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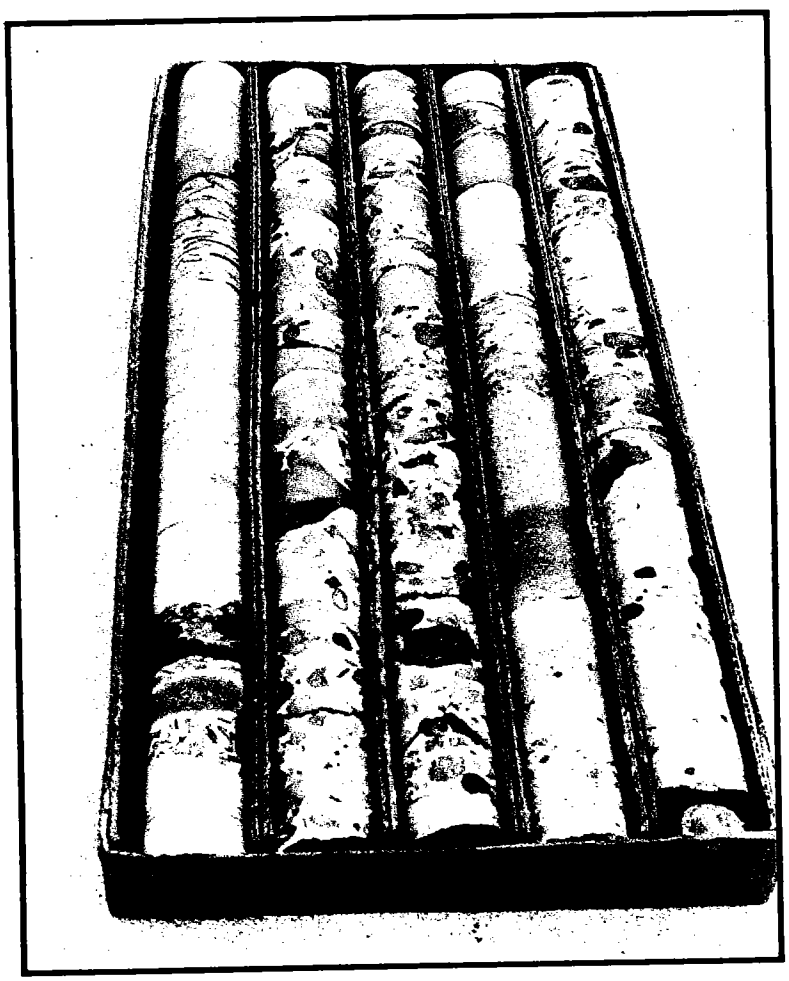

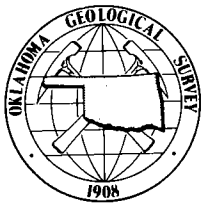

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Lithostratigraphy and Core-Drilling, Upper Atoka Formation through Lower Senora Formation (Pennsylvanian), Northeastern Oklahoma Shelf Area

LeRoy A. Hemish

ABSTRACT.—New knowledge of the strata between the upper part of the Atoka Formation and the lower part of the Senora Formation has resulted from a core-drilling project completed by the Oklahoma Geological Survey during 1988. Ten core-holes, ranging in depth from 150 ft to 441 ft, were drilled in the northeastern Oklahoma shelf, in an area extending from southern Muskogee County on the south to northern Craig County on the north.

A cross section, incorporating logs of the 10 core-holes, shows that seven coal beds observed in the northern shelf area can be correlated with coals named either in the southern shelf area or the Arkoma basin. The coal beds are all in the McAlester and Savanna Formations; from oldest to youngest, they are the Keefton, McAlester (Stigler), Upper McAlester (Stigler rider), Tamaha, Keota, Spaniard, and Sam Creek coals. None of these coal beds is known to have economic importance in the shelf area.

Several problems in stratigraphic nomenclature have developed among the states of Kansas, Missouri, and Oklahoma as the result of a subsurface study in Kansas; the problems apparently originated primarily from earlier miscorrelation of the Bluejacket Sandstone.

INTRODUCTION

This report presents the results of a core-drilling project by the Oklahoma Geological Survey (OGS), completed during the summer of 1988. The core-holes were drilled in the coal belt in the shelf area of northeastern Oklahoma (Fig. 1). Continuous core was cut at each of 10 locations to depths ranging from 150 ft to 441 ft. A total of 2,663.9 ft was drilled. All core was boxed and is stored at the OGS Core and Sample Library in Norman, Oklahoma, where it is available for study by the public. Figure 2 shows the OGS drill rig drilling a core-hole at a site in Craig County, Oklahoma.

Purpose

The primary purposes of the project were (1) to gather information concerning the geologic characteristics of the coal beds and associated strata in the stratigraphic interval from the Atoka Formation to the lower part of the Senora Formation; (2) to trace named lithostratigraphic units from their type areas in the shelf area—from the Arkoma basin on the south to the Kansas state line on the north; (3) to correlate several previously unidentified coal beds in the Atoka–Senora interval; (4) to establish reliable thickness data for several formations in an area where south-to-north thinning, although known to occur, had not been well measured; (5) to establish depths to the post-Mississippian erosion surface, where rig capability permitted; and (6) to provide cores for public use from a stratigraphic interval which is poorly known owing to a paucity of good surface exposures.

Presentation of the logs of the 10 core-holes (Appendix) drilled by the OGS in 1988 for this project is intended to supplement an earlier report of core-drilling by OGS in the northeastern Oklahoma coal belt. Logs of 85 core-holes drilled during 1983–86 were presented in that report (Hemish, 1988).

Methods

The elements of a core-drilling project have been discussed in detail by Hemish (1987a); therefore, only a brief overview of the methods will be included here.

Drill-hole sites are initially selected by the geologist in charge of a new project. All of the

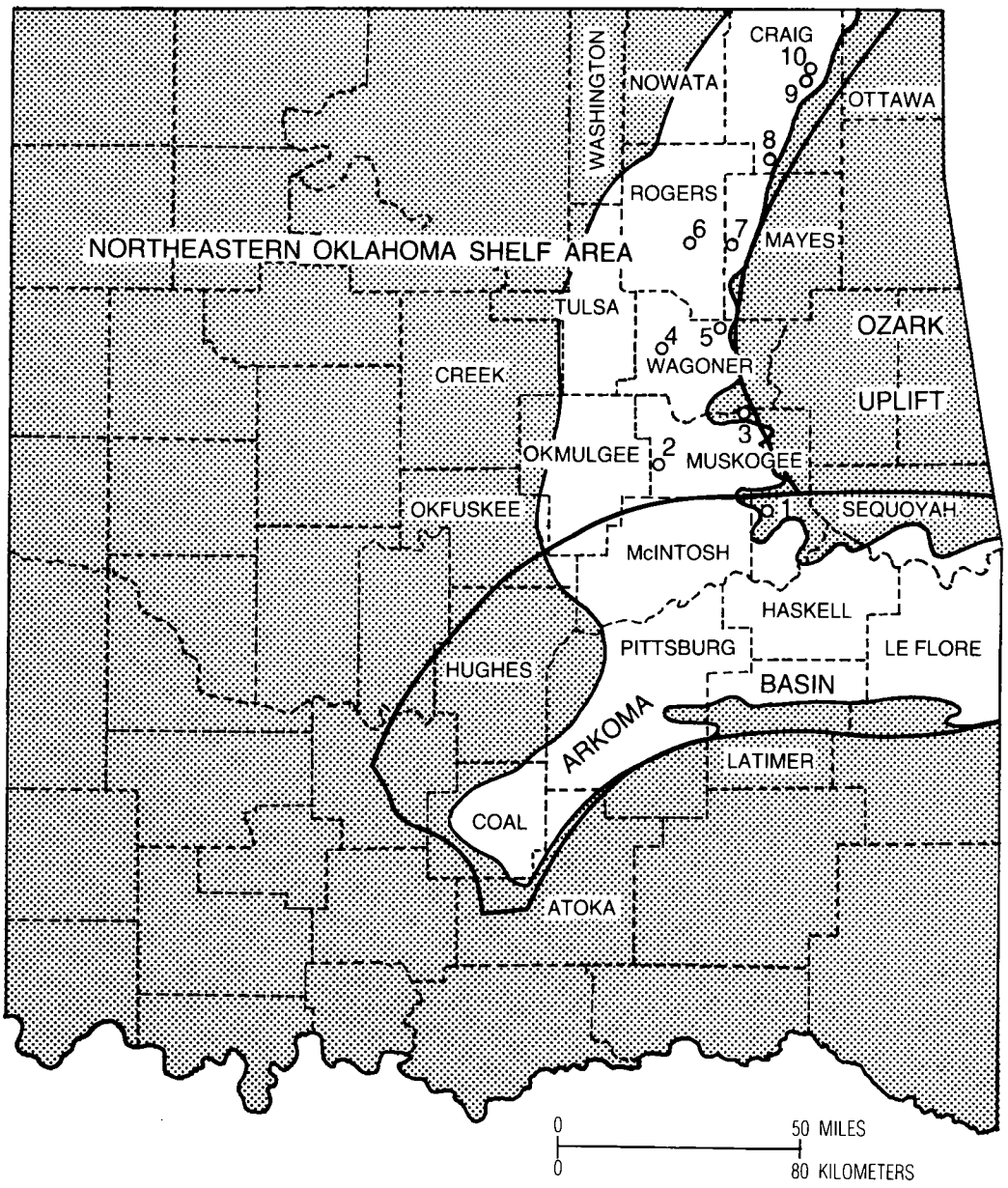


Figure 1. Map of eastern Oklahoma, showing the commercial coal belt (unstippled), the northeastern Oklahoma shelf area, the Arkoma basin, and the Ozark uplift (from Hemish, 1987b, fig. 1). Core-hole sites shown numbered.

site selection, preliminary land work, logistical planning, supervision of drilling, and assimilation of data included in this report were done by the author.

Site preparation, drilling, core recovery, equipment maintenance, and site restoration were done by two OGS drilling technicians. The OGS drill rig is mounted on a 2.5-ton flatbed truck (Fig. 2). A trailer is used to transport drill rods, water, tools, and supplies. The trailer is towed by a four-wheel-drive vehicle, which is also used to haul additional supplies and to transport boxed cores collected during the drilling operation. The following description of the methods used for drilling and collecting cores are quoted from Hemish (1987a).

When the drilling site is reached, the rig is positioned and leveled; siting of the hole is determined by the geologist, generally by pacing from section lines; the location is plotted on a topographic map; and the legal description of the site is recorded. Water is then hauled for circulation in the drill hole, the mast is raised, the portable slush pit is set up, the required drill bit is attached, and drilling commences. Generally, a 5-⅞-in.-diameter hole is drilled to a depth of ~9 ft

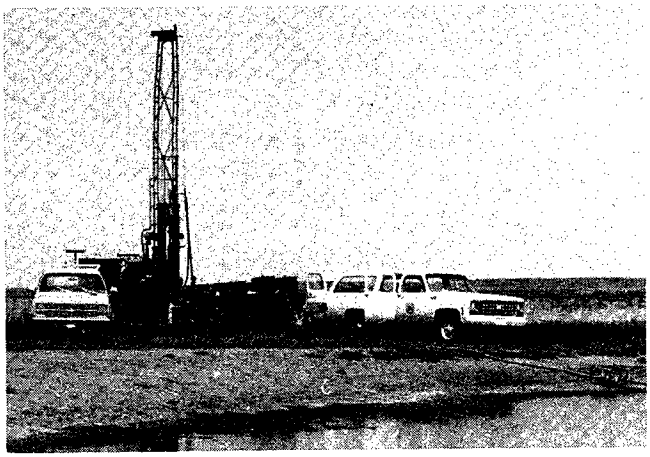


Figure 2. The Oklahoma Geological Survey drill rig, drilling a core hole in Craig County, Oklahoma (from Hemish, 1989b, fig. 2).

with a three-cone-type roller rock bit. Temporary surface casing is set (4-in. pcv pipe), which permits recirculation of drilling fluids.

If continuous coring is desired, a 10-ft core barrel with a 3-in.-diameter diamond bit is attached to the bottom of the drill stem. Two-in.-diameter core is cut, which is retrieved from the outer core barrel through the hollow drill stem by means of a wire-line hoist.

At the surface, the core is forced from the inner core barrel by means of water pressure and collected in trays, where it is washed, marked, described by the geologist, cut into 2-ft lengths, and boxed (Fig. 3). The boxed cores are labeled and hauled to the OGS Core Library in Norman, where they are stored. If a specific segment of the core (such as a coal bed) is to be analyzed, it is removed from the tray prior to boxing and sealed in a clear, tough plastic bag (0.006 mils thick) for transport to the OGS laboratory.

Finally, the hole is plugged in accordance with State regulations, and the site is restored. The rig and crew then move to the next scheduled drilling site.

Core samples of coal received by the OGS laboratory are processed and used for studies of chemical properties and petrographic properties. Portions of the crushed coal core not consumed in processing, as well as polished crushed-particle pellets used in petrographic studies, are stored at the Oklahoma Geological Survey.

Core-Hole Logs

Core-hole logs (Appendix) are numbered from 1 to 10 according to their location by section, township, and range (from south to north and west to east) and are keyed to numbers on the location map (Fig. 1), and on the cross sections (Pls. 1 and 2). The alphanumeric identification enclosed in parentheses includes identification as a core-hole (letter C), a county abbreviation, and a number indicating drilling sequence. The legal description of the location of each drill site is given in the core-log heading and is accurate within an area of 0.625 acre.

A lithologic column diagrammatically shows the sequence of rocks described in each log; lithologic symbols are explained on Plate 1. The lithologic columns are identical with those shown in the cross-sections (Pls. 1 and 2) at a reduced scale.

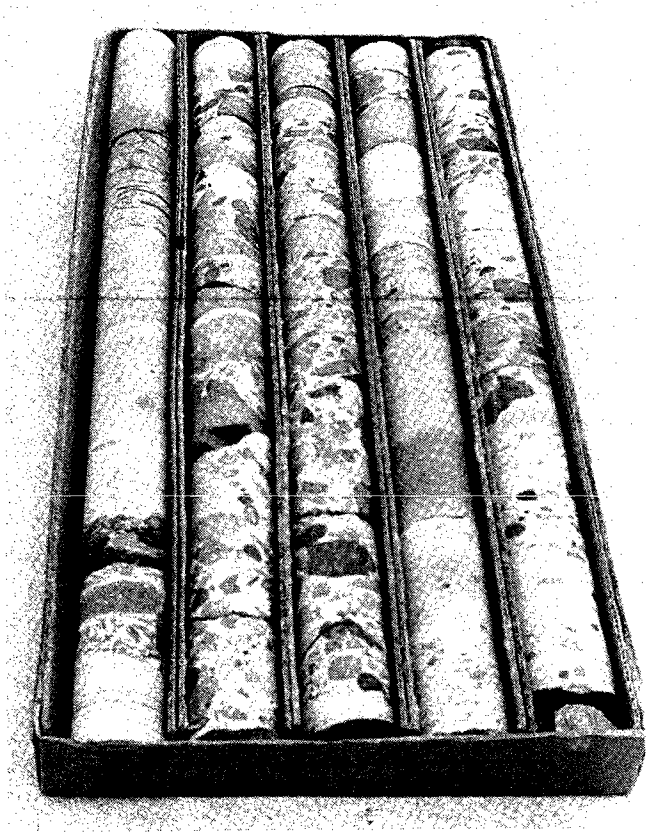


Figure 3. A box containing 2-in.-diameter core samples of conglomeratic sandstone from the Bluejacket Sandstone Member of the Boggy Formation (Appendix, core-hole 10, 28–38 ft below ground surface) (from Hemish, 1989a).

GEOLOGY

Previous Investigations

The earliest noteworthy report on the geology of the northeastern Oklahoma shelf area was by Drake (1897), who discussed the stratigraphy and structure, and made a sketch map

showing the approximate position of the Mississippian–Pennsylvanian contact. Ohern (1910) made a study of the stratigraphy of the older Pennsylvanian rocks of northeastern Oklahoma, and also made a map of the Vinita Quadrangle (Ohern, 1914).

Snider (1915) discussed the stratigraphy, structure, and paleontology of a portion of northeastern Oklahoma.

Cooper (1928) wrote on the correlation of coals in Oklahoma and Kansas.

The geology of the southern part of the Oklahoma shelf area was discussed by Wilson and Newell (1937).

In the 1950s, Howe (1951,1956) and Branson (1954a,b) investigated and reported in detail on the stratigraphic correlations among the Middle Pennsylvanian rock units of northeastern Oklahoma and southeastern Kansas.

Huffman and others (1958) discussed rocks of early Desmoinesian age in a report on the geology of the flanks of the Ozark uplift. Blythe (1959) reported on the Atoka Formation on the north side of the McAlester (Arkoma) basin.

Govett (1959) studied the geology of Wagoner County, Oklahoma. Branson and others (1965) reported on the geology of Craig County, Oklahoma.

In more recent times Friedman (1974) investigated the coal resources of eastern Oklahoma; Oakes (1977) reported on the geology of Muskogee County; Sutherland and Manger (1979) discussed the Mississippian–Pennsylvanian shelf-to-basin transition in the Ozarks region; and Zachry and Sutherland (1984) wrote on the stratigraphy of the Atoka Formation in northeastern Oklahoma.

Reports on coal stratigraphy in the area of present investigation were made by Hemish (1984,1986, 1987b,1988,1989b,c, in preparation a,b).

General Statement

The stratigraphic interval examined in this report extends from the upper part of the Atoka Formation through the lower part of the Senora Formation. The area of investigation lies between the town of Warner, in southern Muskogee County, and the Kansas state line in northeastern Craig County. Generally, core-holes were drilled at intervals which would provide maximum correlation potential of stratigraphic units over the widest area.

Four cross sections were constructed (Pls. 1,2), using logs from the 10 core-holes drilled, and incorporating five logs from a heavy-oil study completed by OGS in northern Craig County (Harrison and others, 1981). Admittedly, the wide spacing between holes over all of the study area except northern Craig County is less than ideal. Perhaps the study will serve to provoke more questions than it answers; therefore, only a tentative correlation of the units is suggested, based chiefly on sequence. Two cross sections (B–B′ and C–C′) were constructed to present alternative stratigraphic interpretations to those shown in Cross Section A–A′ in the problematical interval from the top of the Mississippian limestone to the base of the Warner Sandstone Member of the McAlester Formation; final resolution of the possibilities requires more in-depth study than can be provided in this report.

A discussion of the structural aspects of the study area is not the purpose of this paper. Regionally, the Oklahoma shelf area is on the western and northwestern edge of the Ozark uplift, a broad, domal, NE-trending structure occupying parts of Arkansas, Missouri, and Oklahoma (Fig. 1). Here rocks of Mississippian age pass beneath gently dipping Middle Pennsylvanian beds, with westward to northwestward dips ranging from 15 to 50 ft/mi (Branson and others, 1965).

The following discussion of stratigraphy will point out some problems that have become apparent in recent times; will explain correlations based on the writer's interpretations; will identify through correlations several previously unidentified coal beds that were known to be present in Craig County (Hemish, 1986; Pls. 6,7); and hopefully, will be useful to geologists working on correlations in the same stratigraphic interval in neighboring states to the north and northeast.

Stratigraphy

Figure 4 is a generalized geologic column showing the stratigraphic interval studied in this report. Emphasis is placed on coal beds, because they are the most continuous lithotypes and can be used as key beds in lithostratigraphic correlations (Friedman, 1974, p. 28).

Middle Pennsylvanian rocks unconformably overlie Mississippian rocks in the northern part of the northeast Oklahoma shelf area. This contact was confirmed by drilling holes from the Kansas state line to northern Wagoner County (Pl. 1). The Atoka Formation (Middle Pennsylvanian) unconformably overlies Morrowan (Lower Pennsylvanian) rocks in Muskogee

County (Zachry and Sutherland, 1984). Northward from Muskogee County, along the western margin of the Ozark uplift, the unconformity regionally truncates the Morrowan strata. The irregularity of the erosion surface is shown in Cross Section A–A′ (Pl. 1). Strata cored in core-holes 5 and 8 suggest that parts of the post-Mississippian erosion surface stood as upland areas at those locations during deposition of all sediments below the middle part of the McAlester Formation. These positive areas could have resulted from faulting during Mississippian time in conjunction with ongoing erosion. Perhaps the highs protruded from the seas as small island masses, as suggested by Blythe (1959, p. 33).

The interval of primary interest in this study consists of sedimentary rocks with prominent sandstone and shale beds, thin limestone beds, numerous coal beds, and underclays. Correlations based on surface investigations are difficult, because of a thick mantle of deeply weathered material over much of the area. Sequences thin and, key beds or entire formations may pinch out within a concealed area, which hinders accurate mapping. Therefore, the following interpretations and correlations, based on study of the newly cored rocks, are offered by the writer in hope of clarifying some of the stratigraphic problems in the shelf area of Oklahoma.

Post-Mississippian Erosional Surface to Base of Warner Sandstone

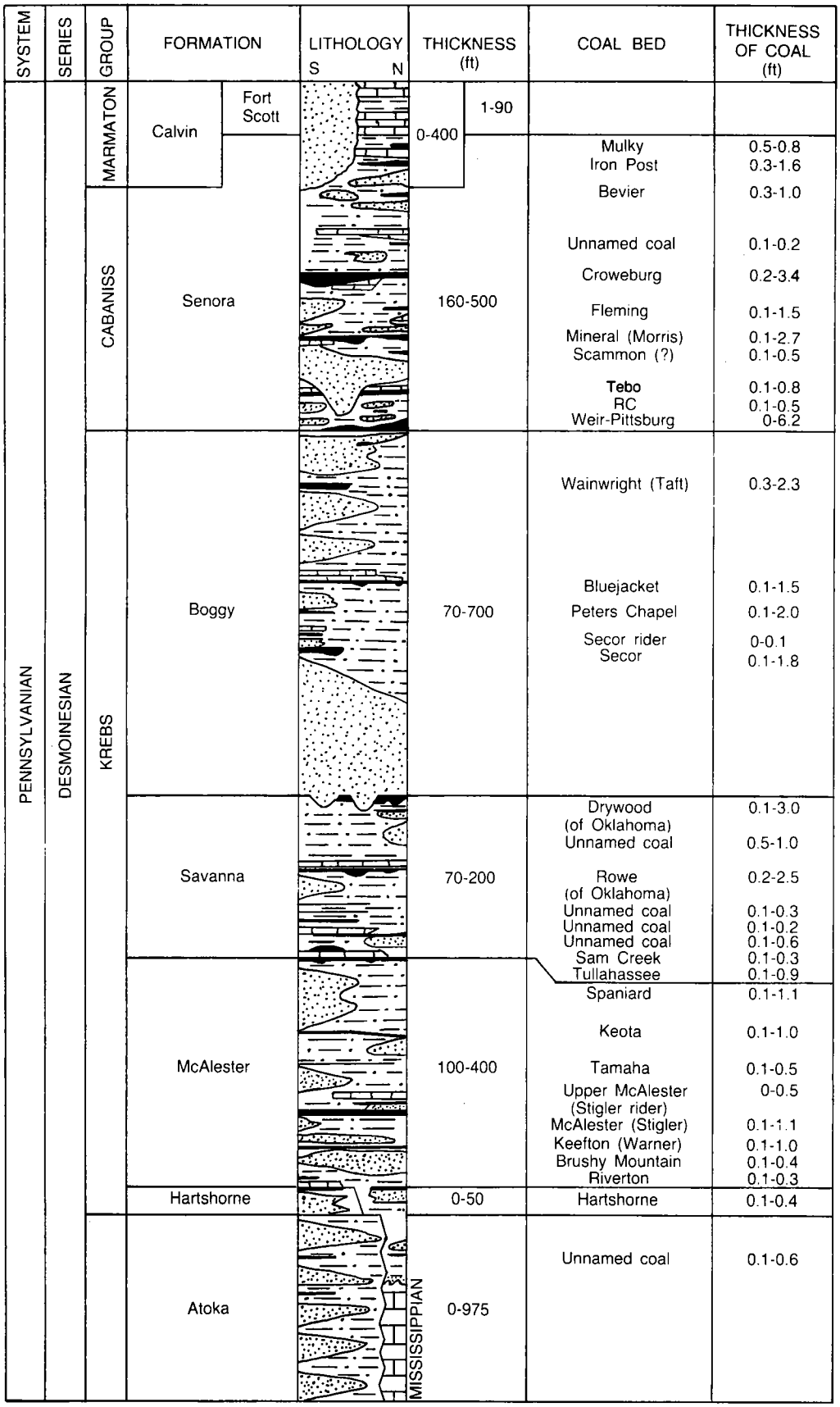
From Wagoner County northward the strata between the top of the Mississippian limestone and the base of the Warner Sandstone have been the subject of various stratigraphic interpretations. Do they belong with the Atoka Formation? The Hartshorne Formation? The McAlester Formation? Or do they include two of these formations, or perhaps all three?

The Atoka Formation was named by Taff and Adams (1900, p. 273) for exposures in the vicinity of the town of Atoka, Atoka County, Oklahoma, but no type locality was designated. Oakes (1977, p. 11) stated that the Atoka Formation is ~975 ft thick in the southern part of Muskogee County (in the vicinity of core-hole 1), and ~600 ft thick in northern Muskogee County (in the vicinity of core-hole 3). In most areas the Atoka Formation consists of shale and sandstone beds, with occasional thin limestones (Blythe, 1959, p. 5). Wilson (1935) subdivided the Atoka Formation into six sandstone members with associated unnamed shales in Muskogee and McIntosh Counties, Oklahoma. Because the thickness of the Atoka Formation in Muskogee County exceeds the continuous-coring capability of the OGS drilling rig, no attempt was made to core beyond the upper strata of the formation in that area. The ensuing discussion shows that only the upper member of the Atoka Formation (Blackjack School Member) is relevant to this study.

Wilson and Newell (1937, p. 33) redefined the Blackjack School Member of the Atoka Formation to include the succession of sandstones and shales midway between the Webbers Falls Sandstone (Atoka Formation) and the overlying Hartshorne Sandstone (Hartshorne Formation). They believed that two scarp-forming sandstones occurring above the Webbers Falls Sandstone in southeastern Wagoner County are the Blackjack School Sandstone and the Warner Sandstone of the McAlester Formation. This correlation was thought to be the most tenable because of the apparent absence of the Hartshorne sandstone east of Muskogee along the Arkansas River. Wilson and Newell (1937, p. 184) did not believe that the Hartshorne Formation was present north of Muskogee County. However, core-hole 3 shows that the Hartshorne Sandstone and overlying Hartshorne coal are present in that area. The lower of their two scarp-forming units appears to be the Hartshorne Sandstone.

Wilson and Newell (1937, p. 34) stated that the Blackjack School Sandstone could be mapped as far north as the area east of Vinita, in southeastern Craig County, owing to the presence of *Taonurus*, a fossil not seen in the Hartshorne Sandstone. Branson (1955, p. 65) disagreed with Wilson and Newell, stating that "Too much emphasis on *Taonurus* as an index to the Atoka is dangerous... It is a facies fossil associated with dirty siltstones." Instead, in Ottawa County, Branson (1955, p. 64,65) assigned to the Hartshorne Formation all rocks from the top of the Mississippian to the top of the Riverton coal (of Craig and Ottawa Counties and adjacent parts of Kansas), or, where the coal is absent, to the base of the Warner Sandstone.

Branson (1955, p. 64) used the name Hartshorne in a different sense than earlier writers. The Hartshorne Formation was named by Taff (1899), presumably for the town of Hartshorne, Pittsburg County, Oklahoma. Taff and Adams (1900, p. 274,275) defined the Hartshorne Formation as extending from the top of the first sandstone below the Upper Hartshorne coal to the base of the first continuous sandstone below the Lower Hartshorne coal. Oakes and Knechtel (1948, p. 25) took the top of the Upper Harts-



Generalized geologic column of coal-bearing strata from the base of the Atoka Formation to the lower part of the Fort Scott Formation, northeastern Oklahoma shelf area (modified from Hemish, 1987b, fig. 2).

horne coal to mark the boundary between the Hartshorne Formation and the overlying McAlester Formation. Branson (1955, p. 64) proposed that the Hartshorne Formation should include all the rocks from the top of the Atoka Formation to the top of the Upper Hartshorne coal, a proposal currently recognized by the OGS. Branson (1955, p. 65) suggested that the Riverton coal is equivalent to the Upper Hartshorne coal of the Arkoma basin, and that the unnamed coal near the base of the section may be equivalent to the Lower Hartshorne coal. Cross Section C–C′ (Pl. 2) shows Branson's interpretations.

Blythe (1959) studied the Atoka Formation in the shelf area of northeastern Oklahoma. He said (p. 5) that the formation thins northward and is overlapped by Desmoinesian rocks. He also stated that sediments of the shelf facies were derived primarily from source areas to the north and east.

The Blackjack School Member overlaps all older Atoka members northward, and has been traced to the general area of pinch-out a few miles north of Adair in northern Mayes County (Blythe, 1959, p. 22). Blythe apparently agreed with Wilson and Newell, as he wrote that the northernmost outcrops of sandstones belonging to the Atoka Formation occur in secs. 21 and 22 of T. 25 N., R. 21 E., in southeastern Craig County. The sandstone there is conglomeratic and exhibits scour-and-fill characteristics typical of stream-channel deposits.

Blythe (1959, p. 21) commented only briefly on strata overlying the Atoka Formation: "The shale zone above the Blackjack School probably contains locally thin Hartshorne sandstone and siltstone. Areas mapped as Atoka Formation in northern Mayes County may be Hartshorne sandstone, entirely or in part."

Branson and others (1965, p. 20–22) discussed sandstones that fill channels cut into Mississippian limestone in southeastern Craig County. The sandstones were mapped as Atoka Formation (Branson and others, 1965; Pl. 1), with reported thicknesses of 0 to 50 ft.

Branson and others (1965, p. 22–24) applied the term Hartshorne to beds between the top of the Atoka (or, in its absence, the Mississippian limestone) and the base of the Warner Sandstone. They included in the lower part of the Hartshorne Formation the *Taonurus* siltstone, classed by Wilson and Newell (1937, p. 54,184) as the Blackjack School(?) Member of the Atoka Formation.

Zachry and Sutherland (1984, p. 13) stated that in central Mayes County (T. 20 N.) Atoka strata rest on Mississippian beds. They also stated that the Atoka Formation at the northern margin of the Arkoma basin is overlain by the Hartshorne Sandstone, and that north of the basin margin, adjacent to the Ozark uplift, the McAlester Formation directly overlies the Atoka (Fig. 5). A regional unconformity at the base of the McAlester Formation truncates the Atoka in northern Mayes County (Sutherland and Manger, 1979). Figure 5 clearly shows this relationship and would seem to preclude the mapping of any strata older than McAlester Formation above the post-Mississippian erosional surface in Craig or Ottawa Counties. Cross Section B–B′ (Pl. 2) shows the above interpretation.

Hemish (1986, p. 11), after consulting with Robert O. Fay, OGS geologist who logged the boreholes drilled by OGS in 1977–78 to evaluate heavy-oil potential in northeastern Craig and northwestern Ottawa Counties (Harrison and others, 1981), concurred with Sutherland and Manger (1979). He concluded that the McCurtain Shale Member of the McAlester Formation is the lowermost unit recognizable in the Pennsylvanian System in Craig County.

Based on the 1988 OGS core-drilling, the writer proposes yet another interpretation of the stratigraphy of the northeastern Oklahoma shelf area, shown in Cross Section A–A′ (Pl. 1). The suggestion is made that the Atoka Formation and the Hartshorne Formation, as well as the McAlester Formation, can all be mapped continuously in the subsurface from the Arkoma basin northward to the Kansas state line.

A sequence of beds—grayish-black, ironstone-bearing shales underlain by a thin (2- to 4-ft) sandstone, underlain by a thin coal bed and underclay—can be traced continuously from Muskogee County (core-hole 3) to northern Craig County (core-hole 10). The sandstone is tentatively correlated with the upper sandstone bed in the Blackjack School Member of the Atoka Formation.

On Plate 1, beds in Muskogee County correlated with the Hartshorne Formation of the Arkoma basin are the Hartshorne coal and underclay, underlain by the Hartshorne Sandstone and siltstone extending downward to the top of the Atoka Formation. Where the Hartshorne coal is absent, the sandstone is overlain by a thin limestone (core-holes 1 and 7). In northern Craig County a thin coal bed (Riverton?) is similarly underlain by sandstone. This sequence in places includes shale or siltstone in T. 29 N., just south of the Kansas state line. This interpretation suggests that the Hartshorne coal and Riverton(?) coal are correlative.

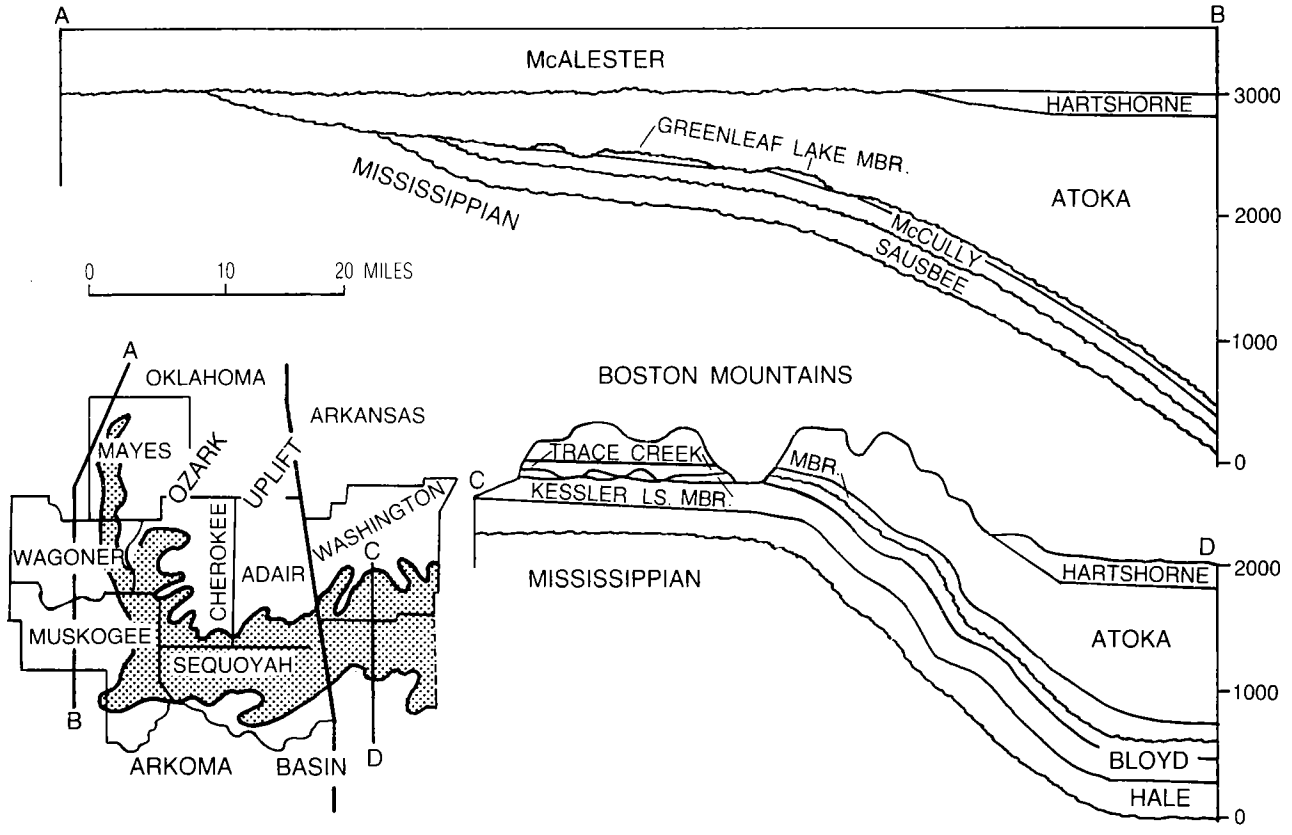


Figure 5. Cross sections from Zachry and Sutherland (1984, fig. 4), showing distribution of the Atoka Formation and bounding units in the Ozark region of Arkansas and Oklahoma. The stippled area on the map depicts outcrop of Atoka Formation.

In Muskogee County the interval from the top of the Hartshorne Formation to the base of the Warner Sandstone is composed predominantly of dark shales and is known as the McCurtain Shale Member of the McAlester Formation. The McCurtain Shale Member throughout Muskogee County includes a thin coal, named the Brushy Mountain coal by Hemish (in preparation b; core-holes 1,3). The unnamed limestone which occurs just above the Hartshorne Sandstone, where the Hartshorne coal is absent, is herein included as the basal bed of the McCurtain Shale Member. The limestone occurs as far north as west-central Mayes County (core-hole 7), where it lies ~20 ft below the base of the Warner Sandstone. Whether this limestone can be correlated with the limestone in Ottawa County discussed by Branson (1955, p. 65), which also occurs 20 ft below the Warner Sandstone, is problematical. A shale interval of varying thickness occurs throughout the northern shelf area between the Riverton(?) coal and the base of the Warner Sandstone. There should be little disagreement that the interval correlates with the McCurtain Shale Member to the south.

Base of Warner Sandstone to Base of Bluejacket Sandstone

This interval includes all beds from the top of the McCurtain Shale Member of the McAlester Formation to the base of the Boggy Formation.

The McAlester Formation was named by Taff (1899) for the city of McAlester in Pittsburg County, Oklahoma. The term McAlester Formation is currently applied to strata between the top of the Hartshorne Formation, below, and the base of the Savanna Formation, above. The base of the Spaniard Limestone is the top of the McAlester Formation (Oakes and Knechtel, 1948, p. 25,51). In northern Craig County, where the Spaniard Limestone is discontinuous or absent, Branson and others (1965, p. 26) used the base of the Rowe coal to map the base of the Savanna Formation. For purposes of this report, the top of the Spaniard coal, which almost directly underlies the Spaniard Limestone (Cross

Section A–A′, Pl. 1), is used as the boundary between the McAlester and Savanna Formations. This approach gives a more realistic view of the thickness of both formations.

The Warner Sandstone Member of the McAlester Formation was first described by Wilson and Newell (1937, p. 37,38). The type locality is ~0.5 mi east of the northwest corner of sec. 21, T. 12 N., R. 19 E., 1 mi north of Warner, Muskogee County, Oklahoma. Core-hole 1 was drilled in the type area of the Warner Sandstone. The Warner is a persistent, remarkably uniform unit, and therefore one of the most useful key beds for this study.

A thin (0.1- to 1.0-ft), persistent coal bed, named the Keefton coal by Hemish (in preparation b) occurs in a shale interval between a lower, resistant, 5- to 30-ft-thick sandstone and an upper, nonresistant, 10-ft-thick sandstone. Although the terms "upper" and "lower" Warner Sandstone are often used informally, Wilson and Newell (1937, p. 38) believed that more than a single depositional unit was involved, and restricted the term Warner to the scarp-forming, massive, lower sandstone.

Howe (1956, p. 32) noted a coal bed in a similar stratigraphic position in southeastern Kansas and thought it was probably a northward equivalent of the coal bed now known in Oklahoma as the Keefton. Cross Section A–A′ (Pl. 1) shows that a coal bed occurs in northern Craig County at a similar horizon. Although the coal occurs discontinuously, correlations suggest that it is probably equivalent to the Keefton coal of Muskogee County.

A pair of persistent coal beds, identified in the shelf area by their stratigraphic position as the McAlester (Stigler) and Upper McAlester (Stigler rider) coals, are the next stratigraphically higher key beds. The McAlester coal was named in the Arkoma basin area of Oklahoma (Hemish, 1987b, p. 108), where it and its rider are commercially important; because of thinness, neither is known to have economic value in the shelf area (except in parts of Muskogee County).

Another persistent, noneconomic coal bed, here correlated with the Tamaha coal, which was named in the Arkoma basin area of Oklahoma (Hemish, 1987b, p. 108), occurs ~40 ft above the Upper McAlester (Stigler rider) coal in the shelf area. A thin, fossiliferous limestone persists from Wagoner County to northern Craig County in the interval between the Upper McAlester (Stigler rider) and the Tamaha coal beds. Although not named, this limestone has been noted in at least one published report; Wilson and Newell (1937, p. 42) described a 6-in.-thick, fossiliferous limestone occupying a similar stratigraphic position in T. 10–12 N. in Muskogee County.

A stratigraphically higher pair of remarkably persistent, noneconomic coal beds occurs near the top of the McAlester Formation in the shelf area. The lower of the two correlates with the Keota coal, named in Haskell County (Hemish, 1987b, p. 107). The Keota coal is part of the Keota Sandstone Member. The upper of the pair of coals correlates with the Spaniard coal, named in Muskogee County (Hemish, 1987b, p. 107). In northern Craig County the two beds are consistently separated by ~14 ft of shale. A thin sandstone occurs in places below the underclay of the Spaniard coal. To the south, the interval between the two beds increases, in keeping with the increase in the thickness of most units in the shelf-to-basin transition area. In Mayes County three thin coal beds occur in the stratigraphic position of the Keota coal, making correlation problematical. In Haskell County, where the Keota Sandstone Member of the McAlester Formation was named, Oakes and Knechtel (1948, p. 43) described the Keota Member as erratic in the number and thickness of its beds. However, the unit does have great lateral continuity and is therefore useful as a persistent, if inexact, marker.

In Wagoner County (core-hole 5) a 3-ft-thick, silty, shaly, limestone with a 0.5-in.-thick layer of coaly, carbonaceous shale at its base occurs in the stratigraphic position of the Keota coal. In T. 14 N., Muskogee County, where the Keota Member is only a few feet below the Spaniard Limestone, Oakes (1977, p. 21) said there is an upper and lower sandstone lens in the Keota Member, with a limestone commonly a few feet below the upper sandstone, and a coal bed a short distance below the limestone. He designated the limestone Pm1 on his plate 1. Wilson and Newell (1937, p. 44,45) also noted and discussed this unnamed limestone.

The upper sandstone of the Keota Member lies directly under the Spaniard coal in northern Wagoner County (Cross Section A–A′, core-hole 5, Pl. 1). Although the Keota coal bed is absent at this location, the similarity in the sequence of other beds to those in Muskogee County makes correlation feasible.

Because work by Harris (1984) in Kansas and Missouri has an effect on the stratigraphic nomenclature of Oklahoma in the section beginning with the Keota coal bed and extending upward to the Chelsea Sandstone, a digression is included here.

Harris (1984), in a subsurface study using core logs and electric logs, has shown that several stratigraphic-nomenclature problems exist among Kansas, Missouri, and Oklahoma in the interval studied in Oklahoma for this report. Numerous apparently erroneous names for rock units have become entrenched in the literature through the years. Most problems seem to have originated from miscorrelation of the Bluejacket Sandstone in Kansas and Missouri. Coal beds in particular have been miscorrelated, because their stratigraphic positions were based on their relationship to the "Bluejacket" Sandstone. It is beyond the scope or the intent of this report to try to provide all the solutions for an obvious interstate problem.

Figure 6 (Howe, 1956, pl. 1) shows the traditional correlation diagram among the three states, and Figure 7 is an exerpt from Harris (1984, pl. 2) showing his stratigraphic interpretations.

One of the problems that came to light as the result of Harris's work was that the Keota coal of Oklahoma is apparently equivalent to the Rowe coal named in Kansas, and the Spaniard coal of Oklahoma is apparently equivalent to the Dry Wood coal, named in Missouri. The coal called "Rowe" in Oklahoma is equivalent to a coal informally designated "Bbj" by Harris, and the coal called "Drywood" in Oklahoma is equivalent to his informally designated "Abj" coal bed. Only the problems relating to Oklahoma's stratigraphic nomenclature are discussed here. Units formally recognized as formations in Oklahoma are treated differently in Kansas and Missouri and need not be part of this discussion.

The Savanna Formation was named by Taff (1899) for the town of Savanna, Pittsburg County, Oklahoma. As currently recognized by the Oklahoma Geological Survey, the Savanna Formation in the shelf area extends from the base of the Spaniard Limestone to the base of the Bluejacket Sandstone (Oakes, 1977, p. 22).

Several good marker beds occur in the Savanna Formation. At the base is the Spaniard Limestone, which is discontinuous in northern Craig County. The next higher limestone marker, the Sam Creek Limestone, extends only into southern Craig County, but it is closely underlain by the traceable Sam Creek coal, named in Muskogee County (Hemish, 1987b, p. 107). The noneconomic Sam Creek coal occurs from about 12 to 30 ft above the Spaniard Limestone (or Spaniard coal), and is one of a persistent pair of coals in the study area (Cross Section A–A′, Pl. 1). The upper coal bed of the pair is the Rowe coal, the oldest known coal having significant commercial value in the shelf area (except for the Stigler coal, locally, in Muskogee County). The Rowe coal bed, owing to its association with the Doneley Limestone (named by Branson, 1954a, p. 192), is an excellent marker bed, and was selected as the datum for Cross Section A–A′ (Pl. 1). The Doneley Limestone at its type section is a calcareous clay-ironstone 3 in. thick (Branson, 1954a, p. 192). Harris (1984) showed the Doneley Limestone to be equivalent to the Seville Limestone of Missouri.

Beds immediately overlying the Doneley Limestone consist of silty shale only a few feet thick, and the overlying Dickson Sandstone. The Dickson Sandstone was named by Branson and others (1965, p. 27–29) for the Dickson School in T. 26 N., R. 20 E., Craig County, Oklahoma. The Dickson is ~12 ft thick, and does not crop out south of Craig County. However, it is well developed in Kansas where it was called the "Upper" Bluejacket Sandstone by Ebanks and others (1977). The "Lower" Bluejacket Sandstone of Kansas which overlies the Dry Wood and Rowe coal beds of Kansas (Fig. 7), either does not occur in Oklahoma, or correlates with an insignificant, unnamed bed. The Bluejacket Sandstone in its type area in northern Craig County, Oklahoma (Hemish, 1989b), is stratigraphically higher than either the "Lower" or "Upper" Bluejacket Sandstones of Kansas.

Near the top of the Savanna Formation is a 4- to 50-ft-thick shale interval which includes an unnamed coal zone with a thick, well-developed underclay; a named coal, the Drywood, which is locally 3 ft or more thick (Hemish, 1986); and discontinuous, silty sandstones of varying thicknesses (Cross Section A–A′, Pl. 1). The Bluejacket Sandstone locally fills channels that cut down nearly to the top of the Dickson Sandstone. Figure 3 shows core cut from a conglomeratic-sandstone facies of the Bluejacket Sandstone in an area of known channeling. The channeling has locally cut out one or both coal horizons in the interval above the Dickson Sandstone, and has diminished the total thickness of the Savanna Formation to 70 ft in places in northern Craig County.

Base of Bluejacket Sandstone to Base of Chelsea Sandstone

This interval is the most difficult to interpret, because of a lack of continuous marker beds in northern Craig County. The interval is characterized by lensing sandstones both above and below the contact of the Boggy and Senora Formations, and is further complicated by deep

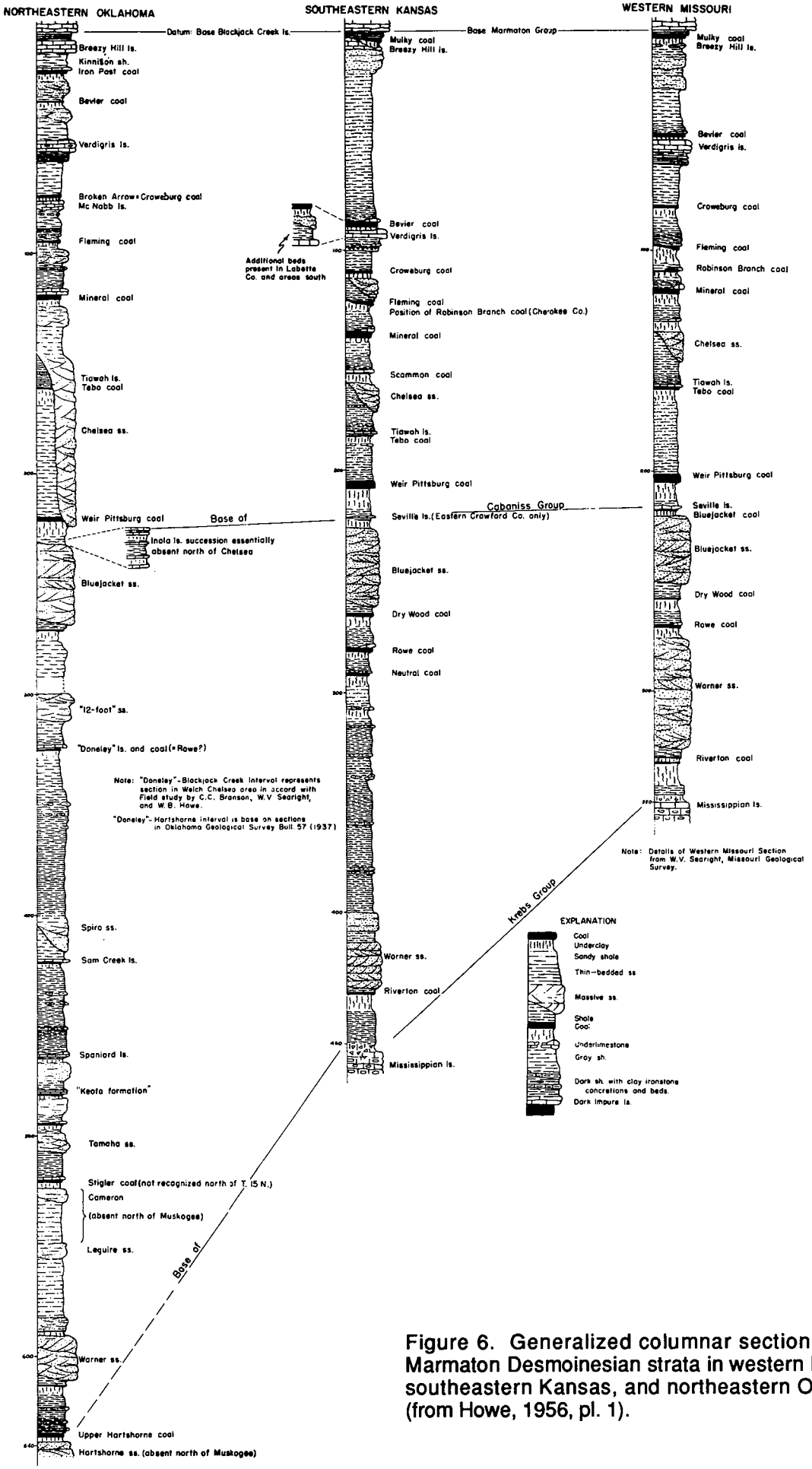


Figure 6. Generalized columnar sections of pre-Marmaton Desmoinesian strata in western Missouri, southeastern Kansas, and northeastern Oklahoma (from Howe, 1956, pl. 1).

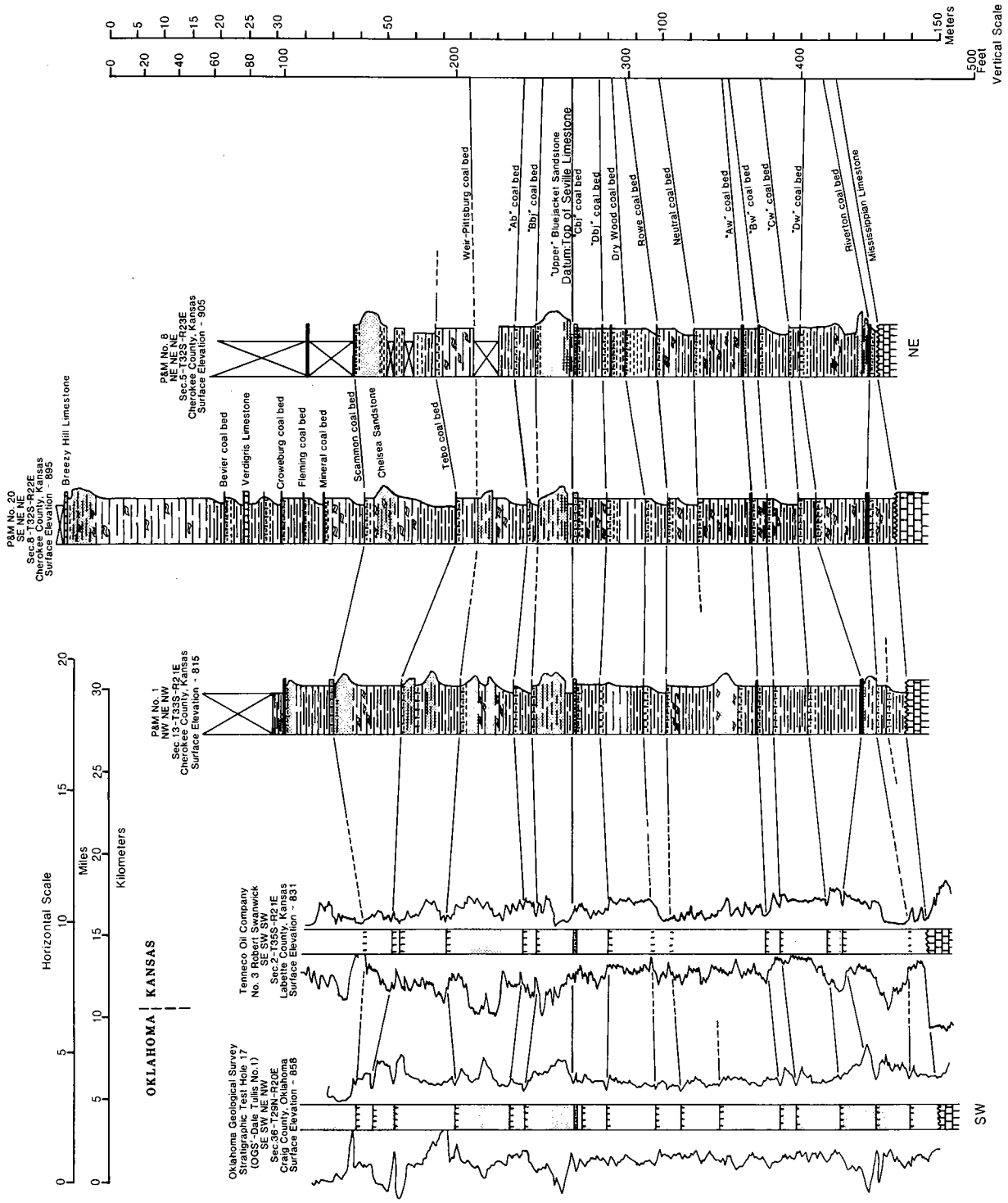


Figure 7. Stratigraphic cross section of the Krebs Formation (Cherokee Group), southeastern Kansas, and northeastern Oklahoma. Reproduced in part from Harris (1984, pl. 2).

channels filled by the Chelsea Sandstone, which may cut down to the top of the Bluejacket Sandstone (Branson and others, 1965, p. 36, pl. II).

The Boggy Formation in the shelf area has been defined by the OGS as the strata between the base of the Bluejacket Sandstone and the base of the Weir-Pittsburg coal, or, in its absence, the top of the Taft Sandstone (Branson and others, 1965, p. 31; Hemish, 1986, p. 13; 1987b, fig. 2).

The Bluejacket Sandstone is the basal member of the Boggy Formation. Its thickness ranges from 0 to 60 ft in the shelf area (Wilson and Newell, 1937, p. 55; Branson and others, 1965, p. 31). Hemish (1989b) described the Bluejacket Sandstone in its type area in northern Craig County, and also discussed the history of usage of the name. The Bluejacket Sandstone was named by Ohern (1914, p. 28) for the town of Bluejacket, Craig County, Oklahoma. Howe (1951, p. 2088) redefined the Bluejacket Sandstone, and Chrisman (1951, p. 18; appendix, 15) described the type section. Hemish (1989b, p. 77) established two reference sections in the type area of the Bluejacket Sandstone (see core-holes 9 and 10, Appendix).

The writer considers the Bluejacket Sandstone to be a crucial stratigraphic element in resolving some of the correlation problems discovered by Harris (1984), and discussed briefly above. Sandstone units in adjacent states must be properly correlated with the formally named Bluejacket Sandstone in its type area, or the name "Bluejacket" should not be used.

Core-holes 9 and 10, both drilled in the type area of the Bluejacket Sandstone, exemplify the lithologic variability of the member, and probably explain why, in some areas, correlations have been difficult.

In the northern shelf area, the next unit above the Bluejacket Sandstone that serves as a reliable marker is the Inola Limestone. The Inola Limestone Member of the Boggy Formation was first mentioned by name in print by Lowman (1932). He stated that it was "named for an outlier on a hill east of the town of Inola, Oklahoma." Branson (1954a, p. 192) designated as the type section rocks exposed in the south road cut on Oklahoma Highway 20, sec. 18, T. 21 N., R. 18 E., and restricted the term Inola to the lower of four distinct limestone beds found there. Hemish (1990) subsequently redefined the Inola Limestone Member of the Boggy Formation to include all beds from the base of the lowermost limestone above the Bluejacket coal bed to the top of the first limestone below an unnamed black, fissile shale containing abundant ironstone concretions and black, phosphatic nodules. Branson and others (1965, p. 31) did not believe that the Inola Limestone occurred northward beyond the Mayes–Craig County line. However, the Inola Limestone was found in core-hole 9 (Appendix; Pl. 1) as far north as T. 27 N. in northern Craig County.

Below the Inola horizon is a gray to buff shale, and a thin, poorly developed coal and underclay. This coal, which ranges from 0.1 to 1.5 ft thick, is the Bluejacket coal of the platform classification (Branson and others, 1965, p. 33; Hemish, 1987b, fig. 2). Howe (1956, p. 44, pl. 1) tentatively correlated the Seville Limestone of Missouri with the Inola Limestone. Harris (1984) showed the Seville Limestone to be equivalent to the Doneley Limestone of Oklahoma. The Inola Limestone pinches out in northern Craig County. The Bluejacket coal of western Missouri, which underlies the Seville Limestone (Howe, 1956, p. 44), is apparently a different bed than the Bluejacket coal of Oklahoma.

The Inola Limestone is overlain by a black, fissile shale of varying thickness that contains ironstone concretions and radioactive, black, phosphatic nodules. A thickness of >27 ft was recorded in core-hole 7 (Appendix) near the type section of the Inola Limestone in Mayes County, and a thickness of 21 ft was measured by Hemish (1989c) on Inola Mound, Rogers County, at the type locality of the Inola Limestone.

For purposes of this report, the Taft Sandstone overlies the black shale unit and extends to the top of the Boggy Formation. According to Oakes (1977, p. 33), the term Taft has been much used in both conversation and writing about sandstones that crop out in the upper part of the Boggy Formation, although the limits have never been adequately established. Wilson (1935, p. 510) named the Taft Sandstone Member of the Boggy Formation for exposures near the town of Taft, Muskogee County, Oklahoma. At the type locality in T. 15 N., the unit forms a prominent escarpment, ranging up to 200 ft in height. Wilson and Newell (1937, p. 57) wrote that "the unit consists of 20 feet of coarse-grained massive sandstone" and that "the upper third of the division consists of silty to sandy shale." They did not determine logical boundaries for the Taft Member.

According to Branson and others (1965, p. 33), three fairly consistent sandstone units separated by shale, with a total thickness of 146 ft, have been mapped as Taft in Mayes County; the lower of the three extends into Craig County. Cross Section A–A′ (Pl. 1) shows the same interval, ranging from about 12 to 20 ft, in northern

Craig County. Govett (1959, p. 79), who mapped Wagoner County, wrote: "The Taft Sandstone north of the Arkansas River is here defined as any sandstone between the Inola Limestone below and the Tiawah Limestone above." Four sandstone units, each designated Taft, were shown on Govett's map. Two appear as members of the Boggy Formation, and two as members of the Senora Formation. Core-hole 6, drilled in Rogers County, shows five sandstones in the same interval. The upper three appear in the Senora Formation, and the lower two in the Boggy Formation (Cross Section D–D′, Pl. 2).

An economically important coal bed, named the Wainwright coal in Muskogee County (Hemish, 1987b, p. 104), is the youngest known coal in the Boggy Formation. It occurs in the interval above the first prominent sandstone above the Inola Limestone (Cross Section D–D′, Pl. 2). The northern limit of the Wainwright coal was extended into Rogers County as one result of the 1988 OGS core-drilling project. It previously had not been known in Rogers County (or Wagoner County immediately to the south). Possibly the bed was confused with the Weir-Pittsburg coal bed by mappers in Rogers County (Hemish, 1989c).

Previous mention was made of the thickening of stratigraphic units in the shelf-to-basin transition area. However, Cross Section D–D′ (Pl. 2) shows that this thickening is much greater by comparison with stratigraphically lower units in the interval from the base of the Chelsea Sandstone to the top of the Bluejacket Sandstone. Apparently, sedimentation occurred at an accelerated rate, accompanied by greater subsidence in the shelf area during this period of Desmoinesian time.

The base of the Weir-Pittsburg coal has been shown to be a reliable mapping horizon from the Kansas state line as far south as western Muskogee County, where the coal apparently pinches out. In this general area the Stuart Shale Formation becomes mappable from the south, and serves to separate the Boggy Formation from the Senora Formation.

The Senora Formation was named by Taff (1901) for the old post office of Senora, in southern Okmulgee County, Oklahoma. Only the lower part of the formation is relevant to this report.

The Weir-Pittsburg coal marks the base of the Senora Formation from western Muskogee County to the Kansas state line. Harris (1984) has tentatively shown that the Weir-Pittsburg coal bed of Kansas is not correlative with the Weir-Pittsburg coal of Oklahoma. However, the writer disagrees with Harris's interpretation, and believes that a miscorrelation occurred in Harris's plate 2 when he dropped the correlation line for the Scammon coal from above the Chelsea Sandstone to *below* the Chelsea Sandstone between logs of Tenneco Oil Company #3 and P & M #1 (see Fig. 7). The coal below the Chelsea Sandstone is the Tebo coal, and the upper of the pair of coals in the Tenneco log is the Weir-Pittsburg coal; the lower of the pair is a local, unnamed bed. The next lower coal, which Harris correlated with the Weir-Pittsburg coal, is shown as the Bluejacket coal on Cross Section A–A′ (Pl. 1). By definition (Branson and others, 1965, p. 33), the coal just below the Inola Limestone (core-holes 7 and 9, Pl. 1) is the Bluejacket coal of the platform classification. The writer suggests that as the stratigraphic interval between the Bluejacket Sandstone and the Chelsea Sandstone thins northward into Kansas several units pinch out, and the Bluejacket coal of Oklahoma and the Weir-Pittsburg coal may eventually coalesce. One log is common to both Harris's cross section (Fig. 7) and Cross Section A–A′ (Pl. 1); it is shown by Harris as OGS Stratigraphic Test Hole 17, and by the writer as Core-Hole 11.

A thin, poorly developed coal called the RC coal by Hemish (1989c) occurs in the interval between the Weir-Pittsburg coal and the Tebo coal (Cross Section D–D′, Pl. 2). Its known occurrence was extended southward from Rogers County through Wagoner County into western Muskogee County as the result of the 1988 OGS coring project.

The Tiawah Limestone, also known as the "Pink lime" of subsurface terminology (Jordan, 1957, p. 157), was named by Lowman (1932, p. 24) for the village of Tiawah in Rogers County. The Tiawah proved invaluable as a marker bed in the construction of Cross Section D–D′ (Pl. 2). It is known to occur from east-central Okmulgee County, Oklahoma, northeastward into Missouri. In Oklahoma it is generally separated from the base of the Chelsea Sandstone by an overlying zone of black shale containing phosphatic nodules (core-hole 4, Appendix). It is closely associated with the Tebo coal, named in western Missouri (Hemish, 1987b, p. 103). Both the limestone and the coal are discontinuous, either because of nondeposition or channeling at the base of the overlying Chelsea Sandstone (Cross Sections A–A′,D–D′, Pls. 1,2).

There presently seems to be general agreement between workers in Oklahoma and Kansas concerning the stratigraphy of the interval from the Chelsea Sandstone to at least as high as the Fort Scott Limestone. This interval is compara-

tively well known in Oklahoma, so no investigation of the beds was undertaken for this project.

CONCLUSIONS

1. Three formations, the Atoka, the Hartshorne, and the McAlester, that occur in the interval between the top of the Lower Pennsylvanian or the top of Mississippian limestone, can be traced continuously in the subsurface from Muskogee County northward to the Kansas state line. Lithologic characteristics and sequences of beds were used to make the correlations. Alternate interpretations should not be abandoned, however, as the lower two formations are too thin for practicable surface mapping.

2. Strata in the McAlester Formation and below, from just above the Warner Sandstone downward, apparently were never deposited in some parts of the shelf area, owing to positive features on the post-Mississippian erosion surface during middle Desmoinesian time.

3. Seven previously unidentified coal beds, known to be present in the northern shelf area, can be correlated with coals named in Muskogee County or counties to the south in Oklahoma; from oldest to youngest, they are the Keefton, McAlester (Stigler), Upper McAlester (Stigler rider), Tamaha, Keota, Spaniard, and Sam Creek coals.

4. Thicknesses of several formations in different localities were established by OGS core-drilling:

Core-hole 1, southern Muskogee County: Hartshorne Formation ~14 ft.

Core-hole 3, northern Muskogee County: Hartshorne Formation ~20 ft.

Core-hole 5, northern Wagoner County: McAlester Formation ~132 ft.

Core-hole 7, western Mayes County: Atoka Formation ~55 ft; Hartshorne Formation(?) ~1 ft; McAlester Formation ~202 ft; Savanna Formation ~82 ft.

Core-hole 8, southern Craig County: McAlester Formation ~115 ft.

Core-hole 9, northern Craig County: Boggy Formation ~72 ft.

Core-hole 10, northern Craig County: Atoka Formation(?) ~16 ft; Hartshorne Formation(?) ~3 ft; McAlester Formation ~162 ft; Savanna Formation ~70 ft.

Thicknesses of members can be obtained by examining the cross sections in Plates 1 and 2. Coal-bed thicknesses are exaggerated on the cross sections, but are reliable in the core-hole logs (Appendix).

5. Further study, with cooperative efforts among the states of Kansas, Missouri, and Oklahoma, is needed to resolve the numerous problems with stratigraphic nomenclature in the interval discussed in this report.

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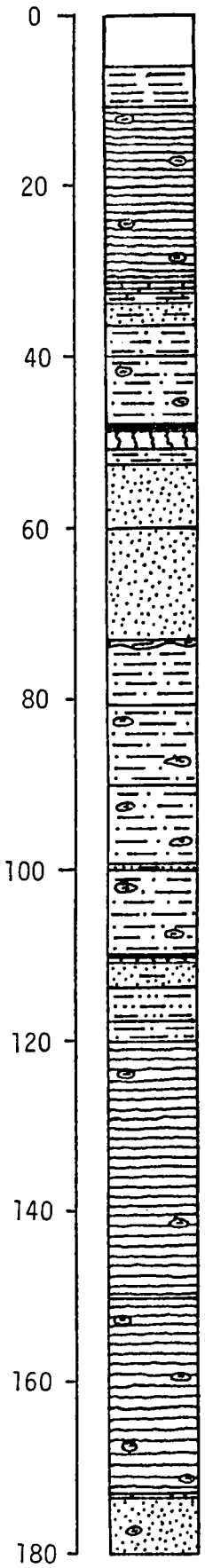
APPENDIX

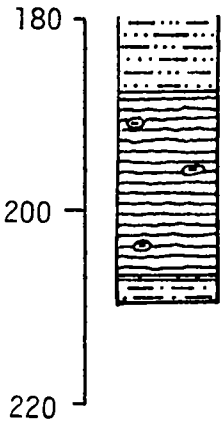
Core-Hole Logs



1 (C-MM-59)

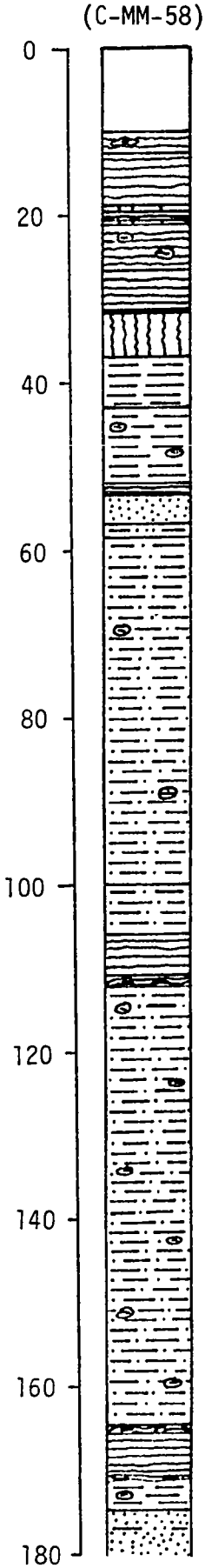
SW 1/4 SE 1/4 SW 1/4 SW 1/4 sec. 16, T. 12 N., R. 19 E., Muskogee County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in pasture just east of farm pond 200 ft FLS and 1,000 ft FWL. (Surface elevation, estimated from topographic map, 578 ft.)

	Depth to unit top (ft)	Thickness of unit (ft)
Silt, pale-yellowish-brown; contains organic matter	0.0	0.5
Gravel, dark-yellowish-brown, fine-grained, silty; contains organic matter	0.5	1.5
Clay, moderate-yellowish-brown, sandy, silty, noncalcareous; contains rare gravel clasts; weathered	2.0	4.0
Desmoinesian Series		
Krebs Group		
McAlester Formation		
Shale, pale-yellowish-brown and dark-reddish-brown, clayey, noncalcareous, weathered	6.0	4.8
Shale, dusky-yellowish-brown, noncalcareous; contains oxidized, moderate-reddish-brown and dark-yellowish-orange ironstone concretions	10.8	0.5
Shale, grayish-black, noncalcareous; contains pyrite lenses and pyrite-filled burrows; includes some light-brownish-gray, sideritic concretions up to 1 in. thick, and rare white, calcareous, fossil shells in lower 6 in.	11.3	20.1
Limestone, medium-dark-gray, impure, silty, fine-grained, hard; contains abundant fossil hash; includes some grayish-black, calcareous, slickensided shale and light-brownish-gray, calcareous concretions in middle 0.3 ft	31.4	0.9
Shale, medium-dark-gray, very calcareous, burrowed	32.3	0.5
Sandstone, very light-gray, very fine-grained, calcareous; interbedded with noncalcareous, medium-dark-gray, silty shale; burrowed, wavy-bedded or cross-laminated in places; includes a 0.3-ft-thick, sandy, yellowish-gray limestone concretion from 33.3 to 33.6 ft (upper Warner Sandstone)	32.8	3.2
Shale, medium-dark-gray, noncalcareous, silty; includes scattered streaks of very light-gray sandstone, and interbedded units of wavy-bedded sandstone and shale up to 0.3 ft thick	36.0	3.9
Shale, medium-dark-gray, noncalcareous, burrowed; contains scattered streaks of very light-gray sandstone, and light-brownish-gray, sideritic concretions from 0.25 to 1 in. thick	39.9	7.9
Coal, black, bright, moderately friable; includes minor pyrite crusts on bedding surfaces (Keefton coal)	47.8	0.7
Underclay, medium-light-gray, carbonaceous in upper part	48.5	2.0
Shale, medium-dark-gray, silty, noncalcareous, burrowed; contains streaks of light-gray, very fine-grained sandstone	50.5	1.8
Sandstone, light-gray with medium-dark-gray streaks, very fine-grained, noncalcareous, micaceous, rippled; includes some contorted beds; contains shale clasts and black, macerated plant debris on stratification surfaces (Warner Sandstone)	52.3	7.7
Sandstone, medium-light-gray, fine- to medium-grained, quartzose, noncalcareous, massive to cross-bedded; contains black, macerated plant debris on bedding planes; including some yellowish-gray shale pebbles and coal streaks in lower 3 ft (Warner Sandstone)	60.0	13.0



Ironstone, yellowish-gray; shows indistinct, relict bedding planes (top unit of McCurtain Shale).....	73.0	0.3
Shale, medium-dark-gray to dark-gray, interbedded with white, very fine-grained sandstone, micaceous, flaser-bedded, rippled, burrowed in part; includes sparse, black, macerated plant debris on stratification surfaces; grades into underlying unit.....	73.3	7.3
Shale, dark-gray with white streaks of very fine-grained sandstone, noncalcareous, burrowed, flat-bedded; contains numerous bands of light-brownish-gray, sideritic concretions up to 1 in. thick.....	80.6	9.4
Shale, dark-gray with numerous light-brownish-gray, sideritic bands, noncalcareous, silty; contains rare burrows and sparse streaks of white sandstone from 90.0 to 95.0 ft; includes black, carbonized plant compressions and plant debris on some bedding planes.....	90.0	9.2
Sandstone, medium-dark-gray, very fine-grained, shaly, noncalcareous, extensively bioturbated; lower contact very irregular.....	99.2	0.5
Shale, dark-gray with numerous light-brownish-gray, sideritic bands, noncalcareous, silty; contains black, macerated plant debris on some bedding planes; includes rare pyrite-filled burrows.....	99.7	10.2
Coal, black, bright, moderately friable, minor white calcite on cleat surfaces, and rare pyrite crusts on bedding planes (unnamed coal).	109.9	0.3
Underclay, grayish-black, very carbonaceous, slickensided; plant compressions abundant; silty in lower part; grades into underlying unit.....	110.2	0.2
Sandstone, medium-gray, silty, very fine-grained, noncalcareous, churned; contains streaks of black, macerated plant debris.....	110.4	3.3
Siltstone, medium-gray, noncalcareous; burrowed; contains streaks of light-gray, very fine-grained sandstone; becomes darker gray and shaly in lower 3 ft.....	113.7	4.0
Shale, medium-dark-gray, silty, noncalcareous; becomes dark-gray at about 119 ft.....	117.7	2.3
Shale, grayish-black, very silty, hard, noncalcareous; contains abundant streaks of white, very fine-grained sandstone; burrowed; includes rare, light-brownish-gray, sideritic concretions up to 1 in. thick and black, macerated plant debris on bedding planes; proportion of silt-sized grains and sandstone streaks decreases gradually downward; sandstone streaks sparse below 129 ft; pyrite occurs in small lenses and crusts; white calcite occurs on some parting surfaces.....	120.0	30.0
Shale, black, hard, brittle, noncalcareous; contains sparse calcareous and pyritized fossil shells, pyrite-filled burrows and light-brownish-gray, sideritic concretions up to 2 in. thick; includes some white calcite in fractures in concretions, and on some parting surfaces...	150.0	22.9
Limestone, black, impure, shaly, carbonaceous, extensively burrowed; contains white fossil shells; sandy in lower 0.1 ft (basal unit of McCurtain Shale).....	172.9	0.2

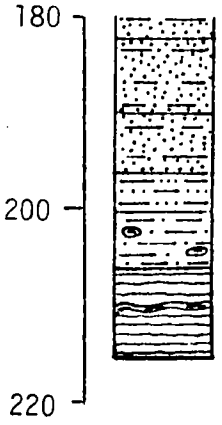
Hartshorne Formation		
Sandstone, light-gray with greenish-gray tint, very fine-grained; noncalcareous, burrowed extensively in upper 1 ft; rooted in upper 1.5 ft; mostly flat-bedded, with some low-angle cross-laminated layers; contains some light-brownish-gray, sideritic concretions about 1 in. thick; grades downward into sandy siltstone.....	173.1	6.9
Siltstone, medium-dark-gray with very light-gray sandstone streaks, coarse-grained, noncalcareous, micaceous; mostly flat-bedded, grain size decreases downward; grades into underlying unit.....	180.0	8.0
Atokan Series		
Atoka Formation		
Shale, grayish-black to black, silty, hard, noncalcareous; contains scattered white, calcareous marine fossils, and light-brownish-gray sideritic concretions up to 2.5 in. thick; includes rare pyrite in small lenses and burrows.....	188.0	19.3
Limestone, grayish-black, very shaly, carbonaceous; contains abundant fossil fragments concentrated in layers; thin streaks of same unit occur in upper 6 in. of underlying unit.....	207.3	0.2
Shale, medium-gray to medium-dark-gray, noncalcareous; contains thin streaks of very light-gray sandstone and siltstone.....	207.5	2.5
Total Depth		210.0



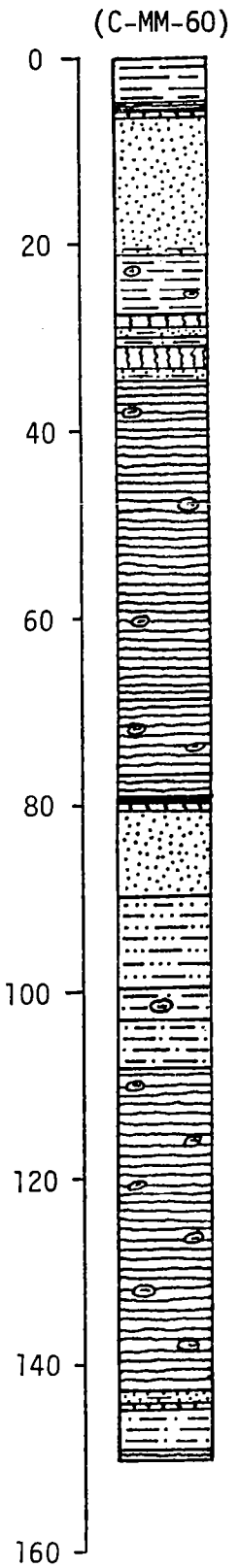
2 (C-MM-58)

SW 1/4 SE 1/4 NW 1/4 NE 1/4 sec. 26, T. 14 N., R. 15 E., Muskogee County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in pasture at north edge of pond 1,660 ft FEL and 1,200 ft FNL. (Surface elevation, estimated from topographic map, 625 ft.)

	Depth to unit top (ft)	Thickness of unit (ft)
Silt, dark-yellowish-brown, well-sorted; contains organic matter	0.0	2.0
Sand, moderate-yellowish-brown, gravelly; contains abundant clay in matrix; includes clasts of oxidized, moderate-reddish-brown clay-ironstone and blackish-red stained sandstone; weathered	2.0	8.0
Cabaniss Group		
Senora Formation		
Shale, dark-yellowish-brown to olive-gray with olive-black streaks, noncalcareous, weathered; contains bands of moderate-reddish-brown ironstone; becomes grayish-black with moderate-reddish-brown bands below 11 ft	10.0	2.8
Shale, black, calcareous; contains scattered, white fossil shells and shell fragments	12.8	4.0
Shale, grayish-black, noncalcareous	16.8	2.4
Limestone, medium-dark-gray, hard, impure, silty; contains abundant fossil hash (Tiawah Limestone)	19.2	0.4
Shale, grayish-black, noncalcareous	19.6	0.3
Limestone, medium-dark-gray, hard, impure, silty; contains abundant fossil hash	19.9	0.1
Shale, black, calcareous; contains scattered white fossil shells and light-brownish-gray, sideritic concretions up to 2.5 in. thick; includes some pyrite-filled burrows	20.0	6.5
Shale, black, noncalcareous; contains rare fossil shells; calcareous from 29.5 to 29.8 ft	26.5	3.5
Shale, grayish-black, noncalcareous	30.0	1.4
Coal, black, moderately friable; contains white calcite on cleats and thin layers of pyrite on bedding surfaces (Tebo coal)	31.4	0.6
Underclay, medium-light-gray; contains rare, black, carbonized plant fragments; feels soapy; grades into underlying unit	32.0	5.3
Shale, medium-light-gray, soft, clayey, noncalcareous	37.3	1.4
Shale, medium-gray, noncalcareous; contains disseminated pyrite; grades into underlying unit	38.7	4.3
Shale, medium-dark-gray, noncalcareous; contains light-brownish-gray, sideritic concretions up to 1.5 in. thick; becomes dark-gray to grayish-black in lower 2 ft; includes white calcite on fracture surfaces in lower 2 in.; contact with underlying unit sharp	43.0	10.4
Coal, black, hard; contains disseminated pyrite and white calcite on cleat surfaces (RC coal)	53.4	0.1
Sandstone, very light-gray, very fine-grained, noncalcareous, rooted, churned; contains black, carbonized plant fragments and abundant disseminated pyrite; grades downward into coarse siltstone	53.5	3.5
Siltstone, medium-gray, sandy, noncalcareous, micaceous; contains light-brownish-gray, sideritic concretions up to 1.5 in. thick; indistinctly rippled	57.0	1.6



Shale, dark-gray, hard, brittle, silty, noncalcareous; contains white, calcareous fossil brachiopods from 58.6 to 62.3 ft; includes rare, yellowish-gray, calcareous and sideritic concretions up to 1 in. thick, as well as pyrite-filled burrows and lenses.....	58.6	41.4
Shale, medium-dark-gray, noncalcareous, silty; contains rare pyrite-filled burrows; includes white calcite in fracture-fillings from 100.0 to 103.0 ft.....	100.0	6.0
Shale, dark-gray to grayish-black, silty, noncalcareous; contains rare pyritized brachiopods...	106.0	5.1
Ironstone, light-brownish-gray; contains white, calcareous fossil shells at contact with underlying unit.....	111.1	0.3
Shale, dark-gray with light-brownish-gray bands, noncalcareous, silty; contains scattered, pyrite-filled burrows and rare, small, light-brownish-gray, sideritic concretions, as well as rare, calcareous fossil brachiopod shells...	111.4	53.2
Ironstone, yellowish-gray, weakly calcareous; contains scattered, white, calcareous fossil shell fragments.....	164.6	0.3
Shale, grayish-black; noncalcareous, except in upper 1 in. of unit; contains rare pyritized brachiopod fossils and pyrite-filled burrows...	164.9	5.8
Ironstone, light-brownish-gray, weakly calcareous; contains rare, white, calcareous fossil shell fragments.....	170.7	0.2
Shale, medium-dark-gray with light-brownish-gray bands, noncalcareous; contains sideritic layers and rare pyrite-filled burrows.....	170.9	3.9
Sandstone, very light-gray with medium-dark-gray bands, very fine-grained, micaceous, shaly, noncalcareous, thin-bedded, rippled, burrowed, cross-laminated; contains some contorted beds, scour features, and dewatering features; includes black, macerated plant debris on stratification planes.....	174.8	7.9
Sandstone, medium-dark-gray with sparse white streaks, silty, micaceous, noncalcareous; contains flat beds, contorted beds, wavy beds, scour features, and load features.....	182.7	7.9
Sandstone, medium-dark-gray and very light-gray, very fine-grained, shaly, micaceous, thin-bedded, noncalcareous, rippled, cross-bedded, flat-bedded; contains rare burrows and black, macerated plant debris on bedding planes.....	190.6	6.4
Siltstone, medium-gray with very light-gray sandstone streaks, flat-bedded, noncalcareous, micaceous, grades into underlying unit.....	197.0	4.0
Shale, medium-gray, silty, hard, noncalcareous; includes some dark-gray bands and light-brownish-gray, sideritic concretions up to 1 in. thick.....	201.0	5.5
Shale, grayish-black, noncalcareous; contains several yellowish-gray sideritic bands from 0.25 to 0.75 in. thick; includes rare fossil brachiopods.....	206.5	9.5
Total Depth		216.0

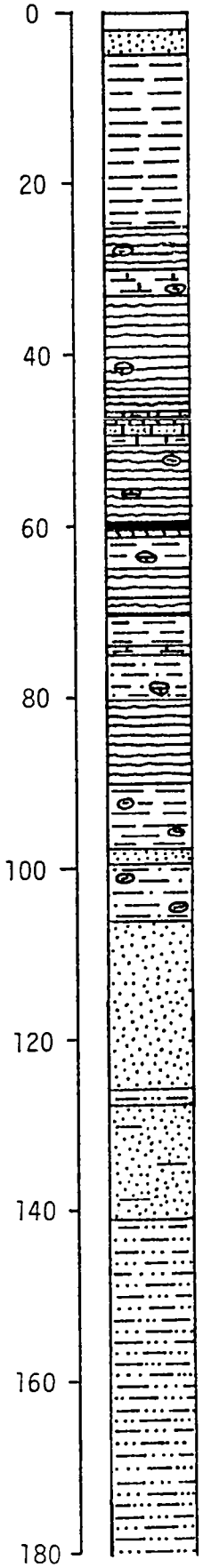


3 (C-MM-60)

SW 1/4 SW 1/4 SW 1/4 NW 1/4 sec. 11, T. 15 N., R. 18 E., Muskogee County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled at edge of driveway 2,600 ft FNL and 45 ft FWL. (Surface elevation, estimated from topographic map, 542 ft.)

	Depth to unit top (ft)	Thickness of unit (ft)
Desmoinesian Series		
Krebs Group		
McAlester Formation		
Shale, pale-yellowish-brown to moderate-yellowish-brown, soft, clayey, noncalcareous; contains stringers of moderate-reddish-brown clay-ironstone	0.0	4.5
Shale, moderate-reddish-orange, soft, clayey, noncalcareous, ferruginous	4.5	0.1
Shale, blackish-red with pale-yellowish-orange and light-brown staining, carbonaceous; contains thin layers of coal	4.6	0.1
Coal, black, bright, very friable; moderate-reddish-brown iron-oxide staining on cleat surfaces (Keefton coal)	4.7	0.4
Underclay, medium-light-gray to medium-gray, micaceous; contains streaks of dark-yellowish-orange iron oxide and abundant black, carbonized plant fragments	5.1	0.4
Sandstone, yellowish-gray with brownish-gray streaks, very fine-grained, micaceous, noncalcareous; wavy-bedded in part, cross-laminated in part; extensively burrowed from 15 to 19 ft; includes abundant black, macerated plant debris on stratification surfaces; becomes very light-gray with medium-dark-gray streaks in lower 7 ft of unit; stained by dark-yellowish-orange iron oxides on fracture surfaces in lower 2 ft; interbedded with shale in lower 0.5 ft (Warner Sandstone)	5.5	15.8
Shale, medium-dark-gray to dark-gray, noncalcareous; contains rare medium-gray, sideritic concretions; includes white, calcareous fossil shells from 25.3 to 25.7 ft (top unit of McCurtain Shale)	21.3	6.2
Coal, black, bright, moderately friable; contains pyrite on stratification surfaces (unnamed coal)	27.5	0.1
Underclay, medium-gray; blocky fracture; contains black, carbonized plant compressions; includes a 1-in.-thick, dark-gray, very carbonaceous zone at top of unit	27.6	1.4
Sandstone, medium-dark-gray, very silty and shaly, noncalcareous, very fine-grained, thin-bedded, burrowed in upper part	29.0	0.9
Shale, medium-gray, silty, noncalcareous; blocky fracture	29.9	0.6
Coal, black, bright, moderately friable, 0.5 in. thick (unnamed coal)	30.5	0.1
Underclay, medium-gray, blocky fracture, slickensided	30.6	2.8
Sandstone, medium-dark-gray, very fine-grained, noncalcareous, very silty, massive to obscurely cross-bedded; grades into underlying unit	33.4	1.4
Shale, grayish-black, hard, silty, noncalcareous, slickensided; contains rare pyrite-filled burrows and lenses; includes fractured, light-brownish-gray, sideritic concretions up to 3 in. thick, with white calcite in veinlets filling fractures	34.8	33.7

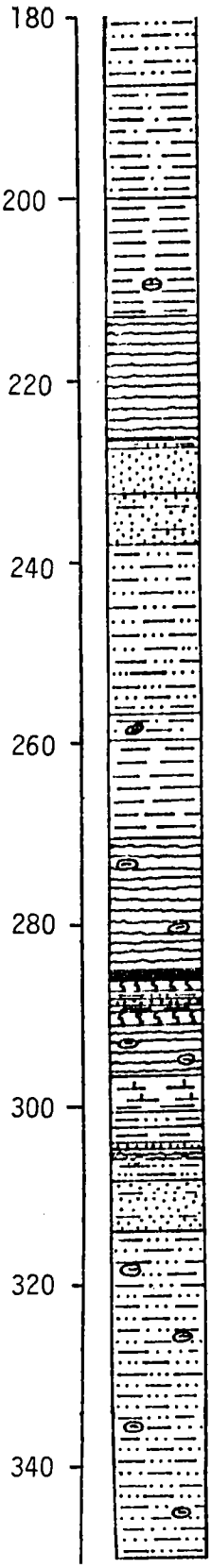
Shale, grayish-black, silty, hard, noncalcareous; contains thin, wavy layers and burrows filled with very light-gray, very fine-grained sandstone, most abundant from 69.8 to 70.3 ft and 74.5 to 75.9 ft; includes pyrite-filled burrows, light-brownish-gray, sideritic concretions up to 2 in. thick, and rare fossil brachiopods.....	68.5	8.2
Shale, grayish-black, noncalcareous to weakly calcareous in lower half of unit; contains abundant disseminated pyrite and pyrite in burrows; includes white calcite in crusts on bedding planes (basal unit of McCurtain Shale).	76.7	2.5
Hartshorne Formation		
Coal, black, bright, moderately friable; includes pyrite in thin laminae concentrated in upper 0.1 ft (Hartshorne coal).....	79.2	0.6
Underclay, medium-gray, silty, carbonaceous, slickensided.....	79.8	0.5
Sandstone, light-gray with medium-gray streaks, very fine-grained, micaceous, noncalcareous, rooted in upper part, rippled, cross-laminated, convolute-bedded, burrowed, microfaulted and massive in various places; contains black, macerated plant debris on some stratification surfaces; grades into underlying unit.....	80.3	9.5
Siltstone, medium-dark-gray with light-gray, very fine-grained sandstone streaks, micaceous, noncalcareous, mostly flat-bedded; contains rare burrows; grades into underlying unit.....	89.8	9.7
Atokan Series		
Atoka Formation		
Shale, medium-gray with light-brownish-gray sideritic bands, silty, noncalcareous; contains broken, white, calcareous fossil shells in lower 1 in.....	99.5	3.3
Shale, medium-light-gray, very silty; blocky fracture; crumbly, noncalcareous; contains irregularly shaped pieces of medium-dark-gray shale; churned in part; includes some dark-gray, sandstone-filled burrows; slickensided...	102.8	5.2
Shale, grayish-black with light-brownish-gray, sideritic bands, noncalcareous; contains thin pyrite lenses and rare pyrite-filled burrows; includes thin calcite crusts on parting surfaces and abundant black, macerated plant debris on stratification planes; sideritic bands absent below 120 ft; contains rare, white, calcareous shell fragments below 138 ft.....	108.0	34.0
Shale, black, noncalcareous; contains light-brownish-gray, sideritic concretions up to 1 in. thick; fossiliferous; white, calcareous fossil shells concentrated in 0.5-in. layer above a 0.25-in.-thick coal bed at base of unit.....	142.0	0.5
Sandstone, medium-gray, very fine-grained, silty, noncalcareous, churned; contains coal spars and some calcite in crusts on fracture surfaces.....	142.5	1.5
Underclay, medium-gray; blocky fracture; shaly...	144.0	0.5
Shale, medium-dark-gray to dark-gray, silty, noncalcareous, burrowed.....	144.5	4.5
Shale, grayish-black, noncalcareous; contains rare pyrite-filled burrows and light-gray streaks of very fine-grained sandstone.....	149.0	1.0
	Total Depth	150.0



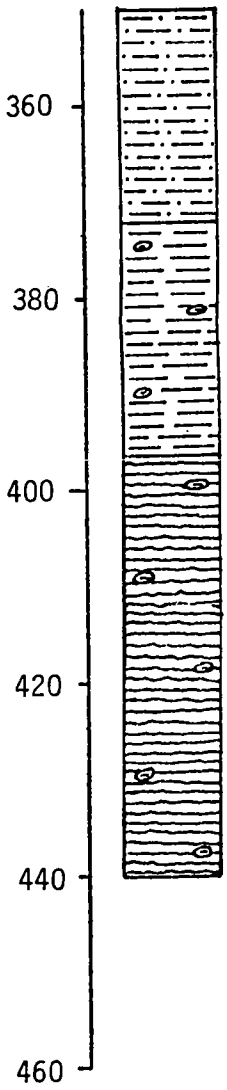
4 (C-TW-4)

NE 1/4 NW 1/4 SE 1/4 SE 1/4 sec. 36, T. 18 N., R. 15 E., Wagoner County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in pasture just west of farm pond 1,200 ft FSL and 760 ft FEL. (Surface elevation, estimated from topographic map, 690 ft.)

	Depth to unit top (ft)	Thickness of unit (ft)
Sand, dark-yellowish-brown, very fine-grained, unconsolidated; contains organic matter.....	0.0	2.0
Cabaniss Group		
Senora Formation		
Sandstone, dark-yellowish-orange with dark-reddish-brown bands, very fine-grained, micaceous, noncalcareous, weathered, clayey in upper part (Chelsea Sandstone).....	2.0	3.0
Shale, moderate-yellowish-brown and dusky-brown, clayey, noncalcareous, weathered; becomes moderate-yellowish-brown with light-gray and dark-yellowish-orange streaks below 9 ft.....	5.0	10.0
Shale, olive-gray to dark-gray with dark-yellowish-orange bands, noncalcareous, partly weathered.....	15.0	5.0
Shale, dark-gray, noncalcareous; includes rare, dark-yellowish-orange iron-oxide staining on bedding planes.....	20.0	5.0
Shale, grayish-black, noncalcareous; contains light-brownish-gray, sideritic concretions up to 2 in. thick.....	25.0	5.0
Shale, dark-gray, very calcareous; contains scattered pyrite-filled burrows and light-brownish-gray, sideritic concretions up to 2 in. thick.....	30.0	3.1
Shale, grayish-black, noncalcareous; contains scattered pyrite-filled burrows and rare calcareous fossil shells; becomes calcareous below 39.3 ft; includes a 2.5-in.-thick, medium-light-gray limestone concretion at 41.1 ft.....	33.1	11.7
Shale, grayish-black, noncalcareous.....	44.8	1.5
Shale, grayish-black, very calcareous; contains pyrite-filled burrows and abundant fossil shells; grades into underlying unit.....	46.3	0.3
Limestone, grayish-black, very shaly; contains abundant white fossil shells and fossil hash...	46.6	0.1
Shale, black, weakly calcareous, very carbonaceous.....	46.7	0.1
Coal, black, moderately friable; white calcite on cleat surfaces (unnamed coal).....	46.8	0.1
Underclay, medium-dark-gray, silty, hard, weakly calcareous, carbonaceous.....	46.9	0.1
Limestone, light-gray with medium-dark-gray streaks, shaly; sandy in upper part; contains abundant white fossil shells and fossil hash from 47.6 to 49 ft, and scattered fossils below 49 ft; grades downward into calcareous, fossiliferous shale (Tiawah Limestone).....	47.0	3.1
Shale, grayish-black, calcareous; contains scattered fossil shells, rare burrows, and light-brownish-gray limestone and sideritic concretions up to 1 in. thick; pyrite-filled burrows concentrated from 54.9 to 55 ft; limestone-filled burrows concentrated from 59.3 to 59.6 ft.....	50.1	9.5
Coal, black, moderately friable; white calcite and pyrite on cleats and bedding planes (Tebo coal).....	59.6	0.6
Underclay, medium-dark-gray to light-gray; contains black, carbonized plant fragments.....	60.2	0.4

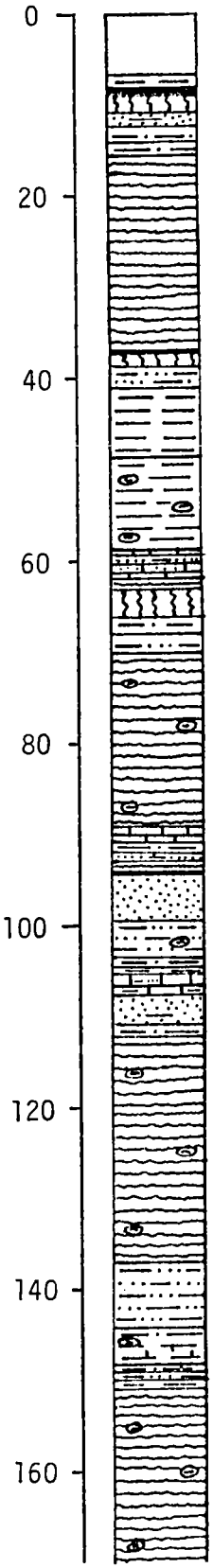


Shale, medium-gray, soft, burrowed; includes a fossiliferous, light-gray, 2-in.-thick limestone concretions at 63.8 ft.....	60.6	4.4
Shale, grayish-black, calcareous; contains scattered, white fossil shells and pyrite-filled burrows.....	65.0	3.1
Shale, grayish-black, noncalcareous; contains rare fossil shells and pyrite-filled burrows...	68.1	1.9
Coal, black, moderately friable, white calcite on cleats; includes a 0.75-in.-thick mass of pyrite (RC coal).....	70.0	0.2
Shale, medium-gray, noncalcareous; includes some disseminated pyrite in lower 3 in.....	70.2	3.7
Shale, medium-light-gray, very calcareous, bioturbated.....	73.9	0.6
Shale, medium-light-gray; silty, noncalcareous, bioturbated; contains brownish-gray, sandstone-filled burrows.....	74.5	2.1
Shale, medium-light-gray with light-gray bands, noncalcareous; contains streaks of siltstone, and sandstone-filled burrows; includes a 1.25-in.-thick limestone concretion at 79 ft.....	76.6	3.5
Shale, grayish-black, noncalcareous; contains rare carbonized and pyritic plant compressions.	80.1	9.9
Shale, dark-gray, noncalcareous; contains rare pyrite-filled burrows and light-brownish-gray, sideritic concretions up to 3.5 in. thick.....	90.0	7.8
Sandstone, light-gray with dark-gray streaks, very fine-grained, bioturbated, noncalcareous; includes minor black, macerated plant material.	97.8	1.5
Shale, medium-gray, silty, noncalcareous; contains scattered pyrite-filled burrows and abundant black, carbonized and pyritized plant compressions; includes rare streaks of light-gray, very fine-grained sandstone, as well as light-brownish-gray, sideritic concretions up to 1.5 in. thick.....	99.3	6.7
Sandstone, medium-light-gray with dark-gray streaks, very fine-grained, micaceous, non-calcareous, cross-bedded in part, wavy-bedded in part; contains some black, macerated plant debris on bedding planes; includes some burrows in lower 6 ft of unit.....	106.0	19.8
Siltstone, medium-dark-gray with white streaks, shaly, noncalcareous, micaceous, burrowed, flat-bedded to wavy-bedded in part; includes some very fine-grained sandstone layers, black, macerated plant debris, and a 1-in.-thick, sideritic concretion at 126.2 ft.....	125.8	1.8
Sandstone, medium-gray with white streaks, shaly, rippled and cross-laminated in part, noncalcareous, micaceous, burrowed in part; includes some black, macerated plant material on bedding planes; microfaulted in places; contains convolute beds and scour features; slickensided on fracture surfaces; grades into underlying unit.....	127.6	13.2
Siltstone, medium-dark-gray, noncalcareous, micaceous, microfaulted; contains streaks of light-gray, very fine-grained sandstone in upper part; bioturbated extensively from 144 to 146 ft; slickensided on fracture surfaces; includes black, macerated plant debris on bedding planes in places; grades into underlying unit.....	140.8	47.2
Shale, medium-gray, silty, hard, noncalcareous; includes sparse streaks of light-gray, very fine-grained sandstone, slickensided.....	188.0	12.3



Shale, dark-gray, noncalcareous; contains rare pyritized brachiopod fossils and pyrite-filled burrows; includes a 2.25-in.-thick, sparsely fossiliferous, dense, light-brownish-gray limestone concretion from 210.4 to 210.6 ft	200.3	13.2
Shale, grayish-black, noncalcareous; contains scattered, white, calcareous and pyritic fossil shells and shell fragments, as well as white calcite in veins and pyrite in layers; includes rare, pyrite-filled burrows; becomes calcareous from 219 to 220.2 ft, and from 225.7 to 226.6 ft	213.5	13.1
Coal, black, moderately friable; contains white calcite on cleats, and thin crusts and laminae of pyrite on bedding planes (Weir-Pittsburg coal)	226.6	0.3
Krebs Group		
Boggy Formation		
Siltstone, grayish-black, carbonaceous, noncalcareous; grades into underlying unit	226.9	0.1
Sandstone, light-gray with medium-gray streaks, very fine-grained, churned and rooted; contains black, carbonized plant fragments; cross-laminated in part	227.0	6.0
Sandstone, medium-light-gray with medium-dark-gray bands; interbedded with siltstone and shaly siltstone, very fine-grained, noncalcerous; scour features and low-angle cross-bed features common; unit includes five well-defined graded-bed sequences 0.5 to 1.5 ft thick	233.0	5.3
Siltstone, medium-gray, sandy, noncalcareous, rippled in places; contains some low-angle cross-bedded sandstone layers, as well as convolute sandstone beds; grades into underlying unit	238.3	19.0
Shale, medium-gray, silty, noncalcareous; contains light-brownish-gray, sideritic concretions up to 1 in. thick	257.3	2.7
Shale, medium-dark-gray to dark-gray, noncalcareous; contains scattered, pyritized pelecypod valves about 0.5 in. long	260.0	11.0
Shale, grayish-black, noncalcareous; contains some white, calcareous fossil shells and pyrite-filled burrows; includes light-brownish-gray, sideritic concretions up to 4 in. thick	271.0	14.6
Coal, black, moderately friable; minor pyrite and calcite on cleat surfaces (Wainwright coal)	285.6	0.7
Underclay, medium-dark-gray to medium-gray, carbonaceous, slickensided	286.3	1.0
Siltstone, medium-gray, shaly, noncalcareous, rooted	287.3	0.3
Sandstone, medium-light-gray, very silty and shaly, micaceous, noncalcareous, very fine-grained; contains black, carbonized plant compressions; grades into underlying unit	287.6	0.9
Shale, dark-gray, noncalcareous, carbonaceous; contains some coaly streaks at base of unit	288.5	0.7
Underclay, medium-dark-gray, slickensided; contains dark-gray to black, carbonaceous and coaly streaks; burrowed	289.2	2.2
Shale, grayish-black, noncalcareous; brittle; contains pyritized trace fossils and white, calcareous shells and shell fragments; includes light-brownish-gray, sideritic concretions up to 3 in. thick	291.4	5.6

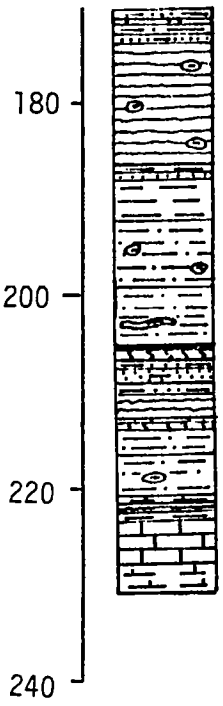
Shale, dark-gray, very calcareous, hard; contains scattered, white fossil shells and fossil hash, and pyritized trace fossils; becomes weakly calcareous to noncalcareous in lower 1 ft	297.0	4.0
Siltstone, medium-gray, calcareous; contains pyritized trace fossils; intertongued with underlying unit	301.0	1.6
Shale, grayish-black to dark-gray, noncalcareous; contains burrows and rare, white fossil shells	302.6	1.5
Sandstone, medium-gray, very calcareous, very fine-grained, churned	304.1	0.5
Shale, grayish-black, noncalcareous, slickensided	304.6	0.5
Siltstone, medium-dark-gray, shaly, very calcareous; contains scattered white fossil shells and shell fragments; burrowed; grades into underlying unit	305.1	3.4
Sandstone, medium-gray with light-gray streaks, very fine-grained, silty, micaceous; microfaulted in places; contains convolute beds and wavy laminae in part	308.5	5.5
Siltstone, medium-gray, sandy, micaceous, noncalcareous, slickensided; contains light-brownish-gray, sideritic concretions up to 3 in. thick; grades into underlying unit	314.0	36.0
Shale, medium-dark-gray, silty, noncalcareous; contains rare carbonized and pyritized wood fragments	350.0	22.0
Shale, medium-dark-gray, noncalcareous; contains pale-yellowish-brown, sideritic concretions up to 2 in. thick; includes rare, black, carbonized wood fragments and fossil shells in lower 1 ft of unit	372.0	24.2
Shale, grayish-black, noncalcareous; contains light-brownish-gray, sideritic and rare calcareous concretions up to 2.5 in. thick; includes scattered white fossil shells and pyrite-filled burrows; becomes black, with increased fossil content, at 409 ft; calcareous from 424.4 to 426.0 ft, with a 0.5-in.-thick, shaly, bioclastic-limestone layer at 425.3 ft	396.2	43.8
Total Depth		440.0



5 (C-TW-3)

NW 1/4 SW 1/4 SE 1/4 SW 1/4 sec. 1, T. 18 N., R. 17 E., Wagoner County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in field directly north from pond 550 ft FSL and 1,600 ft FWL. (Surface elevation, estimated from topographic map, 588 ft.)

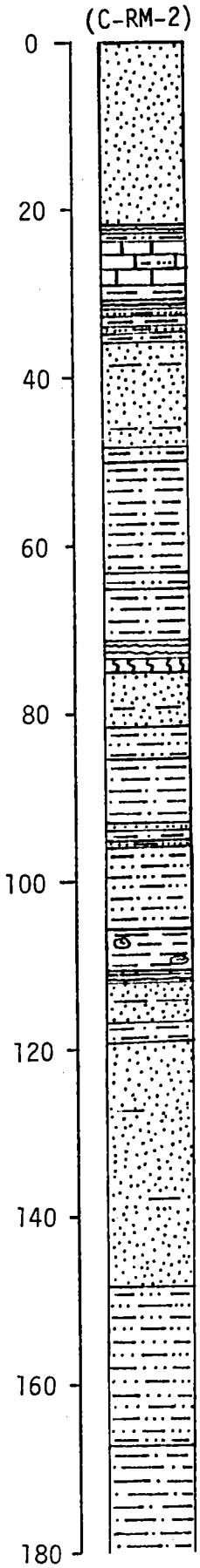
	Depth to unit top (ft)	Thickness of unit (ft)
Sand, grayish-brown, silty; contains organic matter	0.0	1.0
Clay, dark-yellowish-brown, silty, sandy, non-calcareous, unconsolidated	1.0	2.0
Clay, light-brown to moderate-reddish-brown, silty, sandy, noncalcareous, unconsolidated	3.0	3.5
Krebs Group		
Savanna Formation		
Shale, medium-light-gray and dark-yellowish-orange, noncalcareous	6.5	1.5
Coal, black, very friable, minor white gypsum on cleat surfaces (Rowe coal)	8.0	0.8
Underclay, brownish-gray with dark-yellowish-orange streaks, soft, sandy in lower 8 in.	8.8	2.1
Sandstone, medium-gray, shaly, noncalcareous	10.9	1.2
Shale, medium-gray, sandy, noncalcareous	12.1	1.9
Shale, medium-dark-gray, silty, noncalcareous	14.0	1.6
Shale, grayish-black, fissile, carbonaceous, noncalcareous; contains minor pyrite; calcareous in lower 6 in.	15.6	16.4
Shale, black, brittle, weakly calcareous in upper part to very calcareous in lower 2 ft; contains abundant marine fossils and small, pyrite-filled burrows; includes a 1-in.-thick, shaly, fossiliferous limestone layer at 36 ft.	32.0	4.7
Coal, black, moderately friable; contains pyrite layers and white calcite on cleat surfaces (unnamed coal)	36.7	0.2
Underclay, medium-dark-gray; contains black, carbonized plant fragments	36.9	1.6
Mudstone, medium-gray, noncalcareous	38.5	2.5
Shale, light-brownish-gray and medium-gray; contains scattered carbonaceous shale streaks.	41.0	7.3
Shale, medium-dark-gray, noncalcareous; contains pyrite-filled burrows and lenses; includes numerous light-brownish-gray sideritic bands 1/8 in. thick at most	48.3	10.2
Limestone, brownish-gray, hard, fossiliferous, fine-grained	58.5	0.1
Sandstone, dark-gray, silty, very fine-grained, weakly calcareous; contains scattered fossil fragments; grades into underlying unit	58.6	0.6
Limestone, medium-dark-gray, very sandy, fine-grained, cross-bedded; contains fossil shells and fossil fragments; becomes grayish-black and shaly in lower 6 in. (Sam Creek Limestone).	59.2	2.1
Shale, grayish-black, weakly calcareous; contains white, calcareous, fossil shells and fossil fragments	61.3	0.8
Shale, black, carbonaceous; contains thin layers of bright, hard coal (Sam Creek coal)	62.1	0.1
Shale, grayish-black to dark-gray, noncalcareous; contains pyrite-filled burrows	62.2	0.6
Underclay, light-gray, rooted, churned, sandy	62.8	3.2
Shale, medium-light-gray, silty, sandy, non-calcareous; contains brownish-gray, sandstone-filled burrows; grades into underlying unit	66.0	2.0
Siltstone, dark-gray with light-gray streaks, shaly, sandy, noncalcareous, burrowed; grades into underlying unit	68.0	2.0



Shale, grayish-black, silty, noncalcareous; contains light-brownish-gray, sideritic concretions up to 1 in. thick; includes numerous light-gray, sandstone-filled burrows and streaks in places, as well as pyrite-filled burrows	70.0	9.0
Shale, grayish-black, noncalcareous; contains rare pyrite-filled burrows and widely spaced, thin, light-brownish-gray, sideritic layers; contact with underlying unit sharp	79.0	10.2
Limestone, medium-gray, dense, hard, fine-grained, impure, silty, fossiliferous; contains abundant white shells and fossil fragments (Spaniard Limestone)	89.2	1.5
McAlester Formation		
Shale, medium-gray to dark-gray, noncalcareous, silty in lower 4 in	90.7	0.7
Sandstone, very light-gray with dark-gray streaks, very fine-grained, shaly, very calcareous	91.4	0.1
Shale, grayish-black, noncalcareous, carbonaceous, pyritic; contains thin layers of coal in lower part	91.5	0.5
Coal, black, bright, very friable; contains pyrite in layers and on cleats (Spaniard coal)	92.0	0.4
Sandstone, medium-light-gray to light-gray, very fine-grained, noncalcareous, rooted in upper 1 ft, churned to 96 ft, wavy bedded and burrowed below 96 ft	92.4	7.0
Siltstone, medium-dark-gray, noncalcareous, burrowed; contains some low-angle cross-beds, convolute beds, and wavy beds; includes a light-brownish-gray, 3-in.-thick, sideritic concretion at 99.7 ft; grades into underlying unit	99.4	3.6
Shale, medium-dark-gray, silty, noncalcareous; includes light-brownish-gray, sideritic concretions up to 0.75 in. thick	103.0	1.1
Shale, medium-dark-gray, calcareous, fossiliferous	104.1	0.4
Limestone, light-brownish-gray to medium-light-gray, fine-grained, hard, silty; contains shaly layers at 105.5 ft and 106 ft; includes a 0.5-in.-thick layer of black, coaly, carbonaceous shale at base of unit	104.5	3.1
Sandstone, medium-gray to light-gray, very fine-grained, noncalcareous, rippled in part; rooted in upper 4 in.; contains some coalified plant material in upper 2 in.; includes some medium-gray shale streaks in places	107.6	3.1
Shale, medium-gray, silty, interbedded with light-gray, very fine-grained sandstone, noncalcareous, rippled, burrowed	110.7	1.3
Shale, grayish-black with scattered light-gray siltstone and very fine-grained sandstone streaks, noncalcareous, flat-bedded, burrowed; contains rare, light-brownish-gray sideritic concretions up to 1 in. thick; includes pyrite layers and masses up to 1 in. thick, and a 0.75-in.-thick, very calcareous, fossiliferous layer in lower 1 in. of unit	112.0	25.0
Siltstone, medium-gray, shaly; interstratified with light-gray, very fine-grained sandstone, noncalcareous; contains some low-angle cross-bedding, convolute bedding, carbonized and pyritized plant fragments, and minor bioturbation features	137.0	7.0

Shale, medium-dark-gray, noncalcareous, silty in upper 6 in.; noncalcareous; contains rare burrows, slickensides, fractures filled with white calcite, and light-brownish-gray, sideritic concretions up to 3 in. thick; becomes grayish-black in lower 3 ft of unit; calcareous, with rare fossils in lower 2 ft....	144.0	4.0
Shale, dark-gray, silty, very calcareous; grades into underlying unit.....	148.0	0.3
Siltstone, medium-light-gray with dark-gray mottling, very calcareous, shaly; extensively burrowed; contains some very fine-grained sandstone.....	148.3	0.7
Shale, medium-gray, flaky, noncalcareous, slickensided.....	149.0	0.7
Shale, dark-gray to grayish-black, noncalcareous, slickensided, fractured; contains white calcite in veinlets, in blebs, and in thin crusts on bedding planes; includes some pyrite-filled burrows, and light-brownish-gray, sideritic concretions up to 1 in. thick..	149.7	20.3
Siltstone, dark-gray, shaly, very calcareous; contains pyrite-filled burrows.....	170.0	0.8
Limestone, dark-gray, impure, silty, fine-grained; contains abundant fossil shells and fossil hash.....	170.8	0.1
Shale, dark-gray, silty, noncalcareous; contains streaks of light-gray, calcareous siltstone and rare fossil shells.....	170.9	1.4
Sandstone, medium-light-gray, very fine-grained, interbedded with dark-gray shale; contains some brownish-gray limestone concretions, burrows, pyrite masses, and black, carbonized plant debris on stratification planes; cross-bedded.....	172.3	1.2
Shale, grayish-black, noncalcareous; contains white, calcareous, very fine-grained sandstone in burrows and in thin layers on bedding planes; includes minor pyrite and light-brownish-gray, sideritic concretions up to 1 in. thick; lower contact irregular.....	173.5	12.5
Shale, light-brownish-gray, noncalcareous.....	186.0	0.4
Sandstone, medium-gray, very fine-grained, massive, noncalcareous; fault-contact with underlying unit; dip of fault 55°.....	186.4	0.3
Shale, medium-gray, noncalcareous; blocky fracture; slickensided.....	186.7	5.3
Shale, medium-dark-gray with light-brownish-gray bands and light-gray streaks, noncalcareous; contains some very fine-grained sandstone in thin layers and in burrows; includes rare coal spars and scattered sideritic concretions.....	192.0	7.0
Shale, dark-gray, noncalcareous; contains thin light-brownish-gray sideritic bands and rare streaks of light-gray siltstone; includes sparse fossil shells and pyrite-filled burrows.	199.0	6.6
Coal, black, bright, moderately friable, pyritic (Stigler? coal).....	205.6	0.3
Underclay, dark-gray; contains black, carbonized plant fragments.....	205.9	0.5
Siltstone, medium-light-gray, clayey, noncalcareous, rippled.....	206.4	0.4
Sandstone, light-gray with dark-gray shale streaks, very fine-grained, noncalcareous, rippled, cross-bedded in part, burrowed; contains minor pyrite; becomes very shaly in lower 6 in.....	206.8	2.2

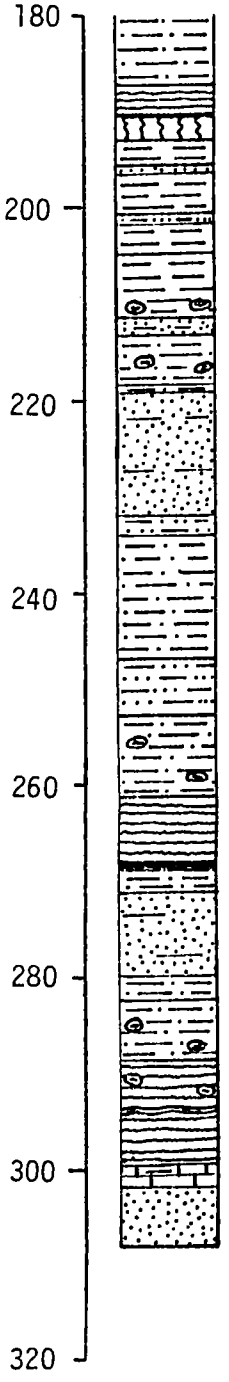
Siltstone, medium-dark-gray, noncalcareous; contains rare, scattered, calcareous and pyritized marine fossils.....	209.0	1.0
Shale, black, noncalcareous; contains pyrite-filled burrows and rare, pyritized fossil shells.....	210.0	2.3
Shale, black, calcareous; contains rare, pyrite-filled burrows.....	212.3	0.3
Limestone, grayish-black, very shaly; contains abundant fossil hash.....	212.6	0.1
Underclay, medium-light-gray, burrowed in part, rooted in upper 2 in.....	212.7	0.3
Shale, medium-gray with light-gray and medium-dark-gray bands; includes some very fine-grained sandstone streaks; burrowed.....	213.0	3.3
Shale, dark-gray, silty; contains rare pyrite-filled burrows and fossil fragments; noncalcareous; includes light-brownish-gray, sideritic concretions up to 1 in. thick.....	216.3	4.5
Shale, black, very calcareous; contains abundant white fossil fragments.....	220.8	0.5
Mississippian System		
Shale, black, irregularly interbedded with light-olive-gray shale, noncalcareous.....	221.3	0.7
Shale, light-olive-gray, noncalcareous; contains brownish-gray, limestone-filled burrows concentrated in lower 7 in.....	222.0	1.3
Limestone, white to pinkish-gray with greenish-gray flecks, mottled in upper part, very fossiliferous, coarsely crystalline, hard; includes some light-olive-gray shale streaks in lower 4 in.....	223.3	4.4
Shale, brownish-gray with olive tint, very calcareous; fossiliferous in part; includes abundant white-limestone-filled burrows and layers.....	227.7	2.7
Total Depth		230.4



6 (C-RM-2)

SE 1/4 SW 1/4 NW 1/4 SE 1/4 sec. 12, T. 21 N., R. 16 E., Rogers County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in pasture 1,540 ft FSL and 2,060 ft FEL. (Surface elevation, estimated from topographic map, 773 ft.)

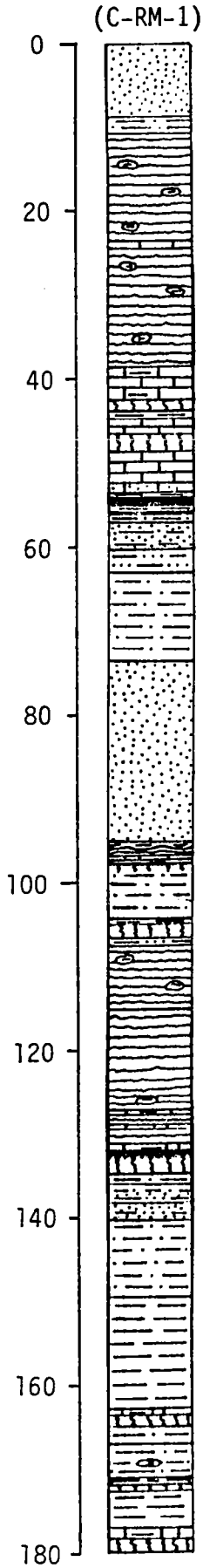
	Depth to unit top (ft)	Thickness of unit (ft)
Cabaniss Group		
Senora Formation		
Sandstone, moderate-reddish-orange, fine-grained, noncalcareous; occurs as broken, weathered, angular cobbles in dark-yellowish-brown, silty soil	0.0	1.0
Sandstone, dark-yellowish-orange, fine-grained, noncalcareous, micaceous	1.0	5.0
Sandstone, dark-reddish-brown, fine-grained, noncalcareous, micaceous	6.0	3.0
Sandstone, dark-yellowish-orange, moderate-reddish-orange, and dark-reddish-brown in alternating layers, fine-grained, noncalcareous, micaceous, ferruginous, fractured; some blackish-red manganese dioxide staining on fracture surfaces; cross-bedded; contains clasts of ironstone in lower 3.5 ft, and abundant coal spars in lower 6 in. (base of Chelsea Sandstone)	9.0	12.8
Shale, brownish-black, blocky fracture, noncalcareous	21.8	0.7
Siltstone, olive-black, muddy, massive, noncalcareous; contains very small fossil shells	22.5	0.3
Limestone, medium-gray, fine-grained, impure, silty, pyritic, vuggy, fossiliferous; poorly preserved marine shells common; dark-gray in places; very light-gray with light-gray mottling and wavy laminae in lower 4 ft; fossil hash concentrated in lower 4 in. (Tiawah Limestone)	22.8	5.6
Shale, medium-gray with greenish-gray tint, clayey, calcareous in upper 1 in.; contains rare streaks of black, carbonaceous shale and some coaly streaks	28.4	2.0
Shale, grayish-black, carbonaceous, noncalcareous	30.4	0.7
Sandstone, light-brownish-gray, shaly, calcareous, very fine-grained, burrowed	31.1	0.1
Shale, medium-gray, clayey, noncalcareous	31.2	2.0
Sandstone, light-gray, shaly, very fine-grained, noncalcareous, burrowed	33.2	0.9
Shale, medium-light-gray with light-gray streaks, noncalcareous, silty	34.1	1.4
Sandstone, medium-light-gray with medium-dark-gray shale streaks, noncalcareous, very fine-grained; mostly flat-bedded, but contains some low-angle cross-beds and cross-laminae; burrowed in part; includes mica and black, macerated plant material on bedding planes; medium-gray below 38 ft; grades into underlying unit	35.5	12.5
Siltstone, medium-dark-gray with light-gray streaks of very fine-grained sandstone, noncalcareous, shaly, flat-bedded; contains pyrite-filled burrows; grades into underlying unit	48.0	2.0
Shale, medium-dark-gray with minor light-gray streaks, silty, hard; contains rare, pyrite-filled burrows	50.0	13.1



Siltstone, medium-gray with light-gray sandstone streaks, noncalcareous, shaly, flat-bedded; includes rare burrows and black, macerated plant material on some bedding planes	63.1	1.9
Shale, medium-dark-gray, silty, noncalcareous	65.0	6.2
Shale, grayish-black, very calcareous; contains irregular bands of limestone composed mostly of shell fragments	71.2	0.3
Shale, grayish-black, noncalcareous, pyritic, brittle, crumbly, slickensided; includes a 0.25-in.-thick, pyritic coal band at base of unit (RC coal)	71.5	1.9
Underclay, light-gray, mottled, slickensided, very sandy, extensively burrowed	73.4	1.6
Sandstone, very light-gray, noncalcareous, very fine-grained, churned; cross-bedded and wavy-bedded, with some bioturbation features below 77 ft; shaly from 77.7 ft to base	75.0	6.7
Siltstone, medium-light-gray, noncalcareous, shaly, flat-bedded; contains rare burrows and some very fine-grained sandstone layers	81.7	3.8
Shale, medium-gray with light-gray siltstone streaks, noncalcareous, dark-gray in lower 6 in.	85.5	7.5
Sandstone, medium-dark-gray with light-gray streaks, noncalcareous, very fine-grained, shaly, bioturbated	93.0	0.5
Shale, medium-dark-gray with numerous streaks of light-gray, very fine-grained sandstone, rippled, noncalcareous, burrowed	93.5	1.4
Sandstone, medium-dark-gray with light-gray streaks, very fine-grained, shaly, noncalcareous; contains some wavy beds and low-angle cross-beds; burrowed	94.9	0.7
Siltstone, medium-dark-gray with light-gray, very fine-grained sandstone streaks, noncalcareous, shaly, flat-bedded; contains rare burrows, some pyrite-filled; coarse-grained in lower 2 ft	95.6	10.0
Shale, dark-gray, noncalcareous; contains light-brownish-gray sideritic concretions up to 3 in. thick, and rare pyritized and carbonized plant fragments	105.6	4.7
Limestone, dark-gray, shaly, fine-grained; contains streaks of coal	110.3	0.1
Shale, black, carbonaceous; contains coal streaks	110.4	0.1
Sandstone, medium-gray to medium-light-gray, shaly, calcareous in upper 2 in., very fine-grained, churned in upper 2 ft, cross-bedded in part, burrowed	110.5	6.0
Shale, medium-gray, silty, noncalcareous; contains numerous streaks of very fine-grained, light-gray sandstone	116.5	2.5
Sandstone, medium-dark-gray to medium-gray, very fine-grained, cross-bedded, micaceous, noncalcareous, contains scattered dark-gray shale streaks and abundant black, macerated plant debris on bedding planes; burrowed in part; grades into underlying unit	119.0	29.0
Siltstone, medium-dark-gray with light-gray sandstone streaks and lenses, shaly, noncalcareous, micaceous; mostly flat-bedded, but includes some low-angle cross-beds; contains scattered bioturbation features, minor pyritic and carbonized plant fragments, and rare coal spars; grades into underlying unit	148.0	19.0

Shale, dark-gray, noncalcareous, silty; contains scattered sandy layers, rare pyrite-filled burrows, and some contorted bedding in the sandy layers; includes rare brachiopod fossils and seed-fern leaves below 186 ft.....	167.0	20.3
Shale, black, noncalcareous; contains scattered calcareous fossil shells and rare pyrite-filled burrows.....	187.3	2.8
Coal, black, bright, moderately friable; contains white calcite on cleats and layers of pyrite up to 0.25 in. thick (Weir-Pittsburg coal).....	190.1	0.2
Krebs Group		
Boggy Formation		
Underclay, light-brownish-gray, blocky fracture, rooted in upper part, churned; grades into underlying unit.....	190.3	3.0
Shale, light-brownish-gray, noncalcareous, clayey.....	193.3	2.4
Sandstone, medium-dark-gray, very fine-grained, massive, hard.....	195.7	0.8
Shale, medium-gray, noncalcareous, carbonaceous and coaly in lower 1 in.....	196.5	3.9
Mudstone, brownish-gray, churned in part; contains some wavy, carbonaceous layers in upper 6 in.....	200.4	1.3
Claystone, greenish-gray, noncalcareous.....	201.7	3.0
Shale, medium-gray to dark-gray, noncalcareous; contains light-brownish-gray, sideritic concretions up to 1.25 in. thick in lower 1.5 ft of unit.....	204.7	6.8
Sandstone, light-gray with medium-gray streaks, noncalcareous, silty, very fine-grained, bioturbated.....	211.5	2.1
Shale, medium-dark-gray, silty, noncalcareous; contains burrowed, light-brownish-gray, sideritic concretions up to 1.75 in. thick; includes rare, pyrite-filled burrows.....	213.6	4.7
Shale, medium-dark-gray with light-gray, very fine-grained, micaceous sandstone streaks, noncalcareous.....	218.3	0.7
Sandstone, light-gray to medium-light-gray with dark-gray streaks, very fine-grained, shaly, noncalcareous, micaceous; rippled in part, flat-bedded in part, cross-bedded in part; includes black, macerated plant debris on bedding planes; grades into underlying unit....	219.0	13.0
Siltstone, medium-gray with medium-light-gray, sandy streaks, shaly, flat- to wavy-bedded, noncalcareous; grades into underlying unit.....	232.0	2.0
Shale, medium-gray with medium-light-gray siltstone and very fine-grained sandstone streaks, noncalcareous; contains rare sandstone- and siderite-filled burrows and minor pyrite; hard; grades into shaly siltstone at about 247 ft.....	234.0	13.0
Siltstone, medium-gray, shaly, noncalcareous; contains rare pyrite-filled burrows and disseminated pyrite.....	247.0	6.0
Shale, medium-dark-gray, silty, noncalcareous; contains light-brownish-gray, sideritic concretions up to 1 in. thick.....	253.0	8.5
Shale, grayish-black to dark-gray, interbedded with light-gray, very fine-grained sandstone, noncalcareous.....	261.5	6.5
Shale, black, carbonaceous.....	268.0	0.1
Coal, black, friable; white calcite and minor pyrite on cleats (Wainwright coal).....	268.1	0.8

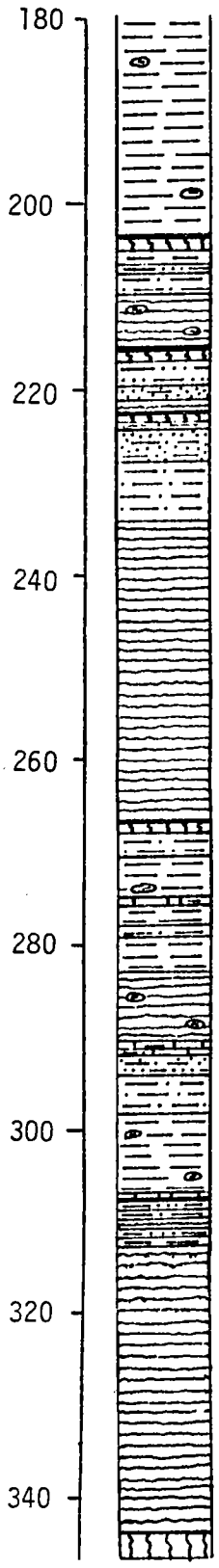
Shale, dark-gray with light-gray, very fine-grained sandstone streaks, noncalcareous, burrowed.....	268.9	2.8
Sandstone, light-gray and medium-dark-gray, very fine-grained, interbedded with shale, noncalcareous, wavy-bedded to cross-bedded, micaceous; black, macerated plant debris on bedding planes; burrowed in part.....	271.7	8.3
Shale, dark-gray, interlaminated with light-gray, very fine-grained sandstone, noncalcareous; some sandstone layers show soft-sediment deformation features.....	280.0	2.3
Shale, dark-gray; contains rare streaks of very fine-grained, light-gray sandstone; noncalcareous; includes numerous light-brownish-gray, sideritic layers up to 0.25 in. thick; grades into underlying unit.....	282.3	6.7
Shale, grayish-black, noncalcareous; contains rare fossil brachiopods and scattered, pyrite-filled burrows; includes several light-brownish-gray, sideritic concretions up to 1.5 in. thick.....	289.0	4.7
Ironstone, dark-gray, fractured; limestone containing fossil hash occurs in a 1/8- to 0.75-in.-thick layer at top of unit and in fracture fillings.....	293.7	0.3
Shale, grayish-black, noncalcareous; contains rare pyrite-filled burrows and small calcareous shells and shell fragments; includes limestone-filled burrows in lower 2 in.....	294.0	5.5
Limestone, light-gray to dark-gray with greenish-gray tint in part, shaly in part, cross-bedded in places, fine-grained, fossiliferous; contains abundant fossil hash composed mostly of shell fragments (Inola Limestone).....	299.5	2.3
Sandstone, very light-gray to light-gray with medium-gray streaks, fine to very fine-grained, micaceous, cross-bedded, very calcareous from 301.8 to 305 ft; contains rare burrows and scattered shale laminae (Bluejacket Sandstone).....	301.8	6.2
Total Depth		308.0



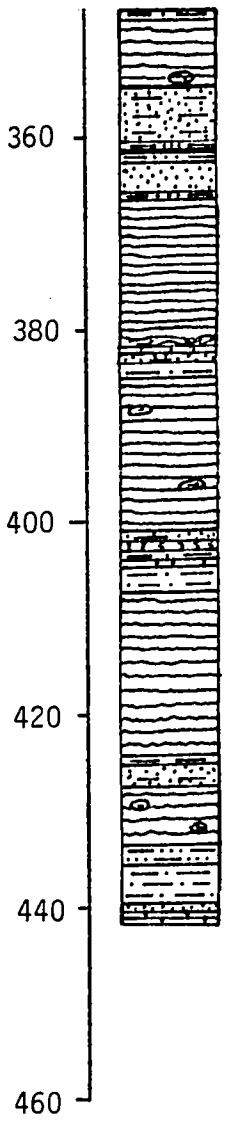
7 (C-RM-1)

SE 1/4 SE 1/4 SW 1/4 NW 1/4 sec. 18, T. 21 N., R. 18 E., Mayes County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in pasture on hill south of pond. (Surface elevation, estimated from topographic map, 815 ft.)

	Depth to unit top (ft)	Thickness of unit (ft)
Pennsylvanian System		
Desmoinesian Series		
Krebs Group		
Boggy Formation		
Sandstone, moderate-reddish-brown, very fine-grained, noncalcareous, weathered.....	0.0	4.0
Sandstone, grayish-orange with dusky-brown flecks, very fine-grained, micaceous, non-calcareous, thin-bedded, weathered.....	4.0	4.5
Shale, dark-yellowish-orange to light-brown to pale-yellowish-brown, interlaminated with siltstone and very fine-grained sandstone, noncalcareous, weathered.....	8.5	2.0
Shale, grayish-black with dark-yellowish-orange bands, noncalcareous; contains some thin stringers of light-gray siltstone; fractured...	10.5	2.5
Shale, grayish-black with medium-light-gray, sideritic bands, noncalcareous.....	13.0	7.8
Shale, grayish-black to black, noncalcareous; contains light-brownish-gray, sideritic concretions up to 2 in. thick.....	20.8	2.8
Limestone, light-brownish-gray, fine-grained, micritic, nonfossiliferous.....	23.6	0.5
Shale, grayish-black, noncalcareous; contains rare pyrite-filled burrows and light-brownish-gray, sideritic concretions up to 1.5 in. thick.....	24.1	14.4
Limestone, medium-dark-gray to light-gray, impure, shaly, fossiliferous; contains abundant broken shells and other fossil fragments; becomes darker gray in lower 1 ft, with better-preserved fossil shells; includes a 1/16-in.-thick coal stringer at contact with underlying unit (Inola Limestone).....	38.5	3.7
Underclay, medium-dark-gray to medium-light-gray; blocky facture; carbonaceous in upper part.....	42.2	1.5
Shale, greenish-gray, clayey, noncalcareous; contains some bioturbation features in lower 8 in.....	43.7	1.1
Limestone, light-gray with very light-gray mottling, fine-grained, hard; contains fossil shells and fossil fragments (Inola Limestone).....	44.8	1.5
Underclay, light-gray with minor grayish-black streaks, blocky fracture, silty; grades into underlying unit.....	46.3	2.2
Limestone, very light-gray, fine-grained, calcarenitic; contains rare fossil shells and minor disseminated pyrite; cross-bedded (Inola Limestone).....	48.5	5.4
Shale, medium-gray, noncalcareous, carbonaceous, pyritic; includes two coal layers totaling 0.75 in. thick at contact with overlying unit..	53.9	0.1
Coal, black, bright, moderately friable; pyrite and calcite on cleats; includes a 4-in.-thick carbonaceous shale parting from 55.0 to 55.3 ft; 6 in. of coal below parting contains some thin shale laminae (Bluejacket coal).....	54.0	1.8
Shale, medium-dark-gray, silty, sandy, coaly in upper part; contains abundant well-preserved, black, carbonized plant compressions.....	55.8	0.4



Sandstone, light-gray with medium-dark-gray shale streaks, micaceous, very fine-grained, noncalcareous, rippled; contains abundant black, carbonized and pyritized plant fragments (upper unit of Bluejacket Sandstone).....	56.2	3.9
Siltstone, medium-light-gray, interbedded with medium-dark-gray shale, noncalcareous, wavy-bedded and cross-laminated in part, burrowed; contains black, carbonized plant fragments.....	60.1	2.9
Shale, dark-gray with medium-light-gray siltstone bands and streaks, noncalcareous; contains black, carbonized plant fragments and rare light-brownish-gray, sideritic concretions; contact with underlying unit sharp.....	63.0	10.7
Sandstone, medium-light-gray, fine-grained, noncalcareous, micaceous; contains scattered dark-gray shale streaks and pebbles, as well as numerous streaks of black, coalified plant material; shows flame structure and flaser bedding in places; includes some coal spars up to 1.5 in. thick in lower 8 in. of unit; contact with underlying unit sharp (basal unit of Bluejacket Sandstone).....	73.7	21.4
Savanna Formation		
Ironstone, brownish-gray; contains a thin, diagonal streak of white gypsum.....	95.1	0.2
Shale, black, noncalcareous.....	95.3	0.7
Limestone, dark-gray, impure, silty, contains abundant fossil shells and fossil fragments....	96.0	0.4
Shale, black, coaly, calcareous.....	96.4	0.1
Coal, black, moderately friable; contains pyrite in thin lenses and streaks (Drywood coal).....	96.5	0.1
Shale, medium-gray, noncalcareous; silty, wavy-laminated; contains black, carbonized plant fragments; includes 2 in. of poorly developed underclay at top of unit; contains scattered pyrite-filled burrows and light-brownish-gray, sideritic concretions up to 1.25 in. thick.....	96.6	7.5
Shale, medium-dark-gray with grayish-black and black streaks, weakly calcareous; contains carbonaceous and pyritic layers, as well as streaks of coal.....	104.1	0.1
Underclay, medium-gray, blocky fracture, slickensided, burrowed, silty.....	104.2	2.1
Siltstone, medium-light-gray, noncalcareous, shaly.....	106.3	0.6
Shale, grayish-black with light-brownish-gray bands in upper 6 ft, noncalcareous, burrowed; contains pyrite masses and sideritic concretions up to 1.25 in. thick.....	106.9	8.1
Shale, grayish-black, noncalcareous; contains rare pyrite-filled burrows, small, calcareous fossil shells, and white calcite in veinlets and on bedding planes; contains some light-brownish-gray sideritic concretions up to 1 in. thick in lower 3.5 ft of unit.....	115.0	11.8
Limestone, grayish-black, impure, silty, fine-grained, fossiliferous; contains shell fragments and small crinoid ossicles.....	126.8	0.1
Shale, grayish-black, noncalcareous; includes thin, very light-gray streaks of calcareous siltstone and sandstone.....	126.9	1.6
Limestone, grayish-black, impure, silty, fossiliferous; contains fossil hash; grades into underlying unit.....	128.5	0.1
Shale, black, very calcareous; contains abundant white fossil shells and crinoid ossicles; grades into underlying unit.....	128.6	2.4
Limestone, grayish-black, very impure, silty, shaly, carbonaceous; fossiliferous; contains fossil hash (Doneley Limestone).....	131.0	0.8



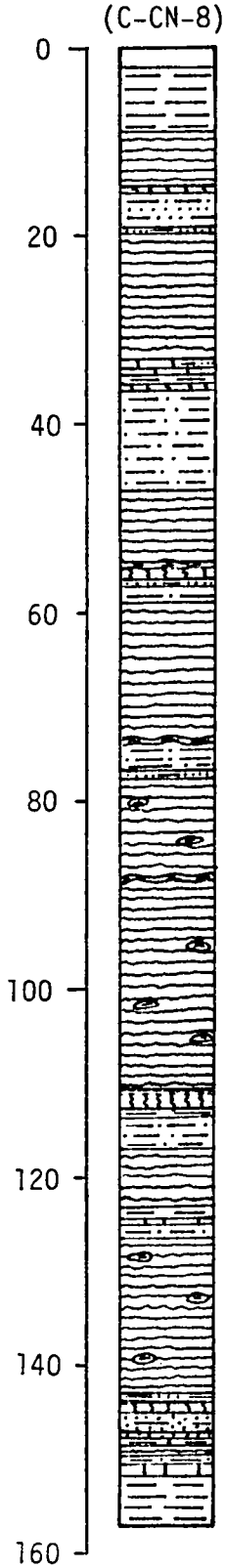
Coal, black, bright, moderately friable, white calcite and pyrite on cleat surfaces (Rowe coal)	131.8	0.7
Underclay, brownish-gray, silty; contains black, carbonized plant fragments	132.5	1.8
Shale, medium-light-gray, silty, noncalcareous	134.3	1.5
Mudstone, medium-light-gray, noncalcareous	135.8	2.2
Sandstone and siltstone, medium-gray, shaly, very fine-grained, noncalcareous, laminated, burrowed	138.0	2.0
Shale, medium-dark-gray with light-gray streaks of siltstone and very fine-grained sandstone, noncalcareous, extensively burrowed; includes rare, light-brownish-gray, sideritic concretions	140.0	9.3
Shale, medium-dark-gray, noncalcareous; contains rare, thin streaks of light-gray siltstone	149.3	13.0
Limestone, brownish-gray, impure, shaly, fine-grained; contains abundant fossil hash; includes a 0.5-in.-thick band of black, carbonaceous shale at base (Sam Creek Limestone)	162.3	0.2
Underclay, medium-dark-gray, churned, slickensided	162.5	1.9
Shale, dark-gray, silty, sandy, noncalcareous; contains large bioturbation features filled with brownish-gray, very fine-grained sandstone	164.4	2.3
Shale, dark-gray with light-gray siltstone streaks and lenses, noncalcareous; contains rare, light-brownish-gray, sideritic concretions	166.7	4.1
Coal, black, interbedded with dark-gray, noncalcareous, slickensided shale and layers of pyrite up to 1/16 in. thick	170.8	0.7
Coal, black, bright, moderately friable, pyrite and calcite on cleat surfaces (unnamed coal)	171.5	0.3
Underclay, medium-gray, soft	171.8	0.4
Shale, medium-light-gray, burrowed, noncalcareous; includes a 0.5-in.-thick layer of fossiliferous limestone 4 in. above base of unit	172.2	4.8
Limestone, medium-dark-gray with light-brownish-gray sideritic bands about 1-in.-thick, impure, shaly, fossiliferous; contains abundant brachiopod shells and fossil hash (Spaniard Limestone)	177.0	1.0
McAlester Formation		
Underclay, medium-gray, churned; contains a 2-in.-thick, calcarenitic limestone layer at 178.8 ft	178.0	1.7
Shale, medium-dark-gray to dark-gray, noncalcareous, brittle; includes rare, light-brownish-gray, sideritic concretions; extensively bioturbated in upper 15 in. of unit; contains rare burrows and streaks of pyrite in remainder of unit, with minor streaks of light-gray siltstone	179.7	24.1
Coal, black, slightly friable, white calcite on cleat surfaces (unnamed coal)	203.8	0.2
Underclay, medium-light-gray, blocky fracture; contains black, carbonized plant fragments; soft, crumbly	204.0	1.5
Shale, medium-gray, noncalcareous, blocky fracture	205.5	1.3
Siltstone, medium-gray, shaly, noncalcareous, hard	206.8	1.0
Shale, medium-gray, noncalcareous, blocky; contains light-gray siltstone streaks and lenses	207.8	2.2
Shale, dark-gray to grayish-black, noncalcareous; contains light-gray siltstone streaks and light-brownish-gray, sideritic concretions up to 1.5 in. thick	210.0	5.8

Coal, black, slightly friable; calcite and minor pyrite on cleats (Keota? coal).....	215.8	0.3
Underclay, medium-gray, churned; contains black, carbonaceous streaks.....	216.1	1.5
Siltstone, medium-light-gray to medium-dark-gray, very shaly, noncalcareous, extensively burrowed, grades into underlying unit.....	217.6	2.4
Sandstone, medium-light-gray with dark-gray shale streaks, very fine-grained, noncalcareous, rippled, burrowed.....	220.0	1.6
Shale, grayish-black, noncalcareous.....	221.6	1.2
Coal, black, moderately friable, white calcite on cleat surfaces (unnamed coal).....	222.8	0.2
Underclay, medium-dark-gray, blocky fracture, slickensided.....	223.0	0.8
Shale, medium-dark-gray, noncalcareous, silty; grades into shaly sandstone.....	223.8	0.6
Sandstone, medium-gray, very fine-grained, very silty and shaly, noncalcareous.....	224.4	3.6
Shale, medium-dark-gray, silty and sandy, noncalcareous, burrowed.....	228.0	3.7
Shale, dark-gray with light-gray, very fine-grained sandstone streaks, rippled, burrowed, noncalcareous.....	231.7	2.5
Shale, grayish-black, noncalcareous; contains rare streaks of light-gray siltstone and pyrite-filled burrows; includes abundant black, macerated plant fragments on some bedding planes.....	234.2	32.4
Coal, black, slightly friable; contains pyrite masses and white calcite on cleat surfaces (Tamaha? coal).....	266.6	0.1
Underclay, medium-gray, rooted; blocky fracture; slickensided; contains black, carbonized plant fragments.....	266.7	1.3
Shale, medium-light-gray, noncalcareous; interbedded with light-gray, very fine-grained, calcareous sandstone; extensively bioturbated; includes abundant sandstone-filled burrows.....	268.0	2.5
Shale, medium-dark-gray, noncalcareous; includes some 1/8-in.-thick, light-brownish-gray, sideritic layers in bottom 1 ft.....	270.5	4.8
Limestone, yellowish-gray, fine-grained, hard; contains abundant fossil shells, small crinoids ossicles, and other fossil debris; shaly in bottom 2 in.....	275.3	0.6
Shale, medium-dark-gray, noncalcareous.....	275.9	2.1
Shale, medium-gray, sandy, silty, noncalcareous, burrowed.....	278.0	1.3
Shale, dark-gray, noncalcareous; contains rare, thin streaks of light-gray siltstone in upper 3 in.....	279.3	3.6
Shale, grayish-black, noncalcareous; contains rare pyrite-filled burrows; includes light-brownish-gray, sideritic concretions up to 1.5 in. thick.....	282.9	7.4
Limestone, light-brownish-gray, fine-grained, impure, silty; shaly in upper 4 in., with pyritic masses up to 0.25 in. thick filling burrows; contains abundant fossil hash, including broken shells and small crinoid ossicles.....	290.3	1.6
Mudstone, dark-gray, churned; sand- and pyrite-filled burrows abundant; noncalcareous.....	291.9	2.1
Shale, medium-gray to dark-gray, with abundant light-gray siltstone and very fine sandstone layers up to 0.75 in. thick, noncalcareous, wavy-bedded, burrowed.....	294.0	4.3

Shale, dark-gray with minor light-gray siltstone streaks, noncalcareous; contains rare pyrite-filled lenses and burrows, and small sideritic nodules; includes some black, carbonized plant fragments on bedding planes.....	298.3	18.5
Limestone, dark-gray to light-brownish-gray, fine-grained, hard; contains abundant broken fossil shells and small crinoid ossicles.....	316.8	0.7
Coal, black, slightly friable; white calcite on cleat surfaces (Stigler? coal).....	317.5	0.1
Siltstone, medium-dark-gray, hard; grades into underlying unit.....	317.6	0.8
Shale, medium-dark-gray, silty, noncalcareous....	318.4	0.6
Shale, black, noncalcareous.....	319.0	1.0
Siltstone, dark-gray, noncalcareous; very hard; contains scattered fossil shells and crinoid ossicles.....	320.0	0.4
Shale, medium-gray, blocky fracture, noncalcareous, burrowed.....	320.4	0.5
Shale, grayish-black with thin, scattered streaks of light-gray, very fine-grained sandstone and siltstone, noncalcareous; contains rare, small burrows and minor black plant compressions on bedding planes; includes some pyrite in burrows and lenses.....	320.9	22.4
Coal, black, slightly friable; veinlets of white calcite and pyrite occur on bedding surfaces and in cleats (unnamed coal).....	343.3	0.2
Underclay, medium-gray; contains black, carbonized plant fragments; blocky fracture; slickensided, pyritic.....	343.5	2.5
Shale, medium-dark-gray, silty, noncalcareous; contains abundant sandstone-filled burrows; pyritic.....	346.0	1.3
Shale, dark-gray to grayish-black, noncalcareous, slickensided; contains rare light-gray siltstone streaks, and pyrite-filled burrows...	347.3	6.4
Shale, black, calcareous; contains abundant fossil shell fragments as well as an irregularly shaped, fossiliferous, light-brownish-gray limestone mass 1 in. thick.....	353.7	0.3
Coal, black, moderately friable; contains white calcite on cleats, as well as pyrite as lenses and crusts on bedding planes (unnamed coal)....	354.0	0.2
Sandstone, medium-light-gray with minor dark-gray shale streaks, noncalcareous, micaceous, very fine-grained, irregularly bedded to wavy-bedded; contains scattered shale pebbles in places (upper unit of Warner Sandstone).....	354.2	3.9
Sandstone, light-gray with dark-gray shale streaks, calcareous, rippled; scour features and burrows abundant; micaceous.....	358.1	1.6
Siltstone, dark-gray, shaly, noncalcareous; includes abundant light-gray, very fine-grained sandstone burrows; pyritic and coaly in lower 1 in.....	359.7	0.8
Coal, black, bright, moderately friable; contains pyrite in cleats (Keefton coal).....	360.5	0.4
Siltstone, dark-gray, noncalcareous; contains carbonaceous particles and coal streaks; bioturbated.....	360.9	0.3
Sandstone, light-gray to medium-gray, very fine-grained, noncalcareous; churned in upper part; contains some black, carbonized, fibrous plant material; cross-bedded in middle part; flat-bedded in lower part, with some convolute bedding near the base (basal unit of Warner Sandstone).....	361.2	4.0

Siltstone, medium-dark-gray with light-gray streaks, noncalcareous, sandy, micro-faulted and burrowed; contains siderite-filled burrows just above contact with underlying unit (upper unit of McCurtain Shale Member).....	365.2	0.4
Shale, grayish-black, noncalcareous; brittle; contains scattered calcareous and pyritized marine fossils and pyrite-filled burrows; slickensided; includes a 3-in.-thick layer of brownish-gray, mottled ironstone occurring as burrow fillings.....	365.6	15.9
Ironstone, brownish-gray with white, calcite-filled fractures, pyritic.....	381.5	0.3
Limestone, medium-dark-gray, impure, shaly; contains fossil fragments (basal unit of McCurtain Shale Member).....	381.8	0.1
Hartshorne? Formation		
Sandstone, medium-gray, very fine-grained, calcareous; includes beds of noncalcareous, medium-gray shale; wavy-bedded; grades into underlying unit.....	381.9	0.9
Atoka? Formation		
Shale, dark-gray with very light-gray streaks of very fine-grained, calcareous sandstone; contains some burrows.....	382.8	1.7
Shale, grayish-black, noncalcareous; contains light-brownish-gray, sideritic concretions up to 2 in. thick; includes rare streaks of light-gray siltstone, small fossil shells, and pyrite lenses; becomes calcareous and contains some irregular beds and lenses of calcarenitic limestone.....	384.5	15.7
Sandstone, light-gray, silty, very fine-grained; contains dark-gray shale clasts and pyritic coal streaks; very calcareous.....	400.2	0.3
Underclay, medium-light-gray, sandy; blocky fracture; contains rare, disseminated pyrite and black, carbonized plant fragments.....	400.5	0.8
Shale, medium-gray, noncalcareous, interbedded with light-gray, very fine-grained, calcareous sandstone.....	401.3	0.7
Limestone, light-brownish-gray, fine-grained, hard; contains scattered shell fragments.....	402.0	0.3
Shale, medium-gray to dark-gray, noncalcareous; contains thin streaks of light-gray siltstone and rare burrows.....	402.3	4.0
Shale, grayish-black, silty, noncalcareous; contains abundant streaks of white, very fine-grained, calcareous sandstone; burrowed, slickensided; streaks of sandstone occur rarely.....	406.3	17.2
Shale, light-brownish-gray, blocky fracture, noncalcareous.....	423.5	1.3
Sandstone, light-gray, very fine-grained; interbedded with medium-light-gray siltstone and shale; noncalcareous, wavy-bedded in part; brownish-gray, fine-grained, and massive, with some indistinct fossil shells; medium-gray, very fine-grained, silty and shaly in lower 5 in.....	424.8	2.1
Shale, dark-gray to grayish-black, noncalcareous; contains rare pyrite-filled burrows; includes light-brownish-gray, sideritic concretions up to 3.5 in. thick; slickensided.....	426.9	5.9
Siltstone, light-bluish-gray to medium-light-gray, very shaly, noncalcareous, flat-bedded to cross-bedded in part; grades into underlying unit.....	432.8	2.2
Shale, medium-gray with light-gray streaks of siltstone, noncalcareous, slickensided.....	435.0	1.5

Shale, dark-gray with light-gray streaks of siltstone and very fine-grained sandstone, noncalcareous, cross-bedded, burrowed.....	436.5	2.5
Sandstone, light-gray with medium-dark-gray shale streaks, very fine-grained, rippled, burrowed; contains a pyritic coal spar in upper 1 in.; noncalcareous, except for lower 2 in., which contain calcarenite-filled burrows.....	439.0	0.7
Fayetteville? Formation (Mississippian)		
Limestone, medium-gray in upper part to light-gray in lower part, calcarenitic; shaly and burrowed in upper part; contains thin, wavy shale streaks in lower part.....	439.7	1.3
Total Depth		441.0



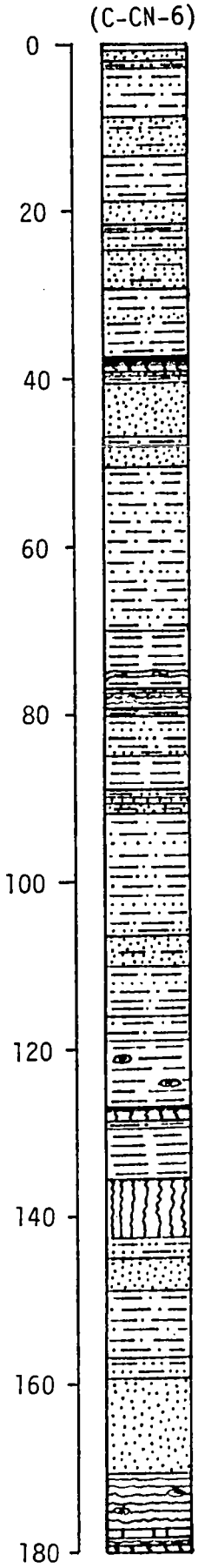
8 (C-CN-8)

SW 1/4 NE 1/4 SE 1/4 SW 1/4 sec. 15, T. 24 N., R. 19 E., Craig County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in hay meadow at northwest edge of farm pond 2,330 ft FWL and 680 ft FSL. (Surface elevation, estimated from topographic map, 715 ft.)

	Depth to unit top (ft)	Thickness of unit (ft)
Silt, pale-yellowish-brown with dark-yellowish-orange mottling; contains organic material.....	0.0	2.0
Krebs Group		
Savanna Formation		
Shale, moderate-yellowish-brown to dark-yellowish-brown, noncalcareous, clayey, weathered.....	2.0	7.0
Shale, olive-black with dark-yellowish-orange staining on fracture surfaces, noncalcareous, partly weathered.....	9.0	1.0
Shale, black, noncalcareous, stained dark-yellowish-orange by iron oxides in upper 2 ft; includes a dark-reddish-brown ironstone concretion underlain by a 1/8-in.-layer of black, carbonaceous, coaly shale.....	10.0	4.4
Underclay, pale-yellowish-brown, soft, churned...	14.4	0.5
Mudstone, medium-gray with a greenish-gray tint, churned, noncalcareous.....	14.9	4.1
Sandstone, medium-gray, shaly, noncalcareous, massive, fine-grained.....	19.0	0.9
Shale, dark-gray to grayish-black, noncalcareous; contains rare pyrite-filled burrows.....	19.9	13.4
Limestone, light-brownish-gray to medium dark-gray, impure, silty, fine-grained; contains broken fossil-shell fragments (Spaniard Limestone).....	33.3	1.4
McAlester Formation		
Shale, dark-gray, noncalcareous, contains scattered, calcareous fossil shell fragments in upper 2.5 in. of unit.....	34.7	0.6
Underclay, light-gray; contains some dark-gray shale clasts.....	35.3	0.7
Shale, medium-light-gray, noncalcareous, silty...	36.0	1.6
Shale, medium-dark-gray to dark-gray with light-gray, very fine-grained sandstone and siltstone streaks and lenses, burrowed, noncalcareous; contains some pyritic lenses and burrow fillings.....	37.6	9.4
Shale, grayish-black, noncalcareous; contains rare pyrite-filled burrows and lenses, and scattered, very thin streaks of light-gray siltstone.....	47.0	7.2
Ironstone, light-brownish-gray, dense, hard, interlayered with minor very fine-grained sandstone and black, carbonaceous shale at base of unit.....	54.2	0.1
Underclay, medium-light-gray, sandy; contains black, carbonized plant fragments; grades into underlying unit.....	54.3	1.5
Sandstone, medium-gray, shaly, very fine-grained, noncalcareous.....	55.8	0.7
Shale, medium-dark-gray with light-gray streaks of very fine-grained sandstone; contains burrows filled with light-brown, very fine-grained sandstone; noncalcareous.....	56.5	2.6
Shale, grayish-black, noncalcareous; contains rare streaks of light-gray siltstone.....	59.1	14.6
Ironstone, light-brownish-gray in black-shale matrix, irregularly shaped.....	73.7	0.2

Shale, medium-light-gray, sandy; blocky fracture; noncalcareous; churned in part; contains abundant sandstone-filled burrows.....	73.9	2.4
Sandstone, medium-dark-gray, very fine- to fine-grained, shaly, noncalcareous, rippled in part.....	76.3	1.3
Shale, grayish-black, noncalcareous; contains light-brownish-gray, sideritic concretions up to 2.5 in. thick, rare sandstone- and pyrite-filled burrows and scattered thin streaks of light-gray siltstone.....	77.6	10.1
Ironstone, mottled, light-brownish-gray with dark-gray sandy-shale matrix.....	87.7	0.5
Shale, grayish-black, very silty, noncalcareous; contains rare pyritic burrows and streaks of light-gray, very fine-grained sandstone; includes some light-brownish-gray, sideritic concretions up to 2 in. thick; silt content decreases below 100 ft; contains black, carbonized plant compressions in lower 3 ft.....	88.2	22.3
Coal, black, shaly; white calcite on cleats (Tamaha coal).....	110.5	0.1
Shale, black; contains coal streaks with thin crusts of white calcite.....	110.6	0.1
Underclay, medium-gray, slickensided; contains black, carbonized plant fragments.....	110.7	1.8
Shale, medium-dark-gray, noncalcareous; contains light-brown calcareous burrow-fillings in lower 4 in.....	112.5	1.1
Shale, dark-gray, silty, noncalcareous; contains light-gray streaks of siltstone and rare, light-brown, calcareous burrow-fillings..	113.6	3.4
Shale, grayish-black, calcareous; contains rare light-gray streaks of siltstone and white fossil shells.....	117.0	5.0
Shale, black, noncalcareous; contains streaks of shale similar to underlying olive-gray shale in bottom 1 in.....	122.0	1.1
Shale, light-olive-gray, clayey, noncalcareous...	123.1	1.1
Limestone, light-brownish-gray, fine-grained, dense, fossiliferous; contains shells and shell fragments.....	124.2	0.4
Shale, light-olive-gray, noncalcareous, clayey, churned.....	124.6	0.4
Shale, medium-gray, silty, sandy, noncalcareous, burrowed, cross-laminated in part.....	125.0	1.3
Shale, grayish-black, noncalcareous; contains rare, light-gray streaks of siltstone and minor pyrite; includes a light-brownish-gray, 2-in.-thick, sideritic concretion at 128.4 ft..	126.3	4.7
Shale, grayish-black to black, calcareous; contains rare fossil shell fragments, scattered pyrite lenses, and light-brownish-gray, sideritic concretions; becomes weakly calcareous from 138 to 140 ft, noncalcareous below 140 ft.....	131.0	11.3
Shale, grayish-black, calcareous; contains abundant white fossil-shell fragments and small crinoid ossicles.....	142.3	0.6
Siltstone, medium-dark-gray, shaly, calcareous, wavy-bedded; contains some thin layers of very fine-grained sandstone.....	142.9	1.0
Coal, black, moderately friable; includes some black, carbonaceous shale and a 0.5-in.-thick mass of pyrite in upper part of bed (Stigler coal).....	143.9	0.1
Underclay, medium-gray, silty, rooted; becomes sandy downward.....	144.0	1.2

Sandstone and siltstone, medium-light-gray, shaly, noncalcareous, very fine-grained, wavy-bedded in part, bioturbated in part (Warner? Sandstone).....	145.2	1.8
Sandstone, medium-gray with a light-grayish-brown tint, fine-grained, noncalcareous, burrowed.....	147.0	0.3
Shale, light-olive-gray, silty, noncalcareous, wavy-laminated.....	147.3	0.7
Shale, grayish-black with some light-olive-gray layers in upper part, noncalcareous; contains some thin, light-gray siltstone streaks, sideritic concretions, and burrows....	148.0	1.3
Shale, light-olive-gray, noncalcareous; contains some fine-gravel clasts consisting primarily of reworked crinoid ossicles; wavy-laminated.....	149.3	0.1
Mississippian System		
Chesterian Series		
Fayetteville Formation		
Limestone, light-brownish-gray, medium-grained, hard, fossiliferous; crinoid ossicles abundant; saturated with oil in upper 20 in.....	149.4	2.1
Shale, greenish-gray, noncalcareous.....	151.5	0.5
Shale, olive-gray to medium-dark-gray, non-calcareous.....	152.0	5.0
Total Depth		157.0



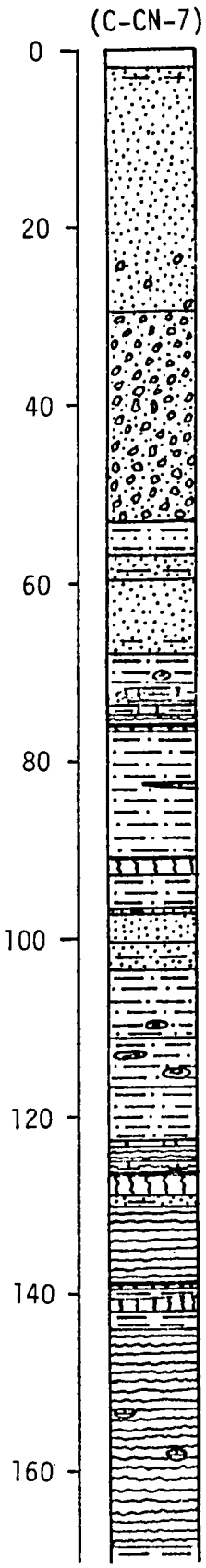
9 (C-CN-6)

SE 1/4 NE 1/4 NW 1/4 SW 1/4 sec. 25, T. 27 N., R. 20 E., Craig County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in pasture just north of farm pond 1,140 ft FWL and 2,200 ft FSL. (Surface elevation, estimated from topographic map, 945 ft.)

	Depth to unit top (ft)	Thickness of unit (ft)
Sand and clay, moderate yellowish-brown, silty, noncalcareous, contains organic material.....	0.0	1.0
Cabaniss Group		
Senora Formation		
Sandstone, light-brown, very fine-grained, noncalcareous, weathered, friable, oxidized....	1.0	1.0
Siltstone, grayish-orange, clayey, calcareous, soft and weathered.....	2.0	1.0
Shale, dark-yellowish-orange, clayey, weathered; contains streaks of oxidized sandstone.....	3.0	6.0
Sandstone, dark-yellowish-orange, very fine-grained, cross-bedded, interlayered with very pale-orange siltstone and shale, fractured, weathered; grades into underlying unit.....	9.0	4.5
Shale, light-olive-gray with dark-yellowish-orange bands, micaceous, sandy, partly weathered, noncalcareous; grades into underlying unit.....	13.5	5.5
Sandstone, moderate-yellowish-brown to dusky-brown, shaly, very fine- to fine-grained, micaceous, noncalcareous, cross-bedded, bioturbated in part; includes streaks of black, macerated plant fragments.....	19.0	2.5
Shale, pale-yellowish-brown, noncalcareous, sandy, micaceous.....	21.5	0.7
Siltstone, dark-gray, noncalcareous, shaly; contains thin laminae of light-gray, very fine-grained sandstone and occasional lenses of medium-grained, light-brownish-gray sandstone.....	22.2	2.6
Sandstone, light-brownish-gray, medium-grained, noncalcareous; interbedded with layers of dark-gray siltstone up to 10 in. thick, cross-bedded in part; contains several coal bands up to 0.5 in. thick, as well as coal spars and black, macerated plant material in thin laminae (basal unit of Chelsea Sandstone).....	24.8	4.6
Shale, medium-light-gray, noncalcareous; contains contorted sandstone layers up to 3 in. thick; becomes medium-dark-gray in lower 4.5 ft of unit.....	29.4	8.1
Coal, black, friable; contains pyrite in veins and nodules, and gypsum on cleats (Weir-Pittsburg coal).....	37.5	0.8
Krebs Group		
Boggy Formation		
Underclay, light-gray, silty, sandy, noncalcareous, churned.....	38.3	0.5
Sandstone, medium-light-gray, very fine-grained, noncalcareous, cross-bedded (upper unit of Taft Sandstone).....	38.8	0.5
Shale, medium-gray, silty.....	39.3	0.8
Sandstone, medium-light-gray with grayish-red laminations, fine-grained, noncalcareous, cross-bedded (Taft Sandstone).....	40.1	6.7
Shale, dark-gray, noncalcareous; contains streaks and cross-bedded lenses of very fine-grained, light-gray sandstone.....	46.8	1.2
Sandstone, medium-light-gray with grayish-black laminations, fine-grained, noncalcareous, cross-bedded (basal unit of Taft Sandstone)....	48.0	2.5

Shale, dark-gray, very silty, noncalcareous; contains abundant laminations and lenses of light-gray, very fine-grained sandstone; some sandstone lenses show scour-and-fill and cross-lamination features; black, macerated plant fragments abundant in some layers; shaly siltstone in part; grades into underlying unit.....	50.5	19.5
Shale, medium-dark-gray to dark-gray in lower half, noncalcareous; includes rare burrow features.....	70.0	5.2
Ironstone, light-brownish-gray, hard, dense.....	75.2	0.3
Shale, grayish-black, noncalcareous; includes some small pyrite-filled bioturbation features; very calcareous and fossiliferous in lower 2 in.; grades into underlying unit....	75.5	1.7
Limestone, light-gray with black shaly matrix, bioclastic, bioturbated in upper part (Inola Limestone).....	77.2	0.1
Shale, black, weakly calcareous in upper 1.5 ft, pyritic; contains calcite-filled burrows, rare fossil brachiopods, and white calcite in laminae and veinlets; slickensided on some fracture surfaces.....	77.3	2.4
Coal, black, moderately friable (Bluejacket coal).....	79.7	0.1
Shale, medium-gray, noncalcareous; contains some black, carbonized plant fragments.....	79.8	0.2
Mudstone, medium-dark-gray with slight greenish-gray tint, extensively bioturbated, noncalcareous; grades downward into shale.....	80.0	5.0
Shale, medium-light-gray to medium-gray, noncalcareous; slickensided along fractures.....	85.0	3.8
Siltstone, light-gray to medium-gray bands, noncalcareous, wavy-laminated.....	88.8	0.7
Sandstone, medium-light-gray, fine-grained, cross-bedded; contains black, carbonized plant fragments; noncalcareous (upper unit of Bluejacket Sandstone).....	89.5	0.8
Sandstone, medium-light-gray, interlaminated with medium-gray shale, very fine-grained, noncalcareous, wavy-bedded; contains some cross-lamination and minor bioturbation features; grades into underlying unit.....	90.3	1.4
Shale, medium-gray, interbedded with light-gray, thin, very fine-grained sandstone and siltstone layers; wavy-bedded in part, with abundant small-scale scour-and-fill and bioturbation features, noncalcareous; includes several light-brownish-gray, sideritic layers 0.5 to 1.5 in. thick; becomes dark-gray to grayish-black, with fewer sandstone and siltstone stringers, in lower 8 ft of unit.....	91.7	14.6
Sandstone, medium-light-gray, very fine-grained, silty, interstratified with dark-gray shale, wavy-bedded, extensively bioturbated, cross-laminated in part; coarsens downward (basal unit of Bluejacket Sandstone)..	106.3	3.7
Savanna Formation		
Shale, dark-gray, interstratified with very fine-grained, light-gray sandstone, noncalcareous, bioturbated in places; small-scale scour-and-fill features abundant; sandstone content decreases downward; grades into underlying unit.....	110.0	6.0
Shale, dark-gray, noncalcareous; includes minor laminae of light-gray sandstone in upper part, and some sideritic layers up to 0.75 in. thick; contains pyrite-filled burrows.....	116.0	3.2
Shale, dark-gray, noncalcareous; contains pyrite-filled burrows and light-brownish-gray, sideritic layers up to 1 in. thick.....	119.2	7.7

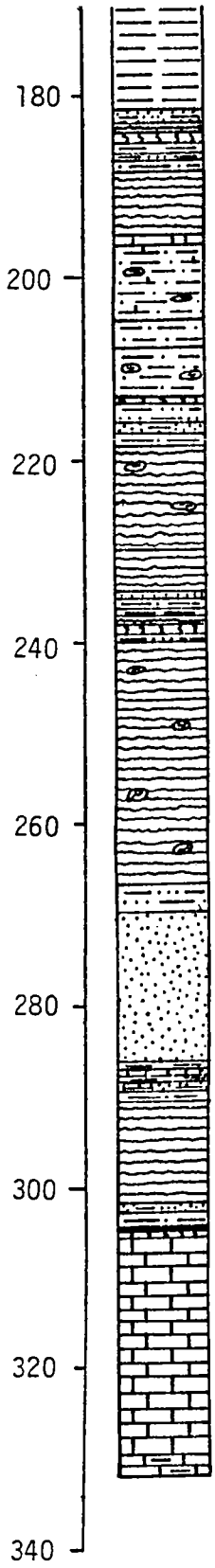
Coal, black, moderately friable; contains white calcite on cleat surfaces, and crusts and 1-in.-thick, irregular masses of pyrite (Drywood coal)	126.9	0.7
Underclay, medium-gray, bioturbated, slickensided; contains black, carbonized plant fragments	127.6	0.7
Shale, medium-dark-gray, silty; contains pyrite-filled burrows and disseminated pyrite	128.3	1.5
Shale, dark-gray to grayish-black, noncalcareous; contains pyrite-filled burrows and lenses; includes rare sideritic concretions up to 1 in. thick	129.8	5.9
Coal, black, moderately friable; pyrite and calcite on fracture surfaces (unnamed coal)	135.7	0.2
Underclay, medium-light-gray, silty; contains black, carbonized plant fragments; bioturbated; includes rooted zones from 139.7 to 140.1 ft and from 141.0 to 142.3 ft; grades into underlying unit	135.9	6.4
Siltstone, shaly, medium-gray, noncalcareous; contains grayish-orange, sandstone-filled burrows	142.3	2.7
Sandstone, medium-light-gray with dark-gray shale streaks, rippled, noncalcareous, very fine-grained, flat-bedded in some intervals, massive in others	145.0	3.8
Shale, dark-gray, silty, burrowed; includes laminae of light-gray, very fine-grained, sandstone-filled burrows; wavy-bedded in part, noncalcareous; contains minor coaly laminae; slickensided at contact with underlying unit	148.8	8.0
Siltstone, dark-gray, very fine-grained, shaly, noncalcareous; contains closely spaced laminae of light-gray, very fine-grained sandstone; rippled, with minor bioturbation	156.8	2.6
Sandstone, medium-light-gray with minor dark-gray shale streaks, micaceous, rippled, noncalcareous, very fine-grained to fine-grained, massive from 161 to 167 ft; angle of faint shale laminae suggests cross-bedding from 167 to 168 ft; basal contact sharp (Dickson Sandstone)	159.4	11.3
Shale, grayish-black to black, with minor light-gray shale streaks, noncalcareous; contains some small brachiopods, pyrite crusts, bioturbation features, and light-brownish-gray, sideritic concretions up to 3 in. thick	170.7	6.8
Limestone, medium-gray; contains abundant fossil shells, including a 2-in.-wide pelecypod; grades into underlying unit (Doneley Limestone)	177.5	0.8
Shale, black, very calcareous; contains abundant fossil shells	178.3	0.6
Coal, black, moderately friable (Rowe coal)	178.9	0.2
Underclay, medium-light-gray, unbedded, slickensided; contains black, carbonized plant fragments	179.1	0.9
Total Depth		180.0



10 (C-CN-7)

NW 1/4 NE 1/4 NE 1/4 NE 1/4 sec. 24, T. 27 N., R. 20 E., Craig County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in hay meadow just south of pond 220 ft FNL and 400 ft FEL. (Surface elevation, estimated from topographic map, 775 ft.)

	Depth to unit top (ft)	Thickness of unit (ft)
Silt, pale-yellowish-brown; contains some very fine-grained sand and organic materials.....	0.0	2.0
Krebs Group		
Boggy Formation		
Sandstone, light-brown to moderate-brown with dusky-brown flecks, clayey, weathered, unconsolidated.....	2.0	3.0
Sandstone, moderate yellowish-brown, fine-grained, well-cemented, noncalcareous.....	5.0	4.0
Sandstone, moderate-brown with black flecks, fine-grained, massive, noncalcareous; includes some laminae of black, macerated plant fragments in lower 6 in.....	9.0	5.3
Sandstone, light-brownish-gray with black coal bands and dark-reddish-brown oxidized zones, fine-grained, micaceous.....	14.3	6.1
Sandstone, pale-yellowish-brown to light-brown to light-brownish-gray, fine- to medium-grained, noncalcareous, micaceous, massive in part, cross-bedded in lower part, conglomeratic; contains dark-gray shale pebbles and some reddish-brown-rimmed ironstone pebbles in lower part.....	20.4	9.1
Conglomerate, light-brownish-gray, medium-dark-gray from 38.0 to 39.5 ft, noncalcareous, massive-bedded; pebbles and cobbles are predominantly light-brownish-gray ironstone and black and gray shale and siltstone; matrix is medium- to coarse-grained sandstone containing black, macerated plant material; lower contact sharp (base of Bluejacket Sandstone)...	29.5	23.7
Savanna Formation		
Shale, medium-dark-gray with light-gray interbedded sandstone; mostly flat-bedded, with minor low-angle cross-bedding; bioturbated.....	53.2	3.9
Sandstone, medium-dark-gray, shaly, very fine-grained, noncalcareous, partly churned; wavy-bedded in lower part, with some bioturbation features (Dickson Sandstone).....	57.1	2.7
Sandstone, medium-gray with dark-gray shale streaks, rippled, noncalcareous; contains some sideritic concretions up to 1.25 in. thick; fines downward, with increased shale content in lower 2 ft (Dickson Sandstone).....	59.8	8.2
Shale, medium-dark-gray to dark-gray, noncalcareous, silty; includes minor sandstone streaks and burrow fillings; contains light-brownish-gray, sideritic concretions up to 2 in. thick.....	68.0	5.9
Limestone, medium-light-gray, impure and shaly in lower 6 in., very fossiliferous; brachiopod shells and shell fragments abundant (Doneley Limestone).....	73.9	1.2
Shale, grayish-black, noncalcareous; contains rare pyrite-filled burrows; becomes carbonaceous with calcite laminae in lower 0.5 in.....	75.1	0.7
Coal, black, moderately friable; includes minor pyrite on fracture surfaces (Rowe coal).....	75.8	0.2
Underclay, medium-gray; contains black, carbonized plant fragments; slickensided.....	76.0	0.5



Shale, medium-gray, silty, churned; noncalcareous; contains disseminated pyrite and irregular pyritic masses	76.5	1.8
Shale, medium-dark-gray to dark-gray, with wavy bands of light-gray siltstone and very fine-grained sandstone, noncalcareous, burrowed; contains minor pyrite; includes a 0.75-in.-thick by 2-in.-wide lens of crinoidal limestone at 82.5 ft (Sam Creek? Limestone)	78.3	12.9
Coal, black, moderately friable, pyrite on cleat surfaces (Sam Creek? coal)	91.2	0.1
Underclay, medium-gray, churned, slickensided; contains black, carbonized plant fragments	91.3	1.5
Shale, medium-light-gray, noncalcareous, sandy, bioturbated	92.8	1.3
Shale, grayish-black with light-gray, very fine-grained sandstone streaks, burrowed, wavy-bedded, noncalcareous	94.1	2.3
Sandstone, light-gray with dark-gray shale layers, very fine-grained, noncalcareous, extensively bioturbated	96.4	0.5
Sandstone, light-gray, very fine-grained, noncalcareous, cross-bedded; includes some blackish-red, oxidized grains	96.9	3.4
Sandstone, light-gray, with medium-dark-gray shale streaks, rippled, noncalcareous; low-angle cross-bedding in part	100.3	3.2
Shale, medium-dark-gray with light-gray sandstone streaks, noncalcareous, wavy-bedded, burrowed; includes a light-brownish-gray, 0.5-in.-thick, sideritic concretion at 110.2 ft	103.5	7.9
Shale, dark-gray, noncalcareous, layered with light-brownish-gray sideritic concretions up to 4 in. thick; includes minor streaks of light-gray sandstone and disseminated pyrite	111.4	5.5
Shale, medium-dark-gray to dark-gray, noncalcareous; contains streaks of very fine-grained, light-gray sandstone, wavy-bedded, burrowed	116.9	5.5
Limestone, grayish-black, very impure, shaly; contains abundant fossil shells (Spaniard Limestone)	122.4	0.8
McAlester Formation		
Shale, black, noncalcareous; contains sparse small, calcareous fossil shells and fossil fragments; grades into underlying unit	123.2	2.0
Shale, grayish-black, interbedded with thin limestone layers consisting of fossil shells, crinoid ossicles, and fossil fragments	125.2	1.1
Shale, black, carbonaceous, calcareous in part; contains wavy laminae of calcite and pyrite	126.3	0.2
Coal, black; pyrite on cleats; moderately friable (Spaniard coal)	126.5	0.5
Underclay, medium-gray, churned, slickensided; contains black, carbonized plant fragments; sandy in lower part	127.0	2.0
Sandstone, medium-light-gray, very fine-grained, silty, massive, noncalcareous	129.0	1.1
Shale, grayish-black to black, noncalcareous; contains rare streaks of very fine-grained sandstone, rare fossil shells, and minor pyrite	130.1	8.7
Coal, black, moderately friable (Keota? coal)	138.8	0.2
Underclay, medium-gray; contains black, carbonized plant fragments	139.0	0.2

Shale, dark-gray, noncalcareous, includes some 1/16- to 1/8-in.-thick coal bands in lower 3 in.	139.2	1.0
Underclay, medium-light-gray, soft, crumbly, slickensided	140.2	1.8
Shale, medium-gray, broken, churned, noncalcareous	142.0	2.0
Shale, grayish-black, noncalcareous; streaked with minor light-gray, very fine-grained sandstone and siltstone; burrowed	144.0	8.4
Shale, black, noncalcareous; contains yellowish-gray, dense, massive, calcareous ironstone concretions up to 1 in. thick, as well as minor calcareous burrow-fillings and rare, small fossil shells	152.4	15.6
Shale, grayish-black, noncalcareous; contains abundant white, calcareous fossil fragments	168.0	0.3
Shale, dark-gray to grayish-black with medium-gray bands, noncalcareous, sparsely bioturbated; contains rare fossil shells and very thin streaks of light-gray siltstone; includes minor pyrite on parting surfaces	168.3	13.5
Sandstone and siltstone, medium-light-gray, interlaminated with medium-gray shale; noncalcareous, rippled; includes rare burrows with pyritic fillings	181.8	1.2
Shale, black with light-gray, wavy, siltstone bands, noncalcareous	183.0	0.2
Underclay, brownish-gray in upper 4 in. to medium-gray downward; blocky fracture; slickensided; contains some black, carbonized plant fragments in upper part; churned; grades into underlying shale	183.2	2.2
Shale, medium-gray, noncalcareous, blocky fracture, burrowed	185.4	1.0
Siltstone, medium-gray with wavy bands of grayish-black shale, noncalcareous	186.4	0.4
Shale, dark-gray with light-gray siltstone streaks in upper 1 ft, noncalcareous	186.8	1.6
Shale, grayish-black with light-brownish-gray, sideritic bands, noncalcareous; contains minor streaks of light-gray siltstone, and small bioturbation features with associated pyrite	188.4	7.4
Limestone, yellowish-gray, fine-grained, dense, fossiliferous; shells and fossil hash concentrated in lower 1 in. and upper 2 in.; shaly in places	195.8	0.6
Shale, dark-gray, silty, hard, weakly calcareous; contains scattered white fossil shells and pyrite-filled burrows, as well as light-brownish-gray, sideritic concretions up to 1.75 in. thick	196.4	8.7
Shale, medium-gray with light-gray siltstone and very fine-grained sandstone layers, wavy-bedded, noncalcareous	205.1	2.8
Shale, dark-gray, noncalcareous; contains sparse, thin laminae of light-gray siltstone, light-brownish-gray ironstone concretions, and pyrite-filled burrows	207.9	5.2
Coal, black, moderately friable; pyrite on cleats (Stigler coal; 0.5 in. thick)	213.1	0.1
Underclay, medium-light-gray, rooted, silty; contains black, carbonized plant fragments	213.2	0.7
Siltstone, light-gray, sandy, noncalcareous; contains black, carbonized plant fragments; grades into underlying unit	213.9	2.1

Sandstone, medium-light-gray, very fine-grained, silty, wavy-laminated, noncalcareous, burrowed in part	216.0	1.3
Shale, medium-dark-gray, silty, noncalcareous; contains rare black, carbonized plant fragments	217.3	1.5
Shale, grayish-black with light-brownish-gray, sideritic bands in upper 2 ft, noncalcareous; contains scattered pyrite-filled burrows	218.8	11.2
Shale, grayish-black, noncalcareous, uniform in appearance; includes a 1-in.-thick, light-brownish-gray, sideritic concretion zone with pyrite-filled burrows and disrupted fragments of underlying sandstone at basal contact of unit	230.0	4.3
Sandstone, light-gray, very fine-grained, massive, noncalcareous; grades into underlying unit	234.3	0.7
Shale, medium-light-gray, sandy, noncalcareous, burrowed	235.0	1.3
Shale, medium-dark-gray, noncalcareous, slickensided	236.3	0.4
Shale, black with light-gray, wavy, sandstone streaks; carbonaceous; silty; contains minor coaly streaks	236.7	0.1
Underclay, medium-dark-gray, slickensided	236.8	2.0
Siltstone, medium-dark-gray, shaly, noncalcareous, burrowed; shale layers slickensided	238.8	1.0
Shale, grayish-black, noncalcareous; contains widely scattered, thin streaks of light-gray siltstone, pyrite-filled burrows, and yellowish-gray, sideritic concretions up to 3 in. thick	239.8	26.7
Siltstone, dark-gray, shaly, noncalcareous; contains thin laminae of light-gray, very fine-grained sandstone; grades into underlying unit	266.5	3.2
Sandstone, medium-light-gray, fine-grained, noncalcareous; contains dark-gray shales streaks, sideritic concretions, and siderite-filled burrows in upper part; rippled, cross-bedded in part; includes some black coal streaks and macerated, pyritized plant fragments in lower 8 ft; basal contact sharp (Warner Sandstone)	269.4	16.3
Shale, medium-dark-gray, noncalcareous, slickensided, broken	286.0	0.5
Underclay, medium-light-gray, churned, slickensided	286.5	1.0
Shale, medium-gray, noncalcareous, slickensided	287.5	0.2
Sandstone, medium-gray, extremely calcareous, very fine-grained, massive; contains rare, poorly preserved marine fossils	287.7	0.7
Shale, medium-dark-gray, noncalcareous, slickensided; contains some light-gray siltstone streaks, and rare pyrite-filled burrows	288.4	1.6
Shale, grayish-black, silty, noncalcareous; contains streaks, lenses, and burrows filled with light-gray, very fine-grained sandstone and pyrite	290.0	11.7
Sandstone and siltstone, medium-gray with dark-gray shale streaks, noncalcareous, rippled; grades into underlying unit	301.7	0.8
Shale, medium-dark-gray; silty, noncalcareous; contains abundant lenses and burrows filled with pyrite	302.5	1.5

Coal, black, bright, moderately friable; contains a 1-in. lens of pyrite (unnamed coal)....	304.0	0.3
Underclay, light-olive-gray, slickensided, churned in upper part; contains pyrite-filled burrows in lower part.....	304.3	0.5
Mississippian System		
Chesterian Series		
Fayetteville Formation		
Limestone, dark-yellowish-brown with brownish-black mottling, calcarenitic, fine- to medium-grained, cross-bedded, highly fractured in upper part; shows cone-in-cone structure in upper 2 ft; contains abundant fossil fragments; good oil show; becomes very light-gray with dark-gray streaks and stylolites from 311 to 324 ft; contains greenish-gray shale clasts below 323 ft.....	304.8	24.4
Limestone, pale-yellowish-brown with light-gray and greenish-gray shale bands, fine- to medium-grained, calcarenitic, cross-bedded; conglomeratic in places; contains some greenish-gray shale pebbles and tar stains.....	329.2	2.3
Total Depth		331.5