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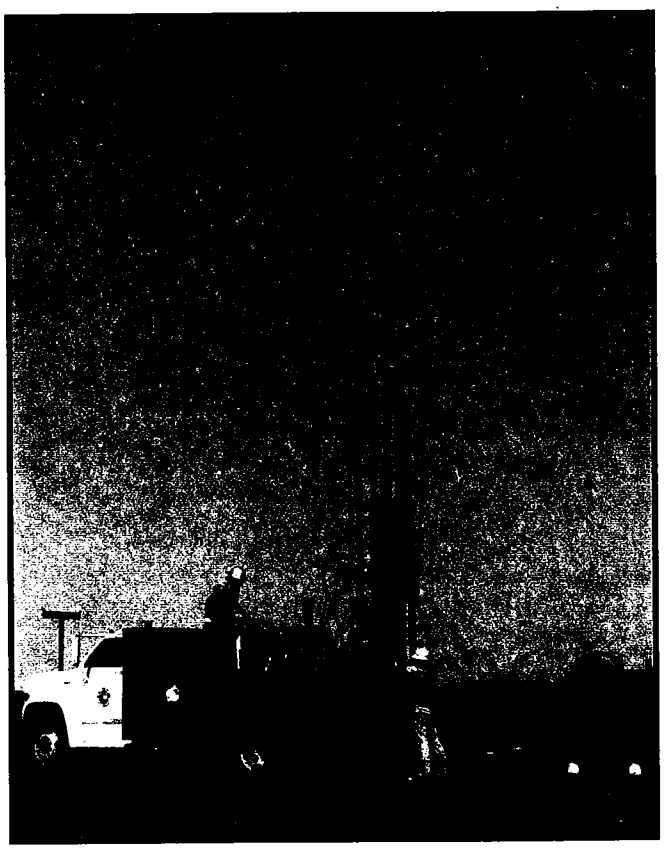
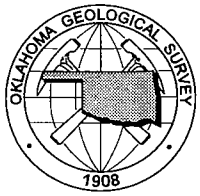
Lithologic Descriptions of Pennsylvanian Strata North and East of Tulsa, Oklahoma

LeRoy A. Hemish





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Lithologic Descriptions of Pennsylvanian Strata North and East of Tulsa, Oklahoma

(From 2,300+ ft of Overlapping Core for a Continuous Stratigraphic Succession from the Top of the Coffeyville Formation [Missourian Series] Downward to the Top of the Mississippian System)

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(From 2,300+ ft of Overlapping Core for a Continuous Stratigraphic Succession from the Top of the Coffeyville Formation [Missourian Series] Downward to the Top of the Mississippian System)

LeRoy A. Hemish

ABSTRACT.—A core-drilling project completed by the Oklahoma Geological Survey (OGS) during 1992 resulted in the acquisition of 848.8 ft of new core. The new core filled a stratigraphic gap in the succession (in the Cabaniss and Marmaton Groups) that had not been cored previously by OGS. As a result, continuous core of the rock column extending downward from the top of the Coffeyville Formation (lower Missourian) to the top of the Mississippian System is now available for study at the OGS Core and Sample Library in Norman, Oklahoma.

A cross section, based on lithologic descriptions of 2,327.8 ft of overlapping core, shows stratigraphic interpretations in the area north and east of Tulsa. A columnar section with lithologic descriptions and stratigraphic interpretations of >1,000 ft of continuous core from an oil company drill site in the same area is shown also.

A new scheme of lithostratigraphic classification and correlation for the interval extending across the Desmoinesian–Missourian Series boundary has been proposed by Heckel (1991) for the Midcontinent Pennsylvanian outcrop belt. His proposals, and their effect on Oklahoma's stratigraphic nomenclature, are presented in this report and compared with the classification currently used by OGS.

INTRODUCTION

Purpose

One of the purposes of this report is to present the results of a core-drilling project by the Oklahoma Geological Survey (OGS), completed during the summer and fall of 1992. Another purpose is to present a cross section showing diagrammatically 2,327.8 ft of overlapping core from this project and a previous project, with stratigraphic interpretations by the author. Detailed lithologic descriptions are included in the Appendix. During the 1992 project, three core holes were drilled in the study area, north and east of the City of Tulsa (Fig. 1), for biostratigraphic research purposes. The interval cored extends downward from just above the Dawson coal bed of the Holdenville Formation (upper Desmoinesian) to the Tiawah Limestone ("Pink lime" in subsurface terminology) of the Senora Formation (lower Desmoinesian). Figure 2 is a generalized stratigraphic column showing the surface and subsurface terminology in the area. The newly collected 848.8 ft of core also filled a gap in the stratigraphic succession that had not been cored previously by OGS. As a result, continuous 2-in.-diameter core that extends stratigraphically downward from the top of the Coffeyville Formation (lower Missourian) to the top of the Mississippian System is now boxed and stored at the OGS Core and Sample Library in Norman, Oklahoma. Because the capability of the OGS coring rig (Fig. 3) is limited to ~500 ft at any one drill site, overlapping core was collected from seven core holes to ensure stratigraphic completeness of the cored strata (four core holes had been drilled prior to this project). The seven core holes were drilled in four counties in the vicinity of the City of Tulsa: Mayes, Rogers, Tulsa, and Washington Counties (Fig. 1; Pl. 1, location map).

Included in this report is a columnar section with lithologic descriptions of >1,000 ft of continuous core from a single drill site, extending downward from the base of the Labette Formation (upper Desmoinesian) to the top of the Mississippian System (Pl. 2). The core hole was drilled in 1965 by Marathon Oil Co. in the NW¼ sec. 23, T. 20 N., R. 14 E., Rogers County. Figure 1 and the inset map in Plate 2 show the location of the core hole, the Marathon No. 1 Kelly, relative to the seven OGS core holes. The combined descriptions of >3,300 ft of core included in this report provide a wealth of detailed information about the subsurface geology in the area northeast of Tulsa.

Methods

Hemish (1987a) discussed in detail the methods for core-drilling with the OGS drill rig. Only a brief overview of the drilling methods is included here.

Drill-hole site selection, preliminary land work, logistical planning, supervision of drilling, whole core description in the field, and assimilation of data included in

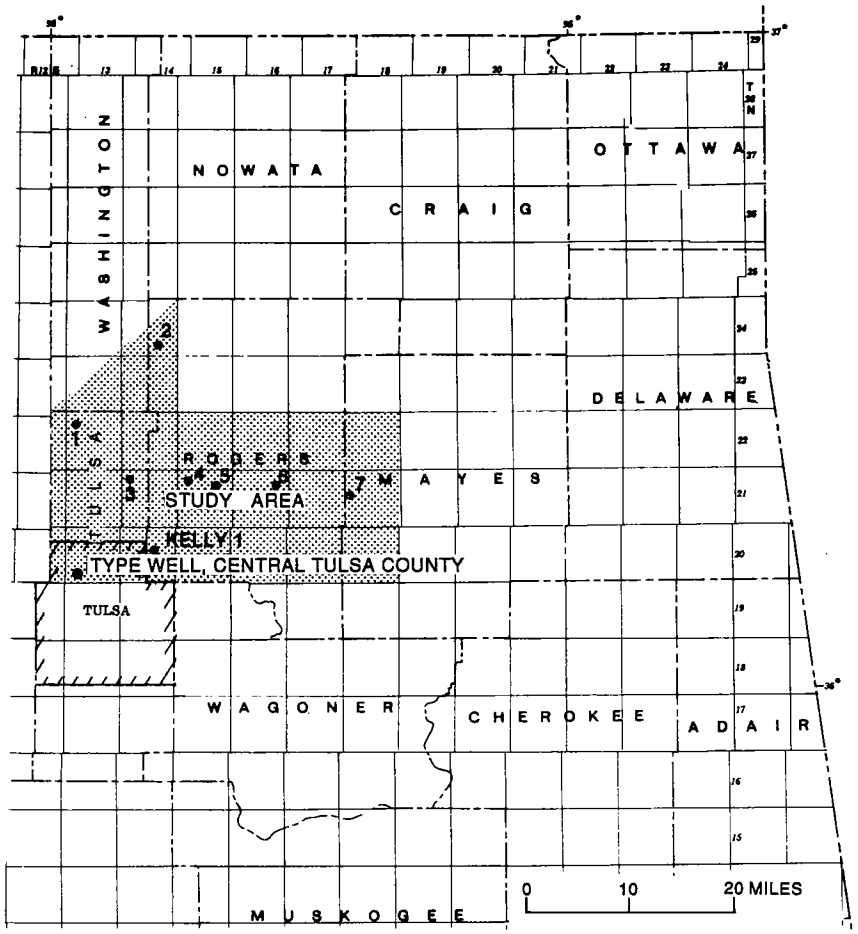

Figure 1. Map of northeastern Oklahoma, showing the study area and the locations of the seven OGS core holes used in this study. (Core holes 3, 4, and 5 were drilled in 1992 for this study; the others were drilled earlier.) Locations are also shown for the Marathon No. 1 Kelly (NW¼ sec. 23, T. 20 N., R. 14 E., Rogers County) and for the type well for central Tulsa County (sec. 3, T. 20 N., R. 13 E.).

this report were done entirely 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. 3). A trailer is used to transport drill rods, tools, supplies, and water. The trailer is towed by a four-wheel-drive vehicle, which also is used to haul additional supplies. Boxed cores collected during the drilling operation generally are transported to the OGS Core and Sample Library by the geologist in charge. All the core is available for study by the public.

Core-Hole Logs

Core-hole logs (Appendix) are numbered from 1 to 7 according to their location by section, township, and range (from west to east) and are keyed to numbers on the inset maps (Pls. 1, 2). The alphanumerical 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 acres.

A lithologic column diagrammatically shows the sequence of rocks described in each log (Appendix); lithologic symbols are explained on Plates 1 and 2. The lithologic columns in the Appendix are identical with those shown in cross section A–A' (Pl. 1), but at a reduced scale.

GEOLOGY

Previous Investigations

In the earliest noteworthy report on the geology of the study area, Drake (1897) discussed the stratigraphy and structure of the northeastern Oklahoma shelf area and made a sketch map showing the approximate position of the Mississippian–Pennsylvanian contact. Ohern (1910) made a study of the older Pennsylvanian rocks of northeastern Oklahoma. 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.

Dott (1941) made stratigraphic revisions and named the Memorial Shale in the Tulsa area. Oakes and Jewett (1943) reported on the upper Desmoinesian and lower Missourian rocks in northeastern Oklahoma and southeastern Kansas.

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. Oakes (1952) reported on the geology and mineral resources of Tulsa County. 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. Numerous reports concerning the stratigraphy of the Tulsa area, by several different authors, are included in Bennison (1972), *Tulsa's Physical Environment—A Symposium on the Physical Aspects of Tulsa's Environment* (Tulsa Geological Society Digest).

The accepted scheme of stratigraphic classification and correlation in the uppermost Desmoinesian and adjacent strata became suspect in the early 1970s when Wilson (1972) noted that fossil plants in the Seminole Formation, Tulsa County, assigned a Missourian age, have Desmoinesian affinities. Later, Pearson (1975) and Wilson (1979) reported that the Dawson coal (assigned a Missourian age at that time) in Tulsa County, its type area, contains Desmoinesian palynomorphs. Bennison and others (1979) reported the presence of *Mesolobus*, a Desmoinesian fossil brachiopod, in a shale overlying the Dawson coal in Tulsa County.

More recent reports by Boardman and Mapes (1984), Wilson (1984), and Heckel (1991) have confirmed that earlier interpretations and correlations were erroneous. Heckel (1991) has proposed a revised classification that incorporates the new findings and removes the Dawson coal and overlying black shale from the Seminole Formation and the Missourian Series. Revised correlations and new nomenclature of the uppermost Desmoinesian and adjacent strata are discussed in this report in the Chronostratigraphy section.

Krumme (1981) discussed the stratigraphic significance of limestones of the Marmaton Group in eastern Oklahoma. Recent reports on coal stratigraphy in the area of present investigation were made by Hemish (1988;1989;1990a,b).

General Statement

The stratigraphic interval discussed in this report extends upward from the top of the Mississippian System to the top of the Coffeyville Formation (Missourian Series). The area of investigation lies a few miles north and northeast of the City of Tulsa (Fig. 1). It is apparent from some of the differences between the No. 1 Kelly and the OGS core holes to the north and east that stratigraphic changes in the cored interval occur within just a few miles (Pls. 1, 2). Thicknesses of units generally are greater to the south, toward the Arkoma basin.

The percentages of sandstone, siltstone, and shale in many named members vary considerably between the two areas. For example, the Warner Sandstone Member ("Booch sand") of the McAlester Formation is poorly developed in both areas. In contrast, the Bluejacket Sandstone Member ("Bartlesville sand") of the Boggy Formation contains a high percentage of sandstone in the OGS core, but predominantly siltstone and shale in the No. 1 Kelly. Likewise, the Taft Sandstone ("Red Fork sand") interval contains a higher percentage of sandstone in the OGS core than in the No. 1 Kelly. However, the Chelsea Sandstone ("Skinner sand") interval contains a much higher percentage of sandstone in the No. 1 Kelly than in the OGS core.

The upper part of the type well log for central Tulsa County (location: sec. 31, T. 20 N., R. 13 E. [Fig. 1]) is reproduced in Figure 4. It shows the geophysical log signatures of the various units discussed below.

Stratigraphy

Stratigraphic interpretations shown in Plates 1 and 2 are those of the author; they are based on published and OGS-accepted stratigraphic nomenclature. Some recently proposed revisions at the Desmoinesian–Missourian Series boundary (Heckel, 1991) are presented in Plate 1 and discussed below.

Middle Pennsylvanian rocks unconformably overlie Mississippian rocks in the study area. To the south, in Muskogee County, the Atoka Formation (Middle Pennsylvanian) unconformably overlies Morrowan (Lower Pennsylvanian) rocks (Fig. 1) (Zachry and Sutherland, 1984). Northward from Muskogee County, a regional unconformity truncates Morrowan and Atokan strata, and Desmoinesian rocks rest on the Mississippian.

The interval from the post-Mississippian erosional surface to the base of the Warner Sandstone (lower Desmoinesian) northward from Wagoner County has been the subject of various stratigraphic interpretations (Hemish, 1990b, p. 5). A detrital sand at the base of the Pennsylvanian rests upon the Mississippian in the study area. In the subsurface, the sand is called the "Burgess sand" of the Desmoinesian Series (Jordan, 1957, p. 31), in which case it would probably correlate to the McAlester Formation. In the type log for central Tulsa County, the "Burgess sand" is tentatively correlated with the Hale Sandstone of Morrowan age and is overlain unconformably by the McAlester Formation (lower Desmoinesian).

Blythe (1959) studied the Atoka Formation in the shelf area of northeastern Oklahoma and stated that the formation thins northward and is overlapped by Desmoinesian rocks. He commented that, "Areas mapped as Atoka Formation in northern Mayes County may be Hartshorne sandstone, entirely or in part." Zachry and Sutherland (1984, p. 13) stated that in central Mayes County (T. 20 N.), Atoka strata rest on Mississippian beds.

Because the interval from the post-Mississippian erosional surface to the base of the Warner Sandstone (lower Desmoinesian) contains no reliable stratigraphic markers in the study area, interpretations of the stratigraphy are tenuous, at best. However, based on statements of previous workers and on my own work, I have tentatively assigned to the Atoka Formation the interval from the top of the Mississippian to the base of an unnamed limestone ~20 ft below the base of the Warner Sandstone. The unnamed limestone occurs as far north as west-central Mayes County and is probably the basal bed of the McCurtain Shale Member of the McAlester Formation (Hemish, 1990b, p. 8). The unnamed limestone is present in OGS Core-Hole 7 as well as in the No. 1 Kelly (Pls. 1, 2).

The McAlester Formation, which extends from the base of the unnamed limestone at the base of the McCurtain Shale Member to the base of the Spaniard Limestone, is ~200 ft thick in OGS Core-Hole 7 (Pl. 1); in the No. 1 Kelly it is ~175 ft thick (Pl. 2). The interval from the Stigler coal to the base of the Spaniard Limestone is ~128 ft in OGS Core-Hole 7 (Pl. 1) and ~120 ft in the No. 1 Kelly (Pl. 2).

The base of the Savanna Formation (lower Desmoinesian), which contains the "Brown limes" (Figs. 2, 4), is marked by the base of the Spaniard Limestone, lowermost of three "Brown limes." The Sam Creek and Doneley Limestones are the other two "Brown limes." The Doneley Limestone, discontinuous in places, overlies the Rowe coal bed. The Rowe coal, which is a good stratigraphic marker, occurs about in the middle of the Savanna Formation. The top of the Savanna Formation is marked by the base of the Bluejacket Sandstone ("Bartlesville sand"). The Savanna is ~80 ft thick in OGS Core-Hole 7 (Pl. 1) and ~68 ft thick in the No. 1 Kelly (Pl. 2). The McAlester and Savanna Formations were not differentiated in the type log for central Tulsa County. It is here

noted that the Oklahoma Geological Survey disagrees with some of the stratigraphic picks (or lack thereof) on the type log for central Tulsa County (Fig. 4). The base of the Spaniard Limestone has served to mark the base of the Savanna Formation in the northeastern Oklahoma shelf area since the designation was made by Oakes and Knechtel (1948, p. 52). The base of the Bluejacket Sandstone ("Bartlesville sand") serves to separate the Savanna Formation, below, from the Boggy Formation, above (Miser, 1954) (Fig. 2).

The overlying Boggy Formation (lower Desmoinesian) extends from the base of the Bluejacket Sandstone to the

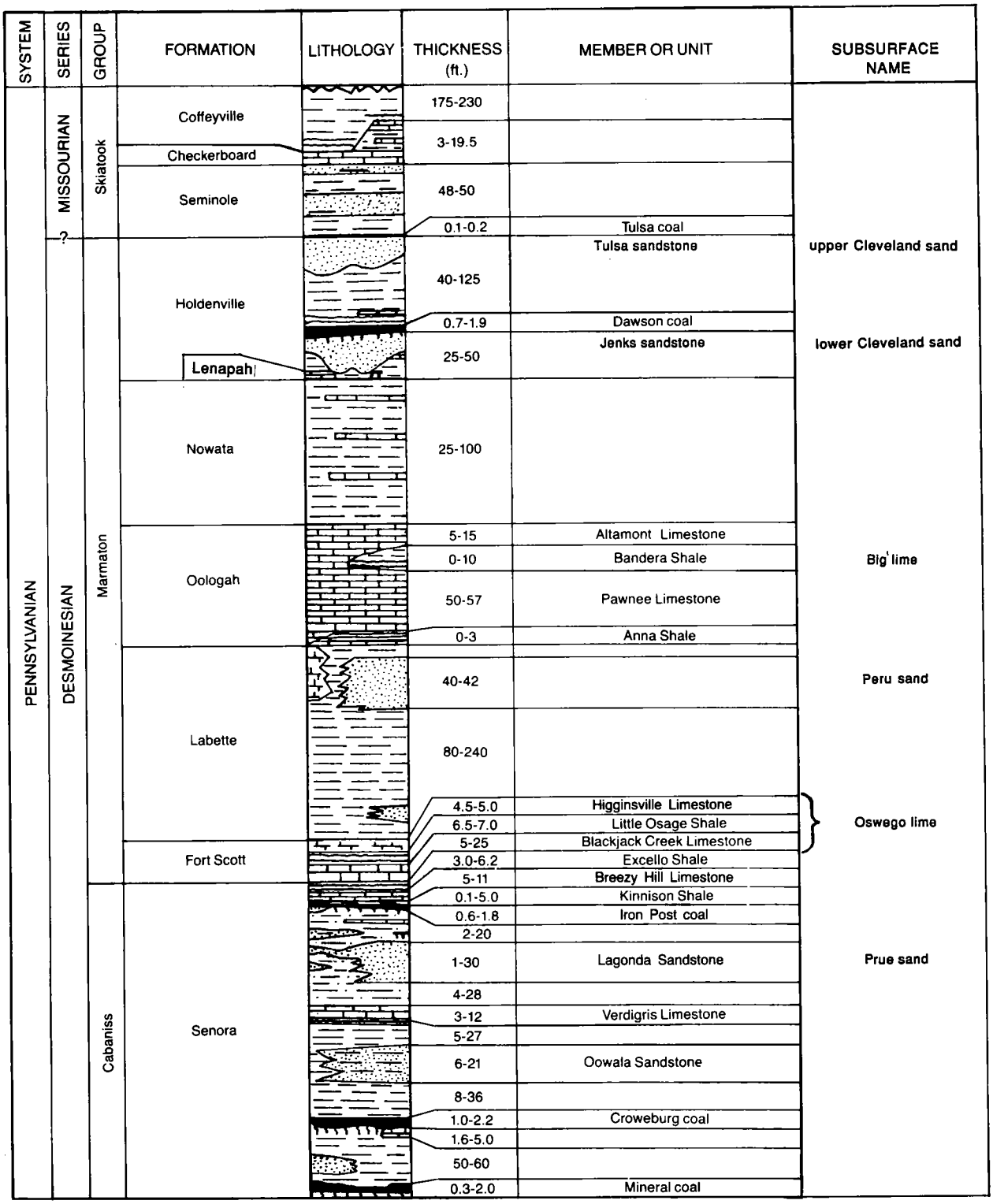

Figure 2 *(above and on facing page)*. Generalized columnar section of the area north and east of Tulsa, Oklahoma. Subsurface terminology is shown in right-hand column. Modified from Hemish (1989, fig. 2).

base of the Weir-Pittsburg coal bed (Fig. 2). The convention of using the base of the Weir-Pittsburg coal as the contact between the Boggy and overlying Senora Formation in the northeastern Oklahoma shelf area was begun by Branson and others (1965, p. 34). The same contact was used by Hemish in his reports on the coal geology of Tulsa County and counties to the north and east of Tulsa (Hemish, 1986,1989,1990a). Subsurface workers place the Boggy-Senora contact at the top of the "Pink lime" (Tiawah Limestone of surface terminology) (Figs. 2, 4).

The Inola Limestone is perhaps the most reliable marker in the Boggy Formation. It consists of one to as many as four limestone beds separated mostly by shale, thin coal stringers, and underclays (Hemish, 1990c, p. 7).

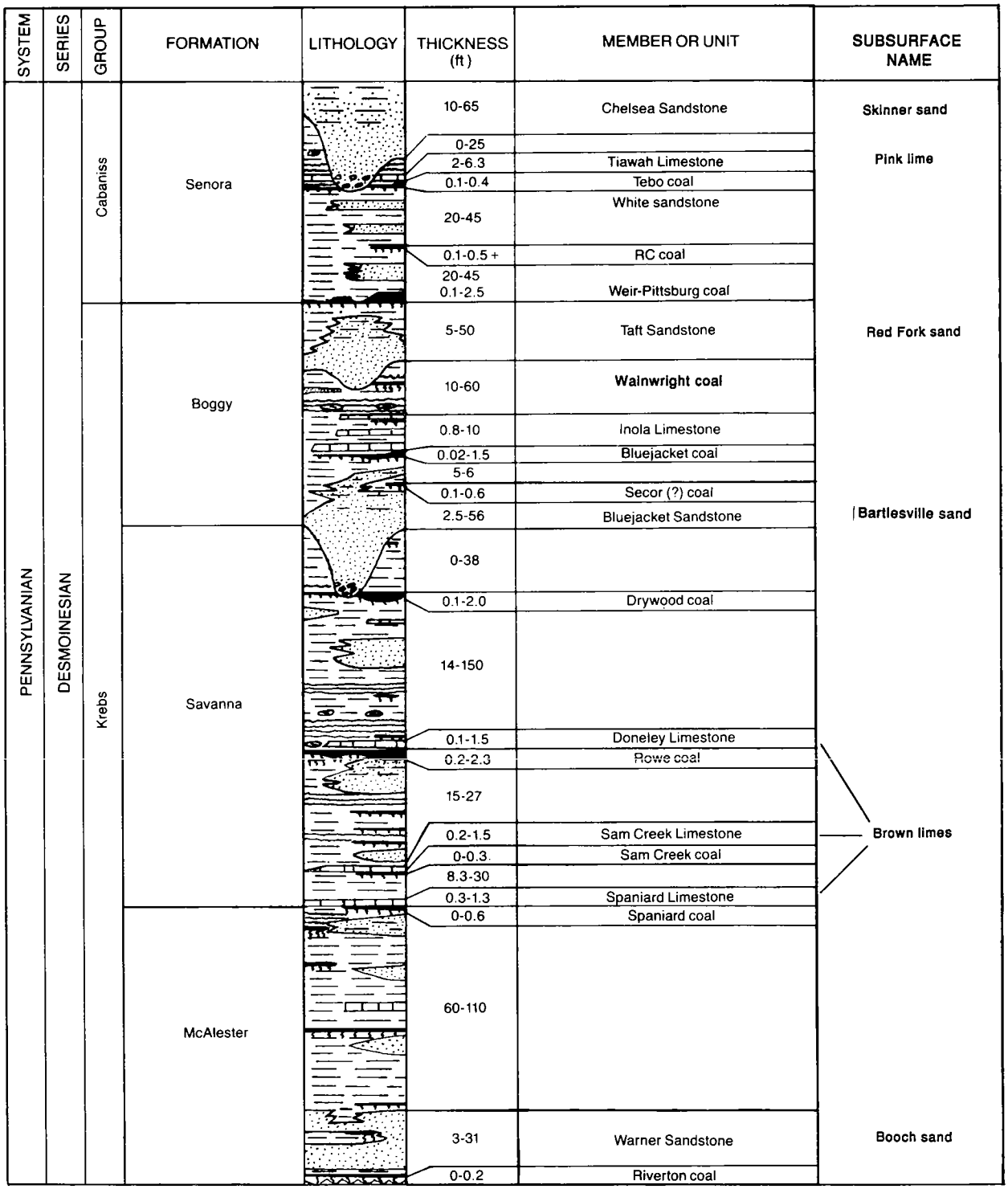

Figure 2 *(continued)*.

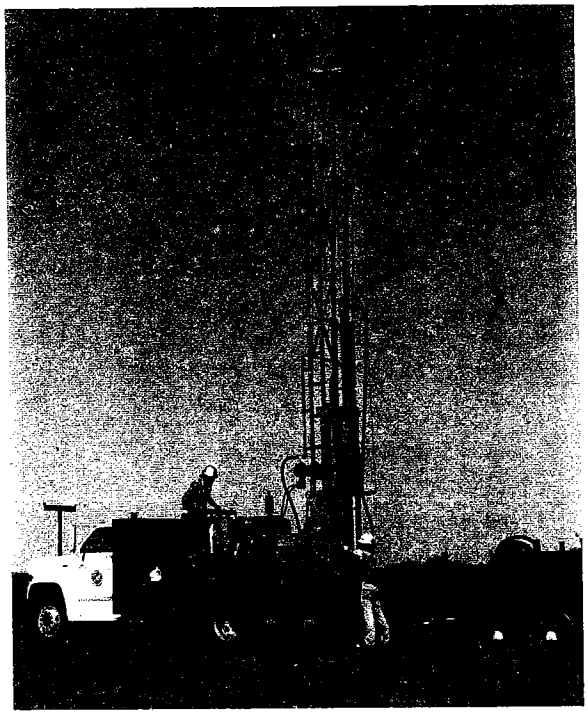

Figure 3. The Oklahoma Geological Survey drilling rig, drilling a core hole in Tulsa County, Oklahoma.

It is overlain by a black shale that is readily recognizable by its geophysical log signature (Fig. 4).

The Inola Limestone separates the Bluejacket Sandstone, below, from the Taft Sandstone, above. The Taft Sandstone's subsurface equivalent is the "Red Fork sand." The "Red Fork" lies between the Inola Limestone, below, and the "Pink lime," above. In this scheme the "Red Fork sand" lies wholly in the upper part of the Boggy Formation. However, if the Weir-Pittsburg coal is used to separate the Boggy Formation from the Senora Formation, only the lowermost of the Taft Sandstone units is included with the Boggy (Hemish, 1989, p. 8–10) (Fig. 2). The Boggy Formation is ~150 ft thick in OGS Core-Holes 6 and 7 combined (Pl. 1) and ~180 ft thick in the No. 1 Kelly (Pl. 2).

The Senora Formation extends from the base of the Weir-Pittsburg coal to the base of the Fort Scott Formation (Fig. 2). All Desmoinesian formations discussed above are in the Krebs Group, which is overlain by the Cabaniss Group. The Senora Formation is the sole representative of the Cabaniss Group in the northeast Oklahoma shelf area. Markers in the Senora Formation include the Tiawah Limestone, Croweburg coal, Verdigris Limestone, Iron Post coal, Breezy Hill Limestone, and at the top, the Excello Shale (Fig. 2). Well-known subsurface units in the Senora are the "Skinner sand" and the "Prue sand" (Figs. 2, 4). The Senora Formation is ~425 ft thick in OGS Core-Holes 4, 5, and 6 combined (Pl. 1) and ~455 ft thick in the No. 1 Kelly (Pl. 2).

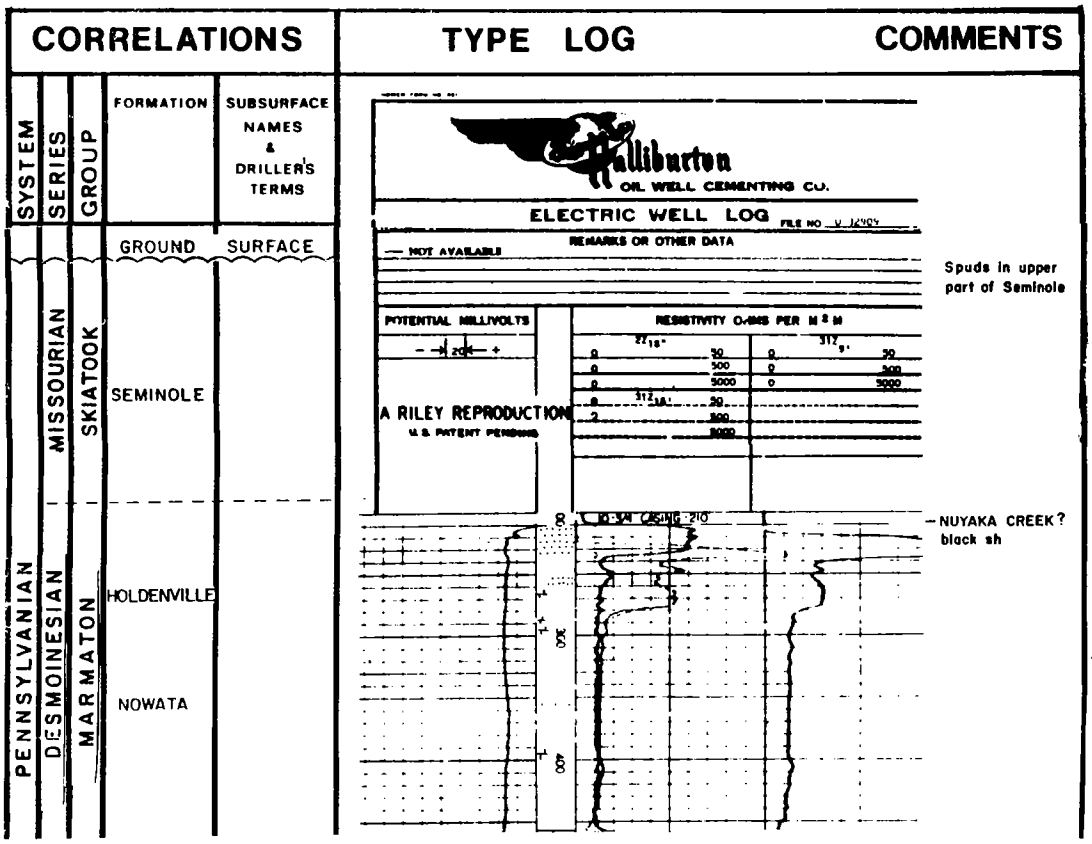

Figure 4 *(above and on facing page)*. The upper part of type well log, sec. 31, T. 20 N., R. 13 E., central Tulsa County, Oklahoma, shows the geophysical log signatures of the various units in the Pennsylvanian System in the study area. From Tulsa Geological Society Stratigraphic Committee (1985). (Note: The Oklahoma Geological Survey disagrees with some of the stratigraphic picks [or lack thereof] shown here. See Stratigraphy section in text.)

The Marmaton Group (Pl. 1) includes the Fort Scott Formation (~34 ft thick, OGS Core-Hole 4); Labette Formation (~144 ft thick, OGS Core-Hole 4); Oologah Formation (~46 ft thick, OGS Core-Holes 3 and 4 combined); Nowata Shale (~134 ft thick, OGS Core-Hole 3); Lenapah Limestone (~9 ft thick, OGS Core-Hole 2, and 0.2 ft thick, OGS Core-Hole 3); and the Holdenville Formation (~135 ft thick, OGS Core-Hole 2, and >300 ft thick, OGS Core-Holes 1 and 2 combined).

The name Memorial Shale was revived and revised by Heckel (1991, p. 23) to apply to the sequence of blocky mudstone, shale, sandstone, and coal (Dawson coal) that overlies, and partly interfingers with, the marine Lenapah Limestone. This stratigraphic interval has been included in the Holdenville Formation (Heckel, 1991, p. 5) in the Tulsa area, but because several recent reports con-

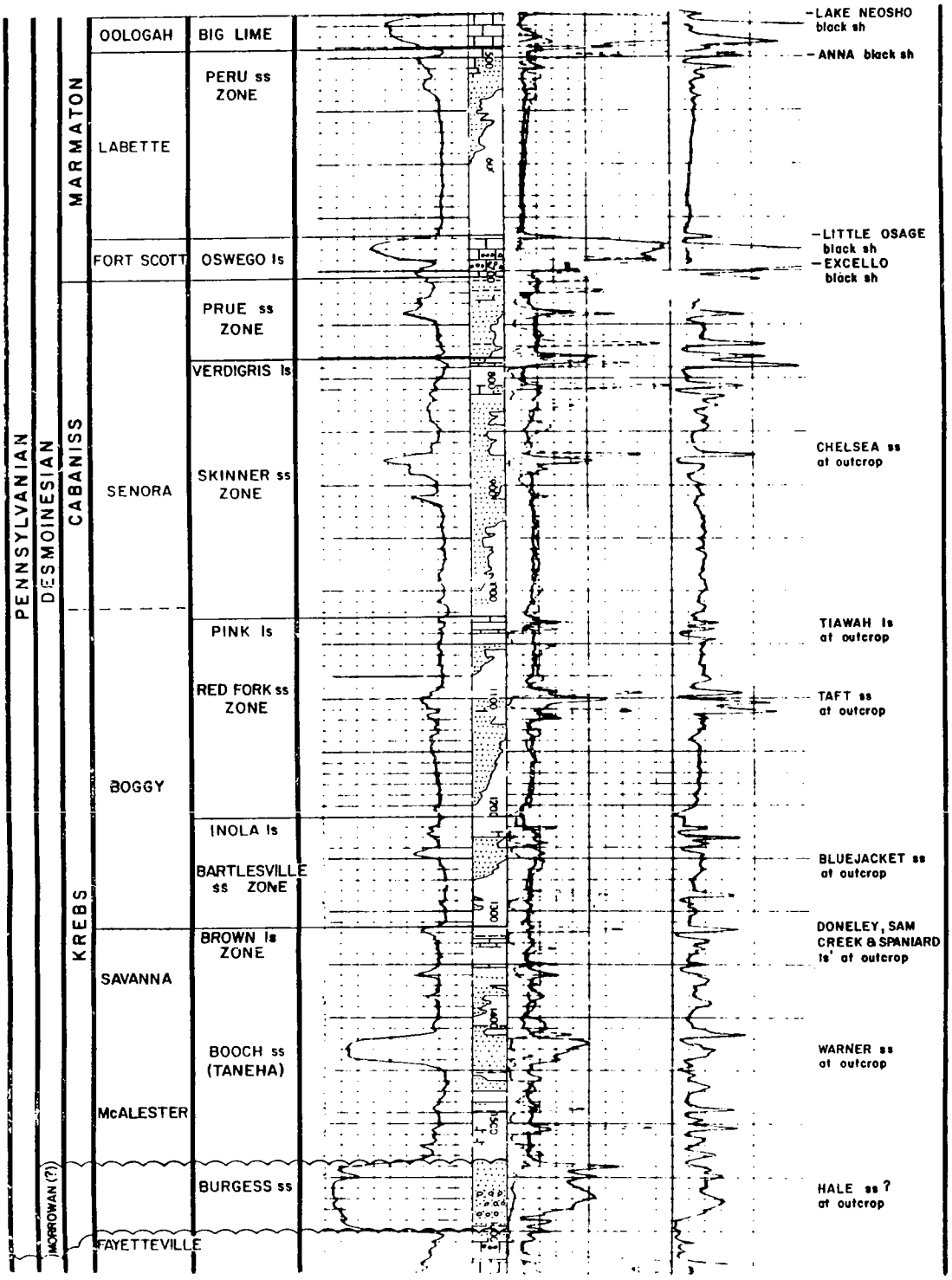

Figure 4 *(continued)*.

firm that earlier interpretations and correlations were erroneous in this part of the section (see Previous Investigations, above), Heckel's proposals are discussed herein and shown on Plate 1 (applied to interpretations of OGS cores from the study area).

The name Memorial shale (revised) applies to shale extending upward from the top of the Eleventh Street limestone to the top of the Dawson coal (Pl. 1). It includes a sandstone facies in the upper part informally referred to as the Jenks sandstone (Heckel, 1991, p. 23–24).

The name Lost Branch Formation was proposed by Heckel (1991, p. 10) for the sequence of gray to black marine shales and thin, pure to impure limestones that extends from the top of the Dawson coal bed and its equivalent strata upward to the base of overlying terrestrial strata. As defined, the Lost Branch Formation includes shale formerly encompassed by the Holdenville Formation and shale formerly included in the middle shaly zone of the Seminole Formation. In the revised correlation and new nomenclature system, Heckel (1991, fig. 4, p. 10, 24) suggests that the Memorial Shale and Lost Branch Formation be extended southward to approximately southern Tulsa County. To the south, in east-central Oklahoma, the type area of the Holdenville Formation, the Holdenville should be retained as a formation, and the Lost Branch could be recognized as its upper member. The Memorial Shale could also be recognized as a member, at least as far south as Seminole County (Heckel, 1991, p. 24), but the base is difficult to define south of Tulsa County.

The type locality of the Lost Branch Formation is an exposure in a cutbank on the west side of Lost Branch, near center NE¼NE¼NE¼ sec. 10, T. 33 S., R. 18 E., Labette County, Kansas (Heckel, 1991, p. 10), just north of Nowata County, Oklahoma. The formation is ~15 ft thick at both the stratotype site and in OGS Core-Hole 1, Tulsa County.

The Seminole Formation, oldest unit in the Skiatook Group and Missourian Series, overlies the Lost Branch Formation. Under Heckel's scheme, its base is defined by a paleosol representing subaerial exposure at the upper contact of the Lost Branch (Heckel, 1991, p. 21), or by a noticeable upward change from fossiliferous marine shale to unfossiliferous terrestrial shale. The base of the Checkerboard Limestone marks the top of the Seminole Formation in the Tulsa area. Under Heckel's definitions, the Seminole Formation is ~150 ft thick in OGS Core-Hole 1 (Pl. 1). It includes the Tulsa coal bed and the "upper Cleveland sand" of subsurface terminology.

The Checkerboard Formation separates the Seminole Formation from the Coffeyville Formation in both the new and revised classifications. It is represented by a 3.2–5-ft-thick limestone in OGS Core-Holes 1 and 2 (Pl. 1).

About 290 ft of the Coffeyville Formation was cored in northern Tulsa County (Core-Hole 1, Appendix), which represents almost its total thickness. It underlies the Hogshooter Limestone, which crops out only a short distance downdip from the drill site. The Coffeyville is composed mostly of silty shales and sandstone, with minor black shales, limestones, and coal. The Cedar Bluff coal is known to be present ~33 ft below the Hogshooter Limestone, from the Tulsa area at least as far north as the Kansas state line (Hemish, 1988, p. 170–171).

Chronostratigraphy

According to Heckel (1991, p. 1), recognition of the Lost Branch Formation would help to correct long-standing miscorrelations across the Desmoinesian–Missourian Series boundary, as it includes strata of Desmoinesian age previously assigned to the Desmoinesian Lenapah Limestone and Holdenville Shale, and to the Missourian Seminole Formation. A distinctive fauna of conodonts and ammonoids allows biostratigraphic correlation of the Lost Branch Formation along the entire Midcontinent outcrop belt into the upper part of the type Holdenville Shale of east-central Oklahoma (Heckel, 1991).

Heckel (1991, fig. 4) places the Desmoinesian–Missourian Series boundary at the Lost Branch–Seminole contact. The highest occurrences of the following taxa mark the top of the Desmoinesian: the conodont genus *Neognathodus* and *Idiognathodus*, the ammonoid genus *Gonioglyphioceras*, the fusulinid genus *Fusulina Beedeina*, the brachiopod genus *Mesolobus*, and the palynomorph genus *Cappasporites*. All the listed invertebrates are found in the Lost Branch Formation, but not in overlying marine beds. The palynomorph is found in the Dawson coal, but not in overlying coal beds (Heckel, 1991, p. 23). First appearances of critical Missourian taxa are in marine units above the Lost Branch. Current biostratigraphic investigations pursued by D. R. Boardman, R. H. Mapes, D. M. Work, James E. Barrick, and R. A. Peppers could provide the basis for further chronostratigraphic correlations. A Desmoinesian–Missourian boundary stratotype will have to be chosen after well-exposed sequences are located and described paleontologically (Heckel, 1991).

The proposed revised placement of the Desmoinesian–Missourian boundary is close to its provisional placement in recent years. Wilson (1972,1979,1984) and Pearson (1975) indicated that fossil plants in the Dawson coal of the Seminole Formation in Tulsa County have Desmoinesian affinities, making it necessary to remove the Dawson coal from the Seminole Formation and the Missourian Series, where earlier workers had placed it. Pearson (1975) discovered a significant break in palynomorph succession between the Dawson and the stratigraphically higher Tulsa coal. He suggested that the Desmoinesian–Missourian boundary be drawn at the base of the "upper Cleveland sand" (Tulsa sandstone) which underlies the Tulsa coal. Hemish (1987b, p. 154) tentatively selected the base of the Tulsa coal as the boundary between Desmoinesian and Missourian strata based on a distinct, traceable paleosol zone immediately underlying the Tulsa coal. Hemish (1988) again selected the top of the paleosol zone as the Desmoinesian–Missourian boundary, which coincides closely with Heckel's placement in most areas. Heckel (1991, appendix), however, places the paleosol (underclay) in the Missourian just above the Lost Branch Formation, or, where it is present, at the base of the "upper Cleveland sand." His placement

of the boundary generally is at the transition from fossiliferous marine beds to overlying terrestrial strata, which may or may not be marked by a disconformity. Figure 5 is modified from Heckel (1991, fig. 4) to show the proposed revised correlations and new nomenclature of uppermost Desmoinesian and adjacent strata in Oklahoma and Kansas.

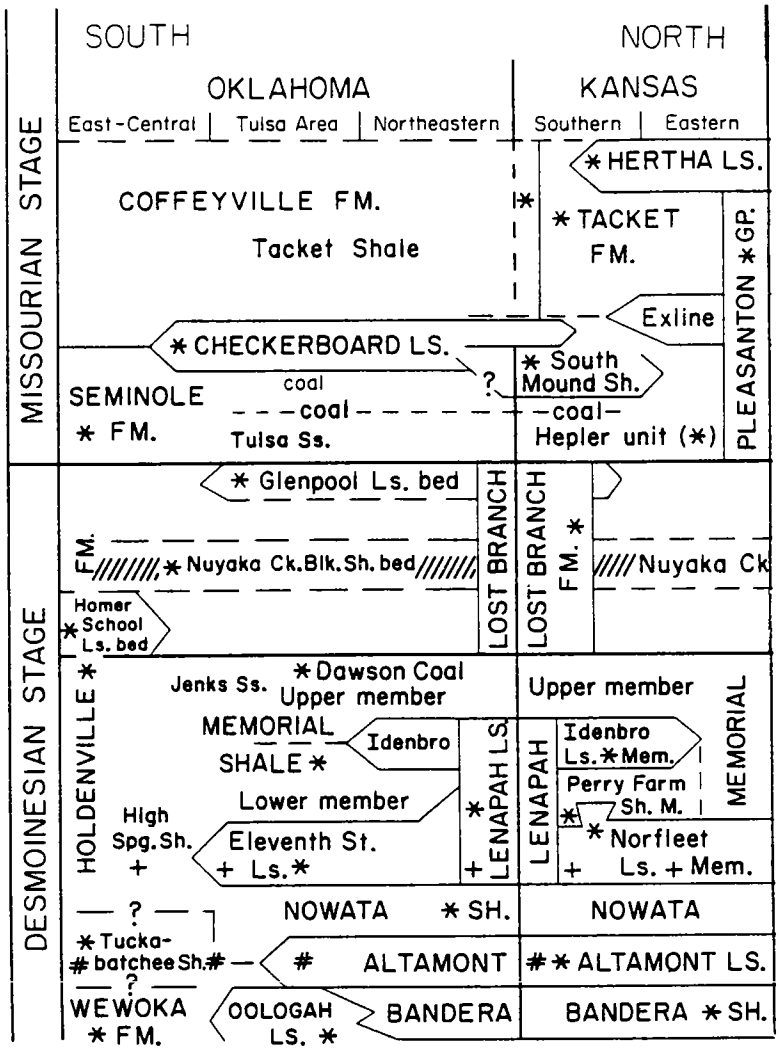

Figure 5. Revised correlation and new nomenclature of uppermost Desmoinesian and adjacent strata along the Oklahoma-Kansas outcrop belt, based on lithic relations in outcrop exposures and cores, and correlated by means of conodonts (Swade, 1985; Parkinson, 1982; Pavlicek, 1986; Greenberg, 1986; Heckel, 1991), ammonoids (Boardman and Mapes, 1984; D. R. Boardman, personal communications, 1982–1986), and palynomorphs (R. A. Peppers, personal communications, 1981–1984). Hatch marks (///) show the correlation of the Lost Branch horizon; plus signs (+) show the correlation of the lower Lenapah horizon; scratch marks (#) show the correlation of the Altamont horizon; and asterisks (*) show the geographic location of the type sections of all named units. Formation and group names are printed in capital letters; member and other names are printed in lowercase letters. Relations between the Bandera Shale and the Oologah Limestone were worked out by Price (1984). The nomenclature of Missourian strata is still in flux. Krumme (1981, p. 220–232) and Bennison (1984, p. 120–122) summarized problems of miscorrelation of the Seminole Formation and Checkerboard Limestone in Oklahoma. Modified from Heckel (1991, fig. 4).

The test of time will determine whether or not Heckel's new proposals are adopted by stratigraphers in Oklahoma. A. P. Bennison (personal communication, 1993) believes that the Memorial Shale should extend from the base of the Eleventh Street limestone to the "base of the Seminole Formation" as originally defined by Dott (1941). The "base of the Seminole Formation" is now known to be lithostratigraphically equivalent to the base of the informally named Jenks sandstone (Bennison, 1984) of the Holdenville Formation. Heckel (1991, p. 23–24) classifies the Jenks sandstone as a subdivision of the Memorial Shale. Bennison would exclude the Jenks sandstone from the Memorial Shale and would revise the Lost Branch Formation to extend from the top of the paleosol underlying the Dawson coal to the top of the paleosol underlying the Tulsa coal. The Tulsa sandstone would be included in the Lost Branch. The Desmoinesian–Missourian Series boundary would still be at the contact between the Lost Branch Formation and the overlying Seminole Formation under this scheme. To the south of Tulsa, the name Holdenville would be retained for the strata extending from the top of the Wewoka Formation (or its equivalent) to the base of the Seminole Formation as originally defined by Dott (1941).

In Plate 1, the stratigraphic classification tentatively proposed by Hemish (1987b;1989; 1990a,b) is used for the interval (discussed above) from the base of the Eleventh Street limestone to the base of the Tulsa coal in the vicinity of Tulsa. Original definitions are adhered to as closely as possible except where incorrect interpretations were made concerning the Holdenville-Seminole Formation contact (also, the Desmoinesian–Missourian boundary). The paleosol immediately underlying, or a few feet below, the Tulsa coal provides a recognizable, traceable horizon in cores as well as outcrops; it can be traced throughout eastern Oklahoma and into adjacent states (A. P. Bennison, personal communication, 1993). A widespread paleosol horizon such as this serves as an excellent lithostratigraphic boundary, but further detailed biostratigraphic work is needed before a final commitment is made regarding placement of the Desmoinesian–Missourian boundary.

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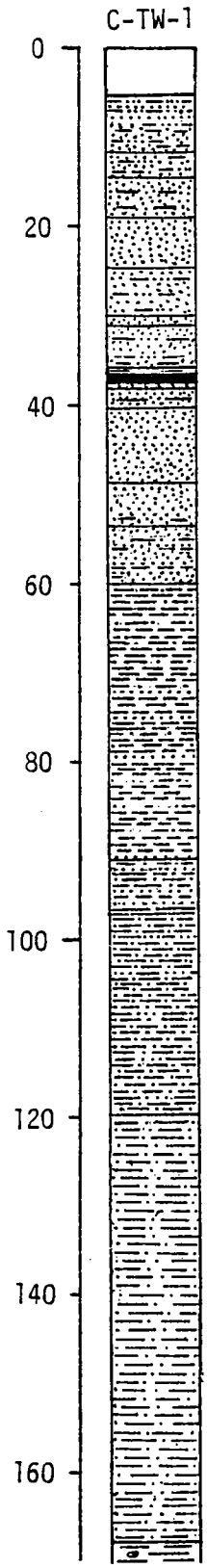
APPENDIX

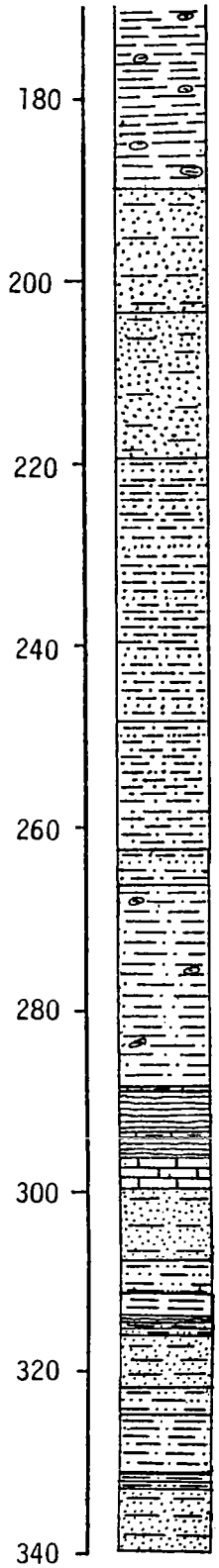
Core-Hole Logs

Core-Hole Log 1
(C-TW-1)

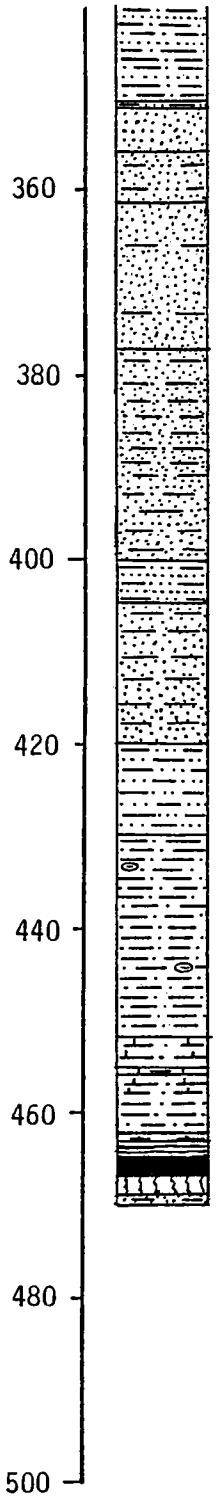


SE¼SW¼NE¼NE¼SE¼ sec. 6, T. 22 N., R. 13 E., Tulsa County. Drilled in pasture at north edge of small farm pond 310 ft FEL and 2200 ft FSL. Surface elevation, estimated from topographic map, 686 ft.

	Depth to unit top (ft)	Thickness of unit (ft)
Silt, dusky-yellowish-brown, contains organic material	0.0	2.0
Sand, moderate-yellowish-brown, silty, clayey, noncalcareous, unconsolidated	2.0	3.5
Skiatook Group		
Coffeyville Formation		
Siltstone, moderate-yellowish-brown to grayish-orange with dark-yellowish-orange bands, shaly, micaceous, noncalcareous, bioturbated; interstratified with well-indurated, very fine-grained sandstone layers 1-2 in. thick	5.5	6.2
Sandstone and silty shale, medium-light-gray and medium-dark-gray with some moderate-yellowish-bands, interstratified, noncalcareous, extensively bioturbated; includes some black macerated plant fragments	11.7	2.7
Sandstone and silty shale, medium-light-gray and medium dark-gray, interstratified, noncalcareous, extensively bioturbated; includes some black macerated plant fragments	14.4	4.6
Sandstone, medium-light-gray, very fine-grained, interlaminated with medium-dark-gray shale, wavy-bedded, noncalcareous, bioturbated; contains black macerated plant material	19.0	5.5
Sandstone, medium-gray, fine- to very fine-grained, massive, noncalcareous; contains black macerated plant fragments	24.5	5.5
Sandstone, medium-dark-gray with medium light-gray bands, silty, micaceous, noncalcareous; contains abundant black macerated plant fragments	30.0	1.0
Sandstone, medium-gray, very fine-grained, cross-laminated; siltstone in part, includes black macerated plant material; contains a repetitive sequence of fining-upward units 1-5 in. thick with scour-and-fill features at the base of each unit; shaly in bottom 6 in	31.0	4.9
Shale, medium-dark-gray, contains black carbonized plant material, noncalcareous	35.9	0.3
Coal, black, very friable, includes abundant pyrite and white calcite on cleat surfaces (Cedar Bluff coal)	36.2	1.2



Underclay, medium-light-gray, contains black carbonized plant fragments.....	37.4	0.6
Sandstone, medium-gray and light-greenish-gray, very fine-grained, silty, noncalcareous, interstratified with thin shale laminae, cross-stratified, scour and slump features common.....	38.0	2.2
Sandstone, light-greenish-gray with medium-gray bands, fine- to very fine-grained, noncalcareous; soft-sediment deformation features common; includes abundant black macerated plant fragments...	40.2	8.5
Sandstone, light-gray, fine-grained, massive, noncalcareous; contains black macerated plant fragments and some light-brownish-gray sideritic concretions ~1 in. thick; includes some thin laminae and rare interbedded medium-dark-gray shale stringers in bottom 2 ft of unit.....	48.7	5.0
Sandstone, medium-dark-gray and light-greenish-gray, very fine-grained, shaly, banded, cross-bedded in part, noncalcareous, soft-sediment deformation features common; contains black macerated plant material.....	53.7	6.3
Shale, medium-dark-gray, silty, interstratified with laminae and thin beds of very fine-grained, light-greenish-gray sandstone, cross-bedded in part, noncalcareous; contains some soft-sediment deformation features; includes some minor bioturbation features and black macerated plant fragments.....	60.0	31.0
Shale, medium-dark-gray, silty, noncalcareous, contains sparse bioturbation features; includes some light-greenish-gray sandstone layers 1/32 to 0.5 in. thick generally spaced at intervals of 12 to 18 in. apart.....	91.0	6.0
Shale, medium-dark-gray, silty, noncalcareous, interbedded with thin layers of hard siltstone, bioturbated in places; includes a 5-in.-thick layer of bioturbated, very fine-grained, silty sandstone from 105.3 to 105.7 ft; includes some black macerated plant fragments.....	97.0	23.0
Shale, medium-dark-gray, silty, noncalcareous.....	120.0	48.0
Shale, dark-gray, to medium-dark-gray, noncalcareous, includes several medium-light-gray to light-brownish-gray, 0.5- to 2-in.-thick sideritic concretions.....	168.0	22.4
Sandstone, dark-gray with pale-blue bands, impure, shaly, noncalcareous, very fine-grained, micaceous, extensively bioturbated, evenly laminated; includes some minor scour-and-fill features and		



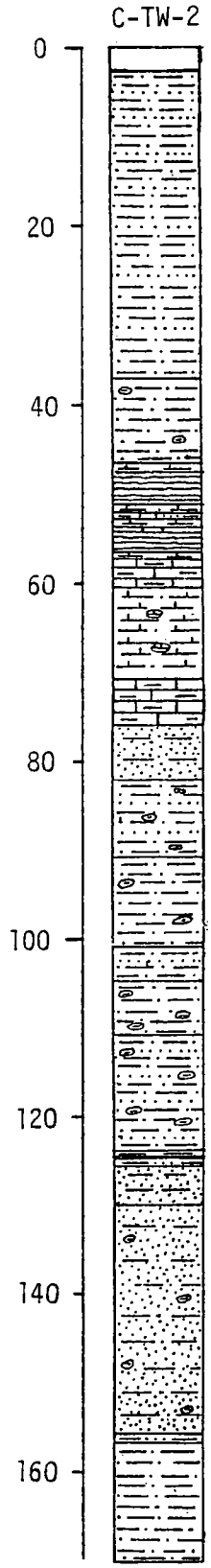
soft-sediment deformation features; contains abundant black macerated plant material on stratification surfaces	190.4	13.6
Sandstone, pale-blue and dark-gray, very fine-grained, shaly, noncalcareous, micaceous, bioturbated, wavy-bedded; includes abundant black macerated plant fragments as well as some laminae of black, bright coal; contains minor soft-sediment deformation features; ratio of sand-sized grains to silt- and clay-sized grains greater than in overlying unit; grades into underlying unit	204.0	16.0
Shale, dark-gray, silty, noncalcareous, interstratified with lenses and thin layers of very fine-grained, medium-light-gray sandstone, bioturbated; contains black macerated plant fragments on stratification surfaces; includes some soft-sediment deformation features	220.0	29.0
Shale, dark-gray to medium-dark-gray, silty, noncalcareous; contains some bioturbation features and siltstone laminae in upper 7 ft of unit	249.0	14.0
Shale, dark-gray, silty, noncalcareous, interstratified with cross-laminated layers of medium-light-gray, very fine-grained sandstone 1/64 to 1.75 in. thick; includes some minor bioturbation features	263.0	4.1
Shale, medium-dark-gray, silty, noncalcareous; contains minor black carbonized plant fragments and pyrite on stratification surfaces; includes sparsely distributed light-brownish-gray sideritic concretions ~1 in. thick; contains some siltstone strata 1/16 to 1 in. thick in middle part of unit; rare pyritized pelecypods observed from 278 to 279 ft; grades into highly calcareous, fossiliferous shale in lower 2 in	267.1	22.2
Limestone, dark-gray, impure, highly shaly, fossiliferous, contains abundant small crinoid columnals; interfingers with underlying unit	289.3	0.1
Shale, black, hard, brittle, pyritic in upper parts; contains some calcite fracture fillings; includes some phosphatic nodules and thin coal stringers	289.4	4.6
Shale, black, brittle, very calcareous; contains pyritized fossil shell fragments; grades into underlying unit	294.0	0.2
Limestone, dark-gray, impure, shaly, very shaly in upper 2 in., fossiliferous; contains abundant small brachiopod shell fragments and crinoid columnals	294.2	0.5
Shale, black, hard, brittle, noncalcareous;		

contains phosphatic nodules.....	294.7	2.4
Checkerboard Formation(?)		
Limestone, light-gray to medium-dark-gray, hard, dense, fine-grained, contains abundant fossil shell fragments and small crinoid columnals (Checkerboard Limestone).....	297.1	3.2
Seminole Formation		
Sandstone, medium-dark-gray with closely spaced, thin light-gray bands, very fine-grained, shaly, noncalcareous, flat-bedded to wavy-bedded with some cross-laminations, bioturbated; grades into underlying unit.....	300.3	7.7
Siltstone, medium-dark-gray, shaly, includes some sandstone laminae in upper 6 in., noncalcareous; contains some pyritic burrows; becomes weakly calcareous in about the lower 12 in.; includes a 3-in.-thick, dense, medium-gray calcareous concretion at base of unit.....	308.0	3.9
Shale, dark-gray, noncalcareous, contains black carbonized and pyritic plant fragments.....	311.9	2.6
Shale, brownish-black, very carbonaceous; contains thin stringers of bright black coal; includes calcite and minor pyrite on fracture surfaces.....	314.5	0.4
Shale, medium-dark-gray, silty, noncalcareous; contains black carbonized and pyritic plant fragments; grades into underlying unit.....	314.9	0.2
Siltstone, medium-dark-gray, noncalcareous, sandy, contains black carbonized and pyritic plant fragments.....	315.1	0.2
Sandstone, medium-light-gray with medium-dark-gray bands, very fine-grained, shaly, noncalcareous, wavy-laminated and cross-bedded, micaceous, contains abundant black macerated plant material on stratification surfaces; grades into underlying unit.....	315.3	6.7
Siltstone, medium-dark-gray with closely spaced light-gray laminations, interlaminated with very fine-grained sandstone, noncalcareous, bioturbated; grades into underlying unit.....	322.0	3.5
Shale, medium-dark-gray, very silty, noncalcareous; includes numerous light-brownish-gray sideritic concretions 1/8 to 1 in. thick.....	325.5	6.2
Coal, black, moderately friable; includes pyrite on stratification surfaces (Tulsa coal).....	331.7	0.2
Shale, medium-dark-gray, silty, noncalcareous, contains black carbonized plant compressions.....	331.9	0.1
Siltstone, medium-dark-gray, noncalcareous; contains abundant black carbonized plant fragments		

on stratification surfaces.....	332.0	0.6
Sandstone, medium-dark-gray with light-gray bands, very fine-grained, shaly, noncalcareous, wavy-laminated and cross-bedded in part; contains some soft-sediment deformation features; includes black macerated plant material on stratification surfaces; bioturbated in places.....	332.6	7.4
Shale, medium-dark-gray, silty; interbedded with several 4- to 5-in.-thick units of very fine-grained, massive to cross-bedded sandstone spaced 1-3 ft apart vertically, noncalcareous; includes some light-brownish-gray sideritic concretions 0.25-1 in. thick, contains abundant black macerated plant fragments on stratification surfaces...	340.0	10.6
Marmaton Group		
Holdenville Formation		
Siltstone, dark-gray to grayish-black, carbonaceous, very fine-grained, dense, hard, noncalcareous (paleosol zone)/.....	350.6	0.2
Siltstone, medium-dark-gray, dense, hard, massive, contains black carbonized plant remains.....	350.8	0.4
Sandstone, greenish-gray, very fine- to fine-grained, noncalcareous, extensively bioturbated; thin-bedded in lower part; bedding mostly obscured in upper part.....	351.2	4.8
Sandstone and siltstone, medium-gray with light-gray bands, very fine-grained, shaly, noncalcareous, extensively bioturbated, even-bedded; includes some light-brownish-gray sideritic concretions; contains black carbonized plant fragments, fines upward.....	356.0	5.8
Sandstone, medium-light-gray, massive, fine- to very fine-grained, noncalcareous, interbedded with medium-dark-gray, wavy-bedded, bioturbated, shaly sandstone containing black macerated plant fragments.....	361.8	15.6
Sandstone, medium-dark-gray, very fine-grained, noncalcareous, wavy-laminated, shaly in part; contains abundant silt-sized grains; includes some contorted layers of light-gray, very fine-grained sandstone.....	377.4	22.9
Siltstone, medium-dark-gray, noncalcareous, contains closely spaced laminae of light-gray, very fine-grained sandstone in places; grades into underlying unit.....	400.3	5.2
Sandstone, medium-dark-gray with light-gray bands, very fine-grained, shaly, noncalcareous, wavy-laminated; bioturbated in part; contains black		

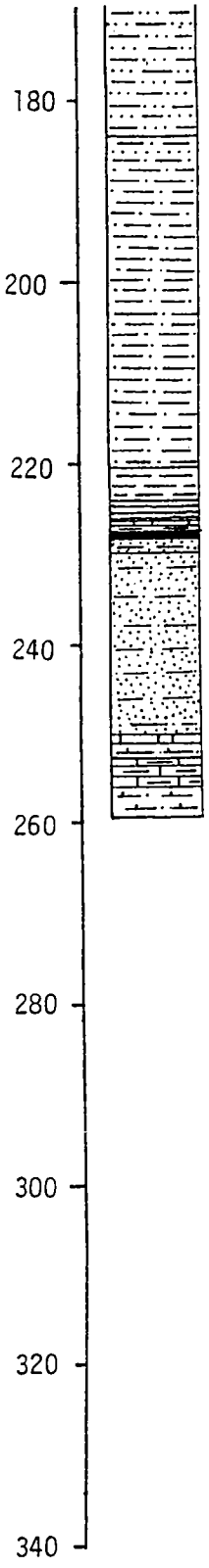
macerated plant fragments on stratification surfaces	405.5	6.5
Sandstone, medium-dark-gray, very fine-grained, noncalcareous, laminated, shaly; contains abundant silt-sized grains; grades into underlying unit	412.0	8.0
Siltstone, medium-dark-gray, shaly, contains some laminae of medium-light-gray, very fine-grained sandstone, noncalcareous; grades into underlying unit	420.0	10.0
Shale, medium-dark-gray, very silty, noncalcareous; includes rare light-brownish-gray sideritic concretions ~0.25 in. thick	430.0	22.0
Shale, medium-dark-gray, silty, calcareous, contains marine fossils such as brachiopods and gastropods(?); also contains pyritized trace fossils on stratification surfaces; becomes dark-gray and extremely calcareous in lower 2 ft of unit	452.0	3.8
Limestone, dark-gray to grayish-black, hard, shaly, nonfossiliferous; exhibits cone-in-cone structure	455.8	0.3
Shale, dark-gray, hard, silty, calcareous in upper 12 in.; includes some light-brownish-gray sideritic concretions ~0.25 in. thick; contains pyritized trace fossils on stratification surfaces	456.1	6.0
Shale, dark-gray to grayish-black, calcareous, contains sparsely distributed marine fossils and pyritized trace fossils	462.1	1.2
Shale, black, hard, brittle, noncalcareous; contains white calcite on fracture surfaces; includes well-preserved brachiopod fossils and phosphatic nodules; lower 1 in. contains abundant pyritized fossils	463.3	1.9
Coal, black, bright, moderately friable; includes minor calcite and pyrite on cleat surfaces (Dawson coal)	465.2	1.8
Underclay, medium-dark-gray, silty, bioturbated; contains black carbonized plant fragments; includes some calcareous fossil remnants in lower part of unit	467.0	2.0
Sandstone, medium-gray, very silty and clayey, noncalcareous, contains streaks of black carbonaceous material, bedding disturbed	469.0	1.0
Total Depth		470.0

Core-Hole Log 2
(C-TW-2)



SE¼SE¼SE¼SW¼SE¼ sec. 32, T. 24 N., R. 14 E., Washington County. Drilled in pasture at northwest edge of pond 90 ft FSL and 1500 ft FEL. Surface elevation, estimated from topographic map, 655 ft.

	Depth to unit top (ft)	Thickness of unit (ft)
Silt, brownish-gray, clayey, contains organic material	0.0	1.0
Silt, dark-yellowish-brown, clayey, contains some gravel-sized clasts of moderate-reddish-brown ironstone	1.0	1.5
Skiatook Group		
Coffeyville Formation		
Shale, grayish-orange to pale-yellowish-brown, flaky, oxidized; contains interstratified layers of very fine-grained sandstone	2.5	6.5
Shale, light-olive-gray with some dark-yellowish-orange bands, interlaminated with very fine-grained sandstone, bioturbated; includes some medium-gray bands in lower 2 ft; partly weathered	9.0	4.3
Shale, medium-dark-gray, interstratified with very fine-grained, light-gray sandstone, noncalcareous, bioturbated; includes sparsely distributed brachiopods; contains black macerated plant fragments and rare calcite crusts on stratification surfaces; proportion of sandstone decreases markedly below 30 ft	13.3	23.8
Shale, medium-dark-gray, silty, noncalcareous; contains widely spaced, light-brownish-gray sideritic concretions ~1 in. thick; bioturbated in part; includes some calcitic brachiopods on stratification surfaces	37.1	9.4
Shale, medium-dark-gray, weakly calcareous, contains some fossil hash and small crinoid columnals	46.5	0.1
Shale, black, hard, brittle, noncalcareous, includes some white calcite along fractures, pyritic, contains phosphatic nodules	46.6	4.5
Shale, grayish-black, extremely calcareous, pyritic, silty, contains some small, poorly preserved fossil fragments; grades into underlying unit	51.1	0.6
Limestone, dark-gray with white mottling, impure, silty, shaly, pyritic, fossiliferous, contains abundant fossil hash	51.7	1.0
Shale, grayish-black, weakly calcareous, pyritic, hard, brittle, contains small phosphatic nodules	52.7	0.4
Limestone, dark-gray, fine-grained, extremely		

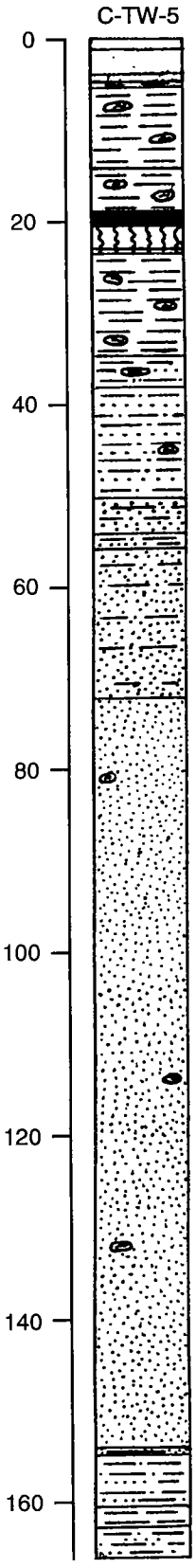


hard, dense, sparsely fossiliferous.....	53.1	0.4
Shale, black, hard, brittle, calcareous, pyritic, contains phosphatic nodules.....	53.5	3.0
Shale, grayish-black, silty, extremely calcareous; contains sparsely distributed fossils; grades into underlying unit.....	56.5	0.4
Limestone, dark-gray, extremely impure and shaly; contains abundant deformed bivalve shells up to 2 in. long; grades into underlying unit.....	56.9	3.6
Shale, dark-gray, silty, very calcareous, contains fossil marine shells.....	60.5	1.8
Shale, dark-gray, silty, calcareous, bioturbated; contains some sparsely distributed marine shells and minor pyrite; includes some hard, dense, medium-gray calcareous concretions up to 3 in. thick; grades into underlying unit.....	62.3	8.7
Checkerboard Formation(?)		
Limestone, dark-gray in part and very light-gray in about equal part; impure and shaly in dark parts, particularly in upper 6 in. and lower 6 in.; very fossiliferous, marine shells and crinoid fragments abundant; dense and hard in light-colored parts; carbonaceous in lower 6 in. (Checkerboard Limestone).....	71.0	5.0
Seminole Formation		
Sandstone, medium-dark-gray with closely spaced light-gray bands, very fine-grained, shaly, noncalcareous, cross-laminated, scour-and-fill features and soft-sediment deformation features common; contains black macerated plant fragments on stratification surfaces.....	76.0	6.0
Shale, medium-gray, closely interlaminated with medium-light-gray very fine-grained sandstone, noncalcareous, even-bedded; includes some minor black macerated plant fragments on stratification surfaces; contains light-brownish-gray sideritic concretion ~1 in. thick in lower part of unit; proportion of sand-sized grains decreases downward.....	82.0	9.0
Shale, medium-dark-gray, silty, noncalcareous; contains light-brownish-gray sideritic concretions 1/8 to 1 in. thick and minor black carbonized plant compressions.....	91.0	10.1
Shale, medium-dark-gray, silty, noncalcareous; includes laminae of very fine-grained sandstone spaced at ~0.5-in. intervals; contains several light-brownish-gray sideritic concretions about 0.5-1 in. thick.....	101.1	3.7

Shale, medium-dark-gray, silty, noncalcareous; contains several ironstone concretions about 1/8 to 0.5 in. thick; includes black carbonized plant compressions in lower 2 ft of unit.....	104.8	6.2
Shale, medium-dark-gray, silty, noncalcareous; interstratified with cross-laminated layers of very fine-grained sandstone in part; includes abundant black macerated plant fragments on stratification surfaces; contains light-brownish-gray sideritic concretions 0.5-1 in. thick.....	111.0	13.4
Shale, grayish-black, carbonaceous.....	124.4	0.2
Coal, black, bright, very friable; includes pyrite on cleat surfaces (Tulsa coal).....	124.6	0.1
Marmaton Group		
Holdenville Formation		
Siltstone, dark-gray, hard, unbedded; contains black carbonized plant material in upper 6 in.; appears to be a paleosol; grades into underlying unit.....	124.7	1.0
Sandstone, greenish-gray, very fine-grained, clayey, noncalcareous, extensively bioturbated, fines upward; bedding disturbed in upper 1 ft of unit; becomes obscurely thin-bedded in lower part; grades into underlying unit.....	125.7	4.3
Sandstone, medium-gray and light-gray, very fine-grained, shaly, thin-bedded in part, extensively bioturbated, bedding contorted in part, noncalcareous, micaceous; contains black macerated plant material on stratification surfaces; cross-laminated in some places; includes light-brownish-gray sideritic concretions 1/8 to 1 in. thick.....	130.0	26.0
Siltstone, medium-gray, shaly, noncalcareous; grades into underlying unit.....	156.0	1.0
Shale, medium-gray, silty and sandy, noncalcareous..	157.0	13.5
Siltstone, medium-gray, shaly, hard, noncalcareous; contains abundant laminae of light-gray, very fine-grained sandstone; becomes finer grained downward and grades into underlying unit.....	170.5	14.5
Shale, medium-gray, silty, hard, noncalcareous; contains minor black carbonized plant fragments below 200 ft; includes rare laminae of very fine-grained sandstone in upper few feet of unit; contains some small pyritized trace fossils.....	185.0	36.4
Shale, dark-gray, noncalcareous, contains small pyritized trace fossils.....	221.4	3.9
Shale, black, hard, brittle, pyritic, noncalcareous; contains rare brachiopod fossils; includes white calcite in fracture fillings.....	225.3	2.2

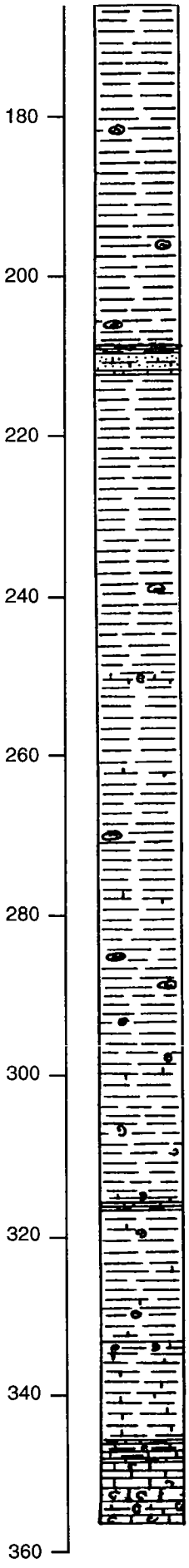
Limestone, dark-gray, dense, hard, nonfossiliferous.	227.5	0.2
Shale, grayish-black, very carbonaceous, coaly.....	227.7	0.3
Coal, black, bright, moderately friable, contains minor pyrite and white calcite on cleat surfaces (Dawson coal).....	228.0	0.9
Sandstone, medium-light-gray to light-bluish-gray, clayey, extensively bioturbated; includes black carbonaceous material in upper 6 in.....	228.9	1.8
Sandstone, medium-light-gray with medium-dark-gray bands, very fine- to fine-grained, shaly, thin- to thick-bedded, noncalcareous; contains numerous soft-sediment deformation features; bioturbated in upper part; includes abundant black macerated plant fragments on stratification surfaces; becomes increasingly shaly downward.....	230.7	20.4
Lenapah Limestone		
Limestone, very light-gray, hard, conglomeratic, contains rounded clasts of reworked limestone up to 1.5 in. long and 0.5 in. thick; includes some crinoid columnals.....	251.1	0.8
Shale, medium-dark-gray, silty, extremely calcareous, contains minor pyritic trace fossils and rare small flecks of black carbonized plant fragments on stratification surfaces.....	251.9	1.9
Limestone, medium-dark-gray with abundant white fossils, impure, silty, very fossiliferous; bivalves ≥1 in. long abundant; interbedded with layers of extremely calcareous shale 1-4 in. thick.....	253.8	3.5
Shale, medium-dark-gray, silty, extremely calcareous, fossiliferous, contains white bivalves and crinoid columnals; includes a 1-in.-thick, shaly, very fossiliferous limestone layer ~1.5 ft below top of unit.....	257.3	2.7
Total Depth		260.0

Core-Hole Log 3
(C-TW-5)



NW¼NW¼SE¼NW¼ sec. 6, T. 21 N., R. 14 E., Tulsa County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in pasture just south of south end of abandoned strip pit 1,440 ft FNL and 1,500 ft FWL. (Surface elevation, estimated from topographic map, 668 ft.)

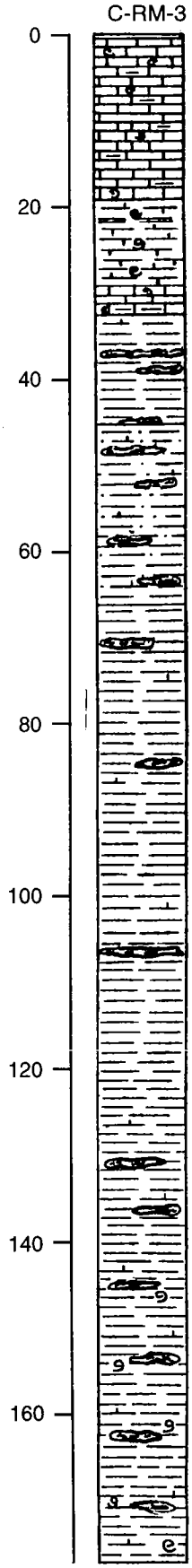
	Depth to unit top (ft)	Thickness of unit (ft)
Silt, grayish-brown (5YR3/2) organic (soil)	0.0	1.5
Clay, grayish-orange (10YR7/4), very sticky, grades into underlying unit	1.5	2.5
Clay, grayish-brown (5YR3/2); contains angular, gravel-size fragments of ironstone	4.0	0.5
DESMOINESIAN SERIES		
Marmaton Group		
Holdenville Formation		
Shale, light-gray (N7), clayey, very weathered	4.5	0.7
Shale, moderate-yellowish-brown (10YR5/4) and pale-yellowish-brown (10YR6/2), mottled in upper part and banded in lower part; contains light-brown (5YR5/6) to dark-yellowish-orange (10YR6/6) clay-ironstone concretions; weathered	5.2	8.8
Shale, medium-gray (N5) and light-olive-gray (5Y5/2); contains light-brown (5YR5/6) to yellowish-gray (5Y7/2) clay-ironstone concretions	14.0	4.9
Coal, black (N1) moderately hard, kaolinite(?) in cleats (Dawson coal)	18.9	1.4
Underclay, medium-gray (N5); contains black, carbonized plant compressions and a thin coal layer at 23.3 ft; contact with underlying unit gradational	20.3	3.2
Shale, medium-gray (N5); contains black, carbonized plant compressions and light-brownish gray (5YR6/1) sideritic concretions	23.5	11.0
Shale, medium-gray (N5) with light-gray (N7) streaks; contains thin lenses and streaks of very fine-grained sandstone (10–30%); includes light-brownish-gray (5YR6/1) sideritic concretions as much as 3 in. thick; sandstone content increases downward	34.5	3.5
Shale, medium-gray (N5), silty, interlaminated with light-gray (N7), very fine-grained sandstone (35–45%); contains black, macerated plant fragments, and rare light-brownish-gray (5YR6/1) sideritic concretions; sandstone lenses contain small-scale, low-angle, cross-stratification; unit is wavy bedded with some flaser bedding; weakly bioturbated; grades into underlying unit	38.0	12.0
Sandstone (60%), greenish-gray (5GY6/1) to light-gray (N7), interbedded with medium-gray (N5), silty shale; sandstone is very fine-grained, contains low-angle, wispy cross-stratification; weakly to moderately bioturbated; includes black, macerated plant fragments; unit is wavy bedded and contains rare soft-sediment deformation features	50.0	4.0



Sandstone, light-gray (N7) to light-olive-gray (5Y6/1), fine- to very fine-grained, contains streaks of medium-gray (N5) shale, very micaceous; includes abundant black, macerated plant material; contains faint, low-angle cross-stratification defined by shale wisps and carbonaceous material in some intervals, but appears mostly massive; base sharp	54.0	1.8
Sandstone, interbedded with shale (same description as interval from 50 to 54 ft); in lower 2 ft sandstone content increases to about 75–80%	55.8	16.2
Sandstone (same description as interval from 54 to 55.8 ft); includes locally abundant shale clasts and widely scattered, light-brown (5YR6/4), clayey, sideritic concretions up to 1 in. thick; shale clasts increase in abundance in lower 1 ft	72.0	82.0
Sandstone, medium-light-gray (N6) to light-olive-gray (5Y6/1), fine- to very fine-grained, bedding contorted; includes abundant black, carbonized plant fragments and pyritic coal stringers as much as 0.5 in. thick (Jenks coal); basal contact sharp, erosional	154.0	1.0
Shale, medium-dark-gray (N4), silty, contains thin streaks of very light-gray (N8) siltstone and very fine-grained sandstone, weakly bioturbated; grades into underlying unit	155.0	5.3
Shale, dark-gray (N3) to medium-dark-gray (N4), noncalcareous, uniform in appearance, base gradational	160.3	2.6
Shale (same description as interval from 155 to 160.3, but with rare very thin laminae of very light-gray (N8) siltstone and very fine-grained sandstone), base gradational	162.9	3.1
Shale, dark-gray (N3) to medium-dark-gray (N4), uniform in appearance, mostly clay shale, contains rare pyritized burrows, below 180 ft includes some brownish-gray (5YR4/1) sideritic bands about 0.5 in. thick	166.0	42.9
Ironstone, brownish-gray (5YR4/1)	208.9	0.1
Shale, dark-gray (N3) to medium-dark-gray (N4), weakly bioturbated; includes scattered light-gray (N7), very fine-grained, calcareous, sandstone-filled burrows; grades into underlying unit	209.0	0.8
Sandstone, light-gray (N7), shaly, very calcareous, very fine-grained, strongly bioturbated; base sharp, flat	209.8	2.0
Lenapah Limestone		
Limestone, dark-gray (N3), bioclastic (skeletal mudstone), contains crinoid ossicles and shell fragments (Eleventh Street limestone)	211.8	0.2
Nowata Shale		
Shale, dark-gray (N3) to medium-dark-gray (N4); contains calcareous, sandstone-filled burrows in upper 2 in.; includes widely spaced, brownish-gray (5YR4/1) ironstone concretions from 0.5 to 1 in. thick; weakly bioturbated—some burrows pyritic (upper part only); becomes slightly calcareous below 242 ft, with rare, white (N9), fossil shell and crinoid fragments; includes a 1.5-in.-thick layer of shaly fossil crinoid hash at 250.4 ft; intermittently slightly calcareous to noncalcareous below 250 ft; in-		

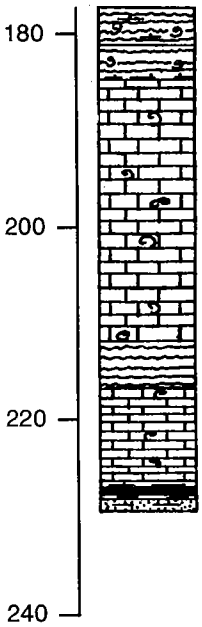
cludes calcite and well-preserved brachiopods on some bedding planes below 278 ft; number of sideritic concretions increases from 285 to 290 ft, and color changes to dark-gray (N3) to grayish-black (N2); scattered bioturbated intervals and pyritized fossils below 294 ft; abundant pyrite-filled burrows below 315 ft; includes a 1-in.-thick layer of fossil hash at 315.8 ft	212.0	104.0
Limestone, dark-gray (N3), bioclastic (skeletal mudstone), contains abundant crinoid and shell fragments, base gradational	316.0	0.4
Ironstone, light-brownish-gray (5YR6/1), very calcareous, fossiliferous; includes a bioturbated, shaly limestone stringer at base	316.4	0.3
Shale, dark-gray (N3) to grayish-black (N2), weakly calcareous; includes rare, white (N9) fossil shells and minor pyrite in stringers and on fracture surfaces	316.7	17.1
Shale, dark-gray (N3) to grayish-black (N2), calcareous; includes several 1-in.-thick bands of fossil debris and scattered fossil shells in upper 2 ft; minor pyrite in rare burrows, base gradational	333.8	12.1
Oologah Formation		
Limestone, dark-gray (N3) (skeletal mudstone), very impure and shaly; contains fossil detritus in bands (top of Altamont Limestone)	345.9	0.5
Shale, dark-gray (N3), very calcareous, interlaminated with finely comminuted fossil debris, base gradational	346.4	1.3
Limestone, medium-dark-gray (N4) (skeletal mudstone), impure, contains abundant crinoids and shells aligned by current flow, base sharp	347.7	0.7
Shale, dark-gray (N3) to brownish-gray (5YR4/1), weakly calcareous, base sharp	348.4	0.25
Limestone, medium-dark-gray (N4), (skeletal mudstone), impure, shaly, fossil content predominantly brachiopods; base marked by very thin layers of white (N9) sparry calcite	348.65	0.25
Shale, dark-gray (N3) to brownish-gray (5YR4/1), very calcareous, fossiliferous, base sharp	348.9	0.2
Limestone, light-brownish-gray (5YR6/1) to light-gray (N7), (skeletal wackestone to packestone), fossiliferous, brachiopod valves common; becomes medium-gray (N5), and grades into calcareous shale at 354 ft	349.1	4.9
Shale, medium-dark-gray (N4), very calcareous at top to weakly calcareous at base; fossiliferous, mostly in upper half of unit; contains minor pyrite; base irregular	354.0	1.4
Limestone, light-gray (N7) to medium-gray (N5), (skeletal wackestone), very fine-grained; fossiliferous, mostly crinoid ossicles and shell debris; weakly bioturbated	355.4	1.0
Total Depth		356.4

Core-Hole Log 4
(C-RM-3)



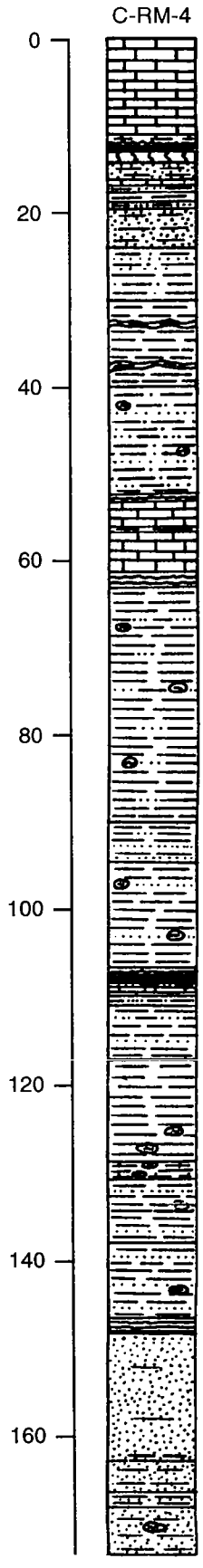
SE¼SW¼SW¼NW¼ sec. 9, T. 21 N., R. 15 E., Rogers County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in pasture just east of pond and just south of house about 40 ft north of property line fence 2,600 ft FNL and 520 ft FWL. (Surface elevation, estimated from topographic map, 810 ft.)

	Depth to unit top (ft)	Thickness of unit (ft)
Silt, sandy, grayish-brown (5YR3/2), organic; contains limestone pebbles (soil)	0.0	0.5
DESMOINESIAN SERIES		
Marmaton Group		
Oologah Formation		
Limestone, light-gray (N7) with light-brown (5YR5/6) mottling where weathered (skeletal wackestone), vuggy, recrystallized in part, fossiliferous, moderately bioturbated, grades into underlying unweathered unit (top of Altamont Limestone)	0.5	3.5
Limestone, medium-gray (N5) and light-gray (N7), (skeletal lime mudstone to skeletal wackestone to packstone), mottled in appearance, porous, contains wispy, dark-gray (N3) streaks; sparsely fossiliferous (mostly crinoids and brachiopods), moderately bioturbated, impure and shaly in some intervals	4.0	15.2
Shale, brownish-black (5YR2/1) to dark-gray (N3), very calcareous, fossiliferous (mostly brachiopods); includes rare, black, carbonized plant compressions; shaly limestone from 20.8 to 21.2 ft; weakly bioturbated; base gradational (Bandera shale)	19.2	9.9
Limestone, medium-dark-gray (N4) to brownish-gray (5YR4/1), (skeletal mudstone to skeletal wackestone), includes sparse crinoid ossicles and brachiopod valves, shaly in bottom 14 in., base gradational (Pawnee Limestone)	29.1	3.2
Labette Shale		
Shale, medium-gray (N5), weakly calcareous to noncalcareous, nonfossiliferous; includes scattered, light-brown (5YR5/6), sideritic bands <0.5 in. thick; also includes a 2-in.-thick, light-brownish-gray (5YR6/1), fractured limestone concretion at base of unit	32.3	13.0
Shale, medium-dark-gray (N4), very silty, weakly calcareous to noncalcareous; includes scattered pyrite-filled burrows and light-brown (5YR6/4) sideritic concretions; silt content decreases downward; base gradational	45.3	20.7
Shale, medium-dark-gray (N4), noncalcareous to weakly calcareous (mostly noncalcareous); contains rare, pyrite-filled bioturbation features and scattered brownish-gray (5YR4/1) sideritic bands; sideritic bands more closely spaced below 130 ft; includes calcareous brachiopod fossils below 143 ft, as well as rare laminae of white (N9) calcite; base sharp	66.0	111.1
Fort Scott Formation		
Shale, grayish-black (N2), very calcareous, fossiliferous; contains		



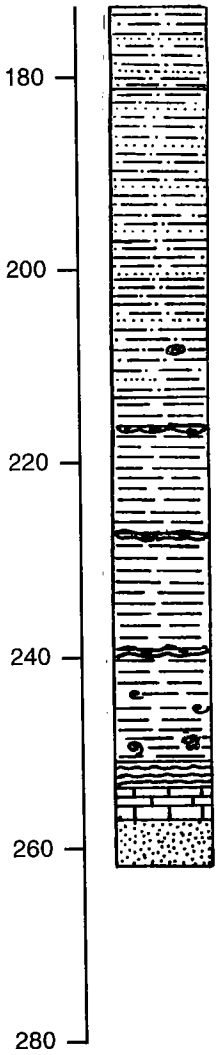
crinoid ossicles and shell fragments, some scattered and some concentrated in 0.5- to 1.0-in. layers; includes minor pyrite in blebs, streaks, and crusts; base gradational (top of Little Osage Shale)	177.1	4.0
Shale, grayish-black (N2), noncalcareous; includes rare white calcite in veins and in fossil shell fragments, becomes calcareous in lower 8 in.; base gradational	181.1	3.4
Limestone, light-gray (N7) to light-brownish-gray (5YR6/1), (skeletal wackestone to packstone to grainstone), good bimoldic porosity, contains poorly preserved fossil shells and crinoid ossicles, irregular-bedded; includes dark-gray (N3), wavy, wispy, shaly laminae in some intervals, with sparry calcite partially filling cavities and replacing fossils throughout; includes several fusulinid-rich layers in medium-dark-gray (N4) matrix from 197 to 203 ft; stylolitic in places, base gradational (Blackjack Creek Limestone)	184.5	27.0
Cabaniss Group		
Senora Formation		
Shale, grayish-black (N2), weakly calcareous and slightly fossiliferous in upper 2 in.; noncalcareous in lower part; contains pyrite, mostly in crusts along fractures and in laminae on bedding planes; includes rare phosphatic nodules; very brittle; base moderately sharp (Excello Shale)	211.5	5.3
Limestone, dark-gray (N3) with white (N9) fossils (skeletal lime mudstone); grades downward into medium-light-gray (N6), fine-grained limestone with indistinct fossils and fossil debris (skeletal wackestone to packstone); stylolitic in places; includes bands of dark-gray (N3), fossiliferous, muddy limestone (skeletal lime mudstone); very hard and dense; weakly bioturbated; includes some sparry calcite; base gradational (Breezy Hill Limestone)	216.8	9.4
Shale, medium-gray (N5), fossiliferous, calcareous; contains abundant crinoid and shell debris, as well as rare pyrite; base gradational (top of Kinnison Shale)	226.2	0.4
Shale, grayish-black (N2) with white (N9) fossil shell fragments; weakly calcareous; very pyritic in lower 1 in.; base sharp, irregular	226.6	0.3
Coal, black (N1), moderately hard, finely cleated, contains calcite and pyrite in fractures, base sharp (Iron Post coal)	226.9	0.9
Shale, grayish-black (N2), very carbonaceous, coaly in part, pyritic; base sharp, flat	227.8	0.1
Sandstone, medium-gray (N5), very fine-grained, silty, noncalcareous, rooted, churned, contains abundant carbonized and pyritized plant material (Lagonda Sandstone)	227.9	1.6
Total Depth		229.5

Core-Hole Log 5
(C-RM-4)



NW¼NE¼SE¼NE¼ sec. 15, T. 21 N., R. 15 E., Rogers County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in pasture, just southeast of farm pond, 1,620 ft FNL and 460 ft FEL. (Surface elevation, estimated from topographic map, 600 ft.)

	Depth to unit top (ft)	Thickness of unit (ft)
DESMOINESIAN SERIES		
Cabaniss Group		
Senora Formation		
Limestone, grayish-orange (10YR7/4) to moderate-yellowish-brown (10YR5/4) to light-brownish-gray (5YR6/1) (skeletal wackestone), hard; fossils consist predominantly of crinoid ossicles and shell fragments; weakly bioturbated; weathered in upper part; contains black carbonaceous material in wisps and fragments; base gradational (Breezy Hill Limestone)	0.0	11.0
Shale, medium-dark-gray (N4), very calcareous; fossiliferous, especially in upper part; fossils consist mostly of shell fragments; base gradational (top of Kinnison Shale)	11.0	0.4
Shale, grayish-black (N2); noncalcareous, but contains white (N9) calcareous, fossil shell fragments; includes pyritized fossils in lower inch; base sharp	11.4	0.2
Coal, black (N1), moderately hard, contains moderate-reddish-brown (10R4/6) iron oxide deposits on cleat surfaces, finely cleated, base sharp (Iron Post coal)	11.6	0.9
Underclay, medium-gray (N5) to medium-dark-gray (N4); silty; silt content increases downward; moderately bioturbated; contains abundant black carbonized plant fragments; base gradational	12.5	2.0
Sandstone (50%) interstratified with shale (50%), medium-light-gray (N6), and medium-dark-gray (N4), noncalcareous, wavy-bedded; contains scour surfaces and low-angle cross-stratification; base sharp (top of Lagonda Sandstone)	14.5	1.6
Limestone, medium-dark-gray (N4), (skeletal lime mudstone); contains abundant fossil crinoid and shell fragments; porous; weathered to grayish-orange (10YR7/4) along a fracture zone; base sharp	16.1	0.4
Shale (80%), medium-dark-gray (N4), with stringers and lenses of light-gray (N7), very fine-grained sandstone, noncalcareous, weakly to moderately bioturbated, base gradational	16.5	0.8
Shale, medium-dark-gray (N4) to dark-gray (N3), noncalcareous; contains scattered black carbonized plant fragments and minor pyrite, base sharp	17.3	1.5
Siltstone, medium-dark-gray (N4); noncalcareous, but contains current-oriented fossil fragments concentrated in upper 3 in.; also contains black carbonized plant fragments; base gradational	18.8	0.7



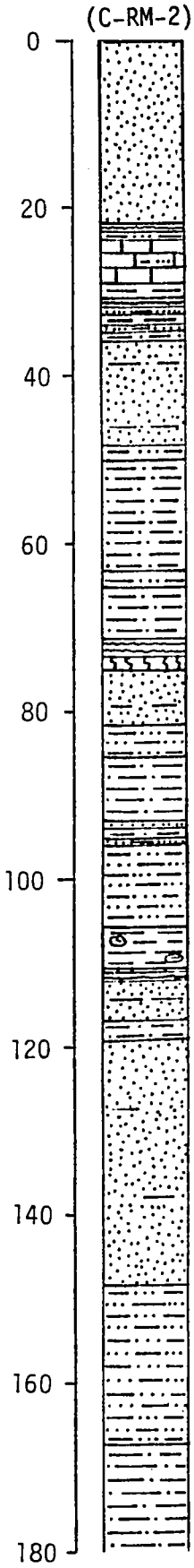
Sandstone (55%), silty, shaly, light-gray (N7) and medium-dark-gray (N4); contains scour surfaces, low-angle cross-stratification, and black carbonized plant fragments; moderately to strongly bioturbated, especially in upper part	19.5	4.5
Shale, medium-dark-gray (N4), noncalcareous; contains very fine-grained sandstone lenses and stringers, especially in upper half; includes rare disseminated pyrite; weakly bioturbated; base gradational	24.0	6.0
Shale, medium-dark-gray (N4), noncalcareous; contains light-brownish-gray (5YR6/1) sideritic bands about 0.5 to 1.5 in. thick; includes pyrite in lenses, irregular layers, and disseminated throughout; contains sparse bioturbation features; base gradational	30.0	10.0
Shale, medium-dark-gray (N4), noncalcareous, contains light-brownish-gray (5YR6/1) sideritic concretions from 0.5 to 1 in. thick; includes thin laminae of light-gray (N7) siltstone and very fine-grained sandstone; contains sparse bioturbation features, mostly in lower 4 ft of unit; base gradational	40.0	12.2
Shale, grayish-black (N2); noncalcareous, but includes layers of calcareous fossil shell and crinoid fragments in lower part; weakly bioturbated; base gradational	52.2	0.2
Limestone, medium-dark-gray (N4) to light-brownish-gray (5YR6/1) (skeletal mudstone); includes abundant white (N9) fossil shell and crinoid fragments, moderately bioturbated; base gradational (top of Verdigris Limestone)	52.4	0.9
Limestone, medium-light-gray (N6) (skeletal wackestone to packstone), dense, very hard; contains scattered shells and crinoid ossicles; includes some sparry calcite in recrystallized fossils and in fracture-fillings, and rare pyrite; weakly bioturbated; base gradational	53.3	1.8
Limestone, medium-dark-gray (N4) to light-brownish-gray (5YR6/1) (skeletal mudstone); includes abundant white (N9) fossil shell and crinoid fragments, moderately bioturbated; base gradational	55.1	0.9
Shale, dark-gray (N3); noncalcareous in upper half to calcareous with abundant fossil shell and crinoid fragments in lower part; base gradational	56.0	0.2
Limestone, medium-light-gray (N6) (skeletal wackestone to packstone), dense, very hard; contains scattered shells and crinoid ossicles; includes some sparry calcite in recrystallized fossils and in fracture-fillings, and rare pyrite; weakly bioturbated; base gradational	56.2	3.5
Limestone, medium-dark-gray (N4) to light-brownish-gray (5YR6/1) (skeletal mudstone); includes abundant white (N9) fossil shell and crinoid fragments, moderately bioturbated; base gradational	59.7	0.7
Limestone, medium-light-gray (N6) (skeletal wackestone to packstone), dense, very hard; contains scattered shells and crinoid ossicles; includes some sparry calcite in recrystallized fossils and in fracture-fillings, and rare pyrite; weakly bioturbated; base		

gradational	60.4	0.7
Shale, black (N1); noncalcareous, but includes some small, white (N9) calcareous, fossil shell and crinoid fragments in upper part; contains phosphatic nodules; slickensided in places	61.1	2.0
Shale, medium-gray (N5) with light-gray (N7) bands; noncalcareous except for a 1-in.-thick fossiliferous layer at top of unit; includes laminae and very thin beds of siltstone; contains minor stringers of pyrite as well as light-brownish-gray (5YR6/1) calcareous and noncalcareous sideritic concretions up to 2 in. thick; includes rare fossil shells within the calcareous concretions, and rare bioturbation features; contains calcite fracture-fillings from 73.6 to 74 ft; base gradational	63.1	26.9
Shale, medium-gray (N5), interlaminated with light-gray (N7), very fine-grained sandstone and siltstone stringers (40%); sandstone content increases downward; unit contains low-angle, small-scale cross-stratification, and rare bioturbation features; base gradational (Oowala Sandstone)	90.0	4.4
Shale, medium-gray (N5), includes minor laminae of light-gray (N7), very fine-grained sandstone as well as scattered 0.5- to 2-in.-thick, light-brownish-gray (5YR6/1) sideritic concretions	94.4	12.1
Shale, grayish-black (N2), very carbonaceous; contains coal stringers	106.5	0.2
Coal, black (N1), finely cleated, moderately friable; includes white (N9) kaolinite and minor pyrite on cleat surfaces; base sharp (Croweburg coal)	106.7	1.2
Mudstone, dark-gray (N3), very silty and sandy, carbonaceous; contains abundant black (N1), carbonized plant fragments; base irregular	107.9	0.2
Limestone, light-gray (N7) with dark-gray (N3) streaks, (skeletal mudstone), mottled, strongly bioturbated; contains vuggy porosity, fossil fragments and carbonaceous streaks; includes pyritized burrows; base bioturbated (McNabb Limestone)	108.1	1.0
Mudstone, dark-gray (N3) to medium-dark-gray (N4), very sandy; contains calcareous burrow-fillings in upper part; includes abundant carbonized plant material; grades into underlying unit	109.1	1.9
Shale, medium-gray (N5), interbedded with light-gray (N7) sandstone and siltstone (25%); includes soft-sediment-deformation features; microfaulted; cross-laminated; moderately bioturbated; some burrows pyritic; base gradational	111.0	6.3
Shale, medium-gray (N5), weakly bioturbated; contains rare calcite crusts on parting surfaces; includes pyrite in thin laminae, lenses, and burrow-fillings; contains light-brownish-gray (5YR6/1) sideritic concretions up to 1.5 in. thick below 124.5 ft; includes a black (N1), carbonized plant compression at 124.9 ft; base gradational	117.3	11.2
Shale, medium-dark-gray (N4); noncalcareous, but includes white (N9), calcareous shells in upper and lower parts in association with 2-in.-thick light-brownish-gray (5YR6/1) sideritic concre-		

tions; limey mudstone occurs for about 1 in. above and 1 in. below the concretions; burrows filled with fossiliferous, calcareous mudstone extend downward into underlying unit	128.5	2.3
Shale, medium-gray (N5) with some light-gray (N7), very fine-grained sandstone laminae (10%), weakly bioturbated; minor pyrite in burrows; some sandstone lenses and layers cross-laminated	130.8	7.5
Shale, medium-gray (N5), interbedded with light-gray (N7) very fine-grained sandstone (40%); moderately bioturbated; wavy to lenticular-bedded; includes rare light-brownish-gray (5YR6/1) sideritic concretions; base sharp	138.3	8.4
Shale, grayish-black (N2) to dark-gray (N3) to medium-dark-gray (N4), very carbonaceous; includes abundant thin coal streaks throughout, and a 1-in.-thick coal layer (Mineral coal) at about 147.8 ft; base sharp	146.7	1.8
Sandstone, light-gray (N7) to medium-light-gray (N6), very fine-grained, noncalcareous, moderately bioturbated to about 152 ft; contains abundant soft-sediment-deformation features such as flow rolls, loads, and contorted bedding; cross-bedded in part; includes rare carbonized plant fragments and bioturbation features below 152 ft; minor shale laminae throughout, except where massive, shale content increases in lower 2 ft; base gradational (top of Chelsea Sandstone)	148.5	14.5
Sandstone, medium-dark-gray (N4) with medium-light-gray (N6) bands; very fine-grained, cross-bedded, weakly bioturbated, very shaly (30%), base gradational	163.0	3.4
Shale, medium-dark-gray (N4), sandy, includes minor laminae of light-gray (N7), very fine-grained sandstone; base gradational	166.4	1.9
Sandstone, medium-gray (N5) (50%), interstratified with sandy shale; very fine-grained; contains contorted bedding, cross-bedding, wavy laminae and minor light-brownish-gray (5YR6/1) sideritic concretions; base gradational	168.3	5.3
Shale, medium-dark-gray (N4), sandy, includes minor laminae of light-gray (N7), very fine-grained sandstone; contains rare pyritized plant fragments; base gradational	173.6	8.7
Shale, medium-dark-gray (N4), very sandy (10–20%); contains rare black (N1), carbonized plant fragments; includes thin laminae of light-gray (N7), very fine-grained sandstone; contains rare bioturbation features; includes some wavy, cross-laminated sandstone lenses; contains rare sideritic concretions below 208 ft; sand content diminishes with depth; base gradational	182.3	32.0
Shale, medium-dark-gray (N4) with medium-light-gray (N6) siderític(?) bands, noncalcareous; includes rare calcareous brachiopod fossils on bedding planes below 244 ft; contains scattered pyritic burrow-fillings; includes rare black (N1), carbonized, pyritic plant fossils below 248 ft; grades downward into dark-gray (N3) shale	214.3	38.0

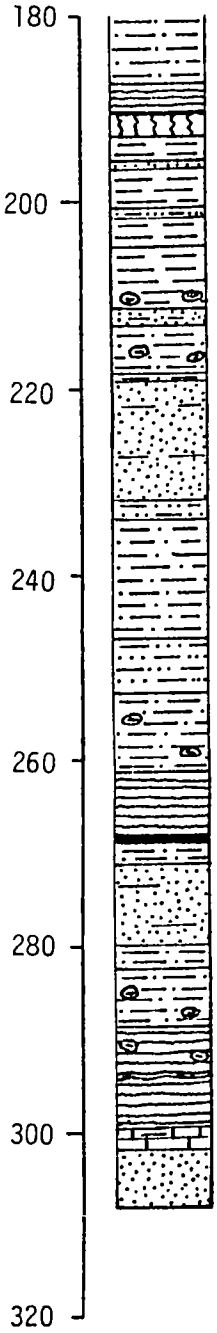
Shale, dark-gray (N3) to grayish-black (N2), weakly bioturbated; contains pyrite-filled burrows; includes 1.5- to 2-in.-thick calcareous concretions at 253.9 and 254.4 ft; slickensided in places; contains some carbonized and pyritized plant fragments in lower 1 in. of unit; base sharp, bioturbated	252.3	2.9
Limestone, light-gray (N7) to light-brownish-gray (5YR6/1) (skeletal mudstone); contains abundant white (N9) fossil shell and crinoid fragments; weakly bioturbated; stylolitic in places; includes grayish-black (N2) carbonaceous shale in layers and wisps in places; basal contact irregular, bioturbated (Tiawah Limestone)	255.2	3.1
Sandstone, light-gray (N7), fine-grained, noncalcareous, mostly massive, weakly bioturbated; total thickness undetermined	258.3	4.6
Total Depth		262.9

Core-Hole Log 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

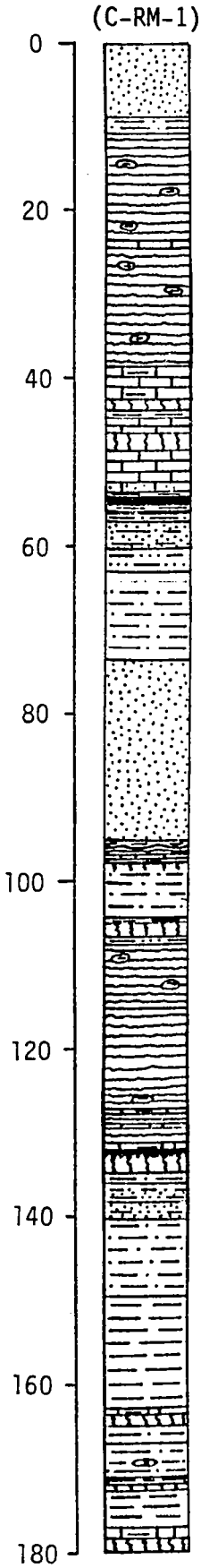


Siltstone, medium-gray with light-gray sandstone streaks, noncalcareous, shaly, flat-bedded; includes rare burrows and black, macerated plant material on some bedding planes	63.1	1.9
Shale, medium-dark-gray, silty, noncalcareous	65.0	6.2
Shale, grayish-black, very calcareous; contains irregular bands 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 (Taft Sandstone).....	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

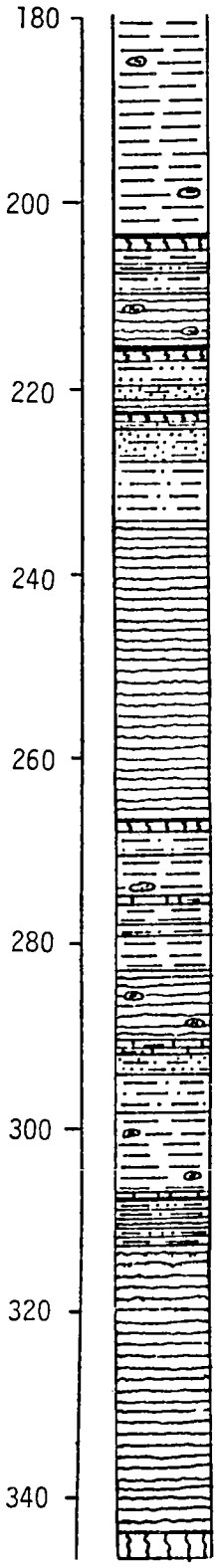
Shale, dark-gray with light-gray, very fine-grained sandstone streaks, noncalcareous, burrowed	268.9	2.8
Sandstone, light-gray and medium-dark-gray, very fine-grained, interbedded with shale, noncalcareous, wavy-bedded to cross-bedded, micaceous; black, macerated plant debris on bedding planes; burrowed 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

Core-Hole Log 7
(C-RM-1)

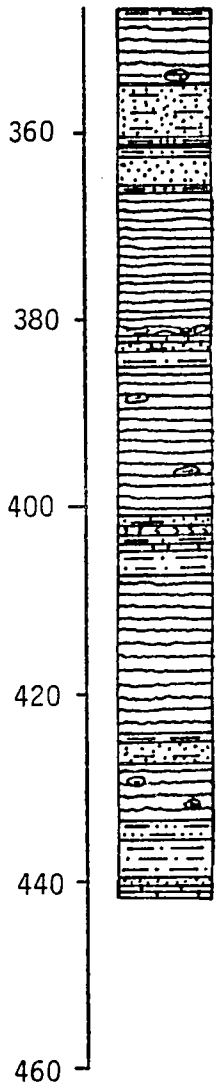


SE 1/4 SE 1/4 SW 1/4 NW 1/4 sec. 18, T. 21 N., R. 18 E., Mayes County, Oklahoma. Well cored by Oklahoma Geological Survey; lithologic descriptions by LeRoy A. Hemish. Drilled in pasture on hill south of pond. (Surface elevation, estimated from topographic map, 815 ft.)

	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, noncalcareous, 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