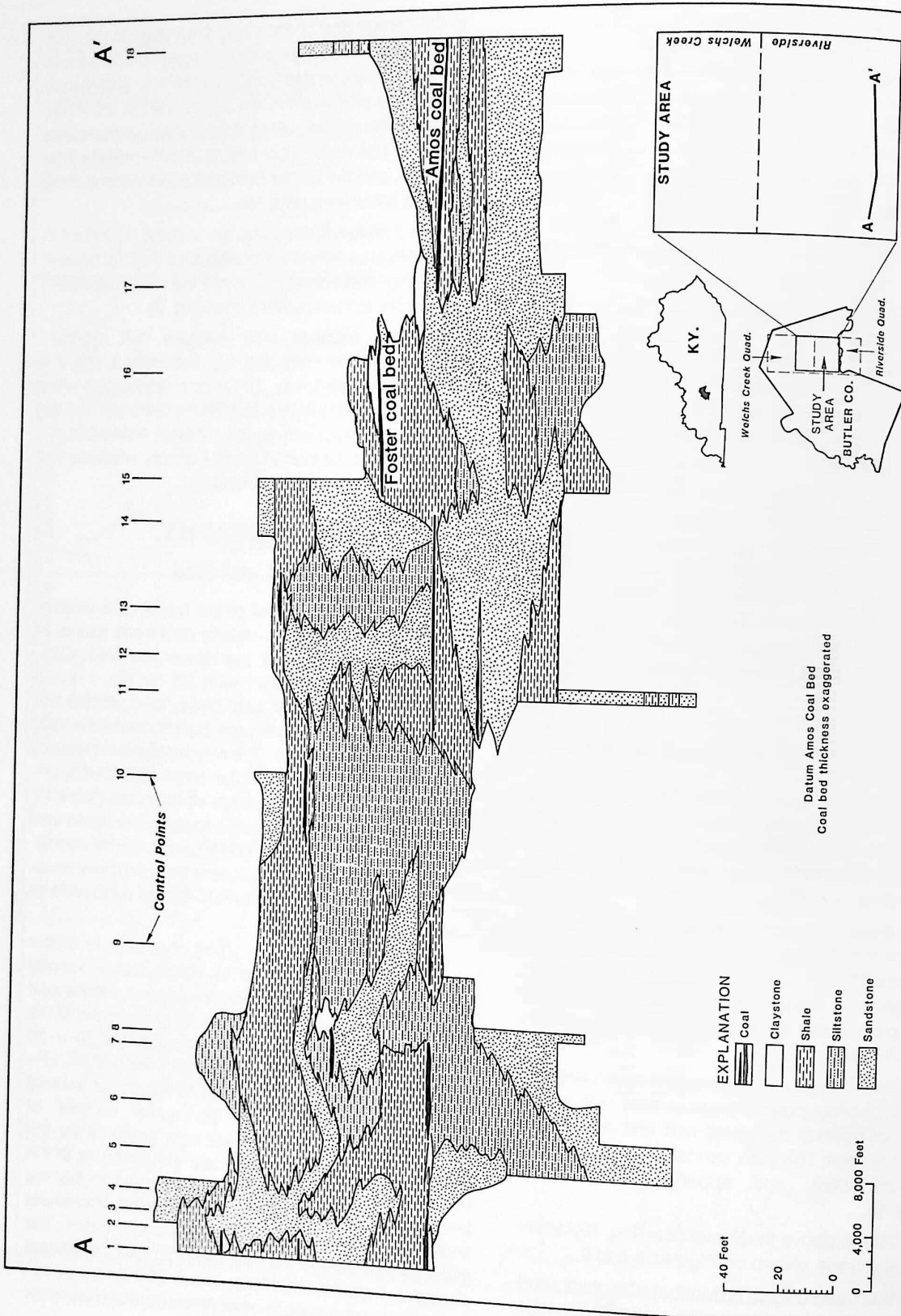


Figure 5. East-west cross section across the southern part of the study area.

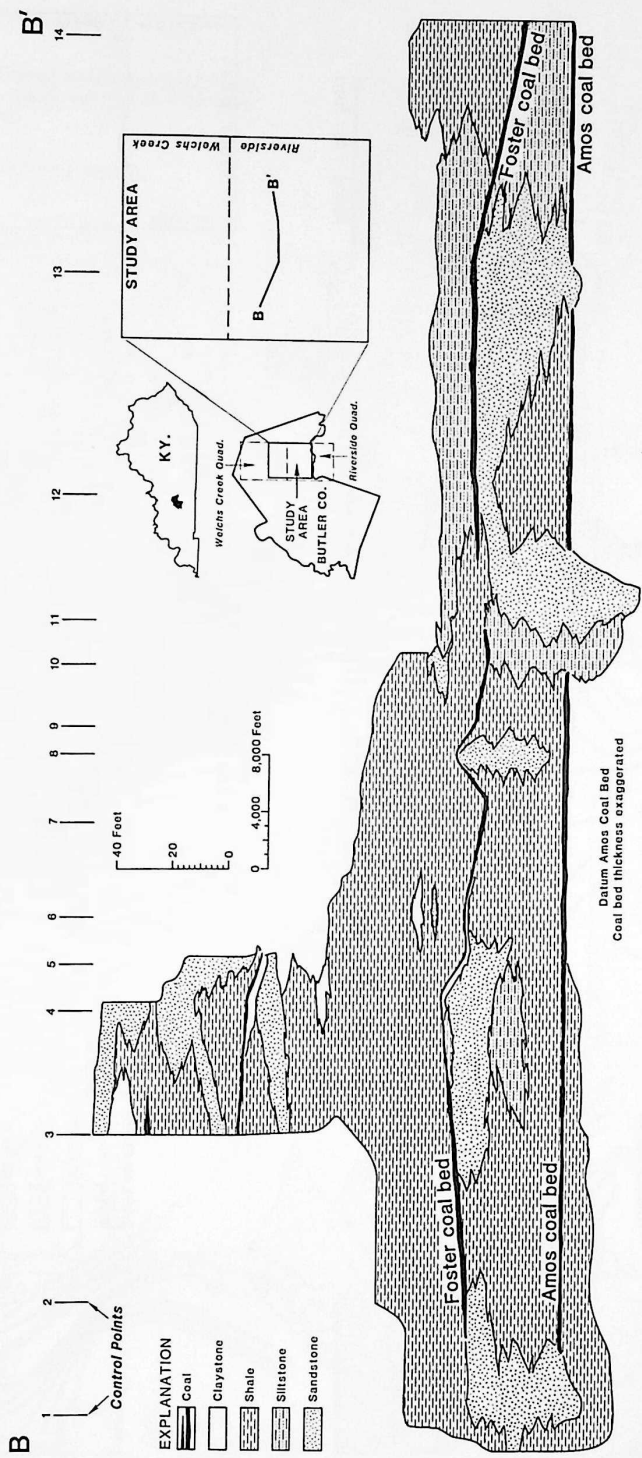


Figure 6. East-west cross section across the central part of the study area.

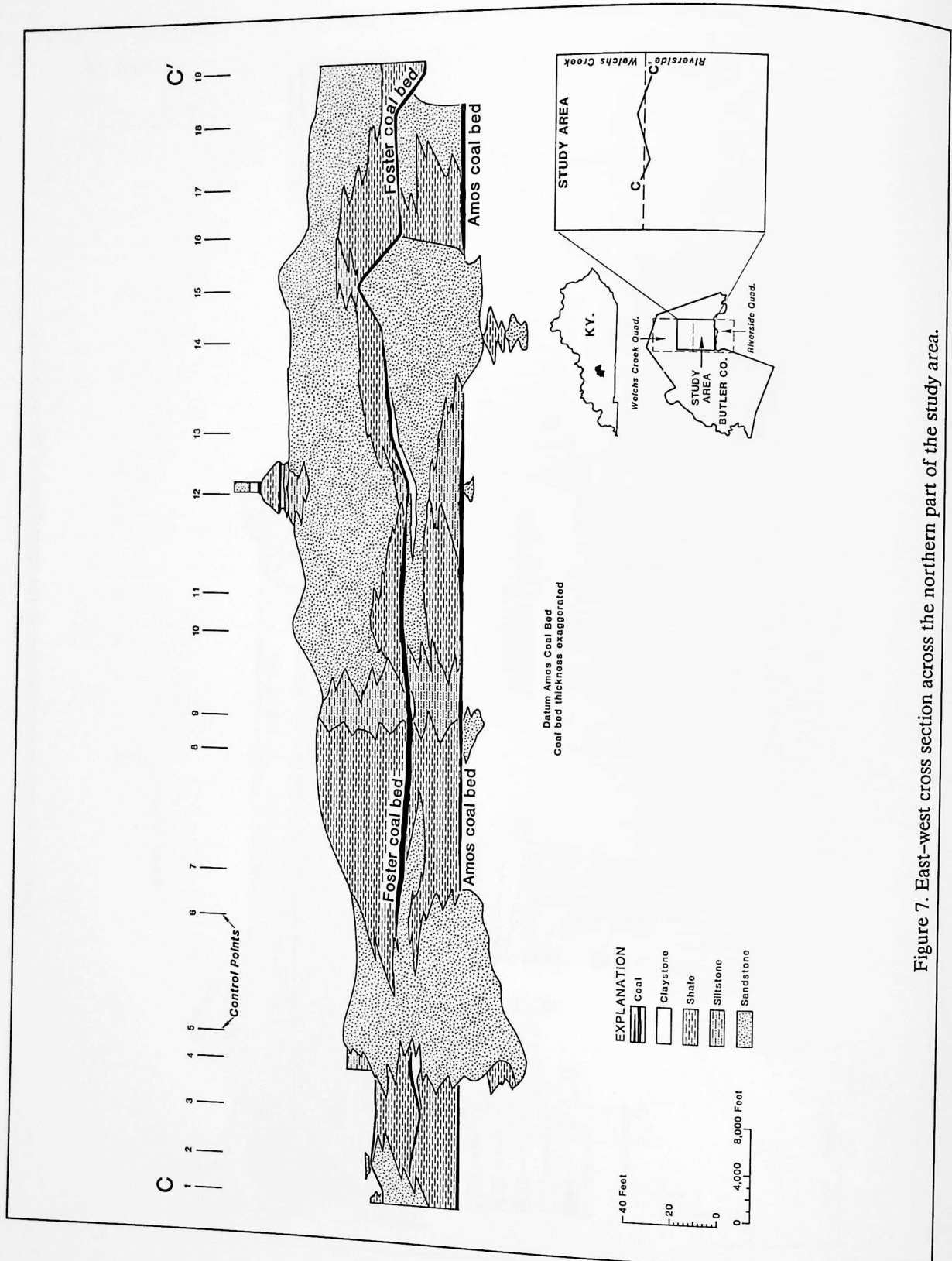
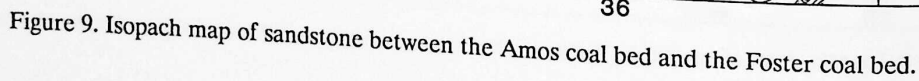


Figure 7. East-west cross section across the northern part of the study area.



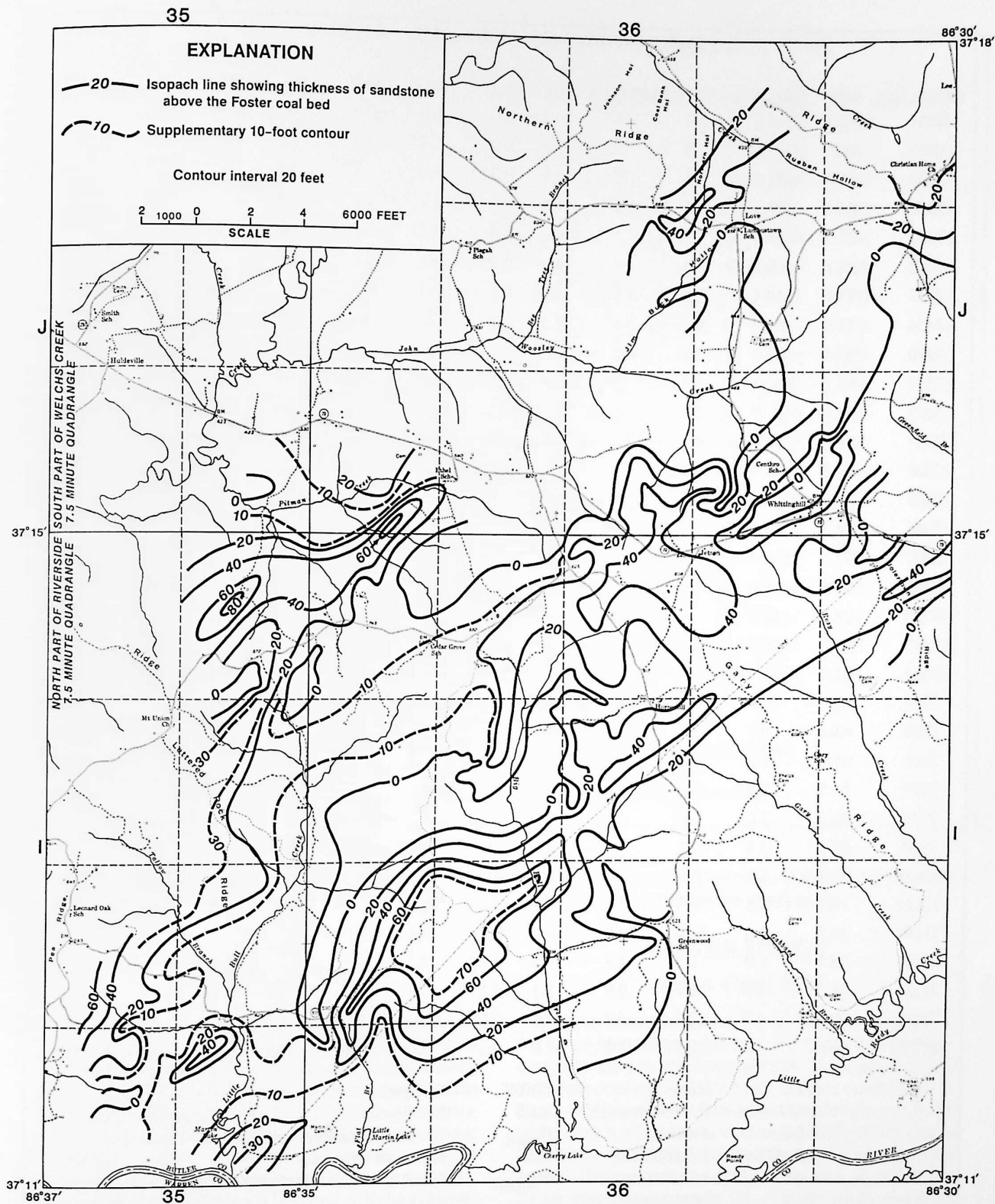


Figure 10. Isopach map of sandstone above the Foster coal bed.

Table 1.—Petrographic Analysis of the Amos Coal.

KCER NO.	VIT	PSU-VIT	FUS	SEMFUS	MIC	MAC	EXIN	RES	R _{max}	SD	R _{mean}	SD
7341	83.3	4.3	1.6	.5	3.7	0.0	6.6	0.0	.66	.033	.61	.071
7445	75.0	11.6	.5	.5	5.0	0.0	5.7	1.7	.57	.026	.53	.043
7449	74.0	13.5	.2	1.2	4.4	0.0	6.0	.7	.68	.043	.64	.051
7450	80.1	8.1	1.1	1.1	4.3	0.0	4.1	1.2	.68	.043	.64	.051
7451	77.5	8.0	.7	.3	4.8	0.0	7.2	1.5	.61	.033	.55	.053
7452	81.2	6.5	.3	.8	4.0	0.0	5.6	1.6	.56	.035	.51	.041
7453	73.1	10.1	2.2	1.8	6.1	0.0	5.1	1.6	.74	.036	.68	.057
7454	72.6	4.8	9.6	3.6	3.5	.2	4.6	1.1	.62	.043	.56	.058
7490	63.4	12.9	5.6	4.7	4.7	.2	6.0	2.5	.53	.028	.49	.038
7572	85.7	.4	.7	.3	6.8	0.0	4.8	1.3	.71	.041	.68	.051
7573	78.0	.7	2.1	.6	8.6	.1	9.7	.2	.56	.029	.52	.038
7701	74.2	6.7	4.7	3.1	3.6	0.0	7.9	.8	.67	.025	.64	.036
7704	81.5	3.9	1.2	1.7	2.7	0.0	8.0	1.0	.65	.026	.61	.038
7705	79.6	7.6	0.0	0.0	1.4	0.0	8.8	2.6	.63	.037	.61	.038
7706	84.7	3.4	1.1	1.2	2.9	.1	5.4	1.2	.65	.030	.60	.046
7707	77.5	6.4	2.5	1.6	3.7	0.0	7.6	1.6	.70	.036	.67	.040
7708	81.8	6.9	.4	.7	2.8	0.0	6.5	.9	.67	.031	.64	.040
7709	78.1	12.2	.1	0.0	.6	0.0	8.3	.7	.59	.029	.56	.036
7745	71.3	6.6	2.6	4.3	6.5	0.3	6.6	1.8	.51	.028	.50	.027
7953	81.7	1.6	1.3	1.1	5.5	0.1	7.8	0.9	.60	.035	.54	.031
7954	68.9	10.3	0.0	0.0	7.8	0.0	10.4	2.6	.60	.038	.55	.039
7955	83.2	5.7	2.1	1.2	3.1	0.1	4.3	0.3	.63	.039	.57	.036
7956	65.5	12.8	1.5	1.1	10.0	0.5	7.1	1.5	.53	.023	.49	.024
7957	84.5	3.7	1.1	0.8	2.5	0.1	6.2	1.2	.61	.033	.55	.031
7958	80.5	5.6	0.0	0.1	5.3	0.1	7.6	0.9	.67	.047	.62	.056
7959	82.9	4.5	1.6	1.8	3.9	0.0	4.6	0.7	.68	.041	.62	.038
71138	81.2	1.1	2.8	2.2	2.8	0.0	9.3	0.6	.55	.031	.51	.043
71139	77.9	0.5	0.9	0.6	5.6	0.2	12.3	2.0	.60	.042	.56	.053
71140	15.8	0.0	53.2	30.8	0.0	0.0	0.2	0.0				
71141	83.1	1.0	1.7	1.3	5.0	0.1	7.2	0.6	.60	.037	.53	.045
71181	86.2	3.9	0.7	0.9	3.3	0.1	3.6	1.3	.64	.055	.59	.064
71182	89.3	4.1	0.2	0.3	0.5	0.0	5.0	0.6	.62	.034	.57	.045
71183	84.0	6.7	0.5	0.9	1.6	0.1	5.6	0.6	.68	.042	.63	.053

VIT	Vitrinite	EXIN	Exinite
PSU-VIT	Pseudovitrinite	RES	Resinite
FUS	Fusinite	R _{max}	Vitrinite maximum reflectance
SEMFUS	Semifusinite	SD	Standard deviation
MIC	Micrinite	R _{mean}	Vitrinite mean reflectance
MAC	Macrinite		

Table 2.—Petrographic Analysis of the Foster Coal.

KCER NO.	VIT	PSU-VIT	FUS	SEMFUS	MIC	MAC	EXIN	RES	R _{max}	SD	R _{mean}	SD
7340	79.0	1.7	6.5	1.6	3.0	0.1	8.1	0.0	.65	.029	.60	.049
7342	79.4	3.2	4.9	0.9	3.3	0.0	8.2	0.0	.67	.034	.61	.051
7446	76.0	5.8	4.3	3.4	4.1	0.5	5.5	0.4	.64	.046	.58	.053
7447	71.5	3.2	9.1	4.1	5.9	0.1	4.3	1.8	.59	.05	.51	.075
7448	73.2	5.5	7.3	4.4	4.8	0.4	3.4	1.0	.65	.046	.61	.046
7455	67.0	7.6	6.8	7.8	5.1	0.3	4.5	0.9	.63	.060	.59	.058
7456	72.1	3.5	5.6	4.9	6.6	0.3	5.9	1.1	.53	.033	.50	.037
7491	64.7	4.3	13.3	4.7	5.8	0.9	5.4	0.9	.55	.042	.52	.044
7492	76.0	5.2	7.0	3.7	2.9	0.4	4.6	0.2	.56	.051	.49	.049
7517	80.1	1.2	5.2	1.3	4.4	0.3	7.1	0.4	.58	.037	.54	.053
7574	72.5	1.0	3.2	1.4	9.7	0.0	9.9	2.3	.55	.030	.52	.035
7575	81.6	3.3	3.0	1.4	3.9	0.0	6.5	0.3	.66	.035	.62	.046
7576	74.9	1.6	7.0	2.6	3.5	0.3	8.8	1.3	.59	.042	.56	.048
7613	84.5	2.4	2.5	0.4	4.1	0.1	5.4	0.6	.57	.035	.53	.049
7702	90.6	1.7	0.5	0.9	3.0	0.1	2.6	0.6	.57	.033	.55	.037
7703	92.5	1.2	0.0	0.2	1.8	0.0	3.2	1.1	.58	.028	.56	.036
71177	79.1	0.9	5.5	4.3	4.0	0.2	5.9	0.1	.55	.056	.51	.062
71178	88.8	0.6	3.2	2.4	1.0	0.0	3.9	0.1	.58	.047	.53	.059
71179	74.6	2.4	6.1	7.0	3.8	0.0	6.0	0.1	.60	.043	.55	.049
71180	79.6	1.3	6.1	6.4	2.7	0.1	3.5	0.3	.59	.034	.55	.044
	VIT		Vitrinite		EXIN		Exinite					
	PSU-VIT		Pseudovitrinite		RES		Resinite					
	FUS		Fusinite		R _{max}		Vitrinite maximum reflectance					
	SEMFUS		Semifusinite		SD		Standard deviation					
	MIC		Micrinite		R _{mean}		Vitrinite mean reflectance					
	MAC		Macrinite									

without the rider/upper bench than the whole channel sample (KCER-7704) is.

banding. No regional trends are apparent for the distribution of total vitrinite in the study area.

Foster Coal Bed

The Foster coal bed exhibits a variable maceral composition, as shown in Table 2. In general, the coal has a high vitrinite content, comparable to most other western Kentucky coal beds, with the maximum of greater than 92 percent vitrinite in KCER-7702. The rider coal associated with the Foster at this site (KCER-7703, Carter coordinate section 1-I-36) has a canneloid appearance, although it contains more than 93 percent vitrinite. The canneloid appearance is because of its high mineral-matter content and the absence of recognizable

MINERALOGY

Amos Coal Bed

Low-temperature ash (LTA) of channel samples of the Amos coal bed ranges from 2.3 percent to 15.8 percent, with a mean of 4.8 percent LTA. The lower bench of the Amos coal bed (KCER-7706, Carter coordinate section 5-I-36) contains 2.9 percent LTA. Samples from the upper bench of the Amos coal bed (KCER-7705, Carter coordinate section 5-I-36) and the rider coal above the Amos in the western part of the study area (KCER-7709, Carter coordinate section 25-J-36) contain nearly 30 percent mineral matter. The minerals consist primarily of

Table 3.—Mineral Composition of Low-Temperature Ash (LTA) in the Amos Coal.

KCER NO.	LTA%	PYRITE	MARCASITE	CALCITE	QUARTZ	KAOLINITE	ILLITE/OTHER CLAYS	OTHER MINERALS
7445	3.1	22.0	1.0		4.0	20.0	53.0	
7449	3.8	24.0	1.0		3.0	26.0	46.0	coquimbite
7450	2.8	28.0			4.0	20.0	48.0	rutile
7451	4.7	16.0	2.0		6.0	29.0	47.0	rutile, illite, coquimbite
7452	3.1	6.0			9.0	30.0	55.0	rutile, illite, gypsum, sphalerite
7453	3.9	4.0			11.0	30.0	55.0	feldspar, illite, rutile
7454	2.3				4.0	16.0	80.0	
7490	7.1	16.0	4.0		3.0	19.0	58.0	gypsum
7572	7.9	2.0			4.0	14.0	80.0	illite, sphalerite
7573	20.2	30.0		2.0	18.0	16.0	32.0	illite
7701	2.8	5.0		1.0	6.0	27.0	61.0	feldspar, sphalerite
7704	15.8	15.0		1.0	22.0	42.0	19.0	illite, feldspar
7705	29.3	15.0		1.0	13.0	36.0	36.0	sphalerite
7706	2.9	4.0		1.0	10.0	21.0	63.0	
7707	4.1	2.0			5.0	18.0	75.0	illite
7708	3.6	9.0			10.0	23.0	58.0	
7709	28.1	40.0			4.0	20.0	36.0	illite

illite, kaolinite, pyrite, and quartz (Table 3). Marcasite, various carbonates, sulfates, rutile, feldspar, sphalerite, and chlorite occur in some samples in very minor amounts. The amount of pyrite varies, and it is not always a major constituent in the high-ash samples. The majority of pyrite occurs in framboidal form. Massive and fracture-fill varieties of pyrite are less common. Sphalerite was observed in some samples during microscopic examinations. It was the major sulfide mineral in one Amos coal sample (KCER-7572). Calcium-bearing minerals are not abundant in either coal. Calcite occurs as cleat or vein filling in only a few samples. Trace amounts of dolomite, possible magnesium-calcite, and gypsum were detected in some of the samples. Kaolinite is more abundant in these coals than in most other Eastern Region Interior Province (Illinois Basin) coal beds. Illite usually shows an indistinct peak in X-ray diffraction of low-temperature ash, and is difficult to quantify; however, diffraction graphs of these coals occa-

sionally showed increased illite crystallinity, suggesting the presence of muscovite, which is probably detrital in origin. Minerals assumed to be present (arrived at by subtracting the total amount of the known mineral occurrences from the net sample) are probably mixed-layer clays, amorphous material, sulfates, and other minerals in minor quantities of less than 1 percent.

Foster Coal Bed

The Foster coal bed is slightly higher in ash (LTA) than the Amos, and ranges from 4.9 to 16.4 percent, with a mean of 9.5 percent LTA (Table 4). This mineral-matter content is generally less than for the Herrin (W. Ky. No. 11) coal bed, which ranges from 9.3 to 20.9 percent LTA (mean 15.5 percent LTA), and for the Springfield coal bed of Illinois (W. Ky. No. 9), which ranges from 10.4 to 23.5 percent LTA (mean 15.7 percent LTA) (Rao and

Table 4.—Mineral Composition of Low-Temperature Ash (LTA) in the Foster Coal.

KCER NO.	LTA%	PYRITE	MARCASITE	CALCITE	QUARTZ	KAOLINITE	ILLITE/OTHER CLAYS	OTHER MINERALS
7446		7.0	28.0		5.0	20.0	47.00	
7447	4.9	6.0	1.0	1.0	9.0	39.0	44.0	
7448	8.2	8.0	1.0	8.0	11.0	21.0	51.0	
7455	13.8	18.0	6.0		5.0	19.0	52.0	
7456	7.0	9.0	1.0		5.0	18.0	67.0	
7491	16.1	39.0	1.0		6.0	12.0	42.0	
7492	9.5	37.0	4.0		3.0	16.0	40.0	
7517	5.4	22.0	5.0		5.0	13.0	55.0	
7574	10.6	14.0	2.0		4.0	12.0	68.0	
7575	7.0	28.0			5.0	20.0	47.0	goethite
7576	16.4	41.0			4.0	7.0	40.0	
7613	11.6	20.0	8.0		19.0	19.0	41.0	
7702	8.3	35.0	8.0		8.0	9.0	40.0	
7703	48.2	4.0		4.0	24.0	15.0	53.0	rutile, feldspar, illite, chlorite

Gluskoter, 1973; Ward, 1977). There are no apparent trends in the distribution of LTA in the study area.

The mineral content of the Foster is similar to the content of the Amos, with two differences. Goethite is a major constituent in one highly oxidized Foster sample (KCER-7575), and quantifiable marcasite occurs in the Foster coal bed. Marcasite was detected in only four of the Amos coal samples.

PROXIMATE AND ULTIMATE ANALYSES

Amos Coal Bed

The results of proximate, ultimate, and calorific analyses of the Amos coal bed (and associated rider coals) are shown in Table 5. The sulfur content of the main coal bed ranges from 0.7 percent to 2.5 percent (mean 1.2 percent, dry basis). The ash content ranges from 1.7 percent to 13.4 percent (mean 4.0 percent, dry basis). The number of sites having coal with less than 1 percent sulfur and less than 3 percent ash (both on dry basis) is exceptional, but probably not unique. Hower and others (1982) noted that several Tradewater Formation coal beds in the Butler-Ohio County area are also low in sulfur and ash. The Btu per pound values of the Amos coal range from 11,570 to 14,670 (dry basis).

Foster Coal Bed

The results of proximate, ultimate, and calorific analyses of the Foster coal bed are shown in Table 6. The samples of the Foster coal bed are higher in total sulfur than the Amos, ranging from 0.8 to 5.9 percent (mean 2.6 percent, dry basis), with eight of 13 samples containing greater than 2 percent sulfur. The high-temperature-ash (HTA) content ranges from 3.8 to 13.8 percent HTA (mean 7.5 percent HTA, dry basis), with nine samples containing greater than 5 percent HTA. The Btu per pound values range from 11,850 to 13,511 (dry basis).

GEOCHEMISTRY

The elemental compositions of the Amos and Foster coals are given in Tables 7 and 8. Few trends are evident for the major elements. The most variable oxide is Fe_2O_3 , reflecting the variable pyrite content. The CaO content is small, confirming the mineralogic observation. In general, trace elements with carbonate associations such as Ba and Sr have low concentrations in contrast to other western Kentucky coals. The increased levels of Ni, along with Zn, Cu, Co, and Cr, in some of the samples may reflect an increased association with sulfide minerals.

Table 5.—Proximate, Ultimate, Forms of Sulfur, Free Swelling, and Calorific Analyses of the Amos Coal.

KCER NO.	BASIS	MOIS	ASH	V.M.	F.C.	S(t)	S(p)	S(s)	S(o)	C	H	N	O	ORG O	FSI	BTU
7445	a-d	8.13	1.95	43.50	46.42	1.28				74.18	5.30	1.50	15.79			13120
	dry		2.12	47.35	50.53	1.39				80.74	4.78	1.63	9.33			14281
	daf			48.38	51.62	1.42				82.50	4.88	1.67	9.53			14590
	dmmf			48.09	51.91											14659
	wmmf															13433
7449	a-d	7.00	2.77	37.00	53.23	1.56				74.66	5.12	1.53	14.36			13140
	dry		2.98	39.78	57.24	1.68				80.28	4.66	1.65	8.76			14129
	daf			41.01	58.99	1.73				82.74	4.81	1.70	9.03			14562
	dmmf			40.55	59.45											14651
	wmmf															13584
7450	a-d	8.26	1.55	38.80	51.39	1.10				74.07	5.16	1.50	16.62			13230
	dry		1.69	42.29	56.02	1.20				80.74	4.62	1.64	10.12			14421
	daf			43.02	56.98	1.22				82.13	4.70	1.66	10.29			14669
	dmmf			42.74	57.26											14726
	wmmf															13482
7451	a-d	7.47	2.86	39.00	50.67	1.50				72.06	4.28	0.97	18.33			13130
	dry		3.09	42.15	54.76	1.62				77.88	3.72	1.05	12.64			14189
	daf			43.49	56.51	1.67				80.36	3.84	1.08	13.04			14642
	dmmf			43.07	56.93											14731
	wmmf															13586
7452	a-d	8.53	1.99	42.70	46.78	0.83				73.37	5.49	1.37	16.95			13120
	dry		2.18	46.68	51.14	0.91				80.21	4.96	1.50	10.25			14343
	daf			47.72	52.28	0.93				82.00	5.07	1.53	10.48			14662
	dmmf			47.50	52.50											14716
	wmmf															13428
7453	a-d	6.81	2.51	42.50	48.18	0.77				73.99	5.54	1.53	15.66			13310
	dry		2.69	45.61	51.70	0.83				79.40	5.13	1.64	10.31			14282
	daf			46.87	53.13	0.85				81.59	5.27	1.69	10.60			14677
	dmmf			46.63	53.37											14736
	wmmf															13700
7454	a-d	8.27	1.82	35.40	54.51	0.62				73.47	5.08	1.35	17.66			12730
	dry		1.98	38.59	59.42	0.68				80.09	4.53	1.47	11.25			13877
	daf			39.37	60.63	0.69				81.72	4.62	1.50	11.47			14158
	dmmf			39.15	60.85											14200
	wmmf															12998
7490	a-d	5.27	6.16	44.50	44.07	2.50	0.76	0.00	1.74	73.50	5.29	1.31	11.24			13480
	dry		6.50	46.98	46.52	2.64	0.80	0.00	1.84	77.59	4.96	1.38	6.92			14229
	daf			50.24	49.76	2.82	0.86	0.00	1.96	82.99	5.31	1.48	7.41			15219
	dmmf			49.60	50.40									6.29		15402
	wmmf															14520

BASIS	Lab reporting basis	S(o)	Organic sulfur	a-d	as determined
MOIS	Moisture content	C	Carbon content	dry	dry
ASH	Ash content	H	Hydrogen	dmmf	dry mineral matter
V.M.	Volatile matter	N	Nitrogen		free
F.C.	Fixed carbon	O	Oxygen	wmmf	wet mineral matter
S(t)	Total sulfur	ORG O	Organic oxygen		free
S(p)	Pyritic sulfur	FSI	Free Swelling Index		
S(s)	Sulfate sulfur	BTU	British thermal units per pound		

Table 5.—Continued.

KCER NO.	BASIS	MOIS	ASH	V.M.	F.C.	S(t)	S(p)	S(s)	S(o)	C	H	N	O	ORG O	FSI	BTU
7572	a-d	8.45	5.82	38.30	47.43	0.88	0.16	0.01	0.71	72.16	5.25	1.44	14.45			12590
	dry		6.36	41.84	51.81	0.96	0.17	0.01	0.78	78.82	4.70	1.57	7.59			13752
	daf			44.68	55.32	1.03	0.19	0.01	0.83	84.17	5.02	1.68	8.10			14685
	dmmf			44.21	55.79											14798
	wmmf													7.27	2.5	13456
7573	a-d	6.32	14.41	39.90	39.37	3.79	2.96	0.10	0.73	63.00	4.96	1.43	12.41			11496
	dry		15.38	42.59	42.03	4.05	3.16	0.11	0.78	67.25	4.54	1.53	7.26			12271
	daf			50.33	49.67	4.78	3.73	0.13	0.92	79.48	5.36	1.80	8.57			14502
	dmmf			48.97	51.03											14869
	wmmf													8.71	3.0	13729
7701	a-d	9.89	3.08	36.50	50.53	0.75				73.67	5.09	1.49	15.92			12770
	dry		3.42	40.51	56.08	0.83				81.76	4.42	1.65	7.92			14171
	daf			41.94	58.06	0.86				84.65	4.58	1.71	8.20			14673
	dmmf			41.63	58.37											14741
	wmmf														3.0	13227
7704	a-d	7.63	12.39	35.60	44.38	1.77				65.19	4.73	1.45	14.47			11570
	dry		13.41	38.54	48.05	1.92				70.57	4.20	1.57	8.33			12525
	daf			44.51	55.49	2.21				81.51	4.85	1.81	9.62			14466
	dmmf			43.45	56.55											14716
	wmmf													9.61	3.0	13405
7705	a-d	7.18	22.92	34.00	35.90	2.92				56.54	4.28	1.18	12.16			9990
	dry		24.69	36.63	38.68	3.15				60.91	3.75	1.27	6.23			10762
	daf			48.64	51.36	4.18				80.89	4.97	1.69	8.27			14291
	dmmf			46.64	53.36											14810
	wmmf													7.92	1.5	13367
7706	a-d	6.56	2.49	38.30	52.65	0.76				75.10	5.10	1.53	15.02			13140
	dry		2.66	40.99	56.35	0.81				80.37	4.67	1.64	9.84			14062
	daf			42.11	57.89	0.84				82.57	4.80	1.68	10.11			14447
	dmmf			41.84	58.16											14503
	wmmf														3.5	13522
7707	a-d	9.29	3.41	36.00	51.30	0.73				73.78	5.16	1.57	15.35			12840
	dry		3.76	39.69	56.55	0.80				81.34	4.54	1.73	7.83			14155
	daf			41.24	58.76	0.84				84.51	4.72	1.80	8.13			14708
	dmmf			40.91	59.09											14780
	wmmf														2.5	13349
7708	a-d	7.78	2.56	38.90	50.76	0.98				74.45	5.30	1.49	15.22			13170
	dry		2.78	42.18	55.04	1.06				80.73	4.80	1.62	9.01			14281
	daf			43.39	56.61	1.09				83.04	4.94	1.66	9.27			14688
	dmmf			43.08	56.92											14756
	wmmf														3.0	13569
7709	a-d	4.23	19.72	36.40	39.70	6.57				58.07	4.48	1.26	9.90			10780
	dry		20.59	38.01	41.40	6.86				60.63	4.18	1.32	6.41			11256
	daf			47.86	52.14	8.64				76.36	5.27	1.66	8.08			14175
	dmmf			45.43	54.57											14750
	wmmf														2.5	13919
7953	a-d	4.42	11.53	35.20	48.85	2.37	1.34	0.13	0.90	66.19	5.29	1.77	12.85			12270
	dry		12.06	36.83	51.11	2.48	1.40	0.14	0.94	69.25	5.02	1.85	9.34			12837
	daf			41.88	58.12	2.82	1.59	0.15	1.07	78.75	5.71	2.11	10.62			14598
	dmmf			40.73	59.27											14850
	wmmf													9.98	2.5	14089

KCER NO.	BASIS	MOIS	ASH	V.M.	F.C.	S(t)	S(p)	S(s)	S(o)	C	H	N	O	ORG O	FSI	BTU
7954	a-d	4.28	12.75	35.00	47.97	5.02	3.31	0.15	1.56	63.80	5.20	1.68	11.55			11950
	dry		13.32	36.56	50.11	5.24	3.46	0.16	1.63	66.65	4.93	1.76	8.10			12484
	daf			42.18	57.82	6.05	3.99	0.18	1.88	76.90	5.69	2.02	9.34	9.38	3.0	14402
	dmmf			40.37	59.63											14773
	wmmf															14015
7955	a-d	4.49	2.26	36.60	56.65	0.81	0.15	0.03	0.63	74.91	5.83	1.96	14.23			13770
	dry		2.37	38.32	59.31	0.85	0.16	0.03	0.66	78.43	5.58	2.05	10.72			14417
	daf			39.25	60.75	0.87	0.16	0.03	0.68	80.33	5.71	2.10	10.98	10.58	2.5	14766
	dmmf			38.97	61.03											14822
	wmmf															14137
7956	a-d	4.56	11.23	36.50	47.71	4.16	3.31	0.08	0.77	65.27	5.34	1.57	12.43			12260
	dry		11.77	38.24	49.99	4.36	3.47	0.08	0.81	68.39	5.06	1.65	8.78			12845
	daf			43.34	56.66	4.94	3.93	0.10	0.91	77.51	5.74	1.86	9.95	10.59	2.0	14558
	dmmf			41.89	58.11											14873
	wmmf															14082
7957	a-d	6.64	1.47	34.50	57.39	0.68	0.06	0.19	0.43	74.35	5.88	2.02	15.60			13500
	dry		1.57	36.95	61.47	0.73	0.06	0.20	0.46	79.64	5.50	2.16	10.39			14460
	daf			37.54	62.46	0.74	0.07	0.21	0.47	80.91	5.59	2.20	10.56	10.35	2.5	14691
	dmmf			37.32	62.68											14733
	wmmf															13735
7958	a-d	6.75	2.52	34.90	55.83	0.74	0.09	0.01	0.64	72.80	5.88	2.07	15.99			13270
	dry		2.70	37.43	59.87	0.79	0.10	0.01	0.69	78.07	5.50	2.22	10.72			14230
	daf			38.47	61.53	0.82	0.10	0.01	0.71	80.24	5.65	2.28	11.02	10.53	2.5	14625
	dmmf			38.17	61.83											14682
	wmmf															13660
7959	a-d	5.58	2.17	34.00	58.25	0.69	0.07	0.00	0.62	74.60	5.66	2.00	14.88			13490
	dry		2.30	36.01	61.69	0.73	0.07	0.00	0.66	79.01	5.33	2.12	10.51			14287
	daf			36.86	63.14	0.75	0.08	0.00	0.67	80.87	5.46	2.17	10.76	10.30	3.5	14623
	dmmf			36.59	63.41											14673
	wmmf															13832
71138	a-d	8.93	1.98	35.90	53.19	0.81	0.12	0.01	0.68	73.10	5.84	1.72	16.55			13360
	dry		2.17	39.42	58.41	0.89	0.13	0.01	0.75	80.27	5.32	1.89	9.46			14670
	daf			40.30	59.70	0.91	0.13	0.01	0.76	82.05	5.43	1.93	9.67			14996
	dmmf			40.03	59.97									9.21	2.5	15052
	wmmf															13672
71139	a-d	10.01	1.80	36.60	51.59	0.92	0.19	0.02	0.71	72.20	6.00	1.72	17.36			13210
	dry		2.00	40.67	57.33	1.02	0.21	0.02	0.79	80.23	5.42	1.91	9.41			14679
	daf			41.50	58.50	1.04	0.22	0.02	0.81	81.87	5.53	1.95	9.60			14979
	dmmf			41.22	58.78									9.17	2.5	15037
	wmmf															13494
71140	a-d	3.53	1.87	13.40	81.20	0.28				86.62	3.10	0.62	7.51			14390
	dry		1.94	13.89	84.17	0.29				89.79	2.80	0.64	4.54			14916
	daf			14.16	85.84	0.30				91.56	2.86	0.66	4.62			15211
	dmmf			13.93	86.07									4.61	0.0	15244
	wmmf															14695
71141	a-d	10.38	1.34	35.70	52.58	0.62	0.03	0.01	0.58	72.11	5.99	1.77	18.17			13220
	dry		1.50	39.83	58.67	0.69	0.03	0.01	0.65	80.46	5.39	1.98	9.99			14751
	daf			40.44	59.56	0.70	0.03	0.01	0.66	81.68	5.47	2.00	10.14			14975
	dmmf			40.24	59.76									9.73	3.0	15016
	wmmf															13429

Table 5.—Continued.

KCER NO.	BASIS	MOIS	ASH	VM.	F.C.	S(t)	S(p)	S(s)	S(o)	C	H	N	O	ORG	O	FSI	BTU
71181	a-d	9.61	1.67	35.00	53.72	1.17	0.31	0.05	0.81	71.62	5.87	1.83	17.84				13070
	dry		1.85	38.72	59.43	1.29	0.34	0.06	0.90	79.23	5.30	2.02	10.29				14459
	daf			39.45	60.55	1.32	0.35	0.06	0.91	80.73	5.40	2.06	10.49				14731
	dmmf			39.11	60.89												14794
	wmmf													10.11		2.5	13337
71182	a-d	9.07	6.87	35.60	48.46	1.33	0.37	0.09	0.87	67.30	5.73	1.70	17.07				12390
	dry		7.56	39.15	53.29	1.46	0.41	0.10	0.96	74.01	5.19	1.87	9.91				13625
	daf			42.35	57.65	1.58	0.44	0.11	1.03	80.06	5.61	2.02	10.72				14739
	dmmf			41.70	58.30												14886
	wmmf													9.90		2.5	13417
71183	a-d	9.01	1.53	35.40	54.06	0.89	0.14	0.02	0.73	72.25	5.81	1.82	17.70				13200
	dry		1.68	38.91	59.41	0.98	0.15	0.02	0.80	79.40	5.28	2.00	10.66				14507
	daf			39.57	60.43	0.99	0.16	0.02	0.82	80.76	5.37	2.03	10.84				14755
	dmmf			39.30	60.70												14806
	wmmf													10.41		2.0	13443

PALYNOLOGY

Geologic age of the Amos and Foster coals is based on comparisons of miospore ranges from Illinois (Peppers, 1984), Great Britain (Smith and Butterworth, 1967), and Western Europe (Clayton and others, 1977). The miospores of the Amos and Foster coal beds (Appendix 1) indicate a correlation with the coal beds of the Abbott Formation of Illinois, the *Dictyotriletes bireticulatus* assemblage zone of Great Britain, and the *Microreticulatisporites nobilis-florinites* junior zone of western Europe. The Abbott Formation of Illinois is Atokan in age, while both the *D. bireticulatus* and the *M. nobilis-F.* zones of Great Britain and western Europe are assigned to the Westphalian Stage. Coal beds below and above the Amos and Foster coal beds have not been examined in this study, so the precise position of the Amos and Foster coal beds within the Atokan or Westphalian B is uncertain.

The long-ranging form *Lycospora pusilla* dominates every sample, and ranges in abundance from 48 to 94 percent of the assemblage. The second most abundant spore, *Punctatosporites minutis*, ranges in abundance from 0.5 percent to 48 percent, and its abundance is roughly inverse to the abundance of *L. pusilla*. *P. minutis* sets a lower limit on the age of the flora, since its documented first occurrence is in mid-Westphalian A (Smith and Butterworth, 1967). The forms *Cristatisporites globiformis*, *Raistrickia fulva*, *Savitrsporites nux*, and *Vestispora tortuosa* are common to the Atokan Series in North America and the Westphalian Stage of Europe and Great

Britain. *Endosporites globiformis* generally becomes a consistent constituent of coal flora at the base of Westphalian B strata in Great Britain or the base of the *Dictyotriletes bireticulatus* zone (Smith and Butterworth, 1967) and the lower Atokan in Illinois (Peppers, 1984). Most of these forms, however, range through more than one zone; therefore, the absence of certain key forms found lower or higher in the section becomes critical in defining the flora as Westphalian B. The chief forms that would indicate a younger, Westphalian C assignment for the Amos and Foster coal beds are the forms *Microreticulatisporites sulcatus*, *Torispora securis*, and *Vestispora fenestrata*. These forms, which are present in Westphalian C equivalents from eastern Kentucky (Helfrich, 1981), have not been observed in either the Amos or Foster coal beds. Older forms occurring within Morrovan or Westphalian A strata that have not been recognized in the Amos and Foster flora include the forms *Radiozonates aligerens* and *Schulzospora rara*. *Paistrickia fulva*, a form that is reported sporadically at various levels of Westphalian B and consistently in Westphalian C strata, is conspicuously absent from both the Amos and Foster coal beds, although it has been found in younger strata from eastern Kentucky (Helfrich, 1981). This absence, in conjunction with the occurrence of *Punctatisporites sinuatus* in one sample of the Amos coal, would indicate a lower to middle Westphalian B correlation for these coal beds, because *P. sinuatus* just crosses the Westphalian A/B boundary in Illinois, Great Britain, and Western Europe (Peppers, 1984).

Table 6.—Proximate, Ultimate, Forms of Sulfur, Free Swelling, and Calorific Analyses of the Foster Coal.

KCER NO.	BASIS	MOIS	ASH	V.M.	F.C.	S(t)	S(p)	S(s)	S(o)	C	H	N	O	ORG O	FSI	BTU
7446	a-d	7.09	4.58	38.90	49.43	2.12				72.05	5.49	1.48	14.28			12840
	dry		4.93	41.87	53.20	2.28				77.55	5.06	1.59	8.59			13819
	daf			44.04	55.96	2.40				81.57	5.32	1.68	9.04			14536
	dmmf			43.42	56.58											14670
	wmmf															13563
7447	a-d	6.53	4.56	34.90	54.01	0.79				73.11	4.53	0.77	16.24			12920
	dry		4.88	37.34	57.78	0.85				78.22	4.06	0.82	11.17			13822
	daf			39.25	60.75	0.89				82.23	4.27	0.87	11.74			14531
	dmmf			38.84	61.16											14617
	wmmf															13609
7448	a-d	6.36	6.47	36.10	51.07	1.09				72.22	5.50	1.52	13.20			12550
	dry		6.91	38.55	54.54	1.16				77.13	5.11	1.62	8.06			13402
	daf			41.41	58.59	1.25				82.85	5.49	1.74	8.66			14397
	dmmf			40.84	59.16											14520
	wmmf															13521
7455	a-d	6.32	9.51	36.10	48.07	3.04	1.52	0.05	1.47	67.70	4.76	1.27	13.72			12210
	dry		10.15	38.54	51.31	3.25	1.62	0.05	1.57	72.27	4.33	1.36	8.65			13033
	daf			42.89	57.11	3.61	1.81	0.06	1.75	80.43	4.82	1.51	9.63			14506
	dmmf			41.75	58.25									8.86	4.0	14751
	wmmf															13693
7456	a-d	6.52	3.86	40.70	48.92	1.50	0.27	0.01	1.22	70.28	4.60	1.30	18.46			12430
	dry		4.13	43.54	52.33	1.60	0.29	0.01	1.31	75.18	4.14	1.39	13.55			13296
	daf			45.41	54.59	1.67	0.30	0.01	1.36	78.42	4.32	1.45	14.14			13869
	dmmf			44.97	55.03									13.35	1.5	13961
	wmmf															13004
7491	a-d	6.70	12.87	36.90	43.53	5.41	1.98	0.20	3.23	65.90	4.51	1.07	10.24			11850
	dry		13.79	39.55	46.66	5.80	2.12	0.21	3.46	70.63	4.03	1.15	4.60			12700
	daf			45.88	54.12	6.73	2.46	0.25	4.02	81.93	4.68	1.33	5.33			14733
	dmmf			44.10	55.90									3.22		15150
	wmmf															13930
7492	a-d	9.04	7.59	37.90	45.47	3.36	1.78	0.21	1.37	69.27	4.59	1.28	13.91			12490
	dry		8.34	41.67	49.99	3.69	1.96	0.23	1.51	76.15	3.93	1.41	6.47			13731
	daf			45.46	54.54	4.03	2.14	0.25	1.64	83.09	4.29	1.54	7.05			14981
	dmmf			44.43	55.57									6.69		15228
	wmmf															13697
7517	a-d	9.96	3.44	43.70	42.90	1.77	0.87	0.06	0.84	71.52	4.82	1.69	16.76			12710
	dry		3.82	48.53	47.65	1.97	0.97	0.07	0.93	79.43	4.12	1.88	8.79			14115
	daf			50.46	49.54	2.04	1.00	0.07	0.97	82.59	4.28	1.95	9.14			14676
	dmmf			50.05	49.95									8.90	3.0	14786
	wmmf															13242

BASIS	Lab reporting basis	S(o)	Organic sulfur	a-d	as determined
MOIS	Moisture content	C	Carbon content	dry	dry
ASH	Ash content	H	Hydrogen	dmmf	dry mineral matter
V.M.	Volatile matter	N	Nitrogen		free
F.C.	Fixed carbon	O	Oxygen	wmmf	wet mineral matter
S(t)	Total sulfur	ORG O	Organic oxygen		free
S(p)	Pyritic sulfur	FSI	Free Swelling Index		
S(s)	Sulfate sulfur	BTU	British thermal units per pound		

KCER NO.	BASIS	MOIS	ASH	VM.	F.C.	S(t)	S(p)	S(s)	S(o)	C	H	N	O	ORG	O	FSI	BTU
7574	a-d	5.85	7.00	41.80	45.35	2.46	0.98	0.04	1.44	71.46	5.18	1.45	12.45				12550
	dry		7.43	44.40	48.17	2.61	1.04	0.04	1.53	75.90	4.81	1.54	7.71				13329
	daf			47.96	52.04	2.82	1.12	0.05	1.65	82.00	5.19	1.66	8.32				14400
	dmmf			47.23	52.77									7.46	2.5		14578
	wmmf																13643
7575	a-d	8.70	5.05	36.10	50.15	0.62	0.13	0.02	0.47	70.47	4.58	1.51	17.77				12080
	dry		5.53	39.54	54.93	0.68	0.14	0.02	0.51	77.19	3.95	1.65	11.00				13231
	daf			41.86	58.14	0.72	0.15	0.02	0.54	81.70	4.18	1.75	11.64	11.05	1.0		14005
	dmmf			41.46	58.54												14091
	wmmf																12790
7576	a-d	6.88	10.62	37.20	45.30	5.49	4.21	0.13	1.15	66.94	4.72	1.26	10.97				12020
	dry		11.40	39.95	48.65	5.90	4.52	0.14	1.23	71.89	4.24	1.35	5.22				12908
	daf			45.09	54.91	6.65	5.10	0.16	1.39	81.14	4.79	1.53	5.89	6.78	4.0		14569
	dmmf			43.44	56.56												14937
	wmmf																13735
7613	a-d	7.08	8.31	41.40	43.20	2.20	1.21	0.07	0.92	69.64	5.18	1.56	13.11				12430
	dry		8.94	44.55	46.51	2.37	1.30	0.08	0.99	74.95	4.72	1.68	7.34				13377
	daf			48.93	51.07	2.60	1.43	0.08	1.09	82.31	5.19	1.84	8.06	7.53	3.5		14691
	dmmf			48.17	51.83												14891
	wmmf																13717
7702	a-d	7.94	6.39	39.10	46.57	2.90				70.32	5.28	1.61	13.50				12560
	dry		6.94	42.47	50.59	3.15				76.38	4.77	1.75	7.00				13643
	daf			45.64	54.36	3.39				82.08	5.13	1.88	7.53			3.0	14660
	dmmf			44.79	55.21												14856
	wmmf																13567
7703	a-d	6.95	41.68	26.00	25.30	1.17				40.04	3.21	1.00	12.90				7210
	dry		44.79	27.94	27.27	1.26				43.03	2.61	1.07	7.23				7749
	daf			50.61	49.39	2.28				77.94	4.73	1.95	13.10			1.0	14035
	dmmf			46.84	53.16												15090
	wmmf																13160
71177	a-d	9.26	7.11	34.30	49.33	1.53	0.74	0.10	0.69	67.18	5.55	1.59	17.04				12260
	dry		7.84	37.80	54.36	1.69	0.82	0.11	0.76	74.04	4.97	1.					

Table 7.—Major-Element Composition of the Amos and Foster Coals.

KCER#	MgO	Na ₂ O	Fe ₂ O ₃	TiO ₂	SiO ₂	CaO	K ₂ O	P ₂ O ₅	Al ₂ O ₃	SO ₃	COMMENTS
<i>Amos coal:</i>											
7445	0.27	0.23	30.69	0.30	16.80	0.70	0.60	0.07	10.60		
7451	0.34	0.23	24.96	0.40	19.64	0.50	0.80	0.08	11.30		
7490	0.48	0.55	38.64	0.50	28.50	2.10	0.60	0.64	21.60	0.3	rider bed
7701	1.06	0.45	9.45	1.10	50.74	1.06	2.32	0.19	30.74	0.3	
7704	0.91	0.00	15.96	1.10	51.32	0.00	2.70	0.09	26.20	0.4	
7705	1.02	0.00	16.12	1.10	50.14	0.00	3.00	0.08	26.80	0.3	upper bench
7706	0.70	0.59	11.13	1.07	54.19	1.34	1.78	0.13	26.68	0.3	lower bench
7707	0.77		26.85	0.80	41.58	0.30	1.70	0.19	26.50	0.2	
7708	0.73	0.53	17.95	1.10	48.15	1.30	1.59	0.13	25.53	0.4	
7709	0.57		40.77	0.80	31.79		2.10	0.07	22.40	0.2	rider bed
7954	0.48	0.00	40.97	0.80	34.85	0.00	1.70	0.06	19.80	0.0	upper bench
7955	0.78	0.26	10.67	0.90	56.60	1.30	1.70	0.09	25.60	0.4	lower bench
7956	0.68	0.00	34.15	0.60	35.88	0.20	1.50	0.12	25.70	0.5	rider bed
7958	1.07	0.00	6.90	1.10	53.04	0.10	2.60	0.11	32.90	0.1	upper bench
7959	0.73	0.00	6.62	1.00	57.12	0.50	1.40	0.20	30.10	0.2	lower bench
71138	0.74	0.00	12.70	1.00	52.23	1.20	1.20	0.15	28.70	0.6	
71139	0.73	0.00	19.23	0.90	44.71	1.10	1.70	0.15	29.10	0.6	upper bench
71140	3.02	0.10	10.36	0.20	42.44	3.60	0.50	0.64	31.20	6.0	middle bench
71141	0.72	0.00	5.14	1.20	52.57	2.00	1.00	0.18	33.70	0.8	lower bench
71181	0.12	0.00	35.98	0.60	33.11	0.90	0.70	0.14	25.90	0.3	
71182	0.87	0.00	15.02	1.10	48.95	0.70	2.20	0.15	28.80	0.2	upper bench
71183	0.54	0.00	17.15	0.80	43.62	1.50	0.90	0.16	32.90	0.6	lower bench
<i>Foster coal:</i>											
7340	0.39	0.13	29.75	0.90	39.39	0.40	0.70	0.18	22.90		
7446	0.34	0.05	36.81	0.40	30.23	0.70	0.40	0.16	21.10		
7447	0.48	0.12	9.67	0.80	47.17	1.00	1.00	0.15	28.20		
7448	0.49	0.27	12.05	1.10	45.59	7.40	1.10	0.15	22.00		
7455	0.52	0.23	30.76	0.80	39.39	0.30	1.10	0.11	24.20	0.2	
7456	1.36	0.44	25.85	1.20	37.70	2.50	2.00	0.16	21.20	1.5	
7491	0.38	0.22	51.71	0.70	26.50	0.40	0.50	0.22	13.50	0.0	
7492	0.23	0.22	56.52	0.30	21.01	0.50	0.30	0.15	13.90	0.3	
7702	0.49	0.34	52.09	0.58	28.00	0.54	1.20	0.07	14.99	0.3	
7703	2.04	0.17	8.25	1.10	58.96		4.10	0.09	23.50	0.2	
71177	0.29	0.00	18.51	1.50	52.05	0.60	0.90	0.15	25.30	0.1	rider bed
71178	0.00	0.00	67.17	0.20	18.00	0.60	0.30	0.09	11.40	0.4	cannel
71179	0.24	0.00	27.77	1.30	43.33	0.70	0.70	0.20	24.50	0.4	upper bench
71180	0.42	0.00	4.91	1.80	59.72	0.80	0.90	0.21	29.70	0.3	middle bench
											lower bench

RANK

The rank of the Amos and Foster coal beds varies from high-volatile-C to high-volatile-B bituminous within the Riverside and Welchs Creek Quadrangles. The coal rank (by vitrinite maximum reflectance) is shown in Tables 1 and 2.

DISCUSSION

Analysis of the areal distribution of coal, sandstone, and associated rocks of the Amos and Foster coals suggests that these coals were deposited in protected, fresh-water swamps. Furthermore, the thickest coals accumulated in well-protected interfluvial areas between channels.

Table 8.—Trace-Element Composition of the Amos and Foster Coals.

KCER#	Zn	Cu	Ni	Co	Cr	Ba	V	Mn	Rb	Sr	Zr	Comments
<i>Amos coal:</i>												
7445	1076	884	3238	29	254	236	380	55	54	161	167	
7451	1307	468	1473	48	264	420	398	0	71	146	179	
7490	346	596	537	19	213	432	364	17	22	1474	184	rider bed
7572	688	339	1097	67	240	649	370	421	108	193	239	
7573	543	320	733	33	194	653	311	4687	68	206	215	rider bed
7701	1202	423	959	96	387	540	584	340	123	277	256	
7704	810	212	630	63	210	482	290	131	135	159	184	
7705	99	320	94	28	236	343	353	256	88	151	221	upper bench
7706	155	230	306	40	155	489	286	225	153	214	245	lower bench
7707	282	406	335	16	157	478	253	339	161	179	194	
7708	455	647	480	74	217	395	348	889	58	291	203	
7709	690	1020	1240	36	251	317	408	317	104	159	173	rider bed
7954	216	367	530	29	194	305	258	109	77	100	129	upper bench
7955	2280	446	1830	200	277	550	356	257	69	250	193	lower bench
7956	224	478	820	36	207	2290	321	221	82	164	150	rider bed
7959	3470	393	2460	265	443	950	750	242	57	162	152	lower bench
71138	1700	660	2450	187	397	670	540	55	47	199	245	
71139	720	720	2390	158	340	454	376	166	63	212	152	upper bench
71140	6560	436	302	49	50	310	54	0	14	304	0	middle bench
71141	660	1100	4840	452	1010	760	1750	383	43	157	417	lower bench
71181	1150	860	2580	108	379	184	600	21	22	130	109	
71182	600	310	264	55	263	388	451	293	46	59	80	upper bench
71183	1650	970	2920	289	640	276	990	255	30	134	137	lower bench
<i>Foster coal:</i>												
7446	3100	486	1576	40	265	152	380	26	22	123	146	
7447	314	404	1220	59	301	5610	602	121	61	239	264	
7448	190	301	532	47	173	944	256	298	60	320	280	
7455	947	401	710	46	142	280	241	66	56	129	166	
7456	207	497	341	33	396	446	508	134	109	289	273	
7491	873	701	427	0	128	151	204	0	22	263	133	
7492	1307	427	1366	0	102	127	182	0	9	134	82	
7574	287	554	583	25	214	254	394	90	69	196	182	
7575	738	532	1988	38	234	657	384	375	75	296	253	
7576	1677	395	882	0	107	122	208	0	19	74	87	
7702	302	282	166	8	97	109	134	143	13	87	66	
7703	43	86	15	5	35			207	14	11	39	rider bed cannel
71177	203	342	670	66	259	305	493	153	31	131	198	
71178	309	0	850	0	22	37	72	154	0	39	36	upper bench
71179	149	424	500	55	138	240	276	112	11	292	152	middle bench
71180	192	288	640	75	330	383	550	177	16	11	51	lower bench

The Amos and Foster coals occur in elongate lobes predominantly oriented northeast-southwest. Thick sandstone deposits also occur in elongate pods, sinuous and bifurcating, also trending northeast-southwest.

The analysis of the sandstone shows both channel and sheet facies. The channel facies indicates deposi-

tion in distributary channels, while the sheet facies are most likely overbank deposits. The pattern of channel-facies sandstones in plan view and cross section strongly suggests a northeast to southwest direction of drainage through the Amos and Foster swamps. The fine-grained rocks characterized by lenticular-bedded

shales and interbedded siltstones are indicative of flood-basin deposition caused by flooding and occasional crevasse splays. The absence of carbonates and marine body fossils suggests no marine conditions were present.

The Amos coal is characterized by low-sulfur, low-ash, and uniformly high vitrinite content. The mineral matter is predominantly clays, with illite more abundant than kaolinite, and lesser amounts of pyrite and quartz. The major and trace elements of this coal, which are dominated by silica (SiO_2) and alumina (Al_2O_3), in general reflect only the abundance of phyllosilicates (clays) and quartz in the mineral matter. The characteristics of this coal indicate that the Amos peat accumulated in a swamp under constant, fresh water of low pH. The low-pH fresh water may account for most of the sulfur being fixed as organic sulfur. The fresh-water, low-pH conditions also explain the high vitrinite content, because of the high degree of preservation of organic material.

The upper bench of the Amos coal represents a departure from the protected environment of the Amos swamp. The upper bench is higher in sulfur and ash and lower in vitrinite, indicating increased detrital influx and the end of highly favorable peat-accumulating conditions.

The Foster coal is characterized as a low- to high-sulfur, low- to high-ash coal of variable but predomi-

nantly vitrinitic composition. The mineral matter is chiefly clay, with illite more abundant than kaolinite, and lesser quantities of pyrite and quartz. These characteristics suggest that the Foster peat accumulated in a less well-protected but predominantly fresh-water swamp environment. The variable ash and sulfur contents of the Foster coal are attributed to possible increased fluvial activity during Foster peat accumulation and to sulphate-bearing saline waters penetrating parts of the Foster swamp.

The paleoslope of the Amos and Foster swamps was to the southwest. South and east of the study area the coal beds are removed by recent erosion; to the west the dip of the Pennsylvanian rocks into the Moorman Syncline takes the coal beds to depths that prohibit mining under current economic constraints. The most likely direction for expanding the area of mining for the Amos and Foster coal beds is therefore to the north and possibly northwest along the strike of the Pennsylvanian rocks.

Currently, there is little subsurface data to indicate whether the Amos and Foster coal beds extend in these directions or whether similar occurrences of high-quality coal exist at depth. Stratigraphic tests drilled by the Kentucky Geological Survey (Williams and others, 1982) in the Flener Quadrangle did not positively identify the Amos or Foster coal beds, but future work in deeper parts of the basin is encouraged.

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APPENDIX 1: PALYNOLOGICAL ANALYSIS

Symbols

+	Observed, but not included in count	
I	Infrequent	< 0.5%
F	Frequent	0.5–2.0%
C	Common	2.1–5.0%
V	Very common	5.1–10%
A	Abundant	> 10%

Amos Coal

	Sample Numbers							
	7445	7449	7450	7451	7452	7453	7454	7489
<i>Acanthotriletes triquetrus</i>				+				
<i>Alatisporites pustulatus</i>						+		
<i>Anapiculatisporites spinosus</i>						I		
<i>Apiculatisporites adbinus</i>						I		
<i>Apiculatisporites spinosaetosus</i>				+				
<i>Calamospora breviradiata</i>							I	F
<i>Calamospora pallida</i>		F	I		+			
<i>Calamospora parva</i>						C	F	F
<i>Calamospora microrugosa</i>	+					+		
<i>Calamospora</i> sp.							+	I
<i>Cirratiradites satumi</i>				+				
<i>Crassispora kosankei</i>	+			I		+		
<i>Cristatisporites indignabundus</i>	V		F	V			V	V
<i>Cyclogranisporites aureus</i>				+		I		
<i>Densosporites annulatus</i>	+	F		I	I	+		
<i>Densosporites sphaerotriangularis</i>	+						F	
<i>Dictyotriletes bireticulatus</i>	F		F	I	+	F	F	I
<i>Dictyotriletes falsus</i>						+		
<i>Dictyotriletes muricatus</i>						I		
<i>Endosporites globiformis</i>	I		I	F	+		+	C
<i>Florinites mediapudens</i>		I			F	F	F	
<i>Florinites pumicosus</i>		I						
<i>Florinites</i> cf. <i>F. florini</i>				F				
<i>Granulatisporites adnatoides</i>			F					
<i>Granulatisporites granulatus</i>				I		F		
<i>Granulatisporites microgranifer</i>							I	
<i>Grimmosporites varioreticulatus</i>	+							
<i>Laevigatosporites minor</i>	V	C	C	F	C	V	C	V
<i>Laevigatosporites minutus</i>				I				
<i>Leiotriletes sphaerotriangularis</i>								I
<i>Leiotriletes</i> cf. <i>L. priddyi</i>	C	I	F	I	I			
<i>Leiotriletes</i> sp.							+	
<i>Lophotriletes</i> cf. <i>L. microsaetosus</i>		I						
<i>Lycospora pusilla</i>	A	A	A	A	A	A	A	A
<i>Microreticulatisporites harrissonii</i>						+		
<i>Punctatosporites minutus</i>	C	A	C	V	F	F	V	C
<i>Punctatosporites minutus</i>	C	A	C	V	F			F
<i>Raistrickia fulva</i>				+	+			
<i>Raistrickia saetosa</i>			+					
<i>Reticulatisporites polygonalis</i>					+			
<i>Triquirites</i> cf. <i>T. protensus</i>								
<i>Verrucosisporites microverrucosus</i>							+	
<i>Verrucosisporites sifati</i>						+		
<i>Vestispora tortuosa</i>						+	I	

Amos Coal

	Sample Numbers							
	7552	7701	7704	7705	7706	7707	7708	7709
<i>Ahrensisporites guerickei</i>						+		
<i>Alatisporites hoffmeisteri</i>		+						
<i>Anapiculatisporites minor</i>		+						
<i>Apiculatisporis adbitus</i>		F						
<i>Apiculatisporis spinosaetosus</i>		F						+
<i>Apiculatisporites spinulistratus</i>	+	+						+
<i>Calamospore breviradiata</i>		+	+	+				
<i>Calamospore pedata</i>			I					
<i>Calamospore microrugosa</i>			+					
<i>Calamospore pallida</i>		+		+	+	F		
<i>Calamospore parva</i>	C	F		I	+	F	I	
<i>Calamospore perrugosa</i>	C		C		C		F	I
<i>Camptotriletes</i> sp.				+				
<i>Cingulizonatisporites loricatus?</i>	I							
<i>Confolutispora?</i> sp.					+			
<i>Crassispore kosankei</i>						+		+
<i>Cristatisporites indignabundus</i>		+	I	+	+			+
<i>Cyclogranisporites aureus</i>		C	V	V	+	C	I	V
<i>Cyclogranisporites minutus</i>		+		+				
<i>Densosporites annulatus</i>	F	+		+		C	F	
<i>Densosporites triangularis?</i>	+	I	+		+	+	I	
<i>Dictyotriletes bireticulatus</i>		+						
<i>Dictyotriletes densoreticulatus</i>	I	F	F		F	I	F	
<i>Dictyotriletes falsus</i>			I	+		I	+	+
<i>Dictyotriletes medioreticulatus</i>					+			
<i>Dictyotriletes muricatus</i>		+	+		+	+	I	
<i>Dictyotriletes</i> cf. <i>D. reticulcingulum</i>		+						
<i>Endosporites globiformis</i>	V	I	V	A	+		F	C
<i>Endosporites staplini</i>				+		+		+
<i>Endosporites zonalis</i>				F		C		
<i>Fabosporites minutus</i>		F			I			
<i>Florinites mediapudens</i>	F					+		
<i>Florinites pumicosus</i>				+				
<i>Florinites</i> cf. <i>F. florini</i>		I						+
<i>Granulatisporites adnatoides</i>		+	I					
<i>Granulatisporites granulatus</i>		+						
<i>Granulatisporites microgranifer</i>			F	I	I	F	F	I
<i>Granulatisporites?</i> sp.		+						
<i>Grumosporites varioreticulatus</i>								+
<i>Knoxisporites camosus</i>					+	+		
<i>Knoxisporites?</i> sp.							+	
<i>Laevigatosporites minor</i>	C	C	F	F	V	F	C	F
<i>Latosporites minutus</i>		F						
<i>Leiotriletes sphaerotriangularis</i>							+	+
<i>Lophotriletes</i> cf. <i>L. microsaetosus</i>				+				+
<i>Lycospora granulata</i>		+	+		F			
<i>Lycospora pusilla</i>	A	A	A	A	A	A	A	A
<i>Punctatisporites minutus</i>				I				I
<i>Punctatisporites obesus</i>				+				
<i>Punctatisporites sinuatus</i>								+
<i>Punctatisporites</i> sp.			+					
<i>Punctatosporites minutus</i>	V	C	C	V	F	V	I	C
<i>Raistrickia fulva</i>				+	I	+	+	
<i>Raistrickia saetosa</i>	I	+						+
<i>Reinschospore triangularis</i>			+		+			

Amos Coal

Amos Coal	Sample Numbers							
	7552	7701	7704	7705	7706	7707	7708	7709
<i>Reticulatisporites polygonalis</i>		I		+			+	+
<i>Reticulatisporites reticulatus</i>		+	+					
<i>Savitrissporites nux</i>			+	+			+	+
<i>Spackmanites facierugosus</i>				+		I	I	
<i>Spencerisporites radiatus</i>						+		
<i>Triquitrites</i> cf. <i>T. protensus</i>		+				+		
<i>Verrucosisporites donarii</i>		+						
<i>Verrucosisporites verrucosus</i>					+	+	+	+
<i>Vestispora tortuosa</i>		+				+		

Amos Rider

	Sample Numbers	
	7490	7573
<i>Acanthotriletes echinatus</i>	F	
<i>Calamospora pallida</i>	F	F
<i>Calamospora parva</i>		F
<i>Calamospora</i> sp.	I	
<i>Crassispora kosankei</i>		I
<i>Cristatisporites indignabundus</i>	V	C
<i>Cyclogranisporites aureus</i>		I
<i>Densosporites annulatus</i>	C	I
<i>Densosporites pseudoannulatus</i>		I
<i>Densosporites sphaerotriangularis</i>	C	F
<i>Dictyotriletes bireticulatus</i>	I	F
<i>Dictyotriletes castaneaeformis</i>		F
<i>Endosporites globiformis</i>	+	C
<i>Endosporites zonalis</i>		+
<i>Florinrites</i> cf. <i>F. florini</i>	I	I
<i>Granulatisporites commissuralis</i>	I	
<i>Granulatisporites granulatus</i>	F	
<i>Laevigatosporites minor</i>	C	A
<i>Lophotriletes microsaetosus</i>		I
<i>Lycospora pusilla</i>	A	A
<i>Punctatisporites minutus</i>	V	
<i>Punctatisporites minutus</i>	F	V
<i>Reticulatisporites polygonalis</i>		F
<i>Verrucosporites sifati</i>	+	
<i>Verrucosporites</i> sp.		I
<i>Vestispora tortuosa</i>		I

Foster Coal

	Sample Numbers							
	7446	7447	7448	7455	7456	7491	7492	7517
<i>Acanthotriletes</i> sp.						I		
<i>Alatisporites hoffmeisteri</i>		+						
<i>Apiculatisporis abditus</i>	+					I		
<i>Apiculatisporis spinosaeosus</i>								+
<i>Apiculatisporites spinulistratus</i>		+	I					
<i>Calamospora breviradiata</i>			+		C			
<i>Calamospora microrugosa</i>	F							F
<i>Calamospora pallida</i>						F	F	
<i>Calamospora parva</i>	F	I	C	C	F			+
<i>Calamospora pedata</i>			I					
<i>Calamospora</i> sp.		I		+				
<i>Cirratriletes satumi</i>						F		
<i>Cirratriletes</i> sp.								
<i>Crassispora kosankei</i>					+			
<i>Cristatisporites indignabundus</i>	C	F	+	+	+		F	F
<i>Cyclogranisporites minutus</i>	F	F	F	I				I
<i>Densosporites annulatus</i>					F			F
<i>Densosporites sphaerotriangularis</i>		+	+	+	F			
<i>Dictyotriletes bireticulatus</i>	I	+	+	F			+	+
<i>Dictyotriletes medioreticulatus</i>				+				
<i>Dictyotriletes muricatus</i>	+		+					+
<i>Dictyotriletes reticulocingulum</i>				+				
<i>Endosporites globiformis</i>	+	F	F		+	F		+
<i>Endosporites zonalis</i>								+
<i>Florinites mediapudens</i>	+	C	C		F	I	I	F
<i>Florinites</i> sp.					F			
<i>Granulatisporites granulatus</i>								I
<i>Laevigatosporites minor</i>	F	C	F	F	C	C	I	F
<i>Latosporites minutus</i>								C
<i>Leiotriletes sphaerotriangularis</i>								+
<i>Leiotriletes</i> cf. <i>L. priddyi</i>						F		
<i>Lophotriletes microsaetosus</i>	I					I		
<i>Lycospora pusilla</i>	A	A	A	A	A	A	A	A
<i>Microretulatisporites nobilis</i>		+						
<i>Planisporites latigranifer</i>								I
<i>Punctatisporites minutus</i>						I		
<i>Punctatisporites</i> sp.								+
<i>Punctatosporites minutus</i>	C	A	V	V	A	A	C	A
<i>Raistrickia fulva</i>			+					
<i>Raistrickia saetosa</i>				+	+			+
<i>Reticulatisporites polygonalis</i>	+							
<i>Reticulatisporites reticulatus</i>		+						+
<i>Savitrissporites nux</i>								+
<i>Triquirites</i> sp.						+		
<i>Verrucosissporites microtuberosus</i>			+	+				+
<i>Verrucosissporites microverrucosus</i>								+
<i>Verrucosissporites monilatus?</i>	+							
<i>Verrucosissporites sifati</i>						I		
<i>Vestispora tortuosa</i>						I	+	

Foster Coal

	Sample Numbers						
	7571	7574	7575	7576	7613	7702	7703
<i>Ahrensiporites guerickei</i>							+
<i>Anapiculatisporites spinosus</i>		I				+	
<i>Anaplanisporites minor</i>				+			
<i>Apiculatisporis abditus</i>	I					+	
<i>Apiculatisporis aculeatus</i>						+	
<i>Apiculatisporis</i> cf. <i>A. latigranifer</i>			I	+		+	
<i>Apiculatisporites spinulistratus</i>						+	
<i>Calamospora brevibradiata</i>							+
<i>Calamospora microrugosa</i>		F				F	
<i>Calamospora mutabilis</i>			+				
<i>Calamospora pallida</i>	I			I	F	F	F
<i>Calamospora parva</i>	F			C		F	F
<i>Calamospora</i> sp.			C				
<i>Cirratriletes satumi</i>						+	+
<i>Convolutispora?</i> sp.							+
<i>Crassispora kosankei</i>				I	F	F	I
<i>Cristatisporites indignabundus</i>				+			+
<i>Cyclogranisporites aureus</i>	F	I		+	+	+	+
<i>Cyclogranisporites minutus</i>	I			I	C	+	+
<i>Cyclogranisporites</i> sp.					F		
<i>Densosporites annulatus</i>		V	+		+	F	
<i>Densosporites sphaerotriangularis</i>						+	+
<i>Dictyotriletes bireticulatus</i>		C	+				
<i>Dictyotriletes falsus</i>				+			
<i>Dictyotriletes muricatus</i>		+					
<i>Endosporites globiformis</i>	V				V	C	V
<i>Florinites mediapudens</i>	F	V	F		C	+	
<i>Florinites millotti</i>	I		F		F	I	+
<i>Florinites pumicosus</i>						+	
<i>Florinites</i> cf. <i>F. florini</i>				C			
<i>Granulatisporites granulatus</i>	F	F		I	+		I
<i>Granulatisporites microgranifer</i>						F	
<i>Laevigatosporites minor</i>	I	F	C	F	C	C	I
<i>Leiotriletes sphaerotriangularis</i>	+		I			+	
<i>Leiotriletes</i> sp.							I
<i>Lophotriletes</i> cf. <i>L. gibbosus</i>	+						
<i>Lophotriletes</i> sp.		F					
<i>Lycospora granulata</i>						F	
<i>Lycospora pusilla</i>	A	A	A	A	A	A	A
<i>Punctatisporites minutus</i>		C		I	I	I	F
<i>Punctatosporites minutus</i>	A	A	C	C	A	A	V
<i>Raistrickia fulva</i>			+			+	
<i>Raistrickia saetosa</i>	I			+		+	+
<i>Raistrickia</i> cf. <i>R. superba</i>							+
<i>Reinschospora triangularis</i>			+			+	
<i>Reticulatisporites carnosus</i>				+			
<i>Reticulatisporites polygonalis</i>						+	
<i>Reticulatisporites reticulatus</i>	+		F				
<i>Spackmanites facientigostus</i>							
<i>Triquitrites</i> cf. <i>T. protensus</i>							+
<i>Vermicosporites donati</i>							+
<i>Vermicosporites microtuberosus</i>						+	
<i>Vermicosporites sifati</i>		+		+			+
<i>Vermicosporites verrucosus</i>				+		+	
<i>Vestispora pseudoreticulata</i>	+						
<i>Vestispora tortuosa</i>							+
<i>Wilsonites</i> cf. <i>W. delicatus</i>					I		
						+	