COAL GEOLOGY OF PARTS OF THE INOLA, CHOUTEAU N.W., CATOOSA S.E., AND NEODESHA QUADRANGLES, SOUTHEASTERN ROGERS AND NORTHERN WAGONER COUNTIES, OKLAHOMA

By

JAY MASON GREGG

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Bowling Green State University

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Thesis Approved:

Gary F. Stewart
Thesis Adviser

Samuel A. Friedman

John Trammell

John D Naff

Norman N Durham
Dean of the Graduate College

PREFACE

This thesis is a study of the coal geology of southeastern Rogers County and northernmost Wagoner County, Oklahoma. Structural contour, isopach, and overburden maps were prepared to aid in the description of the geology of the area and in estimation of coal resources.

I am grateful to many individuals who assisted me in this study. Prof. Samuel A. Friedman suggested the problem. Dr. Gary F. Stewart and Prof. Friedman provided general assistance, especially in field work and writing. Thesis committee members, Dr. John D. Naff and Dr. John Trammell, made helpful suggestions, comments, and criticisms of the study.

The Oklahoma Geological Survey provided some of the funds for field expenses and much data. Data also were supplied by the Peabody, United, and Gable coal companies and Black and Veatch Engineering Company. I thank Mr. Paul Zaman of Black and Veatch Engineering Co. and Mr. Donald Gable of the Gable Coal Co., for the time they took helping me with problems that I had in my work. A special thanks is given to Dr. J. M. Schopf of The Ohio State University for taking the time to explain to me methods of petrographic study of coal. Drafting was done by Robert L. Sloan, and Mrs. Thomas W. Lee typed the final draft of the thesis.

My work would never have been completed without the understanding and the financial support of my parents, Jay B. and Patricia L. Gregg, and my grandmother, Lillian A. Mason. Finally I wish to thank my grandfather, the late Neull L. Mason, whose life-long dedication to the education of his children and grandchildren insured the opportunity of writing this thesis.

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INTRODUCTION

Location

The area under study in this report, approximately 53 sq mi near Inola, Oklahoma, is located primarily in T19N, R16 and 17E, in southeastern Rogers County, and partly in T18N, R17E in northernmost Wagoner County (Fig. 1).

The rock units under investigation make up the Krebs Group, Desmoinesian Series of the Pennsylvanian System. In descending order these rock units are (a) the Boggy Formation, including the Taft Sandstone Member, Inola Limestone Member, Bluejacket coal, Bluejacket Sandstone Member, and several unnamed units; (b) the Savanna Formation including the Drywood coal, Doneley Limestone Member, Rowe coal, the Spiro sandstone[1], and several unnamed units.

A generalized stratigraphic column representative of northeastern Oklahoma is shown in Figure 2, and a generalized geologic map of the area (based on Stringer's /1959/ map) in Figure 3. Geological names of outcropping rock units and of their subsurface equivalents are listed in Table 1.

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[1]The name "Spiro Sandstone Member" is not accepted as a formal stratigraphic name by the U.S. Geological Survey (Keroher and others, 1966, p. 3684-3685). It is used informally here in order to specify a sandstone unit, discussion of which is important to the context of this report.

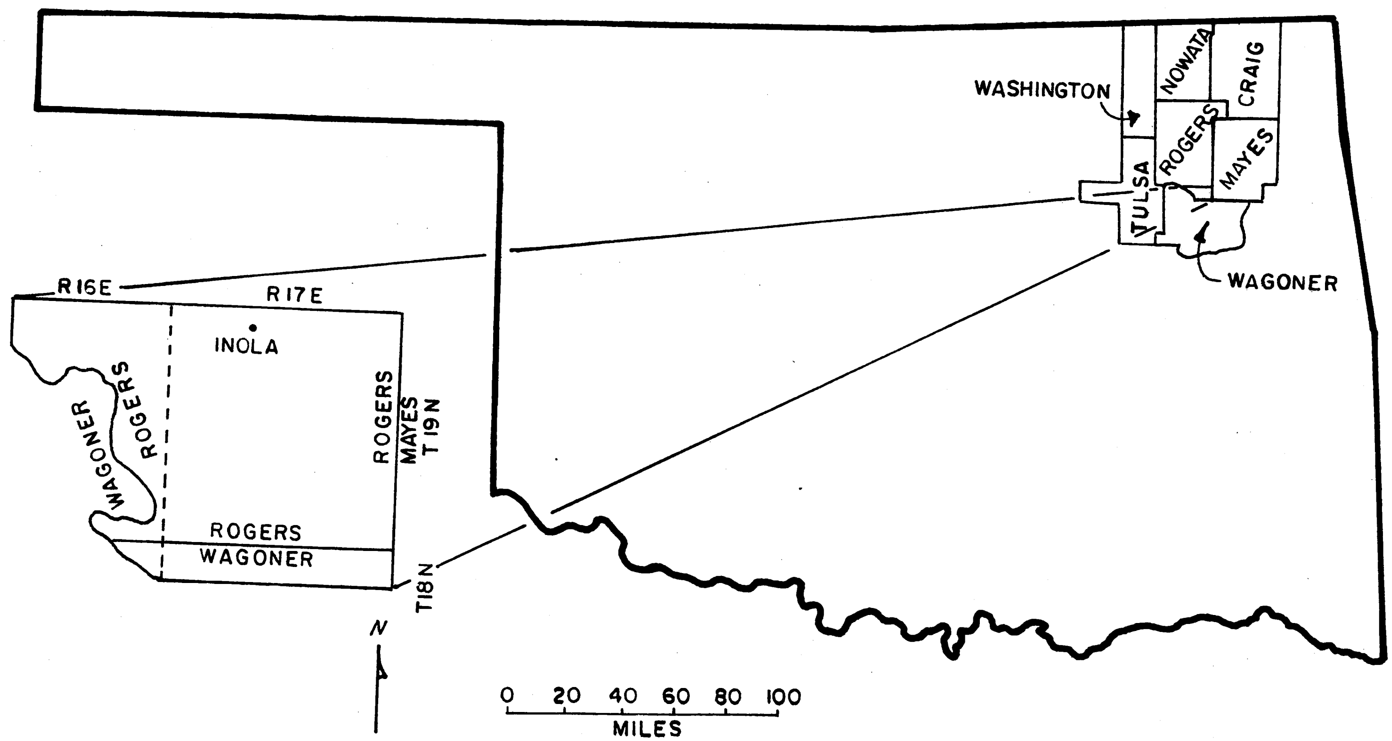


Figure 1.--Location of the study area

System	Series	Group	Formation	Member	Bed
PENNSYLVANIAN	DESMOINESIAN	MARMATON	Holdenville Shale		
			Lenapah Limestone		
			Nowata Shale		
			Oologah Limestone		
			Labette Shale		
			Fort Scott Limestone		
		CABANISS	Senora Fm.	Excello Shale Breezy Hill Limestone Lagonda Sandstone Verdigris Limestone Chelsea Sandstone Tiawah Limestone	Iron Post coal Croweburg coal Tebo coal
			Stuart Shale		
			Thurman Sandstone		Weir-Pittsburg coal
		KREBS	Boggy Fm.	Taft Sandstone Inola Limestone Bluejacket Sandstone	Bluejacket coal
			Savanna Fm.	Doneley Limestone Spiro Sandstone[1] Sam Creek Limestone Spaniard Limestone	Drywood coal Rowe coal
			McAlester Fm.	Warner Sandstone	Neutral coal
			Hartshorne Fm.		Riverton coal Lower Hartshorne coal

[1] Not recognized by Okla. Geol. Survey or U.S. Geol. Survey (Keroher and other, 1966)

Figure 2.--General columnar section of Desmoinesian rocks, northeastern Oklahoma (Branson, 1954b, p. 3-4; 1956b, p. 1; and Creath and Howell, 1974, p. 5)

Figure 3.--Geologic map of the Inola area,
Rogers County, Oklahoma
(adapted from Stringer, 1959)

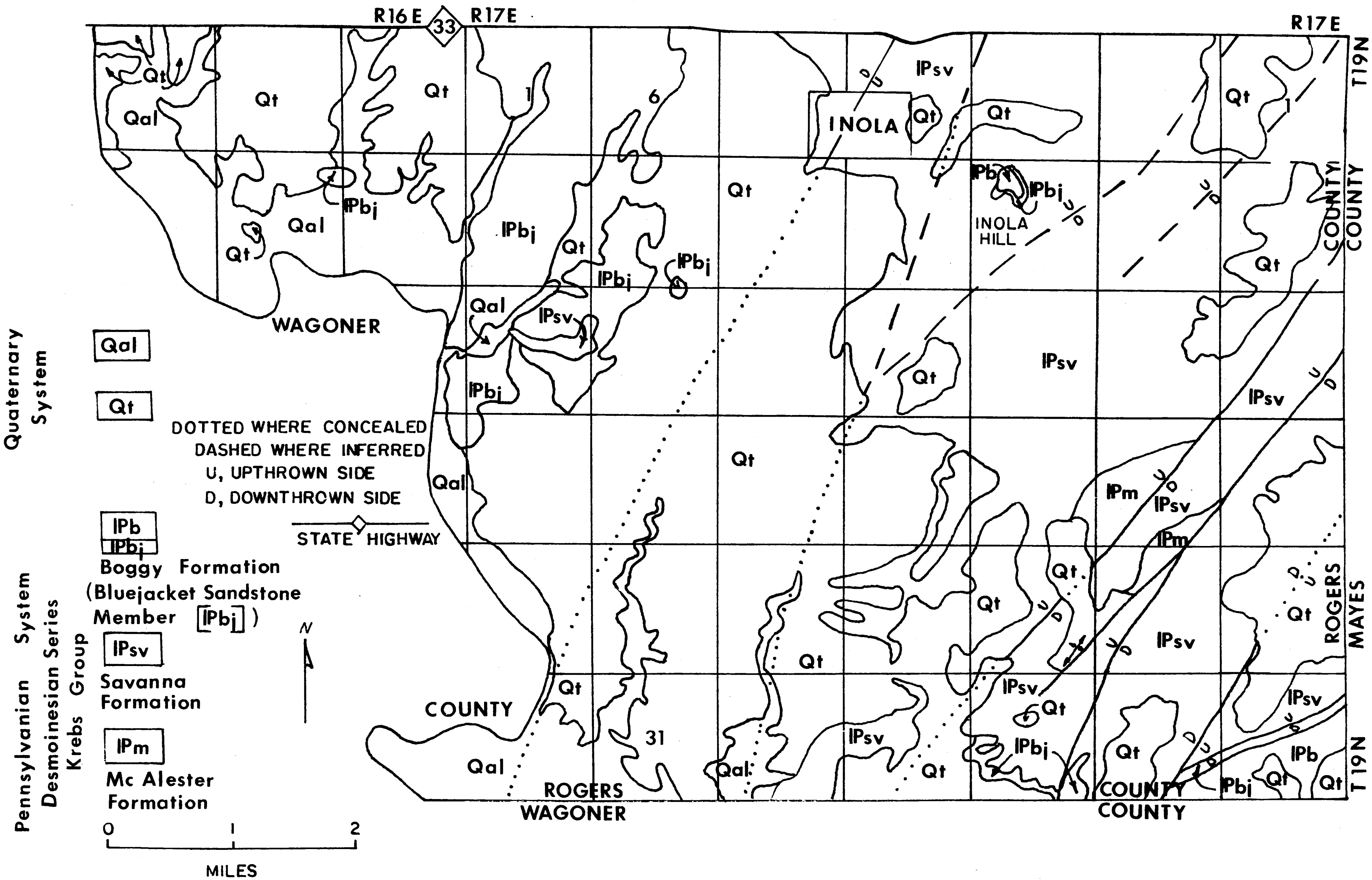

R16E
33
R17E
R17E
T19N
T19N
INOLA
INOLA HILL
WAGONER
COUNTY
ROGERS
WAGONER
COUNTY
COUNTY
ROGERS
MAYES
COUNTY
COUNTY
Qal
Qt
IPbj
IPb
IPsv
IPm
1
6
31
Quaternary System
Qal
Qt
DOTTED WHERE CONCEALED
DASHED WHERE INFERRED
U, UPTHROWN SIDE
D, DOWNTHROWN SIDE
STATE HIGHWAY
Pennsylvanian System
Desmoinesian Series
Krebs Group
IPb
IPbj
Boggy Formation
(Bluejacket Sandstone Member [IPbj])
IPsv
Savanna Formation
IPm
Mc Alester Formation
N
0
1
2
MILES

Table 1.--Surface and correlative subsurface names of stratigraphic units in the study area. Modified from Jordan (1957).

Surface name	Subsurface name
Taft Sandstone Member	Red Fork sand
Inola Limestone Member	Inola Limestone
Bluejacket Sandstone Member	Bartlesville sand
Doneley Limestone Member	Brown lime
Spiro sandstone	Spiro sand
Sam Creek Limestone Member	Brown lime
Spaniard Limestone Member	Brown lime
Warner Sandstone Member	Taneha sand or Booch sand

Objectives

The principal objective of this study was to map the coal beds and associated rock units of southeastern Rogers County, Oklahoma, and to determine the distribution, resources, reserves, and suitabilities of the coals for commercial use.

Procedures

Data for this study were obtained principally from 126 drillers' logs of coal-test borings (or wells) and 32 descriptions of cores taken for a planned nuclear power plant (to be located in sec. 24, T19N, R16E, within the study area) (on file at the Oklahoma Geological

Survey), one gamma-ray log, aerial photographs, field mapping and descriptions of outcrops, petrographic descriptions of rock samples, examination of fossils, and analyses of coals, provided by the Oklahoma Geological Survey. Locations of data points are shown in Plate 1. Correlations of stratigraphic units were based on subsurface and surface data and are shown in Plates 2 and 3. A structural contour map was made based on the top of the Drywood coal and the top of the Rowe coal (Pl. 4). Isopach maps of the Rowe and Drywood coals (Pl. 5) and an overburden map (Pl. 6) supplemented the structural contour map. Measured, indicated, and inferred reserves of coal were calculated from information shown in Plates 3 and 4. Proximate and ultimate analyses were made of samples of coals in order to determine their suitabilities for various uses.

Previous Investigations

The earliest geologic work in the vicinity of Inola was by Smith (1911). This work was used in the compilation of an early geological map of Oklahoma. A generalized geological map of Rogers County was made by Woodruff and Cooper (1928), and the geology of the Inola area was mapped in detail by Stringer (1959).

Studies of the Pennsylvanian System of northeastern Oklahoma and adjoining states were made by Branson (1954, 1956a, 1962). Geology of the flanks of the Ozark Uplift was discussed by Huffman (1958). Genesis and geometry of the Bluejacket delta complex of Kansas and northeastern Oklahoma were discussed by Sandro and Visher (1968) and Shelton (1973).

Strong (1961) mapped the subsurface stratigraphy of Craig, Mayes, eastern Nowata, and eastern Rogers Counties in northeastern Oklahoma. Using subsurface data, Visher (1968) discussed the depositional framework of the Bluejacket Sandstone Member in northeastern Oklahoma.

Earliest discussions of coal in eastern Oklahoma were made by Chance (1890), Drake (1897), and Taff (1899). Coal and coal reserves of Oklahoma were summarized by Friedman (1972a, 1972b, 1974).

Howe (1956) defined the Rowe and Drywood coals in southeastern Kansas and correlated them with coals in Oklahoma. Palynology of the Drywood and Bluejacket coals, including samples taken from near Inola, was described by Urban (1965). Palynology of the Rowe and Drywood coals was studied by Davis (1961) and Bordeau (1964), respectively. Wilson (1968a, 1968b, 1976) made inferences about the paleoecology of coal swamps in northeastern Oklahoma based on palynological data.

STRUCTURAL FRAMEWORK

Regional Structural Geology

The study area is in the eastern part of the Northern Oklahoma Platform (Stable Shelf), adjacent to the Ozark Uplift (Arbenz, 1956; see also Fig. 4, this report). Strata dip westward and northwestward from the Ozark Uplift at an average of 25 to 50 ft per mile (Strong, 1961, pl. IX). Upward movement of the Ozark Uplift during the Pennsylvanian Period caused gradual eastward thinning of the Krebs Group, according to Woodruff and Cooper (1928). The rock units also thin northward from the Arkoma Basin across the Northern Oklahoma Platform.

Local Structural Geology

Local structural configuration is shown by structural contour maps of the Rowe and Drywood coal beds (Pl. 4).

The normal faults in the study area were mapped by Stringer (1959; see also Fig. 3, this report). Although Stringer did not specify the evidence used to locate these faults, I judge that he observed uncommonly straight segments of streams and perhaps local disruption of bedrock. Although most of the faults shown by Stringer probably are inferences, I discovered no evidence that justified rejection of his hypotheses; indeed, as will be discussed below, some of the data compiled in this report tend to refute alternate explanations and thereby to confirm the basic interpretation of faulting that was set out by

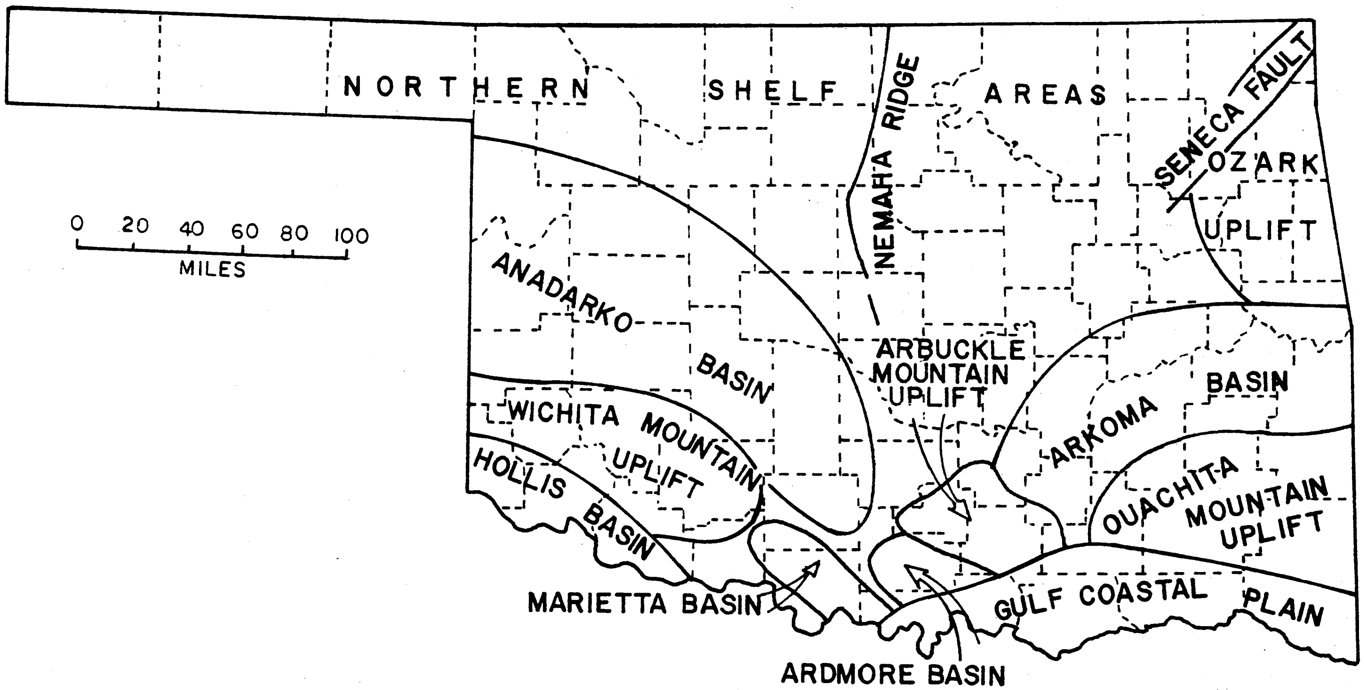


Figure 4.--Major geologic provinces of Oklahoma (modified from Johnson and Denison, 1973).

Stringer.

Faults in the study area are considered to be extensions of the Seneca Fault system described by Huffman (1958) on the west flank of the Ozark Uplift (Fig. 4). This faulting is believed to be the result of tension created by loading in the Arkoma Basin to the south together with the uplift of the Ozarks (Huffman, 1958, p. 89; Strong, 1961, p. 78). Huffman (1958, p. 90) described the Seneca Fault as a

> . . . discontinuous line of breakage extending from near Pryor, Oklahoma northeastward to Spurgen, Missouri. Locally the Seneca graben is a simple fault block varying in width from one eighth to over one half mile.

Stringer (1959, p. 47) suggested that the faults in the Inola area are a continuation of the Seneca Fault. The faulting trends from northeast to southwest in the study area (Pl. 1), similar to trend of the Seneca system.

Faulting occurred during Middle Pennsylvanian time, after deposition of the Boggy Formation (Stringer, 1959, p. 47). Reeder (1974, p. 85) who mapped the Precambrian surface of northeastern Oklahoma using oil- and gas-well logs believed that most faults in northeastern Oklahoma probably originated during the Precambrian, and that movement continued intermittently until late in the Paleozoic.

Folds in the study area trend generally northeastward; they are commonly sub-parallel with and near to the faults described above. An anticline east of Bull Creek (sec. 24, 25, 33, and 34, T19N, R17E) was described by Stringer (1959, p. 46). The Rowe coal is eroded at several locations along the crest of this anticline and it crops out in a stream bed (N½ SE¼ sec. 27, T19N, R17E) where it is overlain by the Doneley Limestone Member. Strike and dip at this location are N33°E and 10° northwestward. On the southeastern limb of the anticline (SE¼ SE¼, sec. 27) beds of sandstone and shale strike N34°E and dip about 5° southeastward.

Other folds are inferred from subsurface data and include both anticlinal and synclinal trends. West of the fault trend that follows the course of Pea Creek, folds grade into a monocline that dips gently west-northwestward (Pl. 4). The folding is irregular and strongly associated with faulting; axes of folds trend northeastward and are approximately 0.5 miles apart. Average closure on anticlines is about 20 feet.

A small monoclinal fold was observed in a strip coal mine of the Gable Coal Company in W½ NE¼ sec. 28, T19N, R17E. The general strike and dip of the Rowe coal is N63°W, and 8 to 10° N at this mine. This is contrary to a southerly dip indicated by subsurface data in the area (Pl. 4). It is assumed that this fold is only local, and that structural geology on a larger scale is as shown in Plate 4. The above-described structure leads to speculation that many similar small folds exist that are not made apparent from study of subsurface data.

Folding in the study area probably is closely related to movement along the Seneca Fault system. According to Blyth (1959, p. 35) rocks of the Atoka Formation, which underlie the Krebs Group, probably were folded soon before faulting.

Existence of faults along Pea Creek and Inola Creek (Pl. 4) has been the subject of controversy (Paul Zaman, Black and Veatch Engineering Co., personal communication, 1975). The structural geology of these areas can be interpreted without postulating the faults. However, along Pea Creek, drill-hole data indicate uncommon vertical displacement of beds, on the order of 30 to 50 ft over a horizontal distance of about 1000 feet. Along Inola Creek similar displacement is indicated, but the apparent vertical movement is probably only about 30 feet. Other evidence that suggests faulting is as follows. Aerial photographs (on file at the Oklahoma Geological Survey, nos. AWM-4FF-19 to AWM-4FF-21) show a definite lineament about one mile long through the town of Inola, which may be evidence of the Inola Creek fault. Eastward-facing escarpments north of State Highway 33 (secs. 33 and 34, T20N, R17E) suggest a continuation of both the Inola Creek and Pea Creek faults. Uncommonly straight segments of both Inola and Pea Creeks are similar to and sub-parallel to Bull Creek (Pl. 4), which is interpreted by myself and by Stringer (1959, p. 47) as being fault-controlled; this suggests that Inola and Pea Creeks also are fault controlled. I did not find incontestable field evidence of faulting, such as offset beds or slickensides, but there are few exposures of rock along Pea and Inola Creeks, and much evidence (in bedrock) of faulting may be concealed.

As an explanation alternate to actual faulting, the Krebs Group may have been folded into a monocline, and therefore may dip sharply to the west at the two localities discussed above. If these monoclines exist, they may be due to draping of beds over deep-seated faults.

Cleat Orientation in Coals

Measurements of cleat taken in the study area are shown in Table 2. In general, face cleat strikes northwestward and butt cleat northeastward. Face cleat seems to be sub-perpendicular and butt cleat sub-parallel to axes of folds in the study area. This suggests that local structural deformation controlled the formation of cleat face, and is consistent with conclusions of McCulloch and others (1974).

Table 2.--Orientation of cleat, T19N, R17E. Data shown below are approximations of cleat at each locality.

Coal	Face Cleat	Butt Cleat	Location
Bluejacket coal	N35W	N60W	NE¼ NW¼ sec. 10
Drywood coal	N30W	N80E	"
First unnamed coal below the Drywood coal	N25W	N80E	"
Rowe coal	N30E	N70W	NE¼ NE¼ sec. 28
"	N26W	N76W	NW¼ NE¼ sec. 28
"	N32W	N70E	"
"	N33W	N75E	SW¼ NE¼ sec. 28
"	N35W	N60E	"
"	N35W	N60E	"

STRATIGRAPHY

Rock units that crop out in the study area are shown in Figure 5. Correlation of rock units in the study area is shown in Plates 2 and 3.

The Krebs Group was defined by Oakes (1953, p. 1523) as the lowest group of the Desmoinesian series, underlain by the Atoka Formation and overlain by the Cabaniss Group. In ascending order, the Krebs Group is divided into the Hartshorne, McAlester, Savanna, and Boggy Formations (Oakes, 1953, p. 1523). These formations, with the probable exception of the Hartshorne, crop out or are penetrated in the subsurface of the study area. The rocks were deposited in sedimentary cycles on the stable shelf area (or platform) of northeastern Oklahoma.

The base of the Boggy Formation is defined as the contact of the Bluejacket Sandstone Member upon strata of the Savanna Formation (Branson, 1952, p. 192). The base of the Savanna Formation is the base of the Spaniard Limestone Member, on the northeastern Oklahoma Platform (Branson, 1954, p. 2). This limestone has not been penetrated in the subsurface of the study area. An unnamed coal that underlies the Spaniard Limestone is the second coal below the Rowe coal (Fig. 5) (Stringer, 1959, Pl. 2). For the purpose of this report, and because of the presumed absence of the Spaniard Limestone in the subsurface of the study area, the base of the Savanna Formation is defined operationally as the top of the second coal below the Rowe coal.

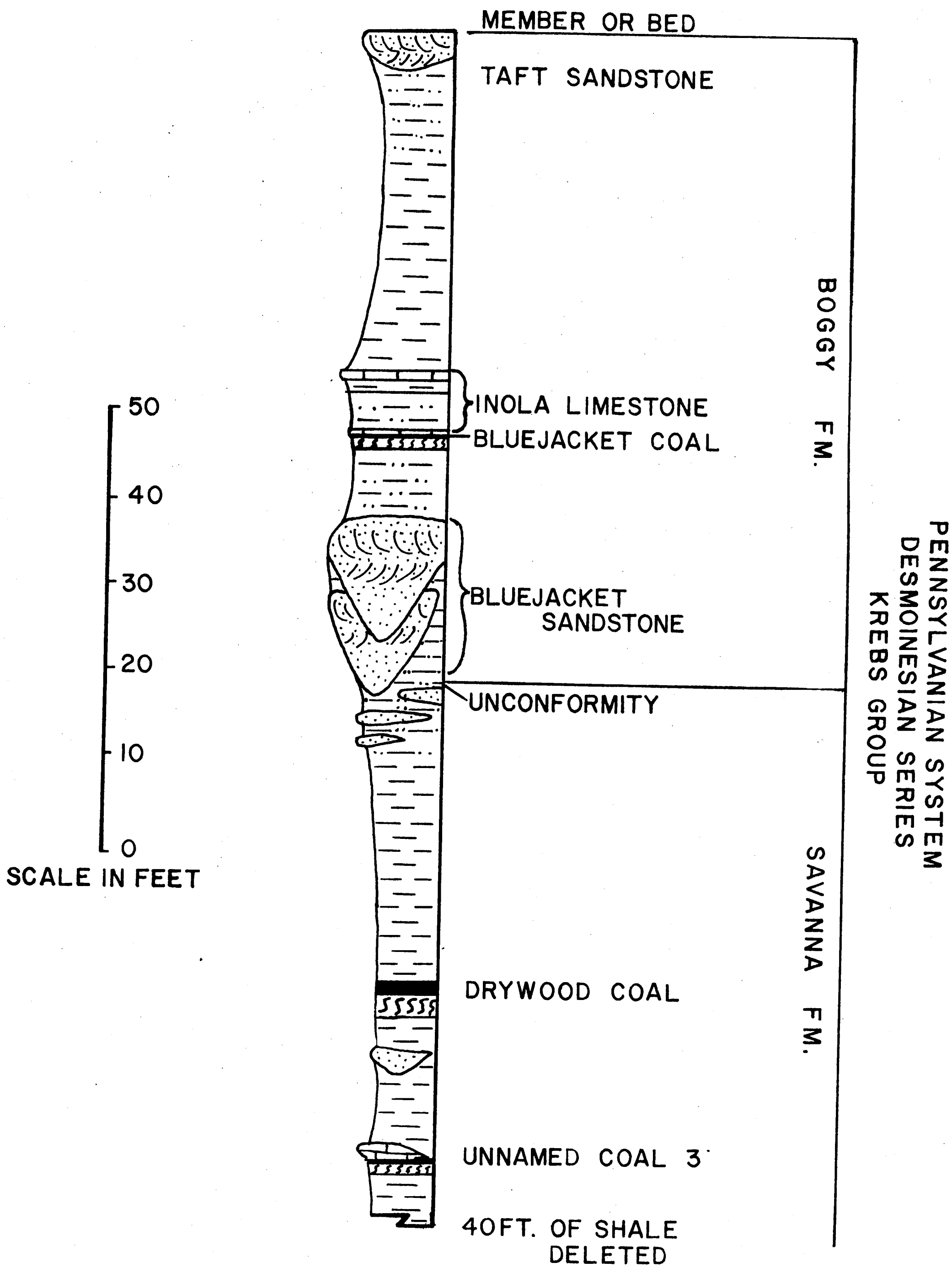


Figure 5.--Columnar section, Inola area, Rogers County, Oklahoma (older and younger strata of McAlester and Boggy Formations, respectively, are not shown)

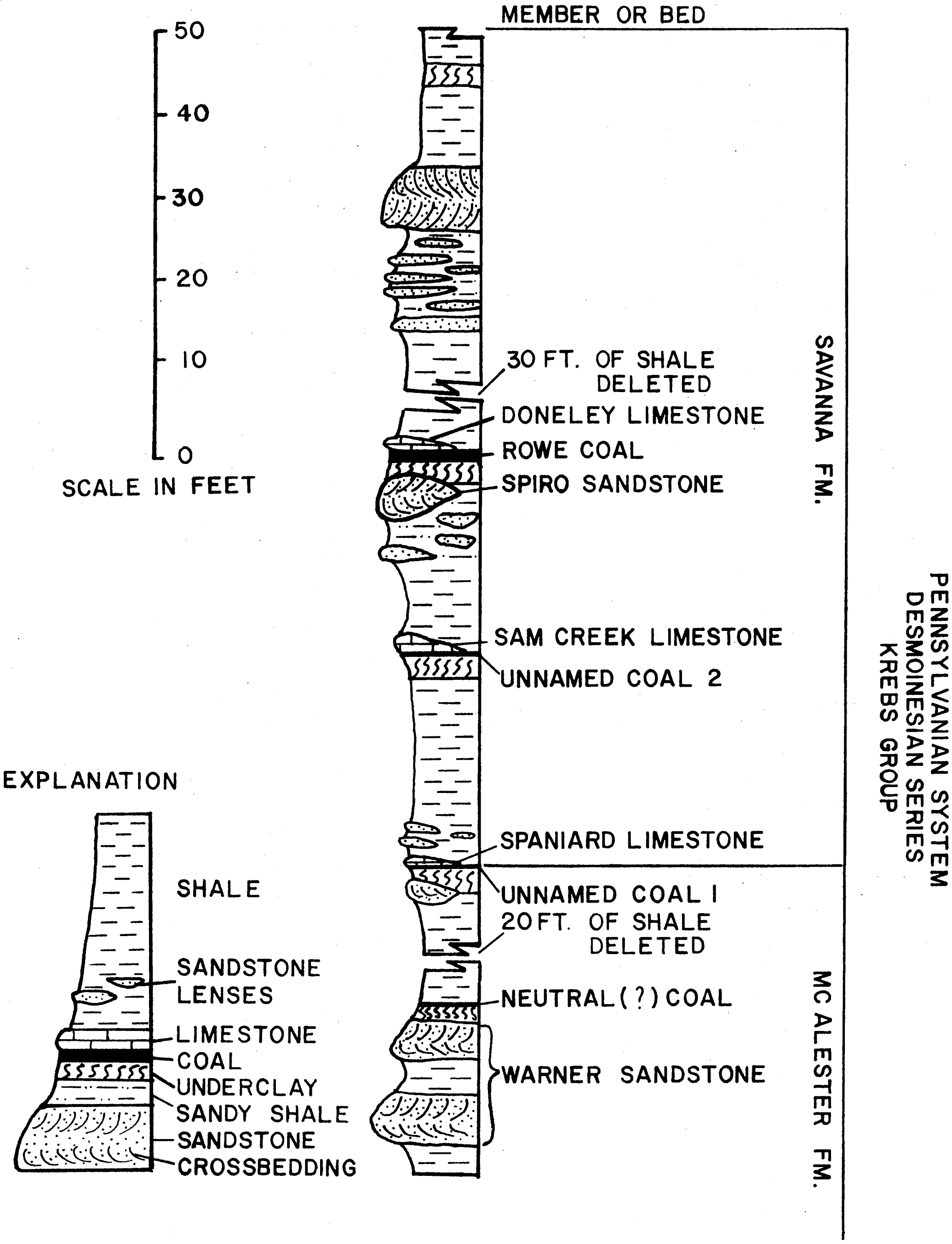


Figure 5.--(continued)

Several exploratory holes penetrated a coal that is the third below the Rowe. This could be the Riverton coal, which is in the uppermost part of the Hartshorne Formation (Fig. 2) (Stringer, 1959, p. 13). However, no sandstone overlies this coal in the position where the widely distributed Warner Sandstone Member of the McAlester Formation is to be expected (Fig. 5). Most likely this is an unnamed coal or perhaps the Neutral coal of Branson (1954), which generally is a short stratigraphic distance above the Warner Sandstone (Branson, 1954, p. 6).

Altogether, eight rather continuous coal beds have been recorded in outcrops or in boreholes in the study area; these are listed in Table 3. The stratigraphic sequence of these coals and associated strata is shown in Figure 5.

In the study area, the coals that may have economic value are the Rowe and Drywood. Both range from 0 to about 30 in. thick according to drillers' logs of coal test boreings and descriptions of cores taken in the study area. The Drywood is the first named coal below the Bluejacket Sandstone Member of the Boggy Formation (Fig. 6) (and is a short distance below the top of the Savanna Formation). The Rowe coal (Fig. 7) normally is the second coal below the Bluejacket Sandstone in northeastern Oklahoma; it overlies the Spiro sandstone and is overlain by the Doneley Limestone Member, which is commonly absent at most observed data points (Fig. 5; see also Pls. 2 and 3, this report).

Among other named coals in the study area is the Bluejacket coal (Fig. 8), which is only about 2 in. thick; it crops out at Inola Hill (sec. 10, T19N, R17E) (Pl. 4) a few feet above the "ledge" formed by the Bluejacket. As mentioned above, the Neutral coal may be in the

Table 3.--Coals in the study area.

Inola coal (informal name) (O)
Bluejacket coal (O)
Drywood coal (O) (S) ($)
Unnamed coal 3 (O) (S)
Rowe coal (O) (S) ($)
Unnamed coal 2 (O)
Unnamed coal 1 (O) (S)
Neutral (?) coal (S)

(O) In outcrop

(S) In subsurface

($) Economically important in the study area

Figure 6.--Exposure of Drywood coal (5 in. thick) on north side of Inola Hill, SE¼ NE¼ NW¼ sec. 10, T19N, R17E, Rogers County, Oklahoma

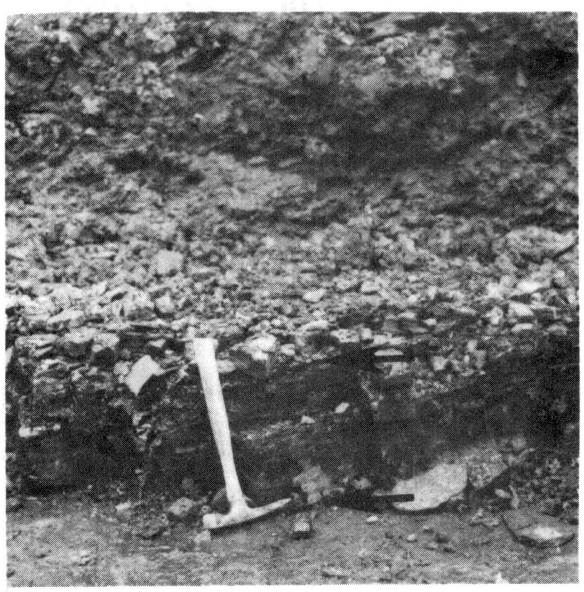


Figure 7.--Exposure of Rowe coal (about 10 in. thick) in Gable Coal Co. strip mine, NW¼ NE¼ sec. 28, T19N, R17E, Rogers County, Oklahoma

subsurface of the study area as the third coal below the Rowe coal. A thin unnamed coal and an overlying limestone was found on Inola Hill (Fig. 9) stratigraphically between the Rowe and Drywood coals. Two unnamed coals stratigraphically between the Rowe and Neutral (?) coals were penetrated in the subsurface. The lower of these was observed in outcrop below the Spaniard Limestone Member in sec. 27, T19N, R17E (Fig. 5). Three thin, discontinuous coals were reported by Stringer (1959, p. 33) in the outcrop of Bluejacket Member along the Verdigris River. Another thin, discontinuous coal in the Savanna Formation, above the Drywood coal, is recorded in core descriptions from the eastern part of the study area.

In a detailed stratigraphic study, Howe (1956) traced the Rowe and Bluejacket coals from eastern Kansas into northeastern Oklahoma and western Missouri. Kosanke and others (1960) correlated the Rowe, Drywood, and Bluejacket coals with coals in Missouri, Kentucky, Illinois, and Indiana on the basis of palynology. However, Davis (1961, p. 104), Bordeau (1964, p. 168), and Urban (1965, p. 75-76) compiled evidence that did not support the conclusions of Kosanke and others (1960).

The Problem of Anomalous Thinning of Strata

The outcrop of the Rowe coal described by Stringer (1959, p. 60) was not found on Inola Hill (sec. 10, T19N, R17E). However, apparently a thin coal bed was uncovered when a pond was dug in NW¼ SW¼ NE¼ sec. 10 (Larry Kindley, personal communication, 1975). This location is consistent with that of the Rowe coal in the section measured by

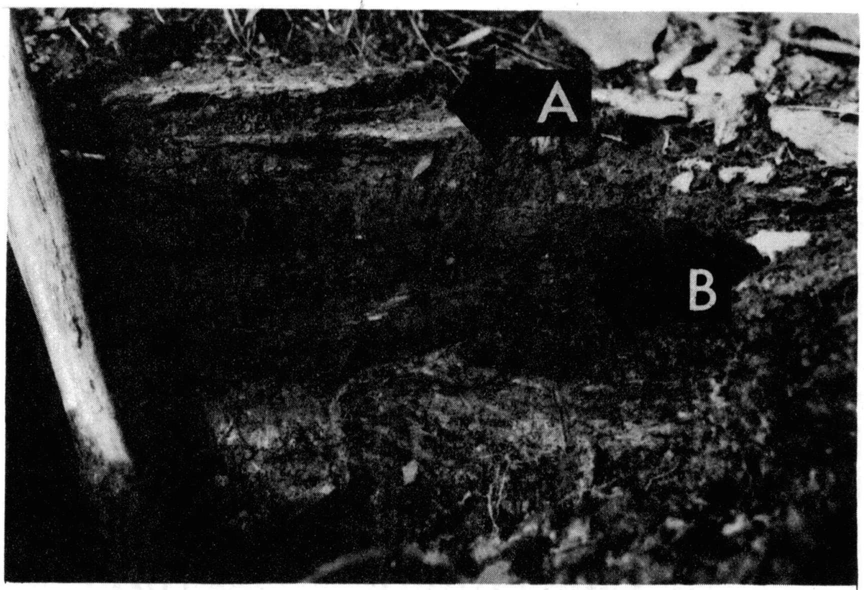


Figure 8.--Exposure of (A) lower Inola Limestone Member (2 in. thick) and (B) Bluejacket coal (2 in. thick) on the west side of Inola Hill, SE¼ NW¼ NW¼ sec. 10, T19N, R17E, Rogers County, Oklahoma

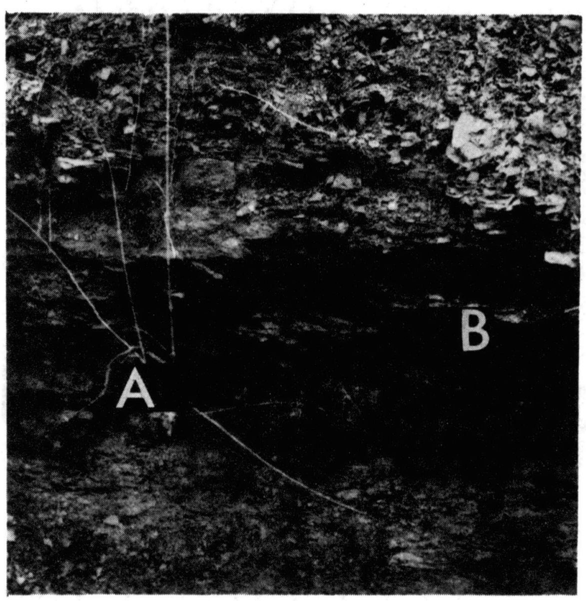


Figure 9.--Exposure of (A) unnamed coal (4 in. thick and (B) overlying limestone (5 in. thick) on north side of Inola Hill, SE¼ NE¼ NW¼ sec. 10, T19N, R17E, Rogers County, Oklahoma

Stringer (1959, p. 60). Figure 5 is a composite of Stringer's work and my own; the thickness and lithologic associations of the Rowe coal are those of Stringer (1959, p. 60).

The Rowe and Drywood coals are separated by 90 to 100 ft of strata at the section measured at Inola Hill (Pl. 3A). In contrast, cores taken from the western part of the study area (sec. 24, T19N, R17E) show this part of the stratigraphic section to be about 150 ft thick (Pl. 2). Several hypotheses would explain this apparent uncommon amount of eastward thinning of strata.

1) The coal mapped by Stringer (1959) at Inola Hill as the Rowe coal is a discontinuous coal with associated underclay and overlying limestone. The true Rowe coal is deeper and crops out somewhere north and east of Inola Hill.

2) Movement along the Seneca Fault system may have been contemporaneous with deposition of sediments of the Krebs Group (S. A. Friedman, personal communication, 1976, and Reeder, 1974, p. 85). A relative upward movement on the eastern side of faults of the Seneca system would have resulted in thinner sediments being deposited there and a thicker section being deposited on the downthrown western side.

3) A topographic high between 1,000 and 1,500 ft in relief is shown on Precambrian basement terrain in the northern part of the study area, in the vicinity of Inola Hill (Visher, 1968, Pl. 1, and Reeder, 1974, p. 86). If this basement "high" existed during the deposition of Krebs sediments, evidence of thinning of Krebs units by differential compaction of by deposition of a thinner section of sediments is to be expected.

4) Perhaps combined movement along the Seneca Fault system and compaction over a topographic high in the Precambrian surface caused thinning of the Krebs strata in the vicinity of Inola Hill.

There is no effective way to eliminate any of these hypotheses with the data available, but I believe that hypothesis (4) is the most probable to be true.

Depositional Environments of Coals and Associated Strata

Interpretations of the depositional framework of coals and associated strata in the study area were made from relationships of rock units observed in the field, evidence of fossils, petrography of rock samples, and evidence from the literature.

Shales

Unweathered exposures of shale of the Boggy and Savanna Formations are not abundant in the study area. Commonly the shales are gray and fissile where exposed, and in some places they are carbonaceous. The shales are sparsely fossiliferous. They weather easily and mostly are covered by colluvium, soil and vegetation. In sections measured on Inola Hill the shales tend to show gradual coarsening upward toward the bases of sandstone units.

Fossils collected from a sparsely fossiliferous, 17-ft section of shale at the Gable Coal Co. strip mine (NE¼ sec. 28, T19N, R17E) included one Nuculana bellistriata, six Aviculopectin sp., two small pelecypod fragments that were too damaged to identify, plant debris, and unidentified organic material. The shale is fissile, dark gray, carbonaceous and contains clay-ironstone concretions. (This shale unit proved to be almost barren of invertebrate fossils; during one of the mornings spent in collecting only six specimens were found.)

Descriptions of cores taken in the study area (on file at the Oklahoma Geological Survey) describe the similar shale units as "medium to dark gray, carbonaceous," in some places "interbedded with thin sandstone laminae" and containing "fossiliferous zones." Descriptions also include rather frequent mention of siltstone, described, for example, as "soft, gray, carbonaceous with fine sand, randomly oriented slickensided surfaces throughout with no apparent offsetting." Where these siltstone beds underlie coal beds, which is commonly the case, they most likely are underclays. At exposures, underclays were observed to be rather silty and they could have been mistaken as siltstone in samples from the subsurface.

Several units of siltstone are described in records of cores, but are not shown to be associated with overlying coal beds. Rather, they are more-or-less continuous beds within the thick shale sequences (Pls. 2 and 3). These siltstones are interpreted as either silty, clayey zones in the shales or kaolinitic underclays not overlain by coal.

Fossils collected from shale at the Gable Coal Co. mine indicate near-shore, brackish-water and swampy environments (J. D. Naff, personal communication, 1976). Lithologically similar dark shales of the Savanna and Boggy Formations probably also were deposited in paralic to shallow-marine environments.

Sandstones

Sandstones that crop out in the study area include (a) the Spiro sandstone, (b) a rather extensive unnamed sandstone unit contained in the interval between the Rowe and Drywood coals, (c) the Bluejacket Sandstone Member, and (d) the Taft Sandstone Member (Fig. 5). Thin beds of sandstone as thick as about 6 ft are contained in all the shale units included in the study. The sandstone unit of the subsurface that lies next below the Neutral (?) coal (Fig. 5) may be the Warner Sandstone Member of the McAlester Formation; on the basis of the information at hand, its proper classification is indefinite.

Examination of exposures and of records of coal-test wells and core descriptions indicates that the sandstones show many similar characteristics. All the sandstones in the study area are quartzose; they range from very fine- to fine-grained, are well sorted, mostly well rounded, micaceous, and weather tan to light brown. Pieces of fossilized wood were found in some samples. Sandstone outcrops commonly show small-scale to medium-scale crossbedding. Crossbedding also was noted in sandstones penetrated in cores. In general, the sandstones are lenticular and vary markedly in thickness from one part of the study area to another. For example the Bluejacket ranges from 0 to 20 ft thick on Inola Hill and is as much as 40 ft thick a few miles to the west in exposures along the Verdigris River.

On the basis of evidence observed in the field and by comparison of this evidence with criteria described by Shelton (1973, Table 3), I judge that the sandstones probably were deposited in deltaic environments. This also seems to be the consensus concerning the origin of the Bluejacket Member in the study area (Sandro and Visher, 1968, p. 60; Visher, 1968, p. 37; Shelton, 1973, p. 67).

Limestones

Limestones in the study area mostly are less than 5 in. thick and are sporadic. The Doneley Limestone Member of the Savanna Formation (Fig. 5) was found in outcrop at only one location (SE¼ sec. 27, T19N, R17E) where it is about 18 in. thick. Limestone rubble was observed in SW¼ sec. 34, T19N, R17E, on a low hill south of the United Coal Co. strip mine; this rubble probably is weathered from the Doneley (Friedman, personal communication, 1975). Stringer (1959, p. 60) described the Doneley in outcrop at Inola Hill (sec. 10, T19N, R17E), but this exposure seems to have become obscured from view. Other limestones found in outcrop include an unnamed limestone, about 4 in. thick, on the north side of Inola Hill, stratigraphically between the Doneley and the Drywood coal and overlying a thin coal bed (Fig. 5). This limestone is also recorded in core descriptions (Pls. 2 and 3) and is found in outcrop in the western part of the study area (NE¼ NE¼ sec. 19, T19N, R17E).

The Inola Limestone Member of the Boggy Formation (Fig. 5) overlies the Bluejacket coal at several exposures on Inola Hill. This member consists of a lower bed about 3 in. thick overlain, in turn, by a 6-ft sandy to carbonaceous shale, a 3-in. coal bed and an upper limestone about 5 in. thick. The Spaniard and Sam Creek Limestone Members of the Savanna Formation were observed in outcrop in sec. 27, T19N, R17E, but were inaccessible throughout most of the time this study was being conducted (see App. E).

The Doneley Member, unnamed limestone, and the lower unit of the Inola Member are similar, in that they are fissile and carbonaceous, as observed in outcrop. Thin sections of samples contain abundant remains of algae, fragmented remains of shallow-water marine invertebrates (bryozoa, crinoids, holothuroids, ostracods, brachiopods, pelecypods, and foraminifera), oöliths and calcispheres, bituminous material (asphaltite), and pyrite. The limestones are composed of ferroan calcite and the matrix material is micritic. These limestones are thus classified as carbonaceous algal biomicrites.

The upper part of the Inola Limestone is more massive in outcrop and less carbonaceous than the lower part. In thin section, samples of it also contain shallow-water marine invertebrates similar to those in the other limestones, fewer algal remains than the other limestones, calcispheres, hematite, and small amounts of dolomite. This rock is a slightly dolomitic biomicrite. Descriptions of the thin sections, including fossils, are contained in Appendix A.

Limestones described above probably were deposited in protected lagoonal environments, as indicated by these lines of evidence: (a) clay is abundant in the limestones, but sand is sparse, (b) pyrite and bituminous material are common, (c) algae are abundant in comparison to fossils suggestive of higher-energy marine waters (such as brachiopods, foraminifera, and pelecypods), and (d) some organic material is macerated, but not winnowed. The lagoonal limestones may record marine transgressions and inundations of the coal swamps.

Coals and Underclays

The stratigraphic positions of coals in the study area have been discussed above.

Petrographic examination was made of the Rowe coal using hand specimens and thin sections. The samples were collected from the Gable Coal Co. mine (NE¼ sec. 28, T19N, R17E) and the United Coal Co. mine (SE¼ sec. 34, T19N, R17E). The coal contains abundant pyrite both in nodules and grains finely disseminated throughout the coal. The average sulfur content of this coal (as received) is 4.8 percent (Table 4). Coal macerals identified in thin section include the following: (a) exinite, including both spore remains and cuticular matter (10 to 15 percent of coal examined), (b) opaque attritus (micrinite and fusinite), mostly fine-grained micrinite that gives the Rowe coal its characteristic dull appearance (makes up as much as 50 percent of some samples of the coal examined), (c) vitrinite, which shows cellular structure of woody material and is concentrated in bands of bright coal (makes up as much as 50 percent of some samples). Other components of the Rowe coal may include disseminated clay, which is indicated by the rather high ash content (Table 4).

Fine attrital coal (micrinite) probably represents degradation of humic material to very small size early in diagenesis (Schopf, 1971, p. 1155). This fine debris may have been transported a short distance before final deposition (J. M. Schopf, personal communication, 1976). This leads to the speculation that sorting during transportation may have concentrated the "hotter" components of the fine attrital coal, resulting in the high Btu value of the Rowe coal (Table 4). This high Btu value is abnormal, considering the high ash and sulfur content of the Rowe coal (S. A. Friedman, personal communication, 1976).

Underclays in the study area range in thickness from a few inches, such as the underclay of the unnamed coal between the upper and lower

Table 4.--Ash, sulfur, and calorific value (as received) for coals in the study area.

	Value	No. of samples	Range
Ash			
Drywood coal	11.5	1	
Rowe coal	14.9	7	21.5-10.1
Sulfur			
Drywood coal	1.1	1	
Rowe coal	4.8	7	2.9-7.5
Calorific value (Btu)			
Drywood coal	9,913	1	
Rowe coal	12,715	7	10,802-13,640

beds of the Inola Limestone Member, to more than 4 ft, as in the case of the underclay of the Rowe coal. Underclays sampled contained root fragments (Stigmaria sp.) and plant rootlets. At natural exposures the underclays commonly are weathered to a gray mud. Unweathered samples of underclay from beneath the Rowe coal at the Gable Co. mine were light gray, silty, and contained flakes of muscovite and cubic grains of pyrite. In records of cores from the study area, underclays are mistakenly described as siltstones, as discussed previously (p. 25). A nodular, pisolitic underlime associated with underclay of the Rowe coal at Inola Hill was reported by Stringer (1959, p. 28). This would be the underclay limestone of the classical Pennsylvanian cyclothem as discussed by Weller (1957, p. 345).

Coals in the study area probably are mostly autochonous. The evidence to support this conclusion is that at all of the observed exposures of coal, the coals overlie underclays; of course, this implies that the coals remained in contact with the strata in which the coal-forming plants were rooted.

Underclays probably developed as soils somewhat independently and previous to development of the overlying coal. The general evidence for this statement is the large number of underclays not overlain by coals and coals not underlain by underclays (Weller, 1957, p. 345).

The dominant clay mineral in lower Pennsylvanian underclays is kaolinite (Grim and Allen, 1938, p. 1500); the underclays become more illitic later in the Pennsylvanian (Weller, 1957, p. 346). Underclays of the Cherokee Group of southeastern Kansas express the lithology of the underlying bed; for example, underclays overlying sandstone tend to be silty or sandy (Howe, 1956, p. 25). This is consistent with the observation that the silty underclays in the study area overlie siltstone or sandstone at many places.

In general, underclays seemed to have developed rather slowly under conditions of relative tectonic stability and relatively cool moist conditions. Bedding may have been destroyed by plant roots, and the characteristic slickensides may have been caused by compaction above decaying roots or by desiccation of the clay (Weller, 1957, p. 345-346).

Inferred Depositional History

Sediments of the Krebs Group in the study area were deposited in or near shallow seas on the stable shelf areas of northern Oklahoma during Desmoinesian time (Weirich, 1953, p. 2039). The general source of sediments may have been the Ozark Uplift, which was a positive element during that time (Scruton, 1950, p. 425-426). However, Shelton (1973, p. 64) and Visher (1968, p. 33) show evidence that sediment may have been derived from far to the north of the Ozark Uplift.

Swamps developed on deltas that built repeatedly into the sea and that were submerged repeatedly. Representative of these deltas and especially of their associated sandstones is the Bluejacket Member of the Boggy Formation and its related units. According to Sandro and Visher (1968, p. 59),

> . . . following the deposition of the Brown Lime (Doneley Limestone Member of the Savanna Formation) and a thick shale overlying it, a major marine regression took place in the area of eastern Kansas and Oklahoma. During this time streams carrying terrigenous materials cut into the subaerial portion of the uplifted continental shelf and formed major fluvial channels. As these channels prograded seaward the large Bluejacket deltaic complex was deposited.

The study area is mapped as part of the eastern "Upper and Lower Deltaic Plain" (Sandro and Visher, 1968, Fig. 7). Inasmuch as the Bluejacket coal occurs a few feet above the Bluejacket Sandstone, it is assumed that the peat from which the Bluejacket coal was developed accumulated in interdistributary swamps or along the coastal margin. Limestone of the Inola Member was deposited as the Bluejacket delta was inundated in a major marine transgression. The proximity of the Inola Limestone to the Bluejacket coal suggests that the coal was deposited during an early stable stage of the marine transgression.

In a study of lignites of Texas, Kaiser (1974, p. 5-12) presented evidence that coals that developed closer to marine environments tend to have higher sulfur and ash contents than coals developed farther inland. In the study area, the Rowe and Drywood coals probably were developed in swamps near the coastal margins of the deltas. Peat probably was deposited in brackish water, as indicated by the color and fossil content of overlying shales and by the relatively high sulfur and ash content of the Rowe and Drywood coals.

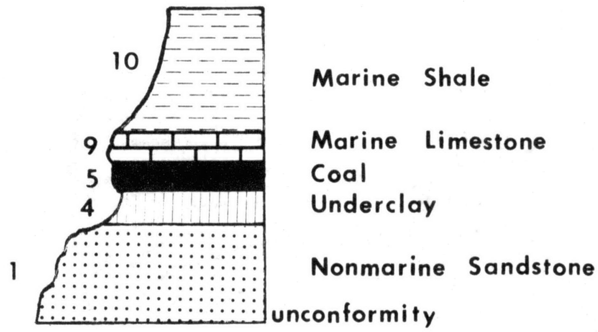
High sulfur content of coals also may indicate that peat underwent a significant amount of anaerobic decay, as evidenced by the favorability of anaerobic environments to deposition of sulfides. This kind of anaerobic process would be favored if the water table were high while the peat was still unconsolidated (Schopf, 1952, p. 68).

Cyclic Sedimentation

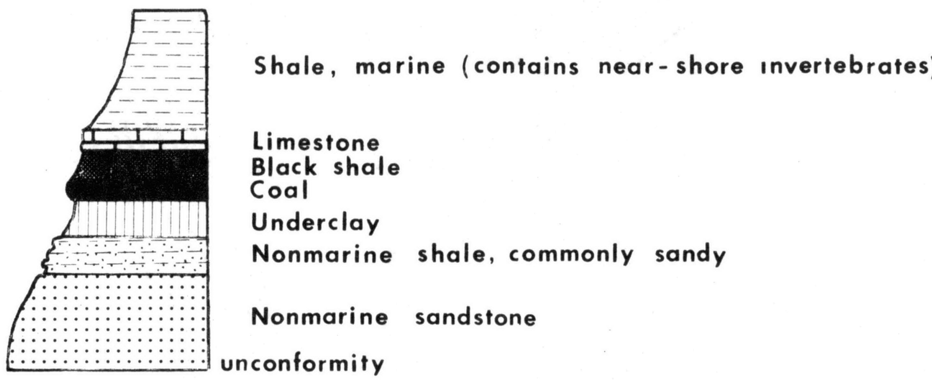
Much work has been done on the subject of cyclic sedimentation and cyclothems in the Midcontinent and the Eastern Interior (for example, Weller, 1930, 1956, 1957, 1964; Moore, 1930, 1936, 1950). Speculation on the mechanisms of cyclic sedimentation is not part of the purpose of this report. That subject has been treated extensively by other authors (such as Weller, 1956; Wanless, 1963; and Beerbower, 1964). Zeller (1964) cautioned against the bias that leads to inference of cyclic sedimentation from records of sedimentation that are, in fact, random. Branson (1964, p. 60) concluded that on the Oklahoma Platform, cyclic units are insufficiently developed to be designated as cyclothems.

The idealized cyclic sequence in the study area is shown in Figure 10. This resembles very closely the Cherokee cycle of Moore (1950, p. 7-8) and the simple cyclothem of Weller (1957, p. 330), also shown in Figure 10. Fossils and lithologies of rock units in the study area tend to support these comparisons. However, only two well developed cycles in the study area fit the models discussed above. These are the cycles associated with (a) the Rowe coal and Doneley Limestone Member of the Savanna Formation and (b) the Bluejacket coal and Inola Limestone Member of the Boggy Formation.

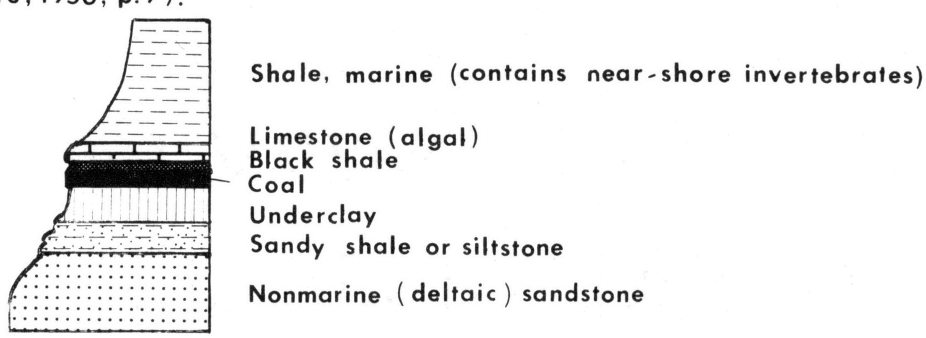
It seems reasonable that conditions resulting in the deposition of a specific type of sediment were recurrent in the study area as deltas were repeatedly built and submerged. Paleontological and lithological factors support this proposition, as discussed above. No sequence seems to have been repeated exactly, however. Having reviewed the relevant work of Weller and Branson, I judge that as Branson (1964, p. 60) suggested, the cyclic units on the Oklahoma Platform probably cannot be regarded as cyclothems in the classic sense.



Idealized section showing simple cyclothem as defined by Weller (1957, p. 331).



Idealized section showing a cyclothem in the Cherokee Group, southeastern Kansas (Moore, 1950, p. 7).



Idealized section showing a sedimentary cycle in the Inola area, Rogers County, Oklahoma.

Figure 10.--Comparison of idealized cyclic sequences of Moore (1950) and Weller (1957) with that inferred in the Inola area, Oklahoma

Quaternary Deposits

Quaternary geology of the study area was described by Stringer (1959, p. 39-40). It is not the purpose of this study to add to the work that has already been done on this subject. However, it should be pointed out that about one half of the study area is covered by Quaternary terrace and alluvial material (Fig. 3). The problem of geologic mapping therefore was compounded by the extensive cover of Quaternary material and vegetation.

ECONOMIC GEOLOGY

Seven strip mines have been developed in the study area; one is active. Five of the abandoned mines are located in secs. 10, 26, 27, 28, and 34, T19N, R17E (Stringer, 1959, p. 50-51). Production records of these mines are not available. The coal probably was mined on a small scale for local use only (S. A. Friedman, personal communication, 1976). Two commercial strip mines have operated in the Inola area during the last few years. The United Coal Co. (now out-of-business) operated a mine in the SE¼ sec. 34, T19N, R17E. Production at this mine was 63,015 short tons of the Rowe coal in 1974, and total production was more than 113,200 short tons for the life of the mine. The mine was closed in 1975 (S. A. Friedman, written communication, April 19, 1976). Gable Coal Co. operates a strip mine in the NE¼ sec. 28, T19N, R17E. More than 32,200 short tons of the Rowe coal were mined during late 1974 and 1975, and slightly more than 12,000 short tons have been mined in 1976 (Donald C. Gable, written communication, April 23, 1976).

The mining companies in the study area may be able to market underclay of the Rowe coal as fire clay. The underclay of the Rowe coal purportedly has good refractory qualities that have interested manufacturers of refractory products (Donald C. Gable, personal communication, 1976).

With thin coals, such as those in the study area, the economic depth of mining is determined by the following parameters: (a) grade of the coal (measured by content of ash, sulfur, and Btu), which determines its market value, (b) thickness of the coal, and (c) lithology and thickness of the overburden. Coal at a depth of more than 100 ft with an overburden-to-coal ratio greater than 60:1 is considered to be economically nonstrippable (Friedman, 1974, p. 15).

Other problems that may have negative effect on the economics of mining coal arise in reclamation of the land and in other environmental problems, all beyond the scope of this report. For a more complete discussion of the general economics of strip mining, see Averitt (1975) and Friedman (1974).

Boundaries of the Rowe and Drywood coals are shown on Plates 4, 5 and 6. Plate 5 is an isopach map that shows thickness of the Rowe and Drywood coals. Plate 6 is an overburden map that shows depth to coal in the study area. Classes of 0 to 20 ft, more than 20 to 40 ft, more than 40 to 100 ft, and more than 100 ft of overburden are shown. Lithology can be inferred from cross sections (Pls. 2 and 3).

Caloric value (Btu) and content of ash and sulfur are shown in Table 4.[1] For proximate and ultimate analyses see Appendix B. Results of proximate and ultimate analyses of the Rowe coal indicates that it is to be ranked as high-volatile B bituminous coal and the Drywood coal a high-volatile C bituminous coal (see standards report by Averitt, 1975, p. 20).

Sulfur and ash contents of the coals in the study area are too high to permit use of the coals for coking. The coals may possibly be suitable for gasification. These coals are best suited for electric-power

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[1]Analyses were made by the Oklahoma Geological Survey.

generation, and the main use at the present is for fuel in manufacture of cement (Friedman, 1974, p. 16, and personal communication, 1976).

Estimates of reserves in the study area are shown in Table 5. Reserves were determined using data obtained from coal-test borings, exposures in mines, and from descriptions of cores. They were classified according to reliability of the estimates (see Averitt, 1975, p. 50-51), thickness of coals, and thickness of overburden. In determining coal reserves, the assumption was made that the average weight of bituminous coal is 1,800 short tons per acre foot.

The minimal economic thickness of minable coal was taken to be 10 in. rather than 14 in. as suggested by Averitt (1974, p. 23). This was done because coal 10 in. thick is being mined at a profit (Donald C. Gable, personal communication, 1976). Therefore, estimates were not made of reserves of coal less than 10 in. thick. Lower limits of 14 in. and 28 in. were used to define the next two higher categories of coal thickness as suggested by the U.S. Geological Survey (Averitt, 1975, p. 23). Overburden categories of 0 to 20 ft and greater than 20 to 40 ft were used because these divisions mark economic limits of mining coal in the study area at this time. The greater-than-100-ft category was included because a thin coal at depth greater than 100 ft, although considered to be not economically strippable with current technology and at current prices (Averitt, 1975, p. 55-56; Friedman, 1974, p. 15), may be mined profitably in the future.

Original, remaining, and recoverable coal resources are shown in Table 6. The "original resources" category includes all coal thicker than 10 inches. Production figures for the mines of the United and the Gable coal companies were combined with estimates of production from

Table 5.--Measured, indicated, and inferred coal resources, ordered by thickness of coal and thickness of overburden (in thousands of short tons)

Measured	Thickness (in.)					
	10 to 14		15 to 28		more than 28	
	acres	tons	acres	tons	acres	tons
T18N, R17E						
Rowe coal						
depth (ft)						
0-20*	36	60	2	4		
21-40	156	280	8	20		
41-100	215	390	136	350		
over 100	57	100				
T19N, R16E						
Rowe coal						
depth (ft)						
over 100	1,117	2,010	186	630		
Drywood coal						
depth (ft)						
21-40	36	60	9	20		
41-100	243	440	210	550		
over 100	98	180				
T19N, R17E						
Rowe coal						
depth (ft)						
0-20	69	120	145	420	3	10
21-40	173	310	374	1,100	19	80
41-100	300	540	739	2,870		
over 100	136	240	285	910		
Drywood coal						
depth (ft)						
21-40			8	20		
41-100	139	250	18	50		

[1]Customarily, values of thickness of coal that include fractions of inches are rounded upward to the nearest whole number. For example, in computation of reserves, a bed of coal 20.5 in. thick would be considered to be 21 in. thick (S. A. Friedman, personal communication, 1976). Therefore, limits of categories are reported here as 0-20 in., 21-40 in., and so forth.

Table 5.--(Continued)

Indicated	Thickness (in.) 10 to 14		15 to 28		more than 28	
	acres	tons	acres	tons	acres	tons
T18N, R17E						
Rowe coal						
depth (ft)						
21-40	139	250				
41-100	1,028	1,850	18	40		
over 100	507	910	12	30		
T19N, R16E						
Rowe coal						
depth (ft)						
over 100	925	170	32	110		
Drywood coal						
depth (ft)						
41-100	249	450	100	260		
over 100	1,565	2,820				
T19N, R17E						
Rowe coal						
depth (ft)						
0-20	14	30	11	30		
21-40	156	280	118	370		
41-100	982	1,770	594	1,770		
over 100	1,313	2,360	251	730		
Drywood coal						
depth (ft)						
21-40	993	1,790				
41-100	320	580	36	90		
over 100	91	160				

Table 5.--(Continued)

Inferred	Thickness (in.) 10 to 14 acres	10 to 14 tons	15 to 28 acres	15 to 28 tons	more than 28 acres	more than 28 tons
T18N, R16E						
Drywood coal						
depth (ft)						
over 100	319	100				
T18N, R17E						
Rowe coal						
depth (ft)						
21-40	22	40				
41-100	59	110				
over 100	553	990				
T19N, R16E						
Rowe coal						
depth (ft)						
over 100	460	830				
Drywood coal						
depth (ft)						
over 100	1,379	2,480				
R19N, R17E						
Rowe coal						
depth (ft)						
41-100	28	50				
over 100	113	200				
Drywood coal						
depth (ft)						
21-40	148	270	27	70		
41-100						
over 100	215	390				

the older mines to determine the total amounts of coal mined and lost in mining. This amount was subtracted from the computed original resources to determine remaining resources. To calculate recoverable reserves, the average recoverability in strip mining was assumed to be 80 percent (see Averitt, 1975, p. 31), and coal more than 100 ft deep was assumed to be not recoverable.

The estimate of total original coal resources (all categories) in the study area is 22,980,000 short tons of Rowe coal and 10,930,000 short tons of Drywood coal. Of these figures 16,370,000 short tons are at depths greater than 100 feet. A total of 280 acres is underlain by 686,900 short tons of coal at least 10 in. thick and within 20 ft of the surface; an additional 544 acres are underlain by 1,580,000 short tons of coal at least 14 in. thick and overlain by more than 20 to 40 ft of overburden. Some of these acres contain coal that is most attractive for strip mining under current economic conditions (see maps, Pls. 5 and 6).

Table 6.--Original, remaining, and recoverable (strippable) coal resources in Inola area (in thousands of short tons).

T19N, R17E			
Rowe coal		Drywood coal	
Original	14,220	Original	3,670
Remaining	13,740	Remaining	3,670
Recoverable	6,530	Recoverable	2,490
T19N, R16E			
Rowe coal		Drywood coal	
Original	3,240	Original	7,260
Remaining	3,240	Remaining	7,260
Recoverable	0	Recoverable	1,430
T18N, R16E			
Rowe coal			
Original	5,410		
Remaining	5,410		
Recoverable	2,700		
T18N, R16E			
Rowe coal			
Original	110		
Remaining	110		
Recoverable	0		
Total			
Rowe coal		Drywood coal	
Original	22,980	Original	10,930
Remaining	22,500	Remaining	10,930
Recoverable	9,230	Recoverable	3,920

CONCLUSIONS

The principal conclusions of this study are as follows.

1) Rocks that are found in outcrop in the study area include units of the Boggy and Savanna Formations. The McAlester Formation is penetrated by coal-test boreings and cores from stratigraphic bore-holes. These units are part of the Krebs Group, Desmoinesian Series, Pennsylvanian System.

2) Eight coals crop out or were penetrated in the subsurface. The Rowe coal of the Savanna Formation and the Drywood coal of the Boggy Formation are of economic importance.

3) Faulting, probably related to the Seneca Fault system, deformed rocks in the study area. Northeast-trending folds seem to be related genetically to the faults.

4) Movement along the Seneca Fault system may have been contem-poraneous with deposition of the Krebs Group.

5) Sediments of the Krebs Group were deposited in or near shallow seas. Coal swamps developed on deltas that built into the seas repeat-edly and that were submerged repeatedly.

6) Remaining coal resources in the study area are 22,500,000 short tons of Rowe coal and 10,930,000 short tons of Drywood coal. Of these amounts 9,230,000 short tons of Rowe coal and 3,920,000 short tons of Drywood coal are in beds greater than 10 in. thick and within 100 ft of the surface.

7) Coal in the study area is high sulfur and ranked as high-volatile B and C bituminous coal. It is best suited for electric-power generation and industrial uses.

SELECTED REFERENCES

Arbenz, J. K., 1956, Tectonic map of Oklahoma: Okla. Geol. Survey Map GM-3.

Averite, Paul, 1974, Coal resources of the United States: United States Geol. Survey Bull. 1412, 131 p.

Beerbower, J. R., 1964, Cyclothems and cyclic depositional mechanisms in alluvial plain sedimentation, in D. F. Merriam (Ed.), Symposium on cyclic sedimentation: Kans. Geol. Survey Bull. 169, vol. 1, p. 31-42.

Blyth, J. G., 1959, Atoka Formation on the north side of the McAlester Basin: Okla. Geol. Survey Circular 47.

Bordeau, K. V., 1964, Palynology of the Drywood coal (Pennaylvanian) of Oklahoma: Unpub. M.S. thesis, Univ. Oklahoma, 205 p.

Branson, C. C., 1952, Marker beds in lower Desmoinesian of northeastern Oklahoma: Okla. Acad. Sci. Proceedings, vol. 33, p. 190-194.

____________, 1954, Field conference on Desmoinesian rocks of northeastern Oklahoma: Okla. Geol. Survey, Guide Book II, 43 p.

____________, 1956a, Pennsylvanian history of northeastern Oklahoma: Tulsa Geol. Soc. Digest, vol. 24, p. 83-86.

____________, 1956b, General geologic section of Oklahoma oil-producing areas: Prepared for National Oil and Landsman Association Yearbook, vol. XXVI, Oklahoma Geol. Survey, reprint, 1 p.

____________, 1962, Pennsylvanian System of the Mid-continent, in C. C. Branson (Ed.), Pennsylvanian System in the United States: Amer. Assoc. Petroleum Geologists, Symposium, p. 431-460.

____________, 1964, Cyclicity in Oklahoma Paleozoic rocks, in D. F. Merriam (Ed.), Symposium on cyclic sedimentation: Kans. Geol. Survey Bull. 169, p. 57-62.

Chance, H. M., 1890, Geology of the Choctaw coal field: Am. Inst. Min. Eng. Trans., vol. 18, p. 653-661.

Creath, W. B., and Howell, G. D., 1974, Environmental geology of metropolitan Tulsa: Geol. Soc. Amer., South Central Section, Guidebook, 27 p.

Davis, P. N., 1961, Palynology of the Rowe coal (Pennsylvanian) of Oklahoma: Unpub. M.S. thesis, Univ. Oklahoma, 152 p.

Drake, N. F., 1897, A geological reconnaissance of the coal fields of the Indian Territory: American Philosophical Society, Proceedings, vol. 36, p. 326-419.

Friedman, S. A., 1960, Channel-fill sandstones in the Middle Pennsylvanian rocks of Indiana: Indiana Geol. Survey Rept. Prog., No. 23, 50 p.

____________, 1972a, A new coal-investigation program in Oklahoma: Shale Shaker, vol. 22, no. 7, p. 152-156.

____________, 1972b, A new coal-investigation program in Oklahoma, *in* South-Central Section 6th Annual Meeting, Geol. Soc. Am., Abstr., vol. 4, no. 4, p. 279-280.

____________, 1974, Investigation of the coal reserves in the Ozarks section of Oklahoma and their potential uses: Final Report to the Ozark Regional Commission, 117 p.

Grim, R. E., and Allen, V. T., 1938, Petrology of Pennsylvanian underclays of Illinois: Geol. Soc. Amer. Bull., vol. 49, p. 1485-1514.

Howe, W. B., 1956, Stratigraphy of Pre-marmaton Desmoinesian (Cherokee) rocks in southeastern Kansas: Kans. Geol. Survey Bull. 123, 132 p.

Huffman, G. G., 1958, Geology of the flanks of the Ozark Uplift: Okla. Geol. Survey Bull. 77, 115 p.

Kaiser, W. R., 1974, Texas lignite: near-surface and deep-basin resources: Bureau of Economic Geology, The University of Texas at Austin, Report of Investigations no. 79, 70 p.

Kercher, G. C., and others, 1966, Lexicon of geologic names of the United States for 1936-1960: U. S. Geol. Survey Bull. 1200, pts. 1, 2 and 3, 4341 p.

Kosanke, R. M., Simon, J. A., Wanless, H. R. and Willman, H. B., 1960, Classification of the Pennsylvanian strata of Illinois: Ill. Geol. Survey, Rept. of Invest. 214, 84 p.

Johnson, K. S., and Denison, R. E., 1973, Igneous geology of the Wichita Mountains and economic geology of Permian rocks in southwest Oklahoma: Geol. Soc. Amer. Annual Meeting, Guide book for field trip 6, Okla. Geol. Survey, 33 p.

Jordan, Louise, 1957, Subsurface stratigraphic names of Oklahoma: Okla. Geol. Survey Guidebook VI, 220 p.

McCulloch, C. M., Deul, M. and Jeran, P. W., 1974, Cleat in bituminous coalbeds: U. S. Bur. Mines Rept. of Invest. 7910, 25 p.

Moore, R. C., 1930, Sedimentation cycles in the Pennsylvanian of the northern Mid-continent region: Geol. Soc. Amer. Bull., vol. 41, p. 51-52.

__________, 1936, Stratigraphic classification of the Pennsylvanian rocks of Kansas: Geol. Soc. Amer. Bull., vol. 47, p. 1785-1808.

__________, 1950, Late Paleozoic cyclic sedimentation in central United States: 18th International Geological Congress, London, 1948, pt. 4, p. 5-16.

Oakes, M. C., 1953, Krebs and Cabaniss Groups, of Pennsylvanian age, in Oklahoma: Amer. Assoc. Petroleum Geologists Bull., vol. 37, p. 1523-1526.

Reeder, L. R., 1974, The control of potential Arbuckle hydrocarbon traps in northeastern Oklahoma by Precambrian topography: Shale Shaker, vol. 24, no. 5, p. 84-96.

Sandro, S. B., and Visher, G. S., 1968, Subsurface study of the southern portion of the Bluejacket Delta, in G. S. Visher (Ed.), A guidebook to the geology of the Bluejacket-Bartlesville sandstone, Oklahoma: Okla. City Geol. Soc., p. 52-65.

Schopf, J. M., 1952, Was decay important in origin of coal: Jour. Sed. Pet., vol. 22, no. 2, p. 61-69.

__________, 1971, Comments about the origin of micrinite: Econ. Geol., vol. 66, p. 1153-1156.

Scruton, P. C., 1950, The petrography and environment of the deposition of the Warner, Little Cabin and Hartshorne sandstones in northern Oklahoma: Amer. Jour. Sci., vol. 48, p. 408-426.

Shelton, J. W., 1973, Models of sand and sandstone deposits: A method for determining sand genesis and trend: Okla. Geol. Survey Bull. 118, 122 p.

Smith, C. C., 1911, Geology of the Claremore Quadrangle: Unpublished manuscript on file at the office of the Oklahoma Geological Survey.

Stringer, R. S., 1959, Geology of the Krebs Group, Inola area, Rogers and Mayes counties, Oklahoma: Unpub. M. S. thesis, Univ. Oklahoma, 63 p.

Strong, D. M., 1961, Subsurface geology of Craig, Mayes and eastern Nowata and Rogers counties, Oklahoma: Unpub. M. S. thesis, Univ. Oklahoma, 235 p.

Taff, J. A., 1899, Geology of the McAlester-Lehigh coal field, Indian Territory: U. S. Geol. Survey, 19th Annual Report, Pt. 3, p. 423-456.

Urban, L. L., 1965, Palynology of the Drywood and Bluejacket coals (Pennaylvanian) of Oklahoma: Unpub. M. S. thesis, Univ. Oklahoma, 91 p.

Visher, G. S., 1968, Depositional framework of the Bluejacket-Bartlesville sandstone, in G. S. Visher (Ed.), A guidebook to the geology of the Bluejacket-Bartlesville sandstone, Oklahoma: Okla. City Geol. Soc., p. 32-51.

Wanless, H. R., 1963, Origin of late Pennsylvanian cyclothems (abs): Amer. Assoc. Petroleum Geologists Bull., vol. 47, p. 375.

Weirich, T. E., 1953, Shelf principle of oil origin and accumulation: Amer. Assoc. Petroleum Geologists Bull., vol. 37, p. 2027-2045.

Weller, J. M., 1930, Cyclical sedimentation in the Pennsylvanian Period and its significance: Jour. Geol., vol. 38, p. 97-135.

____________, 1956, Argument for diastrophic control of late Paleozoic cyclothems: Amer. Assoc. Petroleum Geologists Bull., vol. 40, p. 17-50.

____________, 1957, Paleoecology of the Pennsylvanian Period in Illinois and adjacent states: Geol. Soc. Amer., Mem. 67, p. 325-364.

____________, 1964, Development of the concept and interpretation of cyclic sedimentation, in D. F. Merriam (Ed.), Symposium on cyclic sedimentation: Kans. Geol. Survey Bull. 169, p. 607-622.

Wilson, L. R., 1968a, Paleoecology of Pennsylvanian coal swamps in Oklahoma: Okla. Geol. Survey, Oklahoma Geology Notes, vol. 28, no. 1, p. 10.

____________, 1968b, Palynological stratigraphy and succession of Oklahoma Pennsylvanian coal swamps: Okla. Geol. Survey, Oklahoma Geology Notes, vol. 28, no. 2, p. 91.

____________, 1976, Desmoinesian coal seams of northeastern Oklahoma and their palynological content, in Coal and oil potential of the tri-state area, Guidebook for Tulsa Geological Society field trip, p. 19-32.

Woodruff, E. G., and Cooper, C. L., 1928, Geology of Rogers County, Oklahoma: Okla. Geol. Survey Bull. 40, vol. III, p. 269-288.

Zeller, E. J., 1964, Cycles and psychology, in D. F. Merriam (Ed.), Symposium on cyclic sedimentation: Kans. Geol. Survey Bull. 169, p. 631-636.

APPENDIX A

DESCRIPTIONS OF THIN SECTIONS OF LIMESTONES

<u>Sample</u>: JG D-1, Doneley Limestone Member.

<u>Collection locality</u>: N½ SW¼ sec. 27, T19N, R17E, Rogers County, Oklahoma. Overlies Rowe coal, limestone is 18 in. thick.

<u>Fossils</u>:

Foraminifera

Vedekindellina sp.

other unidentified species

Bryozoa

Rhombopora sp.

other unidentified species

Ostracods

Crinoids (fragments)

Holothuroids (fragments)

Pelecypods (fragments)

Gastropods

Algae (fragments), composing 90 percent of fossil content of sample.

<u>Other constituents</u>:

Oöids and calcispheres

Asphaltite

Pyrite

<u>Matrix material</u>: Micrite, about 15 percent.

<u>Remarks</u>: This limestone is made up of ferroan calcite. Two colors of ferroan material were observed in stained areas. Deep blue filling in the fossils represents an early calcite; the fossil absorbed iron from this filling when it recrystallized, causing it to be stained a lighter blue (N. R. Donovan, personal

communication, 1976). Abundent clay, but less than 10 percent quartz sand or silt.

Hand specimen: Rather fissile, carbonaceous, and fossiliferous. Weathers to light brown.

Name: Algal biomicrite.

Sample: JG D-2, Unnamed limestone below Drywood coal.

Collection locality: NE¼ NW¼ sec. 10, T19N, R17E, Rogers County, Oklahoma. Overlies an unnamed coal, 23 ft below Drywood coal.

Fossils:

Foraminifera, less than 1 percent of fossils.

Bryozoa

Rhombopora sp.

Ostracods? (fragments)

Crinoids (fragments), about 5 percent of fossils.

Brachiopods and pelecypods (fragments), about 20 percent of fossils.

Algae (fragments), about 70 percent of fossil content.

Other constituents:

Oöids and calcispheres

Asphaltite

Pyrite

Matrix material: Micrite, about 20 percent.

Remarks: This limestone is similar in most respects to JG D-1, including being composed of ferroan calcite and having a high clay content.

Hand specimen: Fissile and carbonaceous: in outcrop it resembles a calcareous shale.

Name: Algal biomicrite.

Sample: JG I-1, upper part, Inola Limestone Member.

Collection locality: NW¼ NW¼ sec. 10, T19N, R17E, Rogers County, Oklahoma, found in rubble about 6 ft below the outcrop.

Fossils:

Foraminifera

Tetrataxis sp.

other unidentified fusulinids

Ostracods

Crinoids (fragments)

Punctate brachiopod fragments

Pelecypods (fragments)

Algae (fragments), less than 20 percent of fossil content

Other constituents:

Calcispheres

Hematite (authigenic)

Matrix material: Micrite, about 80 percent of rock.

Remarks: This sample is most likely from the upper unit of the Inola Limestone, although it was collected in rubble a few feet below the outcrop on the west side of Inola Hill. It contains about 10 percent of silt-sized quartz grains and is made up of ferroan calcite. It may represent a deeper-water environment than the other limestones in the study area.

Hand specimen: Calcareous nodule weathered out of limestone bed.

Name: Biomicrite.

Sample: JG I-2, upper part, Inola Limestone Member.

Collection locality: NE¼ NW¼ sec. 10, T19N, R17E, Rogers County, Oklahoma. About 6 ft above the Bluejacket coal.

Fossil content:

Foraminifera

Tetrataxis sp.

Ostracods

Brachiopods and pelecypods (fragments)

Crinoids (fragments)

Holothuroids (fragments)

Echinoid spine

Algae (fragments)

Spores(?)

Other constituents:

Calcispheres

Pyrite, replaces some fossils and calcispheres.

Matrix material: Micrite, recrystallized in some places to sparite; 50 to 60 percent of rock.

Remarks: This limestone is similar in fossil content to JG I-1. It consists of slightly dolomitic ferroan calcite.

Hand specimen: Massive, fossiliferous, weathers to a light brown, 5 in. thick at the outcrop.

Name: Biomicrite

Sample: JG I-3, lower part, Inola Limestone Member.

Collecting locality: NW¼ NW¼ sec. 10, T19N, R17E, Rogers County, Oklahoma. Overlies Bluejacket coal, 12 ft above Bluejacket Sandstone Member.

Fossils:

Ostracod, only one observed.

Algae (fragments) comprising about 90 percent of the rock.

Other constituents:

Asphaltite

Pyrite, euhedral crystals

Matrix material: Micrite, about 5 percent of rock.

Remarks: This limestone contains about 5 percent clay; the calcite is ferroan.

Hand specimen: Fissile and carbonaceous; in outcrop it is about 2 in. thick and resembles calcareous shale.

Name: Algal biomicrite.

Sample: JG I-4, upper part, Inola Limestone Member.

Collection locality: NW¼ NW¼ sec. 10, T19N, R17E, Rogers County, Oklahoma. Stratigraphically, 6.5 ft above JG I-3.

Fossil content:

Foraminifera

Tetrataxis sp.

Ostracods

Holothuroids (1 fragment)

Algae (fragments), about 70 percent of fossil content.

Other constituents:

Calcispheres

Pyrite

Limonite staining

Matrix material: Micrite, partly recrystallized to sparite, about 10 percent of rock.

Remarks: This limestone is made up of ferroan calcite that has been partly dolomitized.

Hand specimen: More massive and less carbonaceous than JG I-3 (lower part, Inola Limestone); about 2 in. thick at the outcrop.

Name: Algal biomicrite.

APPENDIX B

ANALYSES OF COALS IN THE STUDY AREA

OKLAHOMA GEOLOGICAL SURVEY

COAL ANALYSIS REPORT

Field Number 73X4 **Lab Number** 1029

Submitted by ____ **Gross Sample Wt.** ____

Date and Condition Received 4/4/73, in plastic bags, combined after crushing.

Description of Sample Rowe coal, SW¼ SW¼ NW¼ sec. 34, T19N, R17E, Rogers Co.

PER CENT

		Air Dried	As Received	Moisture Free	Moisture & Ash Free
PROXIMATE ANALYSIS	Moisture		1.1		
	Vol. Matter		38.0	38.4	
	Ash		10.1	10.3	
	Fixed Carbon		50.8	51.3	
ULTIMATE ANALYSIS	Hydrogen			5.0	5.6
	Carbon			72.9	81.3
	Nitrogen			1.6	1.8
	Sulfur		4.6	4.7	5.2
	Oxygen			5.5	6.1
HEAT VALUE	Cal/g				
	BTU/lb		13,370	13,520	

Analyst D. Foster

Date 4/30/73

OKLAHOMA GEOLOGICAL SURVEY

COAL ANALYSIS REPORT

Field Number 73X5 **Lab Number** 1030

Submitted by **Gross Sample Wt.**

Date and Condition Received 4/4/73, 1 plastic bag

Description of Sample Rowe coal, SW¼ SW¼ NW¼ sec. 34, T19N, R17E, Rogers Co.

PER CENT

		Air Dried	As Received	Moisture Free	Moisture & Ash Free
PROXIMATE ANALYSIS	Moisture		0.6		
	Vol. Matter		38.5	38.8	
	Ash		15.9	16.0	
	Fixed Carbon		45.0	45.2	
ULTIMATE ANALYSIS	Hydrogen			5.0	5.9
	Carbon			70.8	84.3
	Nitrogen			1.2	1.4
	Sulfur		2.9	2.9	3.4
	Oxygen			4.1	5.0
HEAT VALUE	Cal/g				
	BTU/lb		13,640	13,710	

Analyst D. Foster

Date 4/30/73

OKLAHOMA GEOLOGICAL SURVEY

COAL ANALYSIS REPORT

Field Number 73X6 **Lab Number** 1031

Submitted by ________ **Gross Sample Wt.** ________

Date and Condition Received 4/4/73, in 4 plastic bags, combined after crushing

Description of Sample Rowe coal, SW¼ SW¼ NW¼ sec. 34, T19N, R17E, Rogers Co.

PER CENT

		Air Dried	As Received	Moisture Free	Moisture & Ash Free
PROXIMATE ANALYSIS	Moisture		0.8		
	Vol. Matter		39.1	39.4	
	Ash		14.8	14.9	
	Fixed Carbon		45.3	45.7	
ULTIMATE ANALYSIS	Hydrogen			5.1	6.0
	Carbon			71.7	84.3
	Nitrogen			1.2	1.4
	Sulfur		3.0	3.0	3.5
	Oxygen			4.1	4.8
HEAT VALUE	Cal/g				
	BTU/lb		13,100	13,200	

Analyst D. Foster

Date 4/30/73

OKLAHOMA GEOLOGICAL SURVEY

COAL ANALYSIS REPORT

Field Number 73X7 Lab Number 1032

Submitted by ______ Gross Sample Wt. ______

Date and Condition Received 4/4/73, in 2 plastic bags, combined after crushing

Description of Sample Rowe coal, SW¼ SW¼ NW¼ sec. 34, T19N, R17E, Rogers Co.

PER CENT

		Air Dried	As Received	Moisture Free	Moisture & Ash Free
PROXIMATE ANALYSIS	Moisture		0.4		
	Vol. Matter		37.5	37.7	
	Ash		11.8	11.8	
	Fixed Carbon		50.3	50.3	
ULTIMATE ANALYSIS	Hydrogen			5.1	5.8
	Carbon			72.7	82.5
	Nitrogen			1.7	1.9
	Sulfur		3.2	3.2	3.3
	Oxygen			5.5	6.5
HEAT VALUE	Cal/g				
	BTU/lb		13,280	13,330	

Analyst D. Foster

Date 4/30/73

OKLAHOMA GEOLOGICAL SURVEY

COAL ANALYSIS REPORT

Field Number 74X22 Lab Number 1066

Submitted by S. A. Friedman Gross Sample Wt. 550 g.

Date and Condition Received 10/29/74

Description of Sample Rowe coal (coal bed 0.8 ft. thick), sec. 34, T19N, R17E, Rogers Co.

PER CENT

		Air Dried	As Received	Moisture Free	Moisture & Ash Free
PROXIMATE ANALYSIS	Moisture		3.3		
	Vol. Matter		31.9	33.0	
	Ash		21.5	22.2	
	Fixed Carbon		43.3	44.8	
ULTIMATE ANALYSIS	Hydrogen				
	Carbon				
	Nitrogen				
	Sulfur		7.5	7.8	
	Oxygen				
HEAT VALUE	Cal/g				
	BTU/lb		10,802	11,171	14,358

Analyst D. Foster

Date 11/19/74

OKLAHOMA GEOLOGICAL SURVEY

COAL ANALYSIS REPORT

Field Number 74X33 **Lab Number** 1077

Submitted by S. A. Friedman **Gross Sample Wt.** 835 g.

Date and Condition Received 12/14/74 Rowe coal

Description of Sample Field sample by mine operator, SE¼ SE¼ SE¼ NW¼ sec. 28, T19N, R17E, Rogers Co.

PER CENT

		Air Dried	As Received	Moisture Free	Moisture & Ash Free
PROXIMATE ANALYSIS	Moisture		1.4		
	Vol. Matter		36.1	36.6	
	Ash		13.3	13.5	
	Fixed Carbon		49.2	49.9	
ULTIMATE ANALYSIS	Hydrogen				
	Carbon				
	Nitrogen				
	Sulfur		6.9		
	Oxygen				
HEAT VALUE	Cal/g				
	BTU/lb		12,732	12,913	14,928

Analyst D. Foster

Date 12/30/74

OKLAHOMA GEOLOGICAL SURVEY

COAL ANALYSIS REPORT

Field Number 75X49 **Lab Number** 1142

Submitted by S. A. Friedman **Gross Sample Wt.**

Date and Condition Received 6/10/75 Rowe coal (coal bed 0.9 ft. thick)

Description of Sample SW¼ NE¼ sec. 28, T19N, R17E, Rogers Co.

PER CENT

		Air Dried	As Received	Moisture Free	Moisture & Ash Free
PROXIMATE ANALYSIS	Moisture		0.9		
	Vol. Matter		34.2	34.6	
	Ash		16.8	16.9	
	Fixed Carbon		48.1	48.5	
ULTIMATE ANALYSIS	Hydrogen				
	Carbon				
	Nitrogen				
	Sulfur		5.2	5.3	
	Oxygen				
HEAT VALUE	Cal/g				
	BTU/lb		12,080	12,190	14,670

Sulfur forms (percent)
0.1 Sulfate S
4.2 Pyritic S
1.0 Organic S

Analyst Bob Powell

Date 1/6/76

OKLAHOMA GEOLOGICAL SURVEY

COAL ANALYSIS REPORT

Field Number 76C35 **Lab Number** 1236

Submitted by S. A. Friedman **Gross Sample Wt.**

Date and Condition Received 4/30/76

Description of Sample Drywood coal

PER CENT

		Air Dried	As Received	Moisture Free	Moisture & Ash Free
PROXIMATE ANALYSIS	Moisture		12.4		
	Vol. Matter		38.7*	44.2*	*Values approximate due to high moisture content
	Ash		11.5	13.1	
	Fixed Carbon		37.4	42.7	
ULTIMATE ANALYSIS	Hydrogen				
	Carbon				
	Nitrogen				
	Sulfur		1.1	1.3	
	Oxygen				
HEAT VALUE	Cal/g				
	BTU/lb		9,913	11,316	12,810

Sulfur forms (percent)
0.00 Sulfate S
.10 Pyritic S
1.16 Organic S

Analyst Bob Powell

Date 5/17/76

APPENDIX C

AN EXPLANATION OF MISSING COALS IN BOREHOLES IN THE STUDY AREA

Thirty-seven of the coal-test borings and core borings in the study area did not penetrate coal beds. Several hypotheses explain the absence of coal beds.

1) The driller did not see the coal although it was present.[1]

2) Some holes penetrated underclay but no coal. The coal did not accumulate at this geographic location; however, it is present a short distance away, at the same stratigraphic position.

3) Sandstone was penetrated at the stratigraphic position where coal was expected. In such a case it is possible that the coal had been cut out by erosion of a channel, or, more likely, a channel existed contemporaneously with the deposition of peat. Such sandstone-coal relationships exist in middle Pennsylvanian coal beds of western Indiana (Friedman, 1960, p. 37).

4) At some time in geological history, the coal had been eroded at the location of the boring.

5) The hole was not drilled deep enough.

6) The coal was faulted out at the location of the boring.

7) The coal had been mined at the location of the boring.

8) No explanation is offered, as no log of the boring was available.

After considering each boring on an individual basis, I have listed them under the hypothesis that I consider to be the most likely to be true (Table 7).

---

[1] Although this hypothesis is considered to be reasonable, its occurrence is improbable because the drillers seemed entirely competent.

Table 7.--Favored explanations of missing coal beds in the study area. Asterisk denotes that alternate explanation is considered to be possible.

Coal absent, underclay penetrated.

60*
69
70
71

Sandstone penetrated at stratigraphic position of coal.

37*
57
106*
138

Coal has been eroded.

19	105
20	109
21	113
23	144
25	146

Bore-hole was not drilled deep enough.

13	94	139*
31	95	147
32	96	157
88	108	158
89	135	

Coal faulted out.

106*
139*

Coal mined out.

37*
40
45
43

No explanation offered; log not available.

34
60*
105

APPENDIX D

MEASURED SECTIONS

1. Gable Coal Co. Strip Mine, NW¼ SW¼ NE¼ Sec. 28, T19N, R17E

Description of Unit	Thickness in Ft
Savanna Formation	
Shale, dark gray, carbonaceous, silty, fissile; contains ironstone-concretion zones, brackish water fossils.	19.0
Rowe coal, banded bituminous, flakes and nodules of pyrite; cleat measured.	0.9
Underclay, light gray, silty, mica flakes, fossil rootlets, pyrite cubes; base not observed; underclay probably thicker than shown here.	1.6

2. Western Slope of Inola Hill, NE¼ SW¼ NW¼ Sec. 10, T19N, R17E

Description of Unit	Thickness in Ft
Boggy Formation	
Inola Limestone Mbr., upper bed, light brown where weathered, gray where fresh, fossiliferous; forms brow of hill; fragments are platy and form rubble on slope below outcrop.	0.2
Shale, dark, carbonaceous, mostly covered; weathers to dark clayey soil.	3.5
Coal, banded bituminous, quite weathered; stained red and yellow; covered at most places.	0.2
Covered, probably silty, gray shale or siltstone, as indicated by float.	3.0
Inola Limestone Mbr., lower bed, gray, carbonaceous, thin bedded, fossiliferous; quite weathered.	0.2
Shale, black, very carbonaceous, fissile.	0.1
Bluejacket coal, banded bituminous, quite weathered, stained red.	0.2
Underclay, weathered to light gray mud; contains coalified rootlets	2.0
Covered, probably siltstone, silty shale, and thin bedded sandstone, as indicated by float.	12.0

Bluejacket Sandstone Mbr., light tan where fresh, black-varnish stained and reddish brown where weathered; supports green and blue-green lichens; composed of fine quartz grains, roundness 0.8, sphericity 0.9, well sorted; rather porous; micaceous; weathering cracks indicate low-angle small-scale to medium-scale cross-bedding; forms ridge about one-half the way up Inola Hill.	5.5
Savanna Formation	
Sandy shale, weathers light brown; very fine grained, stained red; fissile; interbedded with lenses of sandstone as much as 1 in. thick.	2.5
Shale, mostly covered, dark gray where fresh, weathers light brown; fissile; contains ironstone concretions; ratio of silt to clay seems to increase upward; grades into overlying sandy shale.	85.0
Sandstone, light tan where fresh, yellow-brown with dark varnish stain where weathered; composed of fine quartz grains, roundness 0.8, sphericity 0.9, well sorted, micaceous; exposure poor; therefore bedding characteristics not observed; base of unit not exposed.	5.0

3. Gully on North Side of Inola Hill, NE¼ NE¼ NW¼ Sec. 10, T19N, R17E

Description of Unit	Thickness in Ft
Boggy Formation	
Taft Sandstone Mbr., light tan where fresh, reddish-brown where weathered; composed of fine to very fine quartz grains, roundness 0.8, sphericity 0.9, well sorted, micaceous; low angle cross-bedding, forms cap of Inola Hill.	4.0
Shale, base is dark gray; carbonaceous; fissile; contains zones of ironstone concretions; upper part covered; probably becomes silty to sandy upward.	40.0
Inola Limestone Mbr., upper bed, gray when fresh, weathers tan; massively bedded; fossiliferous, forms a brow around top of gully.	0.5
Coal, bituminous, forms coating on base of overlying limestone; calcareous; quite weathered.	0.01
Underclay, quite weathered, forms a light gray mud.	0.5

Covered, probably silty shale with lenses of sandstone, as indicated by float.	6.0
Bluejacket coal, banded bituminous, stained red, moderately weathered; covered at most places.	0.3
Underclay, light gray, weathers to mud; sandy; lowermost 1.5 ft covered but presumed to be underclay.	2.0
Bluejacket Sandstone Mbr., light tan where fresh, weathered reddish brown; composed of very fine to fine quartz grains, well sorted; micaceous; contains fossilized wood fragments; low-angle cross-bedding; apparently pinches out eastward into gray shale; may cut out underlying coal at some places.	5.0
Savanna Formation	
Covered, probably shale or siltstone as indicated by float.	2.0
Shale, very dark gray, carbonaceous, fissile.	1.0
Drywood coal, banded bituminous, yellow, dusty coating (sulfur?); moderately weathered, cleat measured.	0.5
Shale, mostly covered, dark gray, silty.	8.0
Sandstone, light tan where fresh, weathers to grayish brown; black-varnish stained; quartzose, fine to very fine grained; micaceous.	2.0
Shale, mostly covered, dark gray, carbonaceous; contains zones of ironstone concretions, fissile.	15.0
Limestone, bluish gray where fresh, weathers to light gray; carbonaceous, fissile, fossiliferous, argillaceous.	0.4
Shale, very dark gray, carbonaceous, fissile.	0.1
Coal, banded bituminous, yellow dusty coating; moderately weathered, cleat measured.	0.3
Covered, probably dark gray shale, perhaps contains beds of sandstone, as indicated by float.	43.0
Shale, dark gray, carbonaceous; weathers to grayish brown; clayey with small amount of silt.	1.5
Covered, probably shale as described above, as indicated by float.	30.0

Sandstone, dark brown where weathered, reddish-tan where fresh; quartzose; fine-grained, roundness 0.8, sphericity 0.9, well sorted; micaceous; appears to include low angle cross-bedding; forms low ledge in bed of gully.	2.0

4. Tributary to Bull Creek, NW¼ SW¼ NE¼ SE¼ Sec. 27, T19N, R17E

Description of Unit	Thickness in Ft
Savanna Formation	
Doneley Limestone Mbr., grayish brown, where weathered, dark gray where fresh; carbonaceous, silty, fossiliferous; fissile; forms ledge in stream bed; jointed into large rectangular slabs; weathering causes parting along bedding plains.	1.5
Shale, very dark gray, carbonaceous, fissile; quite weathered.	0.1
Rowe coal, banded bituminous, quite weathered, forms a black mud.	0.3
Underclay, light gray, silty, weathered to a gray mud; base not observed; unit probably thicker than shown here.	0.5

APPENDIX E

OBSERVATIONS OF THE GEOLOGY IN

SE$\frac{1}{4}$ SEC. 27, T19N, R17E

This part of the study area was inaccessible until the main portion of this report had already been written and approved. The information below has no overriding bearing on the report, but is included for the sake of completeness.

Rocks are exposed along a tributary of Bull Creek in SE¼ sec. 27, T19N, R17E. The stratigraphically lowest units exposed in this tributary are sandstone that contains abundent Stigmaria sp., overlain and gradational with underclay. The underclay is overlain, in turn, by coal that is about one-half inch thick and calcareous siltstone that contains Lepidophyllum sp. and at least one horn coral. This siltstone is presumed to be equivalent stratigraphically to the Spaniard Limestone Member, Savanna Formation (Fig. 5).

The calcareous siltstone is overlain by about 15 ft of gray shale and about 1 ft of algal limestone that is believed to be the Sam Creek Limestone Member (Fig. 5). The Rowe coal and Doneley Limestone Member (Fig. 5) are separated from the algal limestone by about 15 to 20 ft of gray shale.

Structural and stratigraphic geology at this locality are shown diagrammatically in Fig. 11. The fault shown probably is the one mapped by Stringer (1959, Pl. I). It probably also is related to the fault at that location on Pl. 4, this report.

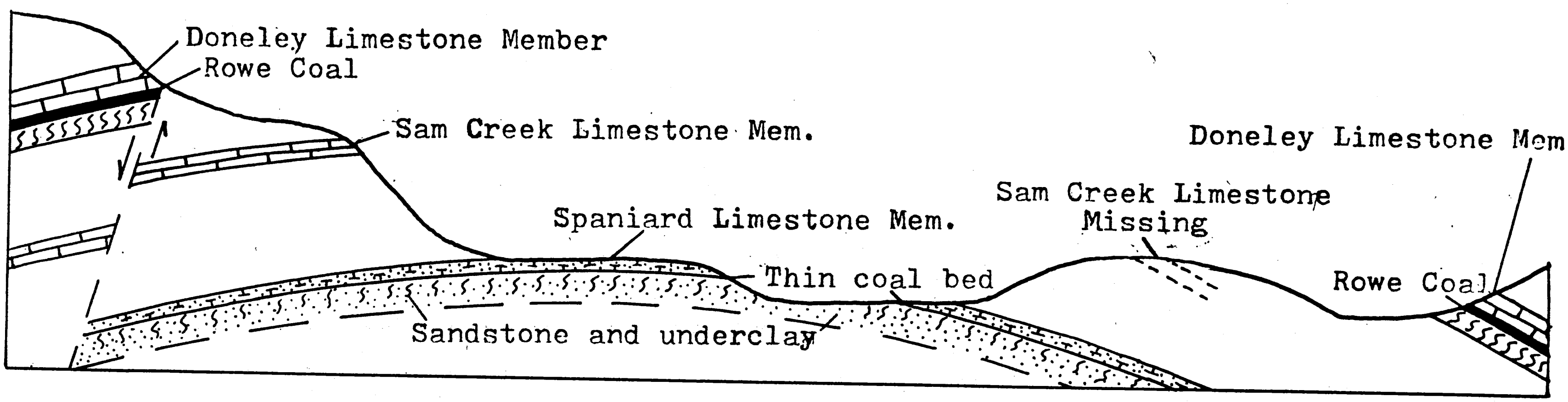

Figure 11.--Diagrammatic stratigraphic and structural relationship on Bull Creek Anticline in SE¼ sec. 27, T19N, R17E

VITA

Jay Mason Gregg

Candidate for the Degree of

Master of Science

Thesis: COAL GEOLOGY OF PARTS OF THE INOLA, CHOUTEAU N.W., CATOOSA S.E., AND NEODESHA QUADRANGLES, SOUTHEASTERN ROGERS AND NORTHERN WAGONER COUNTIES, OKLAHOMA

Major Field: Geology

Biographical:

Personal Data: Born in Pittsburgh, Pennsylvania, January 24, 1951, the son of Mr. and Mrs. Jay B. Gregg.

Education: Graduated from Westerville High School, Westerville, Ohio, in June, 1969; attended Otterbein College, Westerville, Ohio, from September, 1969 to July, 1970; received Bachelor of Science degree in Biology and Geology from Bowling Green State University, Ohio, in June, 1974; completed requirements for the Master of Science degree at Oklahoma State University in July, 1976.

Professional Experience: Graduate teaching assistant, Department of Geology, Oklahoma State University, 1974-1976.