UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Text to accompany:

OPEN-FILE REPORT 79-301

1985

FEDERAL COAL RESOURCE OCCURRENCE AND FEDERAL COAL DEVELOPMENT POTENTIAL MAPS OF THE KREBS 7.5-MINUTE QUADRANGLE, PITTSBURG COUNTY, OKLAHOMA

[Report includes 15 pages]

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INTRODUCTION

Purpose

This text is to be used in conjunction with the Federal Coal Resource Occurrence (FCRO) and Federal Coal Development Potential (FCDP) Maps of the Krebs 7.5-minute quadrangle, Pittsburg County, Oklahoma.

This report was compiled to support the land-planning work of the Bureau of Land Management (BLM). The work was undertaken by Geological Services of Tulsa, Inc., Tulsa, Oklahoma, at the request of the United States Geological Survey under contract number 14-08-0001-17989. The resource information gathered for this report is in response to the Federal Coal Leasing Amendments Act of 1976 (Public Law 94-377). Published and unpublished publicly available information was used as the data base for this study. No new drilling or field mapping was done to supplement this study, nor was any confidential or proprietary data used.

Location

The Krebs 7.5-minute quadrangle is located in the southern part of the Oklahoma coal field, near the center of the McAlester mining district (Trumbull, 1957; Hendricks, 1937). This district is within the southwestern part of the Arkoma basin (McAlester basin or McAlester coal basin in earlier publications). The quadrangle lies entirely within Pittsburg County; the northeast corner of McAlester, the county seat, is on the western edge of the map. This study area is approximately 100 miles south of Tulsa and 60 miles southeast of Muskogee, near the south end of Eufaula Lake.

Accessibility

U. S. Route 270 runs generally east - west through McAlester and Krebs, and crosses the southern part of the quadrangle; U. S. Route 69 (between Sherman, Texas, and through Muskogee to nrotheast Oklahoma) runs northeast through McAlester, near the northwest edge of the quadrangle. The town of Krebs lies approximately 1 mile east of the intersection of these highways, northeast of McAlester.

The small communities of Alderson and Bache, in the southern third of the quadrangle, are located on U. S. 270 and on the Chicago, Rock Island and Pacific Railroad, which parallels the highway. The Missouri-Kansas-Texas Railroad east-west through the smaller communities of Richville and Carbon. State Highway 31 is merged with U. S. 270 coming east through McAlester, continues east through Krebs to near the center of the quadrangle, then proceeds northeast to follow the margin of Eufaula Lake.

Secondary ("section line") roads generally occur two to three miles apart, and skirt the most rugged terrain. A few short unimproved roads lead to relatively isoalted home sites, lakes, recreation areas, or gas well locations.

Physiography

The Krebs quadrangle is situated in the southern part of the Arkansas Valley physiographic province. This valley occupies the Arkoma structural basin north of the Ouachita mountains, south of the Ozark mountains, east of the central Oklahoma platform and northeast of the Arbuckle mountains; it is drained by the Arkansas and Canadian rivers. The general drainage for this portion of the province is north, toward the Canadian River; this is modified by the influence of Eufaula Lake, which occupies the lower portion of several major tributary systems into the Canadian River. One of these tributaries is Mud Creek, flowing southeast toward the center of the Krebs quadrangle, where it turns northeast and enters Eufaula Lake in the northeast quarter of the quadrangle.

Structural influence on the topography is obvious (Plate 1); curving hogback ridges alternating with asymmetrical valleys, or steep knobs and elongate hills occurring in series, outline the major structural elements. Topographic relief ranges between 150 and 200 feet (46 to 61 m) in the southern half to greater than 300 feet (91 m) in the northern third of the quadrangle. On the steeper faces of the ridges intermittent stream valleys are relatively short, straight, and deeply incised. Longer, gently meandering, intermittent streams are found in the valleys between the ridges; these join through steep narrow gaps before entering the floodplain of Mud Creek. Drainage along and into Mud Creek is meandering and partly incised. The normal pool elevation of Eufaula Lake is 585 feet (178 m). Maximum elevations are represented by Bald Knob, in the southeast corner of the quadrangle, at greater than 790 feet (240 m) and Pine Knob, in the north center, which attains over 950 feet (289 m) of elevation. The Mud Creek channel is above 650 feet (198 m) on the west edge of the area and drops below 590 feet (179 m) where it enteres Eufaula Lake.

Climate and Vegetation

The climate in southeastern Oklahoma is for the most part fairly moderate. Winters are short, and extremely cold weather is rare. Summers, however, are generally long and hot. The mean annual temperature is about 62°F (17°C), and ranges from a daily average of about 41°F (5°C) in January to about 82°F (28°C) in July though it is not unusual to have occasional periods of very hot days (Hendricks, 1939). Annual precipation in the area averages approximately 41 in (105 cm), with rains generally abundant in the spring, early summer, fall and winter (Hendricks, 1939). (The above temperature and precipitation figures were confirmed with the Tulsa office, U. S. Department of Commerce, N.O.A.A., on 11/25/80).

The area supports a wide variety of vegetation, with oaks, blackjacks, hickories elms and hackberries being most common. On the higher mountains and ridges pines can also be found. In parts of the valleys that have not been cleared for farming, thick stands of water and willow oaks, hickories, cottonwoods, willows and wild plums may be present.

Land Status

The Federal government owns coal rights to approximately 16,105 acres of land in the Krebs quadrangle (Plate 2). Approximately 3,815 acres were leased as of October 19, 1979. The Krebs Known Recoverable Coal Resource Area (KRCRA) lies within the non-leased Federal coal lands (Plate 1) in sections 12 and 13, T. 5 N., R. 15 E. and sections 17 and 18, T. 5 N., R. 16 E.

GENERAL GEOLOGY

Previous Work

Much work has been done on the southeastern Oklahoma coal field. The first geologic study of the Choctaw coal field was published by Chance (1890) and included a map showing the outcrops of the most important coal beds in the area. In 1897, Drake published the results of his study on the coal fields of the Indian Territory, which consisted of a map and text of the principal coal beds, general stratigraphy and structural features.

From 1899 to 1910, Taff and his associates published several reports on the Oklahoma coal lands. These included a number of investigations carried out for the United States Geological Survey on the extent and general character of local stratigraphy, including coal beds. Much of his work was a part of Senate Document 390 (1910), which represented a compilation of material collected for the purpose of determining the value and extent of coal deposits in and under the segregated coal lands of the Choctaw and Chickasaw Nations in Oklahoma.

The Oklahoma Geological Survey published a bulletin by Snider in 1914 on the geology of east-central Oklahoma, emphasizing the geologic structure and oil and gas possibilities of the area. Further studies on the southern Oklahoma coal lands were carried out by Shannon and others (1926), Moose and Searle (1929), and Hendricks (1939). These, along with later works by Knechtel and Oakes in the 1940's,added greatly to the body of knowledge on Oklahoma coals, particularly in terms of their quality, chemical composition and extent.

A number of estimates as to original and remaining coal reserves have been published, among them are the figures published in papers by Trumbull (1957) and Friedman (1974). Non-proprietary information from coal test holes drilled in various years in the Krebs quadrangle was obtained from USGS files.

Stratigraphy

The Arkoma Basin, once part of the larger Ouachita geosyncline, formed as a result of subsidence beginning in Mississippian time and continuing through Early and Middle Pennsylvanian. Strata in the basin are thought to have been deposited in a deltaic environment with sediment coming primarily from eroding highlands to the northeast, north, and northwest (Branan, 1968). Evidence that the basin was becoming full is provided by coal seams in the upper Atoka and lower Desmoinesian section. Sedimentation continued until late Pennsylvanian time, when the Arbuckle Orogeny of southern Oklahoma took place (Branan, 1968). In early Permian time, Ouachita mountain building to the south of the basin compressed Arkoma Basin strata into a series of long, narrow, east-west anticlinal and synclinal folds (see section on Structure below).

Most of the rock units encountered in the Krebs quadrangle are of Pennsylvanian age, and include the Atoka Formation, as well as the Hartshorne, McAlester, Savanna and Boggy formations of the Lower Desmoinesian Krebs Group. All of these formations contain coal beds, ranging from less than 1 inch (2.5 cm) to more than 6 feet (1.8 m) thick. The Krebs quadrangle is part of the McAlester coal district (Dane and others 1938).

The Atoka Formation was named by Taff and Adams (1900). It is exposed in the Krebs quadrangle along the axis of the Adamson Anticline (Plate 1). Outcrops of the formation in the McAlester district consist mostly of light to dark gray, sandy, micaceous shale containing fragmental plant material and interbedded with sandstone. The sandstone is highly variable in character, both from bed to bed and within a single bed. In most exposures it is brown, fine-grained, highly micaceous, contains plant fragments, and is irregularly bedded; however, locally it may be course-grained, pure white, and massive to thick-bedded. The exposed portion of the Atoka Formation is about 2000 feet (610 m) thick (Hendricks, 1937).

The Hartshorne Formation is the basal unit of the Desmoinesian Series. It is most probably conformable with the underlying Atoka formation (McDaniel, 1961, Oakes and Knechtel, 1948). although the sharp and irregular contact between the Hartshorne and Atoka formations has lead some observers to conclude that a minor unconformity separates them, at least locally (Hendricks, 1939, and Branson, 1962). The contact between the Hartshorne Formation and the overlying McAlester Formation is conformable (Hendricks, 1939).

The boundaries of the Hartshorne Formation have been modified several times since the unit was first mapped by H. M. Chance in 1980. Then called the "Tobucksy" Sandstone, the formation was renamed the Hartshorne Sandstone by Taff in 1899. Early workers limited the formation such that the Upper Hartshorne coal was considered to be part of the McAlester Formation. However, Oakes and Knechtel (1948) recognized a convergence of the Upper and Lower Hartshorne coals in northern LeFlore and eastern Haskell counties, and redefined the Hartshorne formation to include both coals. The Hartshorne coal, undivided to the north, splits into Upper and lower Hartshorne coals along a northeast-southwest trending line. This split line is north of the Krebs quadrangle. The presently used definition of the Hartshorne Formation is one proposed by McDaniel (1961), which supports the boundaries suggested by Oakes and Knechtel (1948), but formally divides the formation into upper and lower members where applicable (based on the above mentioned coal "split line").

The Hartshorne Formation is highly variable in character and thickness, throughout the McAlester district. The sands are fine-grained, white to light gray, silty and micaceous; the shales are gray and sandy. Plant fossils are abundant, especially in the intervening shales. The lower sandstone is massive and persistent; the middle shale and upper sandstone are variable in thickness and frequently intergrade laterally. Thickness of the Hartshorne sandstones with intervening shale averages between 160 feet (48 m) and 300 feet (91 m) in the McAlester district (Hendricks, 1937). Total formation thickness is roughly 350 feet (106 m) in the Krebs quadrangle, including the Upper Hartshorne coal and underlying shale.

The McAlester Formation averages about 1900 to 2400 feet (579 to 632 m) thick in the McAlester district; Contact with the underlying Hartshorne Formation is considered to be gradational and conformable. The formation apparently thins northeastward into the Quinton-Scipio and Howe-Wilburton districts, compaction of the shales, but is partly due to the unconformity with the overlying Savanna Formation (Hendricks, 1937). The McAlester Formation consists basically of shale units alternating with several persistent sandstone members. In the Krebs quadrangle, this formation may be subdivided into three parts: upper and lower divisions consisting primarily of shale and a middle division containing three relatively prominent sandstones.

The lowermost unit of the McAlester Formation is the McCurtain Shale member, a dark-gray, clayey shale with numerous siderite concretions and plant material (Hendricks, 1939). The McCurtain Shale Member contains a few thin sandstone units, including a locally persistent thin sandstone with an associated unnamed coal found approximately 200 feet (61 m) above the base of the shale.

The middle subdivision of the McAlester Formation varies from 500 feet (152 m) to over 1,000 feet (305 m) in thickness. In ascending order, it includes the Warner Sandstone Member, an unnamed shale, the Lequire Sandstone Member, an unnamed shale, and the Cameron Sandstone Member. The shale units range from light gray and sandy to dark gray and carbonaceous; these shales are generally lighter and more sandy than those of the upper or lower McAlester.

The three sandstone members are buff, fine-grained, massive to thinly and regularly bedded, and ripple-marked. The upper sandstone is thickest near Krebs and Carbon (Hendricks, 1937). Thin local coals may be found in the shale just above the sandstone units. The local coal above the Lequire sandstone is commonly noted in the subsurface of the Krebs quadrangle (Plate 3).

The upper portion of the McAlester Formation, in ascending order, consists of the following units: an unnamed shale (containing the Lower McAlester coal, Upper McAlester coal and a local coal), the Tamaha sandstone member (not distinguished as a unit in the Krebs quadrangle), an unnamed shale unit, the Keota sandstone member, and the upper McAlester unnamed shale unit. Thickness of this upper portion averages about 560 feet (171 m) in the northeastern part of the McAlester district (Hendricks, 1937). Well logs indicate roughly 600 feet (183 m) of thickness in the Krebs quadrangle. These upper shales are generally logged as blue or lightcolored. From outcrops in the McAlester district, the shales associated with the McAlester coals and those above the Keota sandstone are described as dark, carbonaceous, and containing plant fragments or marine and brackish invertebrate fossils. Occasionally, one or more thin fossiliferous limestones are described from these intervals (Hendricks, 1937). The Tamaha and Keota sandstone members are discontinous or lenticular units; each is made up of one to three thin sandstone beds that may thicken and unite or intergrade with sandy shale.

Strata of the Savanna Formation occur as a series of alternating shale and sandstone bands in the east center, the southwest quarter, and southern edge of the quadrangle (Hendricks, 1937). Within this sequence may be found thin local coal seams and thin, discontinous, fossilferous limestones. Ridges of Savanna sandstones outline the McAlester Anticline, the Krebs and

Kiowa synclines, and curve across the raised central portion of the Savanna Anticline (Plate 1).

Sandstones predominate in the lower half of the Savanna Formation. They are highly variable in character from place to place. The upper, more lenticular, sandstones seldom exceed 20 feet (6 m) in thickness; these may be massive or strongly cross-bedded, gray, yellow, or white, gritty, coarse to fine-grained, quartzose, with abundant grains or white chert. Some of these thicker sandstones occur as lumps or masses formed as rolled lenses or in concentric sheets. Thinner beds average 1 foot in thickness (0.3 m) and vary from massive to platy or thin-bedded; these thinner beds may contain marine invertebrate casts or plant fragments. They frequently occur as a unit interbedded with sandy clay or shale.

More than half of the Savanna Formation consists of blocky, drab gray or greenish-yellow, sandy, micaceous clay containing small siderite concretions, or gray to black carbonaceous shale. Thin fossiliferous limestone beds also occur in some shaly horizons between sandstones within the lower half of the formation. The approximate outcrop of a local coal (Plate 1), tentatively correlated with the Cavanal Coal, has been mapped in the Savanna beds in the western portion of the quadrangle (Hendricks, 1937).

The nature of the contact between the Savanna and McAlester formations is not well exposed in the Krebs quadrangle. It is believed to be irregular and to represent an unconformity which is more clearly demonstrated in other areas of the McAlester district (Hendricks, 1937).

The Boggy Formation is the upper unit of the Krebs Group in the Desmoinesian Series; it consists of thin sandstone beds alternating with thick shales. It lies conformably on the Savanna Formation and is the youngest Pennsylvanian unit exposed in the Krebs quadrangle. The base of the Boggy is defined to be the base of the Bluejacket Sandstone or its equivalent (Russell, 1960; Oakes, 1977, Friedman, 1978). Gently dipping strata of the Boggy Formation occupy the Talawanda Syncline and the eastern end of the Krebs Syncline (Plate 1). In general, the sandstones are too poorly defined for topographic expression or precise stratigraphic correlation. They are characterized by lenticularity and lateral changes in lithology. They range from fine-grained, thin-bedded, platy, and ripple-marked to coarse-grained and massive; many contain marine invertebrate fossils or borings. The shales are generally dark, platy to blocky, and carbonaceous containing invertebrate fossils. Plant fragments are common at the top and base of the formation. About 20 feet (6.1 m) above the basal sandstone unit is a thin unnamed coal bed, mined locally in the past in the McAlester district. Approximately 50 feet (15 m) above this same basal unit is the Secor coal (Hendricks, 1937) which has been mined in the adjoining Blocker area. The upper part of the Boggy Formation has been removed by erosion, and surface weathering makes it difficult to trace and correlate strata in the sequence above the Secor coal.

Quaternary deposits of recent alluvium occupy some stream valleys and flood plains in the Krebs area. The alluvium is a gray sandy silt ranging in thickness from a few inches at the edges of floodplains to over 25 feet (7 m) where stream channels have cut down into the deposit. In the Krebs area, these deposits sometimes overlie older high-level sands, gravel and clay termed the Gerty Sand (Taff, 1899), from the town of Gerty, Oklahoma. It has been determined that the Gerty Sand represents earlier floodplain deposits of the Canadian River. A remnant of this older deposit is found southeast of Krebs (Hendricks, 1937).

In the northeast corner of the quadrangle, a portion of Lake Eufaula presently occupies the valley of Mud Creek (Plate 1).

Structure

The Krebs quadrangle is located in the northeastern part of the McAlester district (Hendricks, 1938) and adjoins the southeastern corner of the Quinton-Scipio mining district (Dane, et al, 1938). These districts lie within the Arkoma Basin, a larger zone of folded Pennsylvanian rocks that are characterized by broad, shallow synclines and narrow anticlines (Dane, et al 1938; Russell, 1960). The axes of these structures are commonly en echelon, and in general seem parallel to the frontal margin of the adjacent Ouachita salient marked by the Choctaw Fault. Major surface structures in the Krebs quadrangle are shown on Plate 1.

The basic pattern of structures is formed by a series of anticlines and synclines with axes trending northeast-southwest. This pattern is modified by a major thrust fault system aligned east-west across the center of the quadrangle. The eastern end of the Penitentiary Fault crosses the western half of the quadrangle through Sections 29 to 36, T. 6 N., R. 15 E. Thrusting is toward the north and the fault trace approximates the axis of the McAlester Anticline, with dips on the south (overthrust) side measured at 12° to 22°. Approximately two miles south of the end of the Penitentiary Fault, the west end of the Carbon Fault (a major northward overthrust) produces a series of overturned beds. The Carbon Fault trace occupies the approximate axis of the Adamson Anticline and the overturned beds, at the nose of this anticline, exhibit as much as 70° dip. The Krebs Syncline crosses the Krebs quadrangle in an east-northeast direction between the ends of the previously-described faults. The Savanna Anticline occupies the southwest corner of the quadrangle; the axis extends northeast and terminates on the southwest flank of the Adamson Anticline. The Talawanda Syncline crosses the northern edge of the area, swinging southward from the corners toward the center of the quadrangle.

COAL GEOLOGY

Several major coal beds have been identified and mapped in the Krebs quadrangle. They include in ascending order: the Upper and Lower Hartshorne coal beds, two unnamed local coals, the Lower McAlester (Stigler) coal bed, and the Upper McAlester (Stigler Rider) coal bed. Local coals in the Savanna and Boggy formations have been tentatively identified in prospect pits. The outcrop of the Secor coal shown on Plate 1 has been approximated, since surface exposures are weathered or obscured by alluvium.

In the Krebs quadrangle, there were measurements of four local coals which exceed the Reserve Base thickness of 1 foot (0.3 m) which have been treated as isolated data points (see below). They include two local coals measured in data point 5, one measured in data point 6, one measured in data point 31 and one measurement of the Upper McAlester coal exceeding 1 foot in data point 32 (see Plate 1 for location and Plate 3 for correlations).

Upper and Lower Hartshorne Coal Beds

The Hartshorne coals occur at or near the top of the Hartshorne Sandstone Formation. The split line for the Hartshorne coal bed runs roughly east-west across the lower portion of the Quinton-Scipio coal mining district. North of this line only one coal seam is present; south of it the seam is split into Upper and Lower Hartshorne coals. The Krebs quadrangle lies south of the split line. The structures of these coals are presented on Plate 9, and the thickness of the interburden between the upper and lower splits is shown on Plate 10. The interburden ranges from less than 40 feet (12 m) to more than 100 feet (30 m), thickening as a wedge to the southwest.

The Hartshorne coals have been mined along the outcrop. The location and extent of the mines (Plate 1) reflects the structural control and intensity of dip of strata. The Lower Hartshorne coal crops out at the base of a prominent ridge formed by the more massive lower sandstone in the Hartshorne Formation. which outlines the Adamson Anticline in T. 5 N., R. 16 E. In T. 5 N., R. 15 E. this coal is exposed in a saddle between Upper and Lower Hartshorne sandstone ridges; the Upper Hartshorne coal outcrops are traced along the base of this outer sandstone ridge. Slope and shaft mining, much of it now abandoned, was mostly shallow as a result of steep dips. Preferential mining of the Lower Hartshorne coal, which is usually thicker, has more or less limited mining of the Upper Hartshorne coal to the vicinity of its outcrop (Hendricks, 1937).

Isopach measurements of the Upper and Lower Hartshorne coal beds are presented on Plate 4; both coals average over 2.5 feet (0.76 m) in thickness where they are mined. Well log data indicate three areas where at least one of the coals may be thicker than 5 feet (1.5 m) with a combined upper and lower coal thickness greater than 9 feet (2.7 m).

Unnamed Local Coal Beds

Two local coal beds occur in the McAlester Formation below the Lower McAlester coal (Plate 1, 3). Both coals are indicated on well logs; both are estimated to be as much as 2 feet (0.61 m) in thickness. The lower coal occurs in a thin sandy zone or above a thin intermittent sandstone near the center of the McCurtain shale member. The upper coal is found at the base of the shale overlying the Lequire sandstone member, or within the upper sandy shale portion of the Lequire. Hendricks (1937) inferred an outcrop of the lower of these local coals ("coal in the Lower McAlester shale") in the southeast corner of the Krebs quadrangle (Plate 1).

Upper and Lower McAlester Coal Beds

Only a single McAlester coal was described and mapped by Hendricks (1937) in the Krebs area. Bore holes and mine measured sections indicate the seam was up to 4 feet (1.2 m) thick. More recent well log and USGS bore hole data (Plate 3) indicate two coals; the lower coal is estimted at 2.0 to over 6 feet (0.6 to 1.8 m), and the upper coal is 0.5 to 0.8 feet (0.15 to 0.24 m) where encountered. Consequently, the minable McAlester coal is carried as Lower McAlester (Stigler) coal on all accompanying plates. Since the Upper McAlester is consistently less than 1 foot (0.3 m) thick, the overburden, interburden, and structure surfaces were not drawn for this horizon. The interburden between these coals is generally 30 to 50 feet (9 to 15 m).

Unnamed Local Coal Beds, McAlester Formation

A persistent local coal occurs 100 to 130 feet (30 to 39 m) above the Lower McAlester coal. It is slightly thicker than the Upper McAlester coal, varying between 0.2 and 0.9 feet (0.06 and 0.27 m). One or two thin local coals, usually less than 1 foot thick, are occasionally found in bore holes at the approximate horizon of the Keota Sandstone (Plate 3).

Unnamed Local Coal Beds, Savanna Formation

Numerous local coals within the Savanna Formation are exposed in the

McAlester coal district southwest of the Krebs quadrangle; two of these were mined locally in the McAlester area. One of these was correlated tentatively with the Cavanal coal (Hendricks, 1937). The inferred outcrop of this coal is found on Plate 1; the coal was mined locally near McAlester, but thins eastward to less than 1 foot near Krebs. Several thin local coals or traces of coal are encountered in boreholes in T6N, R16E, apparently at this horizon (Plate 3).

Secor Coal Bed

The Secor coal bed has not been mined in the Krebs area. Hendricks (1937) inferred the outcrop line on this quadrangle, from two local slope mines stratigraphically located in the equivalent part of the Boggy Formation (Plate 1). Electric log data from one well drilled in the Talawanda Syncline on the north edge of the quadrangle indicate the possiblity of 3 feet (0.9 m) of Secor coal at approximately 210 feet (64 m) from the surface.

Chemical Analyses of Coal

Chemical analyses were available only for the Lower Hartshorne and Lower McAlester coals in this quadrangle. A summary of the analyses available is presented in Table 1. Average analyses are shown here, as well as the range for all samples used to calculate each average value.

The coal are listed according to Btu/lb, as determined on a moist, mineral-matter-free (mmf) basis. The "as received" Btu/lb values shown on Table 1 for the Lower McAlester coal were converted to moist mmf Btu/lb figures according to the following formula (American Society for Testing and Materials, 1975):

$$\text{Moist mmf Btu/lb} = \frac{\text{As rec'd Btu/lb} - 50\ S}{[100 - (1.08\ A + 0.55\ S)]} \times 100$$

where S = Sulfur, A = Ash

Based on the average Btu/lb shown on Table 1, the Lower McAlester is classified as high volatile A bituminous coals, with an average 14,837 moist mmf Btu/lb.

No heating values for the Lower Hartshorne coal were available, so its ranking was determined on a dry, mineral-matter-free fixed carbon basis, using the following formula (ASTM, 1980):

$$\text{Dry mmf fixed carbon} = \frac{\text{fixed carbon \%} - 0.15\ S}{[100\% - (M + 108\ A + 0.55\ S)]} \times 100$$

where M = Moisture, A = Ash, S = Sulfur.

Using this formula, the Lower Hartshorne coal has a fixed-carbon (mmf) percentage of 63, giving it a rank of high volatile bituminous.

Isolated Data Points

In instances where single or isolated measurements of coal beds thicker than 1.0 foot (0.3 m) are encountered, the standard criteria for construction of isopach, structure contour, mining ratio, and overburden isopach maps are not available. The lack of data concerning these beds limits the extent to which they can be reasonably projected in any direction, and usually precludes their correlation with other, better known beds. For this reason, isolated data points have been mapped on separate figures for non-isopached coal beds. These figures are not included in this report, but are kept on file at the BLM office in Tulsa. However, coal reserves from these isolated data points are included in tables 2 and 3, and in the Reserve Base tonnages shown on Plate 2.

Table 1. Average chemical analyses of coal in the Krebs quadrangle, Pittsburg County, Oklahoma

LOWER MCALESTER COAL BED					LOWER HARTSHORNE COAL BED	
ANALYSES %	FORM OF ANALYSIS	# OF SAMPLES	AVERAGE	RANGE	# OF SAMPLES	AVERAGE
PROXIMATE						
Moisture	A	25	2.8	1.0-3.6	1	1.04
Volatile Matter	A	25	36.5	32.4-39.8	1	38.0
	C	5	35.6	33.8-36.8	1	39.1
Fixed Carbon	A	25	55.6	52.7-58.5	1	58.8
	C	5	58.8	57.5-60.2	1	57.8
Ash	A	25	6.6	4.2-7.0	1	5.2
	C	5	5.6	4.8-7.3	1	3.1
ULTIMATE						
Sulfur	A	24	0.8	0.5-2.4	1	2.0
	C	5	0.6	0.5-0.7	1	0.8
Hydrogen	A	5	5.3	5.2-5.4	-	---
	C	5	5.1	5.0-5.2	-	---
Carbon	A	5	77.3	75.6-78.2	-	---
	C	5	79.8	78.1-80.8	-	---
Nitrogen	A	5	1.8	1.6-1.9	-	---
	C	5	1.8	1.7-2.0	-	---
Oxygen	A	5	9.8	8.9-10.1	-	---
	C	5	7.1	6.5-7.4	-	---
HEATING VALUE						
Calories	A	15	7,677	7,478-7,778	-	---
	C	5	7,889	7,737-7,967	-	---
Btu/lb	A	20	13,886	13,480-13,870	-	---
	C	5	14,200	13,920-14,340	-	---

Form of Analyses: A = as received, C = moisture-free.

NOTE: To convert Btu/lb to kj/kg, multiply by 2.324.

Source of information presented in this table: Hendricks, 1937, Shannon, et al, 1926.

All isolated data points in the Krebs quadrangle are measurements of unnamed local coals, with the exception of one measurement of the Upper McAlester coal in data point 32.

COAL RESOURCES

Data from drill holes, mine measured sections, outcrops, well logs and mine maps were used to construct outcrop, isopach, and structure contour maps of the various coal beds in the Krebs quadrangle (see below). The source of each indexed data point shown on Plate 1 is listed in Appendix I at the end of this report.

A system for classifying coal resources has been published by the U. S. Bureau of Mines and the U.S. Geological Survey, and published in U.S. Geological Survey Bulletin 1450-B (1976). Under this system, resources are classified as either Identified or Undiscovered. Identified Resources are specific bodies of coal whose location, rank, quality and quantity are known from geologic evidence supported by specific measurements, while Undiscovered Resources are bodies of coal which are thought to exist, based on broad geologic knowledge and theory.

Identified Resources may be subdivided into three categories of reliability of occurrence, according to their distance from a known point of coal-bed measurement. In order of decreasing reliability, these categories are: measured, indicated and inferred. Measured coal is that which is located within 0.25 mile (0.4 km) from a measurement point, indicated coal extends 0.5 mile (0.8 km) beyond measured coal to a distance of 0.75 mile (1.2 km) from the measurement point, and inferred coal extends 2.25 miles beyond indicated coal, or a maximum distance of 3 miles (4.8 km) from the measurement point.

Undiscovered Resources may be either hypothetical or specultaive. Hypothetical resources are those undiscovered coal resources that may reasonably be expected to exist in known coal fields under known geologic conditions. They are located beyond the outer boundary of inferred resources (see above) in areas where the coal-bed continuity is assumed, based on geologic evidence. Hypothetical resouces are those more than 3 miles (4.8 km) from the nearest measurement point.

Speculative resources are Undiscovered Resources that may occur in favorable areas where no discoveries have yet been made. Speculative resources have not been estimated in this report.

Coal resources for the Lower McAlester coal and the Upper and Lower Hartshorne coals were calculated using data obtained from their coal isopach maps (Plates 4 and 8 respectively). The coal-bed acreage (measured by planimeter and calculated using the trapezoidal method [modified from Hollo and Fifadara, 1980]) multiplied by the average thickness of the coal bed, and by a conversion factor of 1800 short tons of coal per acre-foot (13,238 metric tons per hectare-meter) for bituminous coal yields to coal resouces in short tons. Coal resouces tonnages were calculated for Identified Resources in the measured, indicated, and inferred categories, and Undiscovered Resources in the hypothetical category, for unleased Federal coal lands. All coal beds thicker than 1 foot (0.305 m) that lie less than 3000 feet (914 m) below the ground surface are included in these calculations. These criteria differ from those stated in U.S. Geological Survey Bulletin 1450-B, which calls for a minimum thickness of 28 inches (70 cm) and a maximum depth of

1000 feet (305 m) for bituminous coal. Narrow strips between mines where undisturbed coal is less than 75 meters from the nearest mine are considered to have no reserves and are included within mined-out areas. Mine boundaries are only approximately located (as stated in the legend on Plate 1) and therefore these narrow areas may in reality not even exist. For this reason they are considered to have no reserves, and have not been planimetered.

Reserve Base and Reserve tonnages for the above mentioned coal beds are shown on Plates 9, 10, 14, 19 and 20, and have been rounded to the nearest 10,000 short tons (9,072 metric tons). In this report, Reserve Base coal is the gross amount of Identified Resources that occurs in beds 1 foot (0.3 m) or more thick and under less than 3,000 feet (914 m) of overburden. Reserves are the recoverable part of the Reserve Base coal. In the southeastern Oklahoma coal field, a recovery factor of 80 percent is applied toward surface-minable coal and a recovery factor of 50 percent is applied toward subsurface minable coal. No recovery factor is applicable for in-situ coal gasification methods.

The total tonnage per section for both Reserve Base and hypothetical coal, including both surface and subsurface minable coal, are shown in the northwest corner of each section in the Federal coal land on Plate 2. All values shown on Plate 2 are rounded to the nearest 10,000 short tons (9072 metric tons), and total approximately 137.88 million short tons (125.08 million metric tons), for the entire quadrangle, including tonnages in the isolated data points. Reserve Base and hypothetical tonnages from the various development potential categories for surface and subsurface mining and in-situ coal gasification methods are shown in tables 2 and 3.

The authors have not made any determination of economic recoverability for any of the coal beds described in this report.

COAL DEVELOPMENT POTENTIAL

Coal development potential areas are drawn to coincide with the boundaries of the smallest legal land subdivisions shown on Plate 2. In sections or parts of sections where no land subdivisions have been surveyed by the BLM, approximate 40-acre (16-hectare) parcels have been used to show to limits of the high, moderate, or low development potentials. A constraint imposed by the BLM specifies that the highest development potential affecting any part of a 40-acre (16-hectare) lot, tract, or parcel be applied to that entire lot, tract, or parcel. For example, if 5 acres (2 hectares) within a parcel meet the criteria for a high development potential; 25 acres (10 hectares), a moderate development potential; and 10 acres (4 hectares), a low development potential; then the entire 40 acres (16 hectares) are assigned a high development potential. For purposes of this report, any lot or tract assigned a coal development potential contains coal in beds with a nominal minimum areal extent of 1 acre (0.4 hectare).

Development Potential for Surface Mining Methods

Areas where the coal beds of Reserve Base thickness are overlain by 150 feet (46 m) or less of overburden are considered to have potential for surface mining and are assigned a high, moderate, or low development potential based on their mining ratios (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining ratios for surface mining of coal is as follows:

$$MR = \frac{t_o\ (cf)}{t_c\ (rf)}$$

where MR = mining ration

t_o = thickness of overburden in feet
t_c = thickness of coal in feet
rf = recovery factor (80 percent for this quadrangle)
cf = conversion factor to yield MR value in terms of cubic yards of overburden per short tons of recoverable coal:

0.896 for bituminous coal

Note: To convert mining ratio to cubic meters of overburden per metric ton of recoverable coal, multiply MR by 0.8428.

Areas of high, moderate, and low development potential for surface mining methods are defined as areas underlain by coal beds having respective mining ratio values of 0 to 10, 10 to 15, and greater than 15. These mining ratio values for each development potential category are based on economic and technological criteria and were provided by the U.S. Geological Survey.

Areas where the coal data are absent or extremely limited between the 150-foot (46 m) overburden line and the coal outcrop are assigned unknown development potential for surface mining methods. This applies to areas where coal beds 1.0 foot (0.305 m) or more thick are not known but may occur, and to those areas influenced by isolated data points. Limited knowledge pertaining to the areal distribution, thickness, depth and attitude of the coals in these areas prevents accurate evaluation of development potential in the high, moderate, or low categories. The areas influenced by isolated data points in this quadrangle contain approximately 0.02 million short tons (0.02 million metric tons) of coal available for surface mining.

The coal development potential for surface mining methods is shown on

Table 2. Coal Reserve Base and hypothetical data for surface mining for Federal coal land (in short tons) in the Krebs quadrangle, Pittsburg County, Oklahoma.

COAL BED	HIGH DEVELOPMENT POTENTIAL	MODERATE DEVELOPMENT POTENTIAL	LOW DEVELOPMENT POTENTIAL	UNKNOWN DEVELOPMENT POTENTIAL	TOTAL
Lower McAlester	530,000	130,000	670,000	------	1,330,000
Upper Hartshorne	10,000	30,000	750,000	------	790,000
Lower Hartshorne	100,000	50,000	560,000	------	710,000
Isolated Data Points	------	------	------	20,000	20,000
TOTAL	640,000	210,000	1,980,000	20,000	2,850,000

plate 14. Of Federal coal land not subject to currently outstanding coal lease, permit, license or preference right lease application having a known development potential for surface mining, 16 percent is rated high, 2 percent is rated moderate, and 8 percent is rated low. The remaining Federal land (74 percent) is classified as having unknown or no development potential for surface mining methods.

Development Potential for Subsurface Mining and In-Situ Coal Gasification Methods

Areas considered to have a development potential for conventional subsurface mining methods are those areas where the coal beds of Reserve Base thickness are between 150 and 3,000 feet (46 to 914 m) below the ground surface and have dips of 15° or less. Unfaulted coal beds lying between 150 and 3,000 feet (46 and 914 m) below the ground surface, dipping greater than 15°, are considered to have a development potential for in-situ coal gasification methods.

Areas or high, moderate, and low development potential for conventional subsurface mining methods are defined as areas underlain by coal beds at depths ranging from 150 to 1,000 feet (46 to 305 m), 1,000 to 2,000 feet (305 to 610 m), and 2,000 and 3,000 feet (610 to 914 m), respectively.

Areas where the coal data are absent or extremely limited between 150 and 3,000 feeet (46 to 914 m) below the ground surface are assigned unknown development potentials. This applies to areas where coal beds of Reserve Base thickness are not known, but may occur, and to those areas influenced by isolated data points. The areas influenced by isolated data points in this quadrangle contain approximatlely 0.75 million short tons (0.68 million metric tons) of coal available for conventional subsurface mining.

The coal development potential for conventional subsurface mining and in-situ gasification methods is shown on Plate 15. A summary of all tonnage values is presented in Table 3. Of the Federal land areas having a known development potential for either conventional subsurface mining or in-situ gasification methods, 30 percent is rated high, 38 percent is rated moderate, and 10 percent is rated low. Six percent of the remaining Federal land in the quadrangle is classified as having unknown development potential for conventional subsurface mining methods.

Based on criteria provided by the U.S. Geological Survey, coal beds of Reserve Base thickness dipping between 15° and 35°, regardless of tonnage, have a low development potential for in-situ coal gasification methods. Beds dipping from 35° to 90°, with a minimum of 50 million tons of coal in a single unfaulted bed or multiple, closely spaced, approximately parallel beds have a moderate development potential for in-situ coal gasification. Coal lying between the 150-foot (46 m) overburden isopach and the outcrop is not included in total coal tonnages available because it is needed for cover and containment in the in-situ process.

In the Krebs quadrangle, 28 percent of Federal coal land has a low development potential for in-situ coal gasification. However, 42 percent of this land also has a development potential for conventional subsurface mining methods. None of the Federal coal land in the quadrangle has a moderate development potential for in-situ gasification.

Table 3. Coal Reserve Base and hypothetical data for subsurface mining and in-situ gasification for Federal coal land (in short tons) in the Krebs quadrangle, Pittsburg County, Oklahoma.

COAL BED	HIGH SUBSURFACE DEVELOPMENT POTENTIAL	MODERATE SUB-SURFACE DEVELOPMENT POTENTIAL	LOW SUBSURFACE DEVELOPMENT POTENTIAL	LOW IN-SITU DEVELOPMENT POTENTIAL	UNKNOWN DEVELOPMENT POTENTIAL	HYPOTHETICAL COAL TONNAGE	TOTAL
Lower McAlester	2,080,000	2,590,000	10,030,000	5,810,000	------	------	20,510,000
Upper Hartshorne	8,990,000	25,780,000	2,410,000	12,680,000	------	530,000	50,390,000
Lower Hartshorne	9,360,000	34,700,000	4,640,000	14,660,000	------	20,000	63,380,000
Isolated Data Points	------	------	------	------	750,000	------	750,000
TOTAL	20,430,000	63,070,000	17,080,000	33,150,000	750,000	550,000	135,030,000

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APPENDIX I. SOURCE AND RELIABILITY OF DATA USED ON PLATE 1.

Listed below is a point by point accounting as to the source and reliability of all information shown on Plate 1. Also presented are any notes or comments pertaining to individual data points.

DATA POINT #	LOCATION	INCREASING RELIABILITY →	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	NE NE	Location					x	R.L. Perkins #1 Hutchinson,	I-E log only. No GL, KB:
	Section 16	Overburden				x		1960	6.5'
1	T 6 N R 15 E	Coal Thickness			x				
	SW NE	Location					x	Tesoro Petrol. #1 Silva,	Kb is 16' above GL. 946'
	Section 21	Overburden				x		1972	FSL, 1162 FWL. CFD, I-GR
2	T 6 N R 15 E	Coal Thickness				x			logs.
	N/2 SE	Location					x	Oxley Petrol, #1 Minnie	I-GR log only. Loc. 1320'
	Section 24	Overburden				x		Galloway, 1973	E, 770' S of C
3	T 6 N R 15 E	Coal Thickness			x				KB: 16' above GL.
	--------	Location		x				Hendricks, T.A., 1937,	Osage #5 Mine (10 sample
	Section 32	Overburden	-	-	-	-	-	Plate 10	average).
4	T 6 N R 15 E	Coal Thickness				x			
	NE SE	Location			x			USGS files, 1903, Core Hole	
	Section 33	Overburden					x	A	
5	T 6 N R 15 E	Coal Thickness					x		
	NW SE	Location				x		Phipps #1-36, 1966, Austral	KB = 17' above GL.
	Section 36	Overburden			x			Oil	Densilog, IE log.
6	T 6 N R 15 E	Coal Thickness		x					
	NE NE	Location					x	USGS files, Bore Hole #29,	Pitch to North corrects
	Section 36	Overburden					x	1907	True Coal Ht. to 3'10"
7	T 6 N R 15 E	Coal Thickness					x		
	SW NW	Location					x	USGS files, Bore Hole #2,	Remarks on log: "see
	Section 31	Overburden					x	1903	original map, Mine #7 Osage
8	T 6 N R 16 E	Coal Thickness					x		C.M. Co.
	NE SW	Location					x	USGS files, Bore Hole #1,	± 1600' N and 543' W, SE
	Section 31	Overburden					x	1903	cor. of SW
9	T 6 N R 16 E	Coal Thickness					x		
	NW SE	Location					x	USGS files, Bore Hole #4,	
	Section 31	Overburden					x	1904	
10	T 6 N R 16 E	Coal Thickness					x		
	NW NW	Location					x	USGS files, 1942, Bore Hole	Cored from 842' to TD
	Section 32	Overburden					x	C-5	
11	T 6 N R 16 E	Coal Thickness					x		

DATE POINT #	LOCATION		INCREASING RELIABILITY →	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	SW SE		Location					x	USGS files, 1942, Core Hole	
	Section 32		Overburden					x	#C-3	
12	T 6 N	R 16 E	Coal Thickness					x		
	SW NW		Location					x	USGS files, 1942, Bore Hole	
	Section 33		Overburden					x	#C-6	
13	T 6 N	R 16 E	Coal Thickness					x		
	NE NE		Location					x	USGS files, Bore Hole #C-1,	Faulted.
	Section 5		Overburden					x	1942	
14	T 5 N	R 16 E	Coal Thickness					x		
	SE NE		Location					x	USGS files, Bore Hole #C-2,	
	Section 5		Overburden					x	1942	
15	T 5 N	R 16 E	Coal Thickness					x		
	NE NW		Location					x	USGS files, Bore Hole #C-4,	
	Section 6		Overburden					x	1942	
16	T 5 N	R 16 E	Coal Thickness					x		
	W/2 NE		Location					x	USGS files, Bore Hole #C-2,	
	Section 6		Overburden					x	1942	
17	T 5 N	R 16 E	Coal Thickness					x		
	C of NW		Location					x	USGS files, Bore Hole #C-1,	
	Section 6		Overburden					x	1942	
18	T 5 N	R 16 E	Coal Thickness					x		
	NE NE		Location		x				USGS Bore Hole #7, Tract	S29° 52'W of data point #21
	Section 1		Overburden					x	30-B, 10/3/04	
19	T 5 N	R 15 E	Coal Thickness					x		
	NE NE		Location					x	USGS files, Bore Hole #6,	
	Section 1		Overburden					x	1904	
20	T 5 N	R 15 E	Coal Thickness					x		
	N/2 NE		Location					x	USGS files, Bore Hole #5,	Hole into faulty coal, 1"
	Section 1		Overburden					x	1904	slate parting in middle.
21	T 5 N	R 15 E	Coal Thickness					x		
	S/2 NE		Location					x	USGS files, Bore Hole #8,	Loc. 113'S of center NE.
	Section 1		Overburden					x	1904	
22	T 5 N	R 15 E	Coal Thickness					x		
	S/2 NE		Location					x	USGS files, Bore Hole #10,	1320'W and 1704'S, NE
	Section 1		Overburden					x	10/17/04, Tract 30-B & 41-B	corner.
23	T 5 N	R 15 E	Coal Thickness					x		
	S/2 NE		Location					x	USGS files, Bore Hole #9,	660'S of center, NE
	Section 1		Overburden					x	1904	
24	T 5 N	R 15 E	Coal Thickness					x		

DATE POINT #	LOCATION	INCREASING RELIABILITY	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	NW SE	Location					x	USGS files, Bore Hole #14,	
	Section 1	Overburden					x	1904	
25	T 5 N R 15 E	Coal Thickness					x		
	SW NE	Location					x	USGS files, Bore Hole #13,	
	Section 1	Overburden					x	1904	
26	T 5 N R 15 E	Coal Thickness					x		
	SW NE	Location					x	USGS files, Bore Hole #12,	Located on axis of Krebs
	Section 1	Overburden					x	1904	Syncline. (Hendricks, 1937)
27	T 5 N R 15 E	Coal Thickness					x		
	W/2 NE	Location					x	USGS files, Bore Hole #11,	1320'S and 660'E of NW
	Section 1	Overburden					x	1904	corner, sec. 1
28	T 5 N R 15 E	Coal Thickness					x		
	SE SW	Location					x	USGS files, Bore Hole #28,	Loc. 10'W of Hole #27
	Section 4	Overburden					x	1906	
29	T 5 N R 15 E	Coal Thickness					x		
	SE SW	Location					x	USGS files, Bore Hole #27,	Loc. near bottom of old #11
	Section 4	Overburden	x					1906	slope - see USGS Bull. 874-
30	T 5 N R 15 E	Coal Thickness					x		A, pl. 7
	NW NW	Location					x	USGS files, Bore Hole #25,	Hole penetrates pillar in
	Section 4	Overburden					x	1906	mine.
31	T 5 N R 15 E	Coal Thickness					x		
	SW SW	Location					x	USGS files, Bore Hole #24,	
	Section 9	Overburden					x	1905	
32	T 5 N R 15 E	Coal Thickness					x		
	--------	Location		x				Hendricks, 1937, Pl. 7, 8	Meas. in Buck #6 mine. Two
	Section 11	Overburden	-	-	-	-	-		sample average (H 67, 68)
33	T 5 N R 15 E	Coal Thickness					x		
	--------	Location		x				Hendricks, 1937, Pl. 7, 8	Meas. in Buck #1 Mine. Two
	Section 12	Overburden	-	-	-	-	-		sample average (H 89, 90).
34	T 5 N R 15 E	Coal Thickness					x		
	--------	Location		x				Hendricks, 1937, Pl. 7, 8	Meas. in Buck #5 Mine. Two
	Section 12	Overburden	-	-	-	-	-		sample average (H 65, 66a).
35	T 5 N R 15 E	Coal Thickness					x		
	NE SW	Location				x		USGS files, 1959, Bore Hole	Also on Krebs KRCRA Map
	Section 12	Overburden					x	#14	(E-14), 1978
36	T 5 N R 15 E	Coal Thickness					x		
	NE SW	Location				x		USGS files, 1959, Bore Hole	Also on Krebs KRCRA Map
	Section 12	Overburden					x	#13	(E-13), 1978
37	T 5 N R 15 E	Coal Thickness					x		

DATA POINT #	LOCATION		INCREASING RELIABILITY	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	NE SW		Location				x		USGS files, 1959, Bore Hole	Also on Krebs KRCRA Map
	Section 12		Overburden				x		#9	(E-9), 1978
38	T 5 N	R 15 E	Coal Thickness				x			
	SE SW		Location				x		USGS files, 1959, Bore Hole	Also on Krebs KRCRA Map
	Section 12		Overburden					x	#11	(E-11), 1978
39	T 5 N	R 15 E	Coal Thickness					x		
	E/2 SW		Location				x		USGS files, 1959, Bore Hole	Also on Krebs KRCRA Map
	Section 12		Overburden					x	#12	(E-12), 1978
40	T 5 N	R 15 E	Coal Thickness					x		
	S/2 S/2		Location				x		USGS files, 1959, Bore Hole	Also on Krebs KRCRA Map
	Section 12		Overburden					x	#16	(E-16), 1978
41	T 5 N	R 15 E	Coal Thickness					x		
	NE SW		Location				x		USGS files, 1959, Bore Hole	Also on Krebs KRCRA Map
	Section 12		Overburden					x	#10	(E-10), 1978
42	T 5 N	R 15 E	Coal Thickness					x		
	NW SE		Location				x		USGS files, 1959, Bore Hole	Also on Krebs KRCRA Map
	Section 12		Overburden					x	#7	(E-7), 1978
43	T 5 N	R 15 E	Coal Thickness					x		
	SW SE		Location				x		USGS files, 1959, Bore Hole	Also on Krebs KRCRA Map
	Section 12		Overburden					x	#5	(E-5), 1978
44	T 5 N	R 15 E	Coal Thickness					x		
	SE SE		Location		x				Hendricks, 1937, Pl. 7, 8	KRCRA H-88, meas. in Buck
	Section 12		Overburden	-	-	-	-	-		#22 Mine
45	T 5 N	R 15 E	Coal Thickness					x		
	--------		Location		x				Hendricks, T.A., 1937,	5 Sample average from
	Section 8		Overburden	-	-	-	-	-	Pl. 9	Carbon #2 Mine.
46	T 5 N	R 16 E	Coal Thickness				x			
	SW NW		Location					x	Okla. Dept. of Mines files,	
	Section 16		Overburden					x	1977-1978	
47	T 5 N	R 16 E	Coal Thickness					x		
	SW NW		Location					x	Okla. Dept. of Mines files,	
	Section 16		Overburden					x	1977-1978	
48	T 5 N	R 16 E	Coal Thickness					x		
	S/2 SW		Location				x		Sinclair, G.B. Hall #1,	No KB reported
	Section 17		Overburden			x			1962	
49	T 5 N	R 16 E	Coal Thickness		x					
	NE NE		Location				x		USGS files, 1959, Bore Hole	Core log has coal analysis.
	Section 13		Overburden					x	#1	Also on KRCRA, #E-1, 1978.
50	T 5 N	R 15 E	Coal Thickness					x		

DATA POINT #	LOCATION	INCREA RELIABIL →	1	2	3	4	5	REFERENCE	NOTES/COMMENTS
	SE NW	Location		x				Hendricks, 1937, Plate 3,	Osage #8 Mine, 1 sample.
	Section 15	Overburden	-	-	-	-	-	Sheet 2.	
51	T 5 N | R 15 E	Coal Thickness				x			
	SW NW	Location					x	USGS files, Bore Hole #26,	Only penetrated 4" of Lower
	Section 15	Overburden					x	1906	McAlester coal.
52	T 5 N | R 15 E	Coal Thickness	x						
	SE SW	Location				x		Austral Oil Co., 1967,	KB = 14' above GL.
	Section 21	Overburden			x			Springer #1-21	
53	T 5 N | R 15 E	Coal Thickness		x					
	--------	Location		x				Hendricks, 1937, Pl. 10	Rock Island #5 Mine (11
	Section 22	Overburden	-	-	-	-	-		sample average).
54	T 5 N | R 15 E	Coal Thickness				x			
	--------	Location		x				Hendricks, 1937, Plates 7,	Rock Island #38 Mine (7
	Section 24	Overburden	-	-	-	-	-	9	sample average.
55	T 5 N | R 15 E	Coal Thickness					x		
	E/2 E/2	Location		x				Shannon, et al, 1926, Plate	Also Hendricks, 1937,
	Section 19	Overburden	-	-	-	-	-	3, sheet 2.	Plates 7, 9.
56	T 5 N | R 15 E	Coal Thickness				x			
	C NE	Location				x		Mustang Prod., 1975, McLean	KB =14' above GL.
	Section 30	Overburden			x			#1-30	
57	T 5 N | R 16 E	Coal Thickness		x					
	SW NE	Location					x	Senate doc. 390, 1910, p.	
	Section 29	Overburden					x	70, Bore Hole No. 37	
58	T 5 N | R 15 E	Coal Thickness					x		

APPENDIX II TABLES OF OIL AND GAS TEST HOLES

Note: "Top Log Int." refers to the measured depth to the top of the interval logged by the particular sonde. Driller log total depth, referenced to K.B. or D.F., has been abbreviated to T.D. (Note: This may vary from T.D. referenced to G.L.). The measured depth at which coal is reported on the scout card appears in the column titled "Scout Card Coal". The column titled "Harts./Drill./Scout" contains the measured depths drilled to the top of the Hartshorne Sandstone, as reported by the driller logs and the scout cards.

* Logged interval stratigraphically below Hartshorne Coals.

Sec-Tn-Rg	Operator/Farm Location	Driller Logs Coal Reported Thickness & Depth	Scout Card Coal	Harts. Drill. Scout	Top Log Int. Gamma Elec.	Top Log Int. Dens. Sonic	T.D. Year
21-5-15	Austral/ #1-21 Springer			NR	502	1400	9518
	NE SE SW	NR	NR	2334	502		1967
17-5-16	Sinclair/#1 G. B. Hall			NR			13440
	C N/2 S/2 SW	NR	NR	969			1962
30-5-16	Mustang/#1-30 McLean			2760	795		11500
	1150 FNL 1320 FEL	NR	NR	2700			1976
13-6-15	Oxley/#1 P. Rodebush			3191			3513
	1900 FSL 740 FWL of NW/4	NR	NR	3191			1975
14-6-15	Oxley/#1 P. Frasher			3075			3300
	1900 FSL 1900 FWL of NW/4	NR	NR	3075			1974
15-6-15	Gadsco/#1 Gossett			3013			3250
	1170 FSL 1170 FWL of NE/4	NR	NR	3013			1977
16-6-15	Xplor/#1 Cole			NR			2510
	SE NE NE	NR	NR	NR			1974
16-6-15	Perkins/#1 Hutchinson			NR			3206
	NE NE NE	NR	NR	2949	108		1960
21-6-15	Tesoro/#1 Silva			NR	1024	2650	9000
	946 FSL 1162 FWL of NE/4	NR	NR	3422	1024		1972
24-6-15	Oxley/#1 M. Galloway			3828	1200		8500
	1420 FSL 1320 FWL of SE/4	NR	NR	3828	1200		1973
34-6-15	Intex & Midway/#1 Southard			NR			1559
	CNW SE			NR			1949
34-6-15	Portman/#1 Southard						1230
	CSW NE			418			1951

Sec-Tn-Rg	Operator/Farm Location	Driller Logs Coal Reported Thickness & Depth	Scout Card Coal	Harts. Drill. Scout	Top Log Int. Gamma Elec.	Top Log Int. Dens. Sonic	T.D. Year
35-6-15	Intex/#1 Welch			NR			2010
	CNW SW			418			1949
35-6-15	Intex/#1 Dupitch			NR			1795
	SE NE SE			800			1950
36-6-15	Austral/#1-36 Phipps			NR		47	10400
	SE NW SE	NR	NR	1055	47		1966
19-6-16	Oxley/#1 Keith			3744			10303
	NE SE NW	NR	NR	3744			1972
19-6-16	Oxley/#1 H. H. Holman			NR			7960
	SE NE NW SE	NR	NR	NR			1973
30-6-16	Oxley/Eva Factory			NR			8000
	1190 FSL 414 FWL of NE/4	NR	NR	NR			