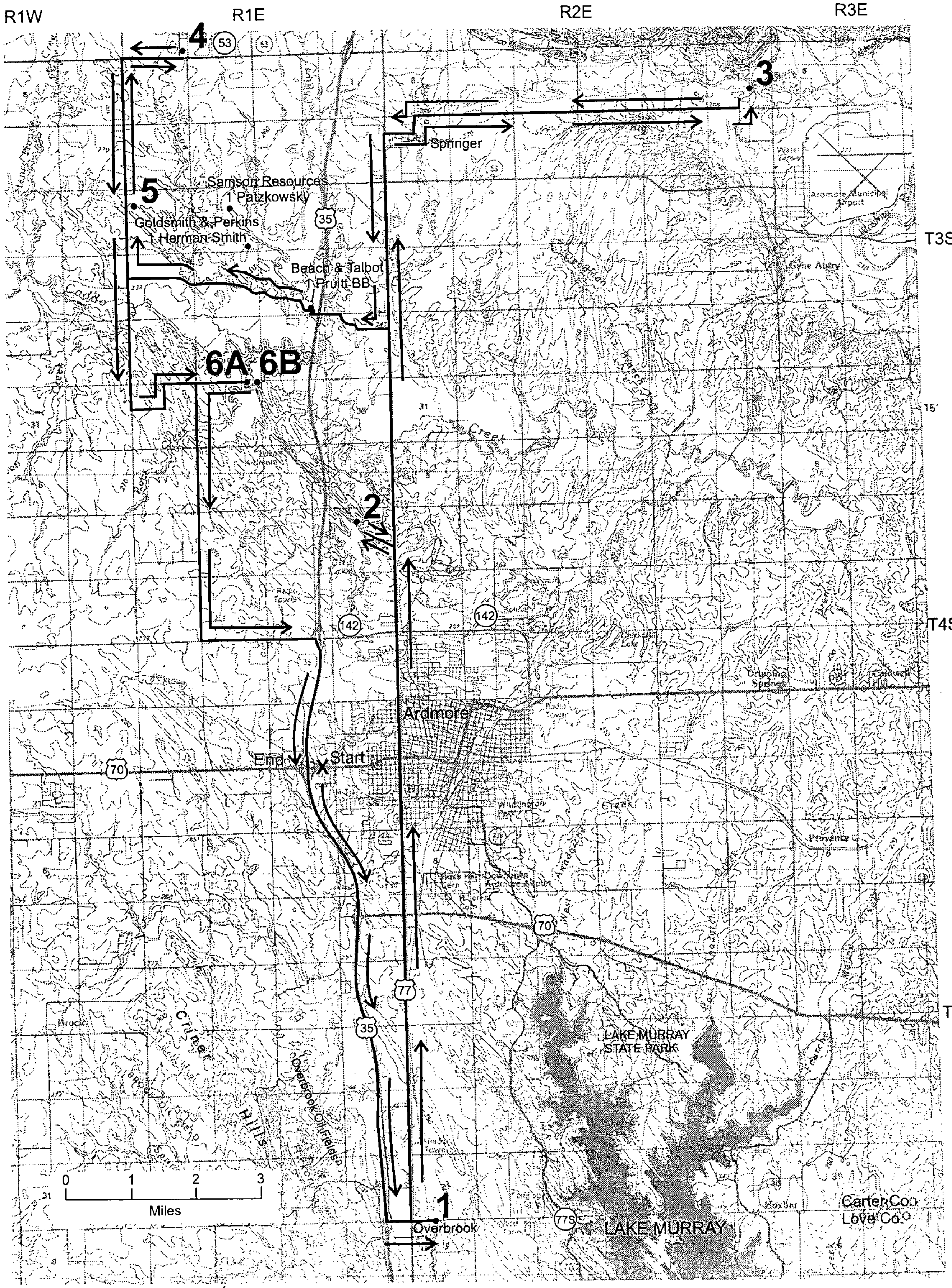
Stratigraphy and Depositional Environments of the Sandstones of the Springer Formation and the Primrose Member of the Golf Course Formation in the Ardmore Basin, Oklahoma

Oklahoma Geological Survey

Guidebook 32

Map of Field-Trip Stops



Modified excerpt from Ardmore, Oklahoma-Texas 30′ × 60′ quadrangle map (U.S. Geological Survey, 1986).

Oklahoma Geological Survey
Charles J. Mankin, *Director*

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LeRoy A. Hemish and Richard D. Andrews

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The Springer field trip has been offered in conjunction with a one-day workshop on the Springer gas play. The workshop information is covered in a companion publication, **Springer Gas Play in Western Oklahoma**, *by Richard D. Andrews (OGS Special Publication 2001-1).*

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Oklahoma Geological Survey
and
Petroleum Technology Transfer Council

South Midcontinent Region
PTTC

The University of Oklahoma
Norman, Oklahoma
2001

Front Cover

Tabular sandstone beds of the Rod Club Sandstone Member of the Springer Formation exposed on the Caddo anticline at Stop 5. The beds strike N. 50° W., and are vertical. The top surface of the beds is to the left in the photograph. The highest point on the outcrop is ~11 ft above ground level.

Photograph by LeRoy A. Hemish

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PREFACE

This guidebook presents information on selected sandstone units in the Springer Formation (which straddles the Mississippian–Pennsylvanian boundary) and in the lower Golf Course Formation (Pennsylvanian) in the Ardmore basin of south-central Oklahoma. The guidebook is divided into two parts: Part I, general geology of the field-trip area; and Part II, descriptions of six field-trip stops near the City of Ardmore, Oklahoma. Some of the information presented is new and some is updated. The focus of the field trip is on viewing outcrops of rocks that, in the subsurface, are hydrocarbon reservoirs. At four of the stops, surface gamma-ray profiles of the outcrops have been made by the authors; they are compared with subsurface log signatures and samples. In addition, descriptions of cuttings from two wells drilled on the Caddo anticline are included as lithologic logs in appendixes; the cuttings are from stratigraphic intervals that are the focus of the field trip. Interpretations of depositional environments are emphasized in Part II. It is our hope that this guidebook will help its readers better understand how important correct interpretation of depositional environments and facies is to successfully predicting the potential of a reservoir rock.

For their assistance in producing this guidebook, we wish to thank Christie Cooper, Oklahoma Geological Survey (OGS) managing editor, and her staff (particularly Frances Young, technical editor). We also thank T. Wayne Furr, OGS manager of cartography, as well as Jim Anderson and Laurie Lollis, OGS cartographers. We are grateful to Jan Coleman for helping to type the manuscript and to Robert Allen and Robert Northcutt for reviewing an early draft of the manuscript. We also thank Robert Kelley, Michael G. McCauley, and Jim Trail, who gave us permission to view Springer Formation outcrops on their properties.

LeRoy A. Hemish and Richard D. Andrews
Field-Trip Leaders

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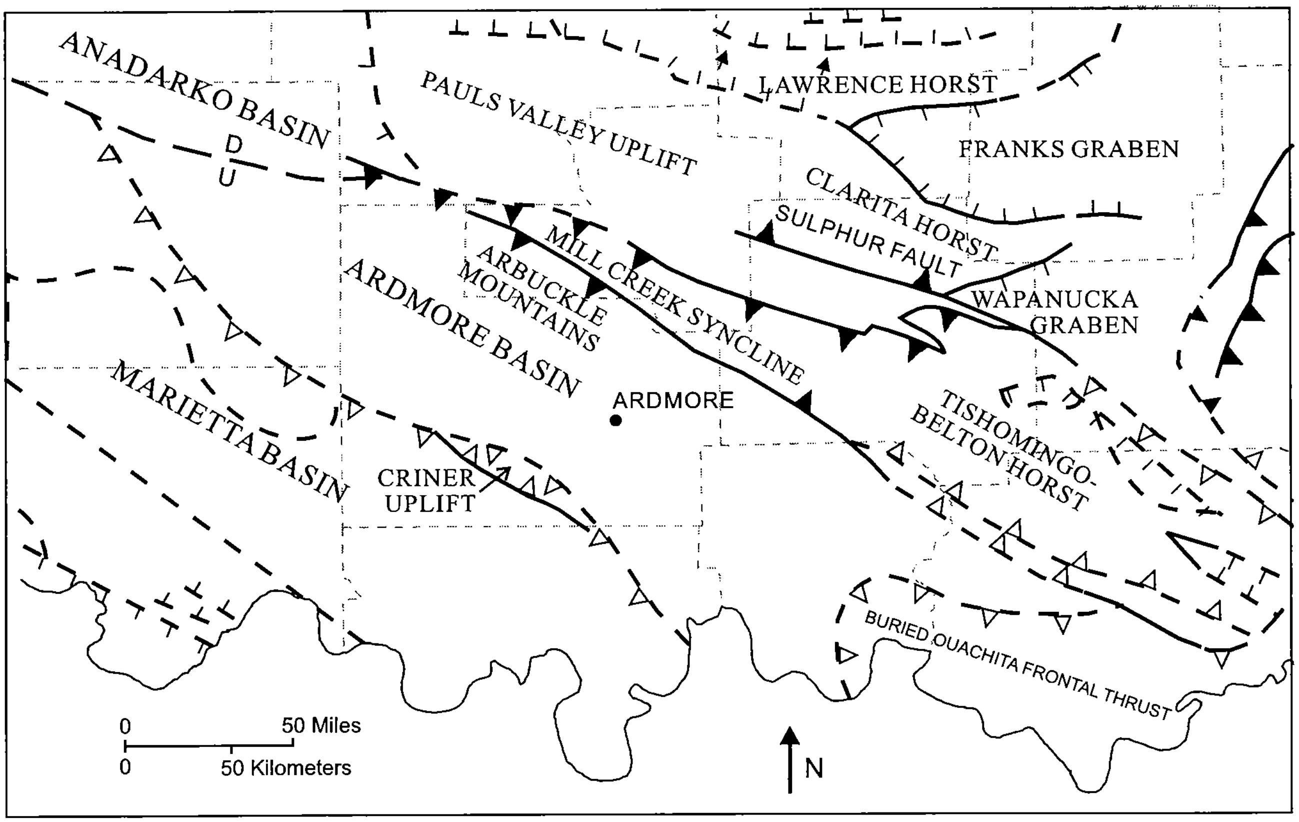
PART I

General Geology

INTRODUCTION

Exposures of rocks in the Springer Group (Chesterian–Morrowan) and in the lower part of the Dornick Hills Group (Primose Member of the lower Golf Course Formation [Morrowan]) are found only within the Ardmore basin (Meek and others, 1988) (Fig. 1). In Oklahoma, the Springer Formation is known to be present in the subsurface only in the Anadarko and Ardmore basins, and in very few, if any, other places in the United States (Robert Allen, personal communication, 2000). Exposures of the named sandstone units in the Springer and Golf Course Formations are of particular interest because, in the subsurface, the sandstones are important hydrocarbon reservoirs. Subsurface nomenclature differs from that of the surface. More sandstone units have been named informally in the subsurface, which makes correlation with the formally named surface units problematic (inside back cover).



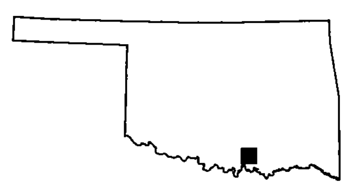


Figure 1. Map of the geologic provinces of south-central Oklahoma showing the positions of the Ardmore basin and related provinces. Modified from Northcutt and Campbell (1995).

GEOLOGIC SETTING

The Ardmore basin is an elongate northwest–southeast-trending structure located in south-central Oklahoma (Fig. 1). It lies between the Criner Hills uplift to the southwest and the Arbuckle Mountains and Pauls Valley uplift to the north. To the southeast, the Ardmore basin extends below the overriding Ouachita thrust belt, and both are buried, in part, by overlapping Cretaceous sediments. To the northwest, the Ardmore basin is separated from the Anadarko basin by a major fault with a displacement of as much as several thousand feet, downthrown to the north.

Curtis and Ham (1979) show the Ardmore basin as a geomorphic province characterized by lowlands of folded Mississippian and Pennsylvanian shales and sandstones lying between the Arbuckle Mountains to the north and the Dissected Coastal Plain to the south. The City of Ardmore is located in the south-central part of the area, and Lake Murray lies a few miles to the southeast of Ardmore (inside front cover).

Sandstones form resistant ridges on the flanks of folds, adjacent to broad, flat valleys underlain by shale. Caddo Creek (inside front cover) flows across the area from northwest to southeast to join the Washita River. Elevations within the Ardmore basin range in general from just under 700 ft (along Caddo Creek) to ~1,000 ft above sea level.

STRUCTURAL GEOLOGY

The structural geology of the Ardmore basin is complex and detailed analyses or interpretations are beyond the scope of this guidebook. However, a brief introduction to the evolutionary history of the basin is important to an understanding of the depositional processes that affected the Springer and Golf Course Formations. The rate of basinal subsidence, the length of time involved, and the provenance of the sediments determined the thickness, geometry, and lithology of the units.

According to Ham (1963, p. 15; Ham and others, 1964, p. 9), the southern Oklahoma geosyncline was initiated by a great intra-cratonic sag that developed upon a deeply eroded continental craton during the late Precambrian. The explanation of Hoffman and others (1974) for these processes involves modern plate tectonic theory, and they use the term "aulacogen" to describe the southern Oklahoma structural feature. (Aulacogens are structural troughs that extend at a high angle from a continental margin onto the craton. An aulacogen first develops as a rift valley; later, it subsides more rapidly than the adjoining continental platform and forms a deep trough that dies out onto the craton [Hoffman and others, 1974].) According to Ham (1963, p. 15; Ham and others, 1964, p. 9, 150), the development of the southern Oklahoma geosyncline took place in three stages. In its earliest stage (basement-rock stage), which was eugeosynclinal, it was bounded by faults and filled with graywacke, bedded chert, spilitic basalt, and rhyolite (Early and Middle Cambrian in age) to a probable thickness of 20,000 ft. At this stage, the trough was ~100 mi wide and, in what is now Oklahoma, nearly 300 mi long. It extended southeastward into an area subsequently overridden by the Paleozoic Ouachita thrust belt (Fig. 1). Before this first stage ended with the outpouring of thick rhyolites and with general emergence, major faults originated along opposite margins of the newly modified basin. The basin was downthrown at least one mile as a graben (Ham, 1963, p. 18; Ham and others, 1964, p. 9).

The second stage was dominated by the deposition of carbonate rocks from Late Cambrian through Devonian time, and the third stage was marked by the deposition of clastic sediments, Mississippian, Pennsylvanian, and Permian in age (Ham and others, 1964, p. 150–151). Sedimentary strata above the basement rocks range in thickness from 30,000 to 40,000 ft (Ham and others, 1964, p. 10). In the Permian, the southern Oklahoma geosyncline collapsed by strong folding accompanied by thrust faulting (Ham and others, 1964, p. 10).

More recent works by Gilbert and Donovan (1982), Coffman and others (1986), Gilbert (1986, 1992), Granath (1989), McConnell and Gilbert (1990), and Hogan and Gilbert (1995) support Ham's earlier interpretations of the evolution of the southern Oklahoma aulacogen (SOA). Hogan and Gilbert (1995, p. 41) state that:

> The SOA (Hoffman et al., 1974) is one of several aulacogens that developed during rifting of the Laurentian Supercontinent in Late Proterozoic to Cambrian time.... Subsequent to Cambrian rifting, a large interior basin developed over the SOA and igneous rocks of the rifting event were buried by up to 4–5 km of Cambrian to Mississippian sediments (Gilbert, 1992). During late Mississippian to early Pennsylvanian time, igneous rocks of the SOA were uplifted as large fault-bounded blocks as a result of plate collisions associated with the Ouachita Orogeny.

Included within the region of maximum subsidence of the southern Oklahoma aulacogen are the Ardmore basin, the Anadarko basin, the Marietta basin, and, at the western edge of the Arbuckle uplift, the closely folded Arbuckle Mountains (Fig. 1). In the Ardmore basin, the west–northwest alignment of folds and faults is a pervasive structural trend that developed during the Late Paleozoic orogeny (Pruatt, 1975, p. 3). Ham and others (1964, p. 10) say that "the basement rocks of the Wichita Province influenced the magnitude and intensity of folding that occurred during the several stages of Pennsylvanian orogeny." Where it is covered by sediments of the Ouachita frontal thrust (Fig. 1), the Ardmore basin contains a thickness of 5.8 mi of Paleozoic strata (Pruatt, 1975, p. 4).

Local structural features of importance in, and adjacent to, the Ardmore basin include the Arbuckle Mountains, Berwyn syncline, Caddo anticline, Criner Hills uplift, Glenn syncline, Overbrook anticline, and Woodford anticline (Fig. 2). Dionisio (1975) and Ghazal (1975), respectively, mapped the eastern and western parts of the Caddo anticline and produced geologic maps showing the outcrop areas of the strata that are the focus of this field trip. In general, dips on rocks on the flanks of the structures in the field-trip area are steep; most are 50°–85°. In places where the beds are nearly vertical and erosion has removed the less resistant shales from around the sandstones, it is possible to study not only the tops and soles of the beds but also the layered sequences within each unit.

STRATIGRAPHY, PETROLOGY AND PETROGRAPHY

General Overview

Upper Mississippian (Chesterian) and Lower Pennsylvanian (Morrowan) strata in the Ardmore basin consist primarily of shallow to deep marine shelf facies. The focus of this guidebook is on two units within these strata—the Springer Formation and the Primrose Member of the Golf Course Formation. The Springer Formation (which straddles the Mississippian–Pennsylvanian boundary) is composed almost entirely of shales and sandstones, and the overlying Primrose Member of the Golf Course Formation (Morrowan) is composed mostly of sandstone with interbedded shales of variable thickness (Fig. 3).

The Goddard Formation of the Springer Group underlies the Springer Formation (Fig. 3). It is a noncalcareous, fissile, mouse-gray shale containing some discontinuous pale yellowish orange sandstones in the upper 1,000 ft. The shales and sandstones are identical to those of the overlying Springer Formation, except that the sandstones are fewer and thinner. The Goddard Formation is 2,000–2,500 ft thick. It contains one formally named sandstone, the Red Oak Hollow (Elias, 1956) (Fig. 3).

The Springer Formation contains three unnamed shale members and three named sandstone members: (1) the Rod Club Sandstone, at the base; (2) the Overbrook Sandstone; and (3) the Lake Ardmore Sandstone. The three unnamed shale members are identified by their stratigraphic positions above each of the named sandstone members. The Target limestone, which was named and described by Bennison (1954), is a lentil within the Lake Ardmore Member. Elias (1956) identified more than 40 forms of invertebrate fossils from this limestone, including brachiopods, crinoids, bryozoans, rugose corals, and conodonts. Based on faunal evidence, Straka (1969, fig. 3)

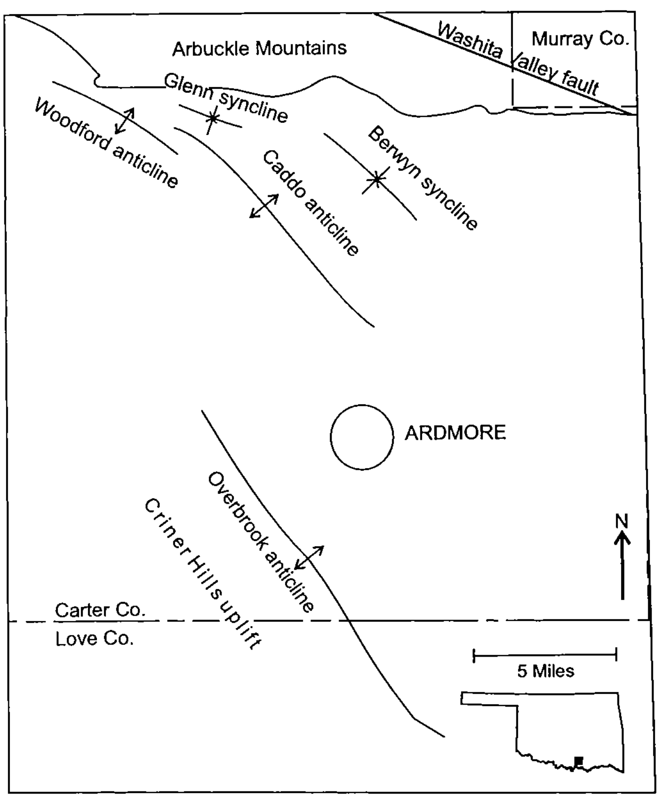


Figure 2. Structural features in, and adjacent to, the field-trip area in the vicinity of Ardmore, Oklahoma.

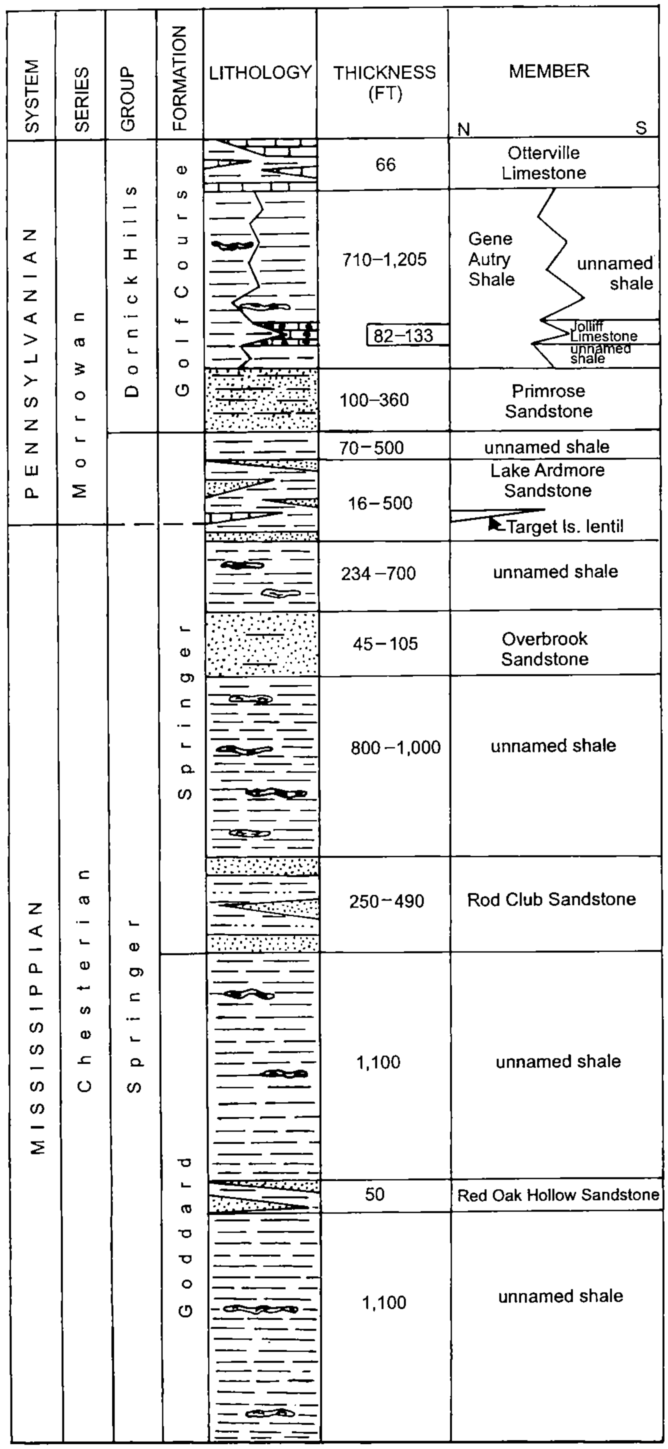


Figure 3. Generalized stratigraphic column showing the Springer Group and the lower part of the Dornick Hills Group in the Ardmore basin. Explanation of symbols in Appendix 1.

placed the Mississippian–Pennsylvanian (Chesterian–Morrowan) boundary at the base of the Target limestone, which occurs in a shale unit above the lowermost sandstone bed of the Lake Ardmore Member. The Springer Formation ranges in thickness from >1,400 ft to >3,200 ft (Fig. 3). Lithologic subsurface logs from the upper part of two wells drilled on the Caddo anticline show the relations of the members of the Springer in that area (Appendixes 2 and 3).

The Primrose Member of the Golf Course Formation overlies an unnamed shale of variable thickness at the top of the Springer Formation (Fig. 3). This unnamed shale unit is composed of dark gray ferruginous shale and scattered layers of rhythmically bedded siltstones (Meek, 1983, p. 44). As described in this guidebook (Part II, Measured Section, Stop 3, Unit 3), a black, noncalcareous, fissile shale, devoid of ironstone concretions, occupies the interval between the Lake Ardmore Sandstone and the Primrose Sandstone. The Primrose Sandstone is overlain by the Gene Autry Shale in the northern part of the Ardmore basin and by an unnamed shale containing the Jolliff Limestone in the south (Fig. 3). The 204 ft of the Gene Autry Shale just above the Primrose Sandstone consists mostly of dark gray to olive gray, highly calcareous shale containing interstratified layers of highly calcareous siltstone and very fine grained sandstone (Part II, Measured Section, Stop 3, Units 15–17 [this guidebook]). The overlying 104 ft consists of medium gray, noncalcareous shale containing numerous ironstone layers (Part II, Measured Section, Stop 3, Unit 18 [this guidebook]).

Stratigraphy

Rod Club Sandstone

The Rod Club Sandstone is the basal member of the Springer Formation as recognized by the Oklahoma Geological Survey (OGS). It is correlated with the Sims sand in the subsurface of the Ardmore basin (inside back cover). The 250–490-ft-thick Rod Club Member consists chiefly of shales but contains several ledges of discontinuous sandstone (Fig. 3). Meek (1983, p. 21) identifies as many as 11 sandstone beds in the Rod Club, which he describes as fine-grained, green-gray and buff, well-sorted quartzarenites containing wood fragments. According to Meek (1983), the depositional environments for the sandstones were, in general, marine bars and turbidites; paleocurrent data from flutes, ripples, cross-bedding, and soft-sediment microfaults indicate that the source area was to the northwest.

McBride (1986, p. 52, 54) reports that the Rod Club Sandstone in sec. 15, T. 3 S., R. 3 E., is a very fine grained, angular to subangular, well-sorted, porous quartzarenite that contains *Calamites*. Clay constituents include kaolinite and only minor amounts of illite and smectite. Cementing agents include quartz overgrowths and asphaltic hydrocarbons. Porosity (12–27%) in the Rod Club is mainly secondary, created by the dissolution of the clay matrix and framework grains (McBride, 1986).

Overbrook Sandstone

The Overbrook Sandstone is 800–1,000 ft above the Rod Club Sandstone and is 45–105 ft thick on the outcrop (Tomlinson and McBee, 1959, p. 11) (Fig. 3). It is correlated with the Humphrey's sand in the subsurface of the Ardmore basin (inside back cover). According to Meek and others (1988, p. 192), the Overbrook consists of discontinuous sandstone lenses deposited in a typical coarsening-upward deltaic sequence, and their paleocurrent data and the isopach indicate a sediment source to the northwest. We agree that the Overbrook has a coarsening-upward textural profile. However, our interpretation is that the Overbrook was deposited as a submerged, detached marine bar (offshore) in a relatively shallow, inner- to middle-shelf environment (see Stop 2, Part II, this guidebook).

According to McBride (1986, p. 54–55), the Overbrook Sandstone in sec. 6, T. 3 S., R. 3 E., is a very fine to fine grained, moderately well-sorted, subangular to well-rounded, locally porous subarkose. The clay matrix of the Overbrook Sandstone is similar to that in the Rod Club, and it accounts for as much as 33% of the total rock. It too consists of brownish kaolinite and minor amounts of illite and smectite. Quartz overgrowths and hematite, which are present as authigenic cements, constitute ~1% and ~50% of the rock, respectively. Porosity ranges from <1% to as much as 34%.

Lake Ardmore Sandstone

The Lake Ardmore Sandstone is the uppermost named member of the Springer Formation. It lies 234–700 ft above the Overbrook and is 16–500 ft thick (Tomlinson and McBee, 1959, p. 11; Meek, 1983, p. 26) (Fig. 3). It is correlated with the Aldridge sand in the subsurface (inside back cover). The Lake Ardmore is an interval of discontinuous sandstones interbedded with shales that typically includes three sandstones; at one locality, it includes the Target limestone lentil, a mixed skeletal packstone. The Lake Ardmore sandstones are similar to those of the Overbrook Member. They are commonly thin-bedded to massive, silica cemented, noncalcareous, and porous (Meek, 1983, p. 30). Limited data suggest transport of sediment from the north and the west, but the dominant source area was to the north (Meek, 1983, p. 33).

McBride (1986, p. 56–57) reported that the Lake Ardmore in sec. 15, T. 3 S., R. 3 E., is a light gray, very fine grained, well-sorted, angular to subrounded sublitharenite to litharenite. The matrix in the Lake Ardmore Sandstone is a smectitic clay, which constitutes 10–30% of the rock. Porosity is 0–22%.

Primrose Sandstone

The Primrose Sandstone marks the base of the Golf Course Formation of the Dornick Hills Group (Fig. 3). It lies 70–500 ft above the Lake Ardmore Member of the Springer Formation (Meek and others, 1988, p. 193). It consists of 100–360 ft of thinly bedded, light gray, calcareous sandstones and shales, and a few thin limestones (Meek, 1983, p. 38). The name "Primrose" applies to the same stratigraphic interval in the subsurface and in surface exposures (Jordan, 1957, p. 158) (inside back cover).

According to Meek (1983, p. 38–39), "the sandstones of the Primrose are distinctly different in mineralogy from the underlying Springer sandstones. The Primrose sandstones have calcareous cement, and they contain abundant pale green to brown glauconite (up to 30%). The Primrose sandstones also contain chert grains (up to 1%), and limestone rock fragments....Laminated carbonate mudstones and calcareous shale are locally found in this member. These contain silty laminae and minute sized fossil fragments....Fossils from the sandstones and limestones include sponge spicules, ostracods, crinoids, brachiopods, calcispheres, and wood fragments." According to Meek (1983, p. 42), the chert and limestone fragments in the Primrose indicate that the most likely source was the Criner Hills–Wichita uplift, or possibly another uplift further to the northwest. Brown and Corrigan (1997, p. 5) state that "the first Wichitan deformation is manifested by uplift of the Criner Hills. Wichitan deformation generated coarse-grained sediment supply from the south (Primrose Ss.) and separated the Marietta and Ardmore basins."

McBride (1986, p. 57–58) reports that, in sec. 3, T. 3 S., R. 2 E., the Primrose Sandstone is a fine-grained, angular to subangular, well-sorted sublitharenite to litharenite. Dark green glauconite pellets amount to 7–10% of the total rock. Scattered gray shale partings may be found throughout the Primrose. The clay matrix of the Primrose is mainly smectite but also includes minor amounts of kaolinite and illite. Clay is abundant in the Primrose, and it locally may account for as much as 58% of the total rock. Carbonate cement and asphaltic hydrocarbons also are present as bonding agents; they compose up to 40% and 3% of the rock, respectively. Porosity generally has been destroyed by calcite cements, clays, and asphaltic hydrocarbons and is only ≤5% (McBride, 1986, p. 58).

Petrology and Petrography

In general, the outcropping Springer sandstones and the Primrose Sandstone are composed of four types of sandstone: quartzarenite, subarkose, sublitharenite, and litharenite (McBride, 1986, p. 58). Figure 4 is a quartz-feldspar-rock (Q.F.R.) fragment diagram that shows the composition of the Springer sandstones and the Primrose Sandstone.

Quartz is the dominant framework grain in all four of the sandstone classifications; it averages 98% in the quartzarenites, 93% in the subarkoses, 79% in the sublitharenites, and 64% in the litharenites (McBride, 1986, p. 58). Feldspars make up 0.5–6% of the framework grains in the four classifications, and rock fragments (mostly glauconite pellets and fossil fragments) make up 0–35%.

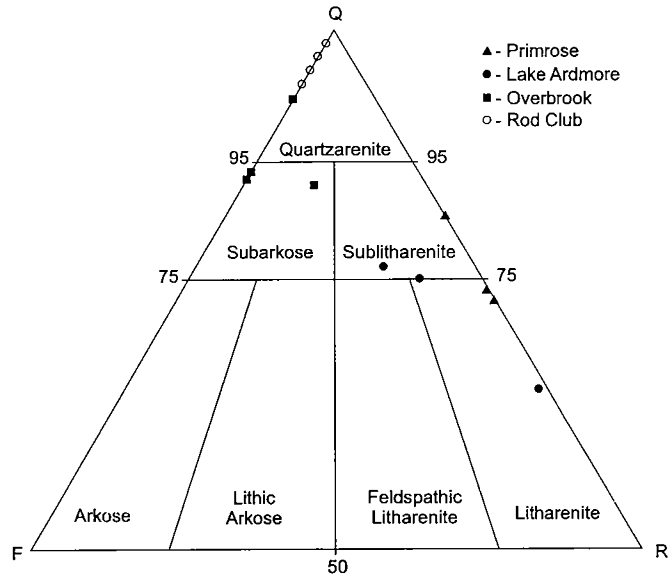


Figure 4. A quartz-feldspar-rock (QFR) diagram shows the composition (by percentage) of outcropping lower Morrowan and Springer sandstones according to Folk's (1974) classification. From McBride (1986, fig. 12).

Cement occurs as (1) quartz overgrowths; (2) carbonate minerals (mainly calcite and traces of siderite), both as intergranular cement and as grain replacements; and (3) hematite, which fills pores and is associated with partially corroded feldspar grains.

Asphaltic hydrocarbons compose 3–5% of some rocks sampled; they occur as pore-filling and pore-lining material, and as thick films of bitumen. Clay materials include kaolinite, smectite, and minor amounts of illite (McBride, 1986, p. 58–63).

PART II

Stop Descriptions

INTRODUCTION

The following descriptions are of rock outcrops that were judged by the authors to represent the best exposures in the field-trip area of all three Springer Formations Members, as well as of the Primrose Member of the Golf Course Formation. These outcrops exemplify important depositional environments.

At outcrops that contain a substantial portion of a representative Member (including overlying and/or underlying strata), detailed gamma-ray (GR) measurements were made of entire sections in order to plot GR responses for the various lithologies. The GR responses are different for shales and sandstones because minerals containing radioactive isotopes (potassium and thorium) tend to concentrate in clays and shales. Sandstones generally have smaller amounts of isotopic minerals. The surface GR profiles can be compared to well logs to correlate sandstone and shale sequences of surface Springer units with subsurface Springer strata penetrated in nearby wells. Surface GR profiles also can support the practice of interpreting lithology and depositional environments based only on well logs. This is possible because of the striking similarities between the GR responses for Springer units at the surface and those for subsurface units as shown on well logs. Through the use of such surface analogies, the character of subsurface sandstone beds can be accurately interpreted from modern well logs.

For this field trip, surface GR profiles were made using a Scintrex GRS-500 gamma-ray spectrometer/scintillometer. For statistical clarity, a 10-second time constant measuring total radiation (uranium plus thorium plus potassium) above 400keV was used for all outcrop GR measurements. GR measurements were made every 2 ft vertically except in diversified strata consisting of thick, discrete, alternating beds of sandstone and shale. In such lithology, measurements were made every vertical foot. In covered areas, GR measurements were made at larger intervals, often of several vertical feet where vegetation and/or soil was minimal.

Cuttings from the Springer Formation and some of the underlying strata from two wells in the study area were examined for comparison to outcrop rocks. Descriptions of cuttings from the Beach & Talbot No. 1 Pruitt BB well are presented in Appendix 2; those from the Goldsmith & Perkins No. 1 Herman Smith well are presented in Appendix 3. These wells were selected because of their location on the north flank of the Caddo anticline and their proximity to Stops 2, 5, 6A, and 6B.

In petroleum exploration and field development, it is very important to be able to interpret basic depositional environments, facies, and lithology from well logs. Working knowledge of this technique enables the geologist to predict reservoir quality and depositional orientation of sand bodies. It also aids in predicting the occurrence of certain types of deposits (both sandstone and nonreservoir deposits) and provides a good basis for predicting areal extent, thickness, and lateral variability of certain deposits.

Locations in this guidebook use standard section-township-range abbreviations. Rock-color terms are those shown on the rock-color chart (Rock-Color Chart Committee, 1991).

STOP 1

ROD CLUB (?) SANDSTONE MEMBER OF THE SPRINGER FORMATION (Overbrook Measured Section)

Location: SW¼SE¼SW¼ sec. 31, T. 5 S., R. 2 E., Carter County, and N½NE¼NW¼ sec. 6, T. 6 S., R. 2 E., Love County (Overbrook 7.5′ quadrangle)

Directions: From U.S. Highway 70, at the south edge of Ardmore, drive ~5 mi south on either Interstate Highway 35 or U.S. Highway 77 to the intersection with State Highway 77S; turn east and cross the Burlington-Northern-Santa Fe railroad tracks. The outcrop is on both sides of the road, ~250 yds east of the railroad tracks.

The sandstone exposed in the cuts on either side of S.H. 77S (Fig. 5) was named the "Overbrook" by Roth (1928). (Note that the sandstone called "Overbrook" on the Caddo anticline [see Stop 2, this guidebook] is not the same lithostratigraphic unit as the one here at its type locality [Straka, 1969].) Lang (1966) identified the sandstone that crops out near Overbrook, Oklahoma, as a Goddard sandstone, based on surface and subsurface studies. However, based on stratigraphic position, lithologic similarities, and interpretations of its depositional environment, we tentatively correlate the sandstone that crops out at Stop 1 with the lowest member of the Springer Formation—the Rod Club.

The thickness of the sandstone at this exposure is difficult to measure because of structural deformation. What appears to be an asymmetrical anticline with a steeply dipping east limb and a more gently dipping west limb can be observed in the road cuts (Fig. 5). Unit 2 (Fig. 6), a

Figure 5. Exposure of fine-grained, mostly massive, porous sandstone in the road cut on the north side of State Highway 77S at Stop 1. The arrow (upper right) points to the axis of the fold of what appears to be an asymmetrical anticline; the more gently dipping (west) limb is on the left in the photograph.

grayish red shale, is poorly exposed on the west flank of the structure in the north road ditch and again on the east flank. According to our interpretation, the base of the Rod Club and, therefore, of the Springer Formation is not exposed at this location.

Note the massive character of some of the sandstone beds, the channeling, and the facies changes in the outcrop. Also note the calcarenite layers and the abundance of trace fossils in shale Units 3–8 overlying the sandstone (Fig. 6). These features can be examined best in the cut south of the highway.

We interpret the depositional environment of the Springer sandstone at Stop 1 as that of a midfan turbidite channel deposit. The sandstone thickness differentiates it from lower turbidite facies, which often have more numerous, but thinner, sandstone beds. Sedimentary structures consisting of basal scouring, massive bedding, and soft-sediment deformation are very characteristic of the sandstone at Stop 1 and are typical of rapid deposition in a channel environment. However, there are no indicators of an interstratified delta-plain environment—such as coal, lagoonal or marsh deposits, or splays—nor is there any indication of a subaqueous delta front, which would have underlain a distributary channel. We do not interpret this Springer sandstone as an incised-channel or flood-plain sandstone because it is not known to be bounded stratigraphically or spatially with terrestrial sediments or to correlate with a basinward delta front; thus, its depositional environment was not a subaerial coastal plain. Exposures of the Springer sandstone in the woods south of the highway at Stop 1 reveal the persistent lateral extent of this sandstone, which is not characteristic of most channel deposits of a coastal or delta plain.

MEASURED SECTION, STOP 1

Rod Club (?) Sandstone Member of the Springer Formation (Overbrook Measured Section)

SW¼SE¼SW¼ sec. 31, T. 5 S., R. 2 E., Carter County, and N½NE¼NW¼ sec. 6, T. 6 S., R. 2 E., Love County (Overbrook 7.5′ quadrangle). Measured by LeRoy A. Hemish in the road cut, north and south of State Highway 77S, from ~250 yds east of the railroad tracks to the field driveway at the east end of the cut. Beds strike N. 5° W. and dip N. 85° E. at 55°.

	Thickness (feet)
SPRINGER FORMATION	
UNNAMED SHALE	
9. Shale, medium dark gray (N4) to dark yellowish brown (10YR4/2) with dark yellowish orange (10YR6/6) mottling; noncalcareous; contains numerous moderate reddish brown (10R4/6) to light brown (5YR5/6) ironstone layers 0.5–2.0 in. thick; in places, a 0.25-in.-thick pale yellowish orange (10YR8/6), bioturbated limestone occurs in abundance as float chips on the outcrop (not observed in situ)	80.0
8. Shale, medium gray (N5) to dark yellowish brown (10YR4/2) with dark yellowish orange (10YR6/6) mottling; noncalcareous; includes some 0.5-in.-thick light brown (5YR5/6) ironstone layers; contains beds of very light gray (N8) to yellowish gray (5Y7/2) calcarenite 0.5–2.5 in. thick that contain abundant trace fossils	20.0
7. Shale, grayish red (10R4/2); contains a pale red (5R6/2) limestone layer 2.5 in. thick, numerous 0.5–1.0-in.-thick moderate reddish brown (10R4/6) ironstone layers, and several 0.5–1.5-in.-thick yellowish gray (5Y7/2) calcarenite layers with abundant trace fossils	15.0
6. Shale, grayish orange (10YR7/4), very sandy, calcareous; includes abundant 0.5–2.0-in.-thick layers of grayish orange (10YR7/4) calcarenite with abundant trace fossils	6.5
5. Calcarenite, very pale orange (10YR8/2) to grayish orange (10YR7/4), very fine grained, very thin bedded, wavy-bedded, trace fossils abundant; upper contact gradational; lower contact sharp	3.8
4. Shale, mostly grayish red (10R4/2); contains abundant 0.5–1.5-in.-thick, light brown (5YR5/6) ironstone layers; noncalcareous	~94.0
3. Calcarenite, dark yellowish orange (10YR6/6) to moderate brown (5YR4/4), very fine grained, very thin bedded; wavy-, parallel-bedded with abundant trace fossils; some load casts	3.0
2. Shale, grayish red (10R4/2) with sparse moderate reddish brown (10R4/6) ironstone concretions; grades downward to dark yellowish brown (10YR4/2) shale; upper and lower contacts sharp; poorly exposed	48.0
ROD CLUB (?) MEMBER	
1. Sandstone, grayish orange (10YR7/4) to dark yellowish orange (10YR6/6) to very pale orange (10YR8/2), fine-grained, thin- to medium-bedded in upper 3 ft and very limonitic; noncalcar-	

eous; massive, with large-scale soft-sediment deformation features in lower part, friable, very porous; Liesegang banding common in some places; contains voids from weathered-out mud

Stop 1

Rod Club (?) Sandstone Member of the Springer Formation (Overbrook Measured Section)

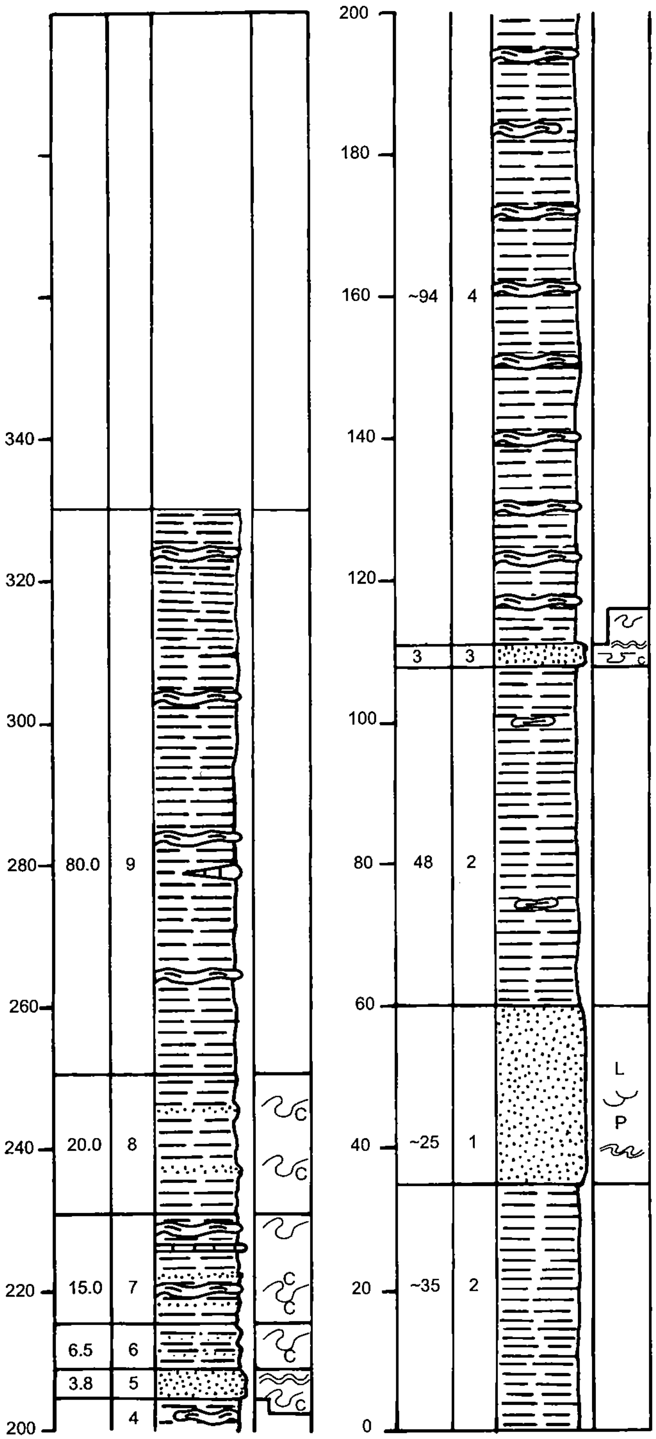


Figure 6. Graphic columnar section of rocks exposed along S.H. 77S at Stop 1. Explanation of symbols in Appendix 1.

clasts in places, amalgamated channels observed in south road cut; because of an asymmetrical anticline with a steeply dipping east limb in the road cut, accurate measurement of thickness is impossible .... ~25.0

UNNAMED SHALE

2. Shale, grayish red (10R4/2), poorly exposed in north road ditch, contact with Unit 1 covered; total thickness not exposed. (Note: As the viewer walks south from the railroad tracks, the first exposure of bedrock observed is Unit 2. This shale is stratigraphically higher than Unit 1. Although eroded from above the sandstone of Unit 1 exposed in the road cut, it crops out on both flanks of the asymmetrical anticline discussed earlier in the text about Stop 1.) .... ~35.0

Total ~330.3

STOP 2

OVERBROOK SANDSTONE MEMBER OF THE SPRINGER FORMATION (City Lake Spillway Section)

Location: SE¼SW¼NE¼NW¼ and SW¼SE¼ NE¼NW¼ sec.12, T. 4 S., R. 1 E., Carter County (Ardmore West 7.5′ quadrangle)

Directions: From the intersection of State Highway 142 and U.S. Highway 77 at the northwest edge of Ardmore, drive ~1.4 mi north on U. S. Hwy. 77, then turn west onto the driveway for the water treatment plant and drive 0.5 mi to the boat launching area at the southeast end of City Lake dam. Walk northwest across the dam to the spillway. Exposures are in the cut northwest of the spillway and in the eroded area below the concrete apron of the spillway.

The sandstone exposed at Stop 2 is not equivalent to the unit exposed at the type locality of the Overbrook (Stop 1). When Roth (1928) named the Overbrook Sandstone, he used the names "Overbrook" and "City Lake" interchangeably because he believed them to be the same lithostratigraphic unit. This interpretation has subsequently been disproved (Peace, 1965; Lang, 1966). However, the name "City Lake" is not well known or commonly used, and the name "Overbrook" has become so well established in the literature that displacing it is not justified if stability of nomenclature is to be maintained. Lang (1966, p. 65) suggested that the term "Overbrook" should be suppressed and a new name proposed, with its type section on the Caddo anticline. Meek (1983, p. 24) suggested that a new type locality for the redefined Overbrook be established at the City Lake spillway. We propose here that the Measured Section at Stop 2 of this field trip be designated formally as the principle reference section (North American Commission on Stratigraphic Nomenclature, 1983, p. 853) for the Overbrook Sandstone Member of the Springer Formation and that the name "Overbrook" be preserved.

Stop 2
Overbrook Sandstone Member of the Springer Formation
(City Lake Spillway Section)

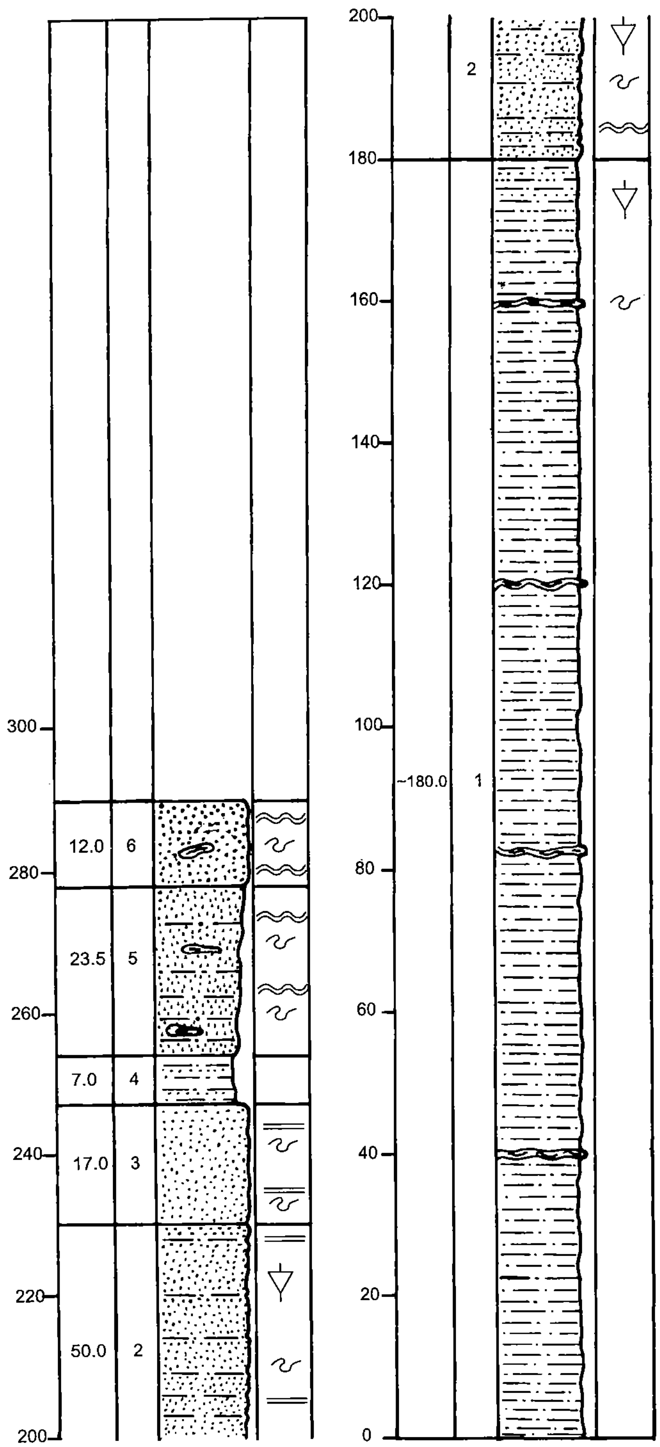


Figure 7. Graphic columnar section of rocks exposed at the spillway for City Lake dam (Stop 2). Explanation of symbols in Appendix 1.

Approximately 180 ft of the upper part of the unnamed shale (Unit 1, Fig. 7; Fig. 8A) that occurs between the Rod Club Member and the Overbrook Member (Fig. 3) is exposed at the edge of the creek below the spillway; note the 1–2-in.-thick ironstone layers that occur at scattered intervals within the shale (Fig. 8B). Figure 9 shows the contact (at the pick head) between the unnamed shale

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MEASURED SECTION, STOP 2

Overbrook Sandstone Member of the Springer Formation (City Lake Spillway Section)

SE¼SW¼NE¼NW¼ and SW¼SE¼NE¼NW¼ sec. 12, T. 4 S., R. 1 E., Carter County (Ardmore West 7.5′ quadrangle). Measured by LeRoy A. Hemish in the cut at the northwest side of City Lake spillway and in the eroded gullies just below the spillway. Beds strike N. 40° W. and dip S. 50° W. at 76°.

	Thickness (feet)
SPRINGER FORMATION	
OVERBROOK MEMBER	
6. Sandstone, very pale orange (10YR8/2) to grayish orange (10YR7/4) to dark yellowish orange (10YR 6/6), with some moderate brown (5YR4/4), staining, very fine to fine grained, well sorted, subrounded, quartz-rich, noncalcareous, flaggy; parallel-, ripple-bedded; contains ironstone concretions; extensively horizontally and vertically burrowed; upper contact covered at lake level; beds are slumped toward lake shore	12.0
5. Sandstone, grayish orange (10YR7/4), to very pale orange (10YR8/2), to dark yellowish orange (10YR 6/6), very fine grained, well sorted, subrounded, quartz-rich, noncalcareous; very thin bedded; interbedded and interlaminated with grayish orange (10YR7/4), sandy and silty shale, wavy-, parallel-bedded; contains ironstone concretions; trace fossils abundant, upper and lower contacts gradational	23.5
4. Shale, medium gray (N5), weathers grayish orange (10YR7/4), silty, noncalcareous; contains scattered, very fine grained sandstone laminae and lenses; lower contact sharp	7.0
3. Sandstone, very pale orange (10YR8/2) to grayish orange (10YR7/4), some moderate brown (5YR 4/4), ferruginous beds, very fine grained; beds mostly plane-, parallel-bedded; thin- to medium-bedded in upper part, thin-bedded in lower part, well cemented, well sorted, subrounded, trace fossils abundant; lower contact gradational	17.0
2. Sandstone, same as Unit 3, but thin- to very thin, plane-, parallel-bedded with interlaminated siltstone and shale; light gray (N7) with dark gray (N3) shale whisps on fresh surfaces where exposed in eroded spillway, trace fossils abundant, interstratified with dark gray (N3) shale beds in lower part; wavy bedded and increasingly shaly in lower 2 ft; contact gradational; coarsening-upward sequence	50.0

UNNAMED SHALE

1. Shale, dark gray (N3), includes some very light gray (N8), thin laminae of siltstone; slightly calcareous; contains widely scattered 1–2-in.-thick layers of dark reddish brown (10R3/4) ironstone that have moderate yellowish brown (10YR5/4) limestone interiors; weathered surfaces of ironstone layers have polygonal healed fractures about 0.25–0.5 in. across that resemble desiccation cracks; upper part contains interstratified sandstone and siltstone with rare burrows; upper contact gradational; lower contact covered .. ~180.0

Total ~289.5

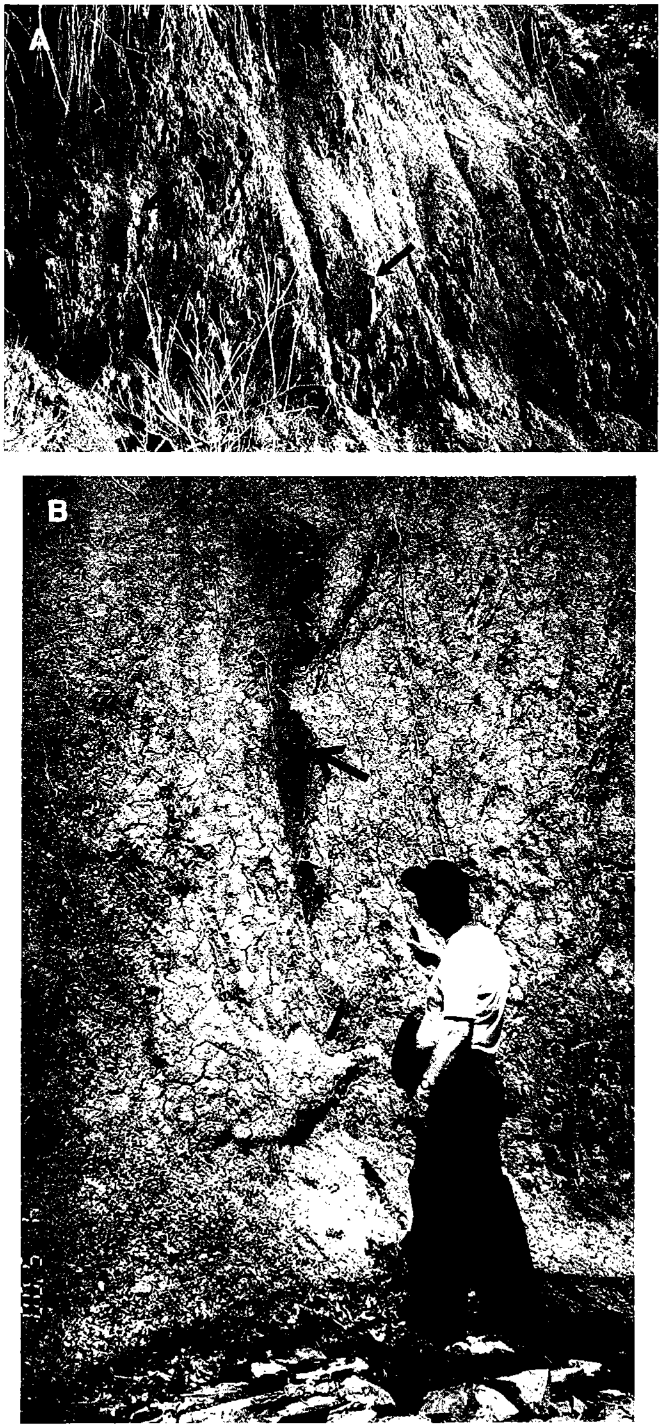


Figure 8. *A*—Unnamed shale in the Springer Formation at the edge of the creek below the spillway for City Lake dam. Note the resistant 1–2-in.-thick ironstone layers that protrude from the bluff (shown by arrows). *B*—R. D. Andrews examining one of the ironstone layers (arrow) in the shale shown in 8A. Ironstones are common throughout the Springer shales.

Figure 9. Contact between the lowermost unnamed shale unit of the Springer Formation and the base of the Overbrook Sandstone Member at the eroded spillway of City Lake dam (Stop 2). Pick head (at arrow) marks the contact. Geologic pick is ~2 ft long.

and the base of the Overbrook Sandstone. Note that the lithology just below the rock pick is predominantly shale, while the shale just above the contact contains interstratified layers of sandstone and siltstone that are very thin, parallel-, and ripple-bedded. Figure 10 shows the abundant trace fossils that are common throughout the Overbrook.

Sedimentary structures, together with stratigraphic and spatial relationships, indicate that the Overbrook sandstone was deposited as a submerged detached marine bar (offshore) in a relatively shallow inner- to middle-shelf environment. The specific type of bar is important because a detached bar is not associated with the more lobate delta-plain and delta-front (distributary mouth bar) deposits that are "attached" to the shoreline. Barrier-island and shoreface deposits also differ from submerged detached bars: although all are narrow, elongate features, submerged detached bars do not develop emergent facies (foreshore, backshore, etc.). Detached bars commonly are stratigraphically and spatially bounded by marine shale; thus, in the subsurface, they make excellent stratigraphic traps for hydrocarbons.

Figure 10. A displaced slab of the Overbrook Sandstone at Stop 2 shows the abundance of trace fossils in Unit 2 (Fig. 7). Lip balm tube is 2.5 in. long.

The Overbrook Sandstone has diagnostic facies that reveal the depositional setting and lithologic character of the bars. Throughout its exposed extent, the Overbrook has a coarsening-upward textural profile, and it is composed of two or three main facies. Only two are present at City Lake spillway. The lower facies, called the *transition zone*, consists of thin ripple-bedded layers of sandstone, shale, and siltstone (Fig. 11). These sediments probably were deposited in water at least 50–100 ft. They are highly bioturbated, and the only indicator of current is ripple bedding, which attests to the low depositional energy at these depths. Stratigraphically higher in the bar sequence, the Overbrook lithology becomes increasingly dominated by sandstone with mostly planar, medium-bedded layers (Fig. 12). This is the *lower bar* (or *bar margin*) facies, and these sediments probably were deposited in water <50 ft deep. An *upper bar* (or *central bar*) facies (characterized by high-angle cross-bedding) is not present at City Lake spillway.

The textural profile of the Overbrook Sandstone and underlying unnamed shale at City Lake is represented by a surface gamma-ray (GR) profile in Figure 13 (left side of the figure). The profile clearly shows a coarsening-upward GR response, from a shale baseline of ~140 counts/sec (cts/sec). Sandstone tended to have a GR response of <90 cts/sec and "clean" sandstone had a GR response of <60 cts/sec. The GR values of 90–120 cts/sec for about the 180–212-ft interval indicate the presence of interbedded sandstone, shale, and silty strata that defines the transition zone.

Cuttings from the Goldsmith & Perkins No. 1 Herman Smith well (located ~4 mi northwest of Stop 2, and the Beach & Talbot No. 1 Pruitt BB well (located ~3 mi northwest of Stop 2) (see Appendixes 2 and 3; map inside front cover) indicate that the Overbrook Sandstone Member varies in thickness. However, in general, the coarsening-upward characteristics of the interval persist.

The surface GR profile of the Overbrook Sandstone and underlying shale correlates very well with subsurface GR log of the same stratigraphic interval in the Samson Resources No. 1 Patzkowsky well (Fig. 13). This well is ~5 mi north–northwest of City Lake, and the thickness and quality of sandstone in the well is comparable to that in the measured section here at Stop 2 (Fig. 7). This comparison demonstrates that subsurface well logs can be used to interpret the character of specific facies in order to visualize a sandstone and shale sequence in the subsurface.

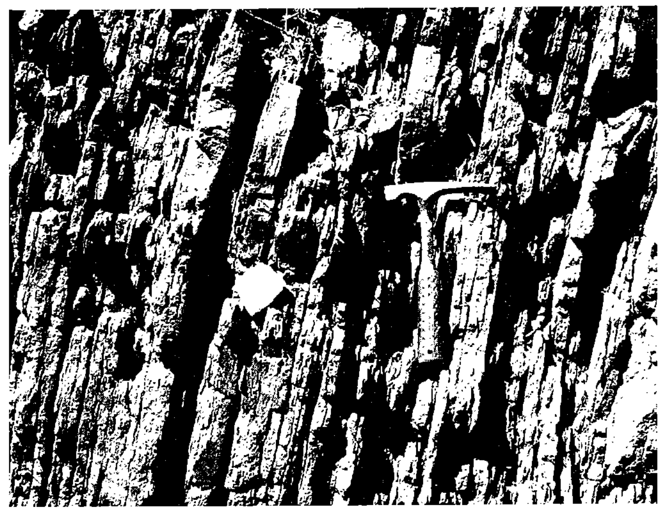


Figure 11. A close-up view of interbedded sandstones, siltstones, and shales in Unit 2 (Fig. 7) at Stop 2, shows their thin-bedded character. Geologic pick for scale.

Figure 12. Thin- to medium-bedded, planar-bedded sandstone of Unit 3 (Fig. 7) at Stop 2. Deposition was in shallower water than for Unit 2. Geologic pick for scale.

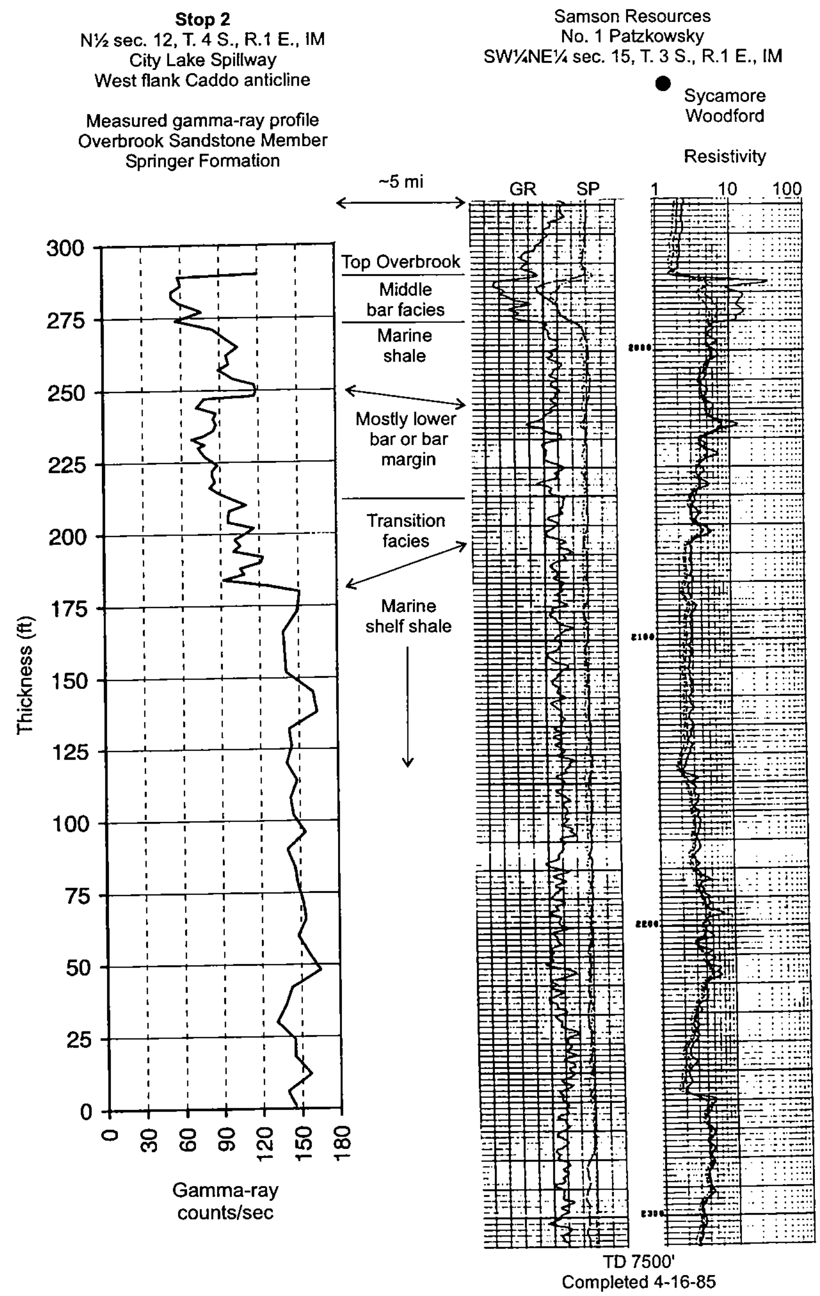


Figure 13. *Left side of figure*—Surface gamma-ray (GR) profile of the Overbrook Sandstone Member of the Springer Formation (Stop 2), measured at the spillway for City Lake dam. *Right side of figure*—Subsurface well logs from the Samson Resources No. 1 Patzkowsky well for the same stratigraphic interval shown in the surface GR profile. The surface GR profile and the well logs are plotted at the same vertical scale.

STOP 3

PRIMROSE SANDSTONE MEMBER OF THE GOLF COURSE FORMATION AND LAKE ARDMORE SANDSTONE MEMBER OF THE SPRINGER FORMATION

(Academy Church Section)

Location: SE¼NW¼SE¼ and NE¼SW¼SE¼ sec. 1, T. 3 S., R. 2 E., Carter County (Gene Autry 7.5′ quadrangle)

Directions: From Springer, drive 5.5 mi east on the blacktop road (1 mi north of State Highway 53); turn north at the Calvary Baptist Church sign and proceed to the church (shown as the Academy Church on the Gene Autry 7.5′ quadrangle map); park at the east side of the cemetery and walk east down to the creek. The measured section starts at the east-west property-line fence and ends downstream, where alluvium covers the exposures of bedrock.

Two named sandstones are exposed at Stop 3 (Fig. 14). They are (1) the Primrose Sandstone, which crops out along the tributary of Cool Creek (Fig. 15) and in the railroad cut just east of the stream (Fig. 16), and (2) the Lake Ardmore Sandstone, of which only a single 2.4-ft-thick bed (Fig. 17) is exposed downstream from the Primrose outcrop. The two units are separated by 118 ft of black, noncalcareous shale at the top of the Springer Formation (Fig. 14). Figure 18 shows the contact between the upper, 5-ft-thick, ripple-bedded sandstone bed of the Primrose Member and the overlying Gene Autry Shale Member of

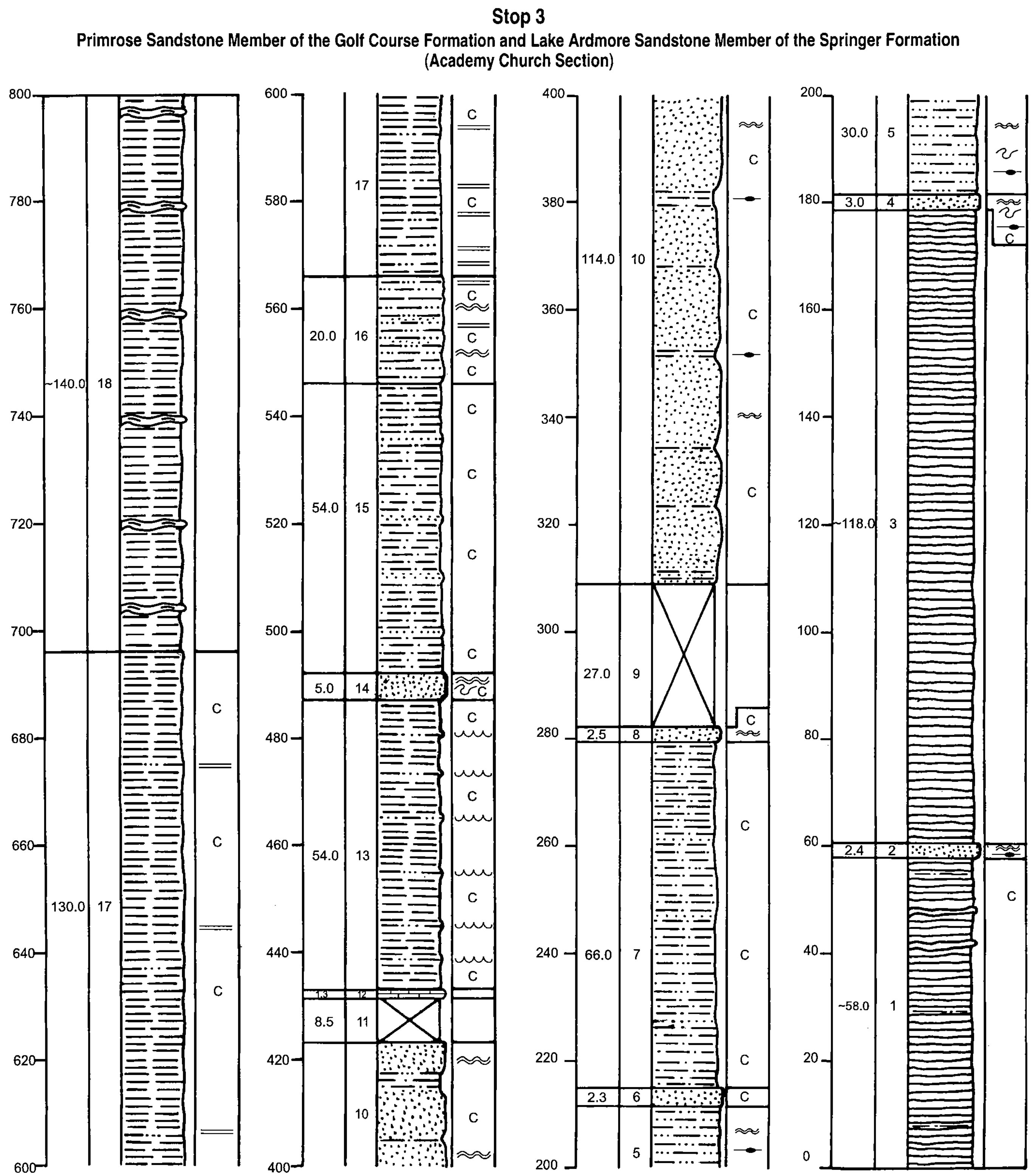


Figure 14. Graphic columnar section of rocks exposed along the tributary creek of Cool Creek at Stop 3. Explanation of symbols in Appendix 1.

MEASURED SECTION, STOP 3

Primrose Sandstone Member of the Golf Course Formation and Lake Ardmore Sandstone Member of the Springer Formation (Academy Church Section)

SE¼NW¼SE¼ and NE¼SW¼SE¼ sec. 1, T. 3 S., R. 2 E., Carter County (Gene Autry 7.5′ quadrangle). Measured by LeRoy A. Hemish in the gully along the north-flowing tributary of Cool Creek (just west of the Burlington-Northern-Santa Fe railroad tracks), from the east-west property-line fence, downstream to the area covered by alluvium. Beds strike N. 85° E. and dip N. 5° W. at 80° (overturned).

Thickness (feet)

GOLF COURSE FORMATION

GENE AUTRY SHALE MEMBER

18. Shale, medium gray (N5), olive gray (5Y3/2) on fresh surfaces, noncalcareous; contains numerous light brown (5YR5/6) to moderate reddish brown (10R4/6), sideritic ironstone layers 1–3 in. thick; poorly exposed at contact with underlying unit ~104.0
17. Shale, dark gray (N3), to olive gray (5Y4/1) on fresh surfaces, highly calcareous; contains numerous light gray (N7) to grayish orange (10YR 7/4) medium gray (N5) (where fresh), interstratified, very highly calcareous, planar-laminated siltstone layers that increase in frequency of occurrence in lower part of unit 130.0
16. Siltstone, shaly, to very fine grained sandstone, olive gray (5Y4/1) to greenish black (5GY2/1), very thin bedded, parallel-bedded, planar- to irregular-bedded and ripple-bedded, very highly calcareous; top and base gradational 20.0
15. Shale, olive gray (5Y4/1), very silty, hard, highly calcareous; includes some interstratified, well indurated, highly calcareous, very fine grained, grayish red (10R4/2), weathered sandstone lenses and layers ≤1 ft thick 54.0

PRIMROSE SANDSTONE MEMBER

14. Sandstone, grayish red (5R4/2), very fine grained, well indurated, very highly calcareous, thin-, ripple-bedded; some indistinct, small, trace fossils; forms resistant ridge at bend in creek 5.0
13. Shale, medium dark gray (N4) with moderate yellowish brown (10YR5/4) mottling, calcareous; includes scattered layers of ripple-laminated, olive black (5Y2/1) siltstone; poorly exposed 54.0
12. Limestone, brownish black (5YR2/1), very fine grained; fractured, with white (N9), crystalline calcite filling veins; exposed only in stream bed. 1.3
11. Covered interval 8.5
10. Sandstone, brownish gray (5YR4/1) to olive gray (5Y4/1), very fine grained, glauconitic, highly calcareous, thin-bedded, parallel-bedded, ripple-bedded, lenticular-bedded, resistant; includes interstratified olive gray (5Y4/1), calcar-

Figure 15. Sandstone of the Primrose Member of the Golf Course Formation (Unit 10, Fig. 14) at Stop 3 exposed in the valley east of the church.

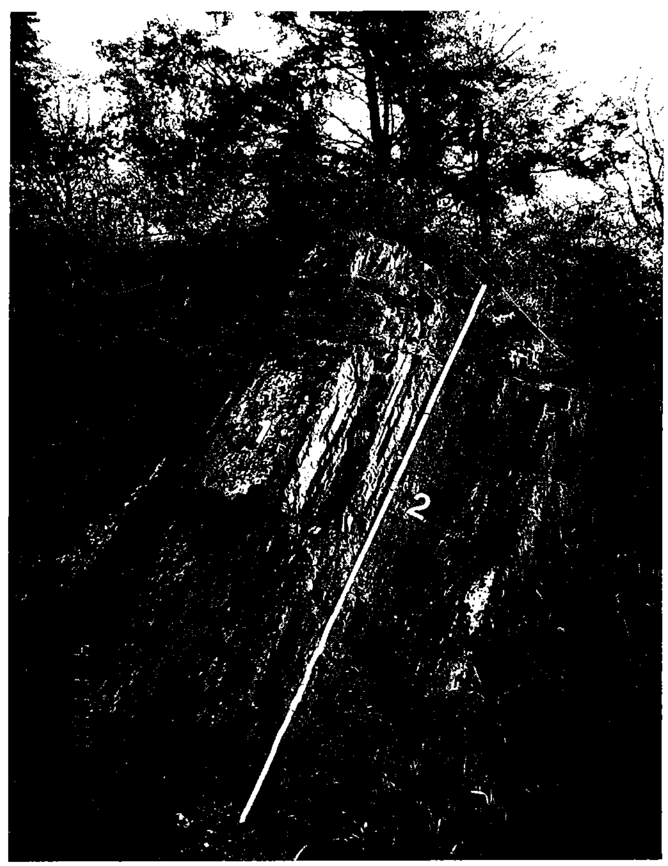


Figure 16. Thin-, parallel-, ripple-bedded sandstone beds (Unit 10, Fig. 14) of the Primrose Member of the Golf Course Formation are shown at the east side of the Burlington-Northern-Santa Fe railroad tracks east of the church at Stop 3. The beds strike N. 85° E. and dip N. 5° W. at 80° (overturned). In the Primrose, the sandstone intervals have multiple cycles that appear to become more coarse upward. Two possible cycles can be seen here. North is to the left in the photograph.

eous shales in upper part; some very thin bedded, silty, shaly layers form wide notches in cliff edge above stream; shaly in lower 3 ft; contact gradational 114.0

9. Covered interval 27.0
8. Sandstone, grayish orange (10YR7/4) to light brown (5YR6/4) with dark gray (N3) wavy laminae, thick-bedded, blocky, very highly calcareous, very fine grained, well cemented 2.5
7. Shale, silty, olive black (5Y2/1), with thin laminae of siltstone and very fine grained sandstone, highly calcareous, mostly poorly exposed, except at base of unit 66.0
6. Sandstone, grayish orange (10YR7/4) to pale yellowish brown (10YR6/2), very fine grained, calcareous, contains numerous grayish black (N2) blebs and streaks 2.3
5. Siltstone, black (N1), with olive gray (5Y4/1) streaks and lenses, ripple-bedded to lenticular-bedded, burrowed, noncalcareous 30.0
4. Sandstone, light gray (N7) with abundant black streaks, blebs, and films; very fine grained; highly calcareous; carbonaceous; very thin bedded; ripple-bedded, lenticular-bedded; indistinct trace fossils; base gradational, upper contact sharp 3.0

SPRINGER FORMATION

UNNAMED SHALE

3. Shale, black (N1), noncalcareous, fissile, no ironstone observed in outcrop .... ~118.0

LAKE ARDMORE MEMBER

2. Sandstone, brownish black (5YR2/1) with dark reddish brown (10R3/4) staining, thin-bedded, parallel-bedded, ripple-bedded, lenticular-bedded, very fine grained, noncalcareous, carbonaceous; forms resistant ledge across creek, but tends to be friable and crumbly; upper and lower contacts sharp 2.4

UNNAMED SHALE

1. Shale, black (N1), weakly calcareous, silty; includes two, 4-in.-thick, dense, brownish gray (5YR4/1) siderite layers in upper part; total thickness not exposed; .... ~58.0

Total ~800.0

Figure 17. The Lake Ardmore Sandstone Member of the Springer Formation (Unit 2, Fig. 14) exposed in the valley northeast of the church at Stop 3. The 2.4-ft-thick sandstone bed (shown by arrow) is overlain and underlain by black, weakly calcareous to noncalcareous shales (Units 1 and 3, Fig. 14) in the upper part of the Springer Formation.

the Golf Course Formation. The contact is sharp; however, some thin sandstone layers and lenses occur in the lower part of the Gene Autry Shale. The entire Primrose Member is >300 ft thick (as interpreted in Measured Section, Stop 3), but ~60% of the member consists of siltstones and shales, together with other minor constituents.

The Primrose Sandstone is lower Morrowan and was included in the Springer field trip to contrast its lithology with the lithologies of the sandstones of the Springer Formation. We did not do a detailed analysis of depositional environments in the Primrose; thus, the following discussion is generalized.

In the Ardmore basin, the Primrose is considerably more "dirty" and its sandstone beds are much thinner than in the subsurface of the Anadarko basin. At the Stop 3 outcrop, the Primrose has considerable amounts of interstitial and interbedded clay and shale. The conspicuous color, in various shades of olive gray, is probably due to the presence of chlorite as an alteration of glauconite. Sedimentary structures are sparse but include horizontal and crude ripple bedding. No fossils or burrowing were identified, and the sandstone is very calcareous. Sandstone intervals have multiple cycles with poorly defined textural profiles that appear to be "cleaning" (coarsening) upward (Fig. 16; note two possible cycles).

The very fine grained, "dirty" character of the sandstone and the thinness of individual sandstone cycles in the Primrose at Stop 3 indicates that it probably was deposited in a mid-shelf environment, more basinward (farther from shore) than was the Morrow Primrose of the Anadarko basin. The abundance of glauconite is a clear indicator of low-energy, low-sedimentation, and relatively shallow marine conditions. The abundance of cal-

Figure 18. Uppermost bed of sandstone in the Primrose Member of the Golf Course Formation (Unit 14, Fig. 14) exposed in the creek bed and valley east of the church at Stop 3. The contact between the Primrose Member and the lowermost shale of the Gene Autry Shale Member (Unit 15, Fig. 14) is shown by the arrow. Geologic pick is ~2 ft long.

cite as a framework cement is also characteristic of marine conditions. All of these characteristics prevail in a marine-shelf environment at depths generally just below wave base.

In the Academy Church Section, the Lake Ardmore is a very fine grained, noncalcareous, brownish black and dark reddish brown, thin-bedded, parallel-bedded, ripple-bedded sandstone with sharp upper and lower contacts (Fig. 17). This 2.4-ft-thick sandstone bed that crops out ~5 mi east of Springer, Oklahoma, is the only unit of the Lake Ardmore Sandstone Member exposed at Stop 3. Meek (1983, p. 2) reported that four sandstones occur in the Lake Ardmore east of Springer. McBride (1986, p. 135–137) measured multiple sandstone beds in the Lake Ardmore ~9 mi east of Springer. Apparently, in some areas of the Ardmore basin, additional discontinuous sandstones occur in the Lake Ardmore Member. However, only a single sandstone crops out at the type locality at Lake Ardmore. At Stop 6A (this guidebook), on the Caddo anticline ~1.5 mi northwest from the type locality, the Lake Ardmore Sandstone is a single 17-ft-thick unit.

STOP 4

ROD CLUB SANDSTONE MEMBER OF THE SPRINGER FORMATION (Trail Ranch Pond Section)

Location: SE¼SE¼SE¼ sec. 33, T. 2 S., R. 1 E., Carter County (Springer 7.5′ quadrangle)

This stop is on private property.
Please contact Jim Trail, Ardmore, Oklahoma, phone (580) 226-4545, for permission to visit the outcrops.

Directions: From Interstate Highway 35, exit west at State Highway 53 and drive west ~2.25 mi to the site of an abandoned farm building site (on the north side of the road). Do not stop, but note good exposures of the Rod Club Sandstone in the low ridge just north of the road and west of the farm house. Continue ~0.25 mi west on S.H. 53 to a small, south-flowing stream. There are outcrops just north of the pond and in the spillway just south of the pond. The upper unit of the Rod Club Sandstone is well exposed for ~0.25 mi in the ridge east of the spillway. Examine it and note the similarities to the sandstone exposed near Overbrook (Stop 1).

Two sandstone units of the Rod Club Member of the Springer Formation are exposed near the ranch pond (Fig. 19). The two units are similar in appearance, but the older of the two (exposed at the north side of the pond) (Fig. 19, Unit 1; Fig. 20) is only ~9.0 ft thick, whereas the stratigraphically higher unit (exposed in the spillway) (Fig. 19, Unit 3; Fig. 21) is ~25 ft thick. Characteristics that are similar in the sandstones exposed at Stops 4 and 1 include grain size, friability, porosity, soft-sediment deformation features, bedding characteristics, color, and common Liesegang banding.

About 40 ft of an unnamed shale that occurs between the Rod Club and the Overbrook Members is exposed in the gully below the spillway. It is a medium dark gray shale that contains 1–2.5-in.-thick ironstone layers (Fig. 19, Unit 4; Fig. 22).

The Rod Club Sandstone exposed at the ranch pond is interpreted to be turbidite deposits of the lower (distal) to middle fan facies. Both the Rod Club at Stop 4 and the sandstone exposed near Overbrook (Stop 1) have fluvial channel characteristics, but neither is deltaic or flood plain in nature. The Rod Club Sandstone is interstratified with marine shale and is laterally persistent with very little change in thickness or character. The thinner nature, overall, of sandstone beds and individual sandstone units in the Rod Club here at Stop 4 indicates that the depositional environment locally may have been slightly farther basinward (farther from shore) than that of the turbidite channel sandstone exposed at Stop 1.

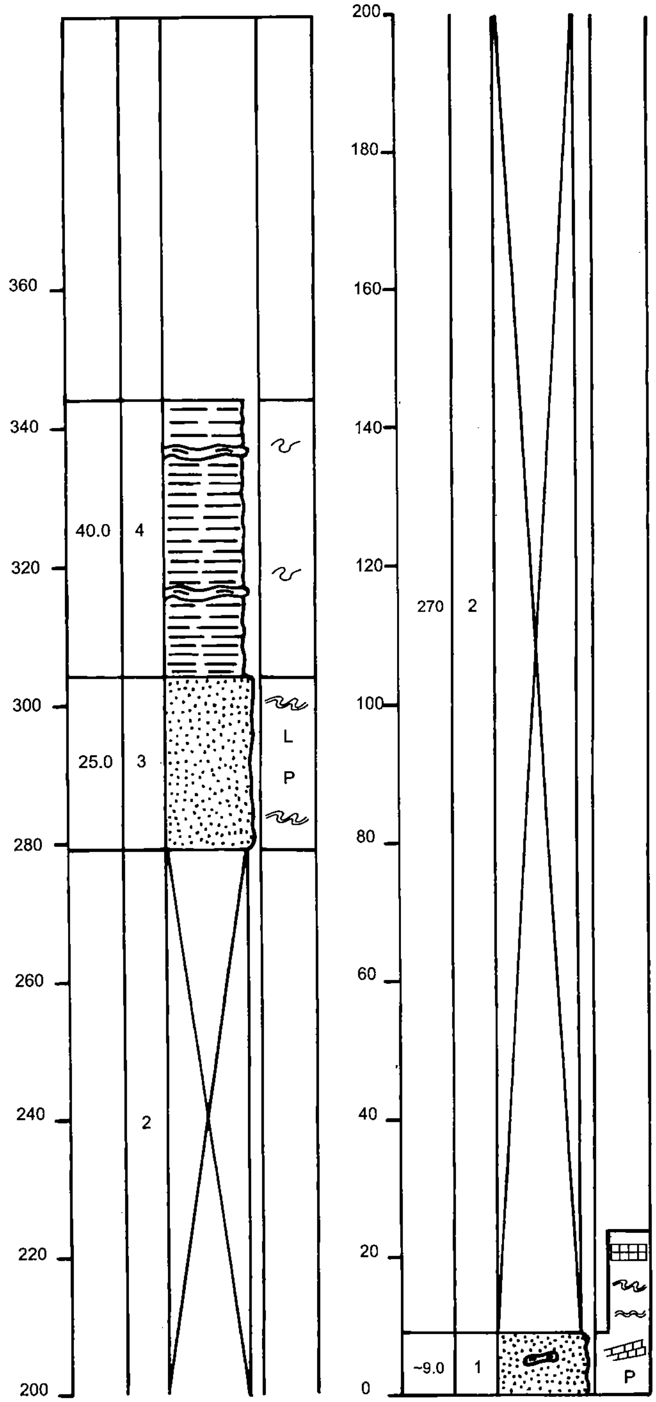


Figure 19. Graphic columnar section of rocks exposed in the vicinity of the ranch pond at Stop 4. Explanation of symbols in Appendix 1.

MEASURED SECTION, STOP 4

Rod Club Sandstone Member of the Springer Formation (Trail Ranch Pond Section)

SE¼SE¼SE¼ sec. 33, T. 2 S., R. 1 E., Carter County (Springer 7.5′ quadrangle). Measured by LeRoy A. Hemish in the low ridge at the north end of the ranch pond and in the ridge east of the pond, and in the eroded spillway just below the south end of the pond. Beds strike N. 85° W. and dip S. 5° W. at 55°.

Thickness (feet)

SPRINGER FORMATION

UNNAMED SHALE

4. Shale, medium dark gray (N4) with moderate yellowish brown (10YR5/4) bands, noncalcareous; contains scattered dark yellowish orange (10YR 6/6) and 1–2.5-in.-thick dusky red (5R3/4) ironstone layers, with calcite crusts and limonite deposits along fractures; some trace fossils on ironstone surfaces; lower contact sharp; upper contact covered .... ~40.0

ROD CLUB MEMBER

3. Sandstone, very pale orange (10YR8/2) to dark yellowish orange (10YR6/6) to light brown (5YR5/6) and moderate brown (5YR4/4), fine to very fine grained, well sorted, subrounded, good porosity, moderately friable; mostly thick-bedded, but includes some thin-bedded, slabby layers in middle of unit; weathers blocky, with irregular, pitted surfaces; soft-sediment deformation common; fractured, with white calcite in veins; Liesegang band-

Figure 20. The oldest exposed sandstone of the Rod Club Sandstone Member of the Springer Formation (Unit 1, Fig. 19) crops out at the north end of the ranch pond at Stop 4. The beds strike N. 85° W. and dip S. 5° W. at 58°. South is to the left in the photograph. Geologic pick for scale.

ing common; some surfaces slickensided; includes pimple-like, iron-cemented concretions (~1 mm in diameter); iron staining common; lower contact concealed .... ~25.0

2. Covered interval; assumed to be shale .... ~270.0

1. Sandstone, grayish orange (10YR7/4) to grayish orange pink (5YR7/2), very fine grained, quartzose, well sorted, subrounded, moderately friable, good porosity; irregular-bedded, medium- to thick-bedded, some laminations, some small-scale cross-stratification, weathers blocky; some soft-sediment deformation; some crinkled bedding; weathers knobby, with abundant pits; some surfaces have pimple-like, iron-cemented concretions (1–2 mm in diameter); some incipient boxwork in places; contains numerous healed fractures .... ~9.0

Total ~344.0

Figure 21. The uppermost sandstone of the Rod Club Sandstone Member of the Springer Formation (Unit 3, Fig. 19) is exposed in the eroded spillway just south of the ranch pond. The beds strike N. 85° W. and dip S. 5° W. at 55°. South is to the left in the photograph. Jointing in the rocks gives a false impression that the dip is to the north. Geologic pick for scale.

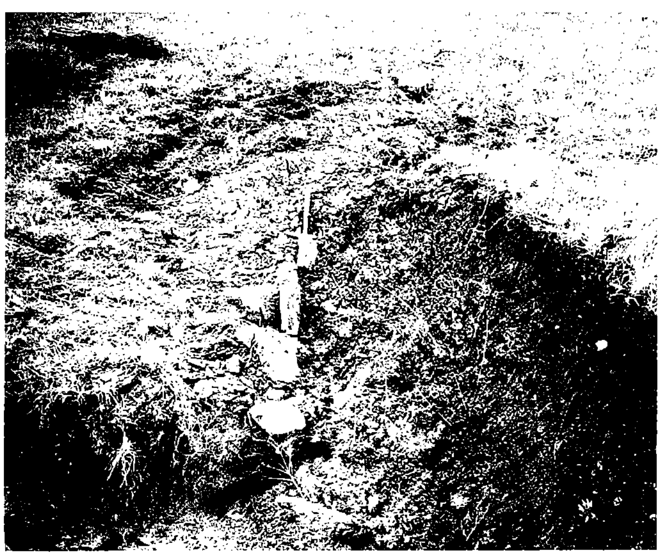


Figure 22. The lower part of the lowest unnamed shale member of the Springer Formation (Unit 4, Fig. 19) is exposed in the gully below the spillway. Note the resistant ironstone layer (marked by the geologic pick). Unit 4 at this stop is equivalent to the lower covered part of Unit 1 (Fig. 7) at Stop 2, the unnamed shale exposed along the creek below the spillway for City Lake dam.

STOP 5

ROD CLUB SANDSTONE MEMBER OF THE SPRINGER FORMATION (Caddo Anticline Section)

Location: NE¼NW¼SW¼NW¼ sec. 16, T. 3 S., R. 1 E., Carter County (Springer 7.5′ quadrangle)

This stop is on private property.
Please contact Robert Kelley, 818 Wood-N-Creek, Ardmore, Oklahoma, phone (580) 223-1862 for permission to visit the outcrops.

Directions: From Stop 4, drive 1 mi west on State Highway 53; turn south (left) onto a county road, and drive 2.25 mi. Park, cross the fence, and climb the ridge east of the road. Examine the outcrops on the southwest-facing slope (southwest limb of the Caddo anticline).

Numerous beds of the Rod Club crop out at this stop (Fig. 23). The beds are exposed intermittently, but they stand vertically and provide good three-dimensional views (Fig. 24). Facies of the Rod Club at this stop differ from those at Stops 1 and 4. Here, the beds tend to be thin- to medium-bedded, parallel-bedded, and ferruginous, and they are separated more commonly by shale interbeds. However, similarities to the facies at Stops 1 and 4—such as grain size, sorting, soft-sediment deformation features, and Liesegang banding—are also abundant. There are dewatering structures in Unit 9 (Fig. 23). Unit 6 (Figs. 23, 25) has pitted surfaces and abundant soft-sediment deformation features. It tends to be more friable than Unit 4 and does not form a high, resistant outcrop as Unit 4 does. Small imprints of wood fragments can be seen in the poorly exposed Unit 3 (Figs. 23, 26).

Sandstone in the Rod Club interval at this stop on the Caddo anticline is interpreted to be a series of turbidite deposits. The more resistant upper beds (Units 4, 6, 8, and 10) in the Rod Club Formation are tabular in nature and only a few feet thick; they do not vary significantly in thickness or character for hundreds of feet along strike. These beds probably were deposited in a sparsely channelized lower (distal) turbidite fan. The lower sandstone in the Rod Club Formation (Unit 2) is moderately friable

Stop 5
Rod Club Sandstone Member of the Springer Formation
(Caddo Anticline Section)

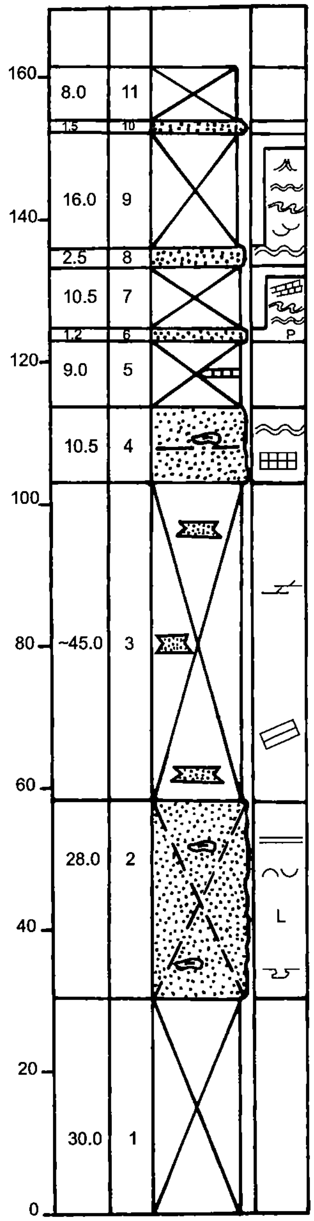


Figure 23. Graphic columnar section of rocks exposed on the southwest flank of the Caddo anticline at Stop 5. Explanation of symbols in Appendix 1.

and not well exposed. However, it is sufficiently resistant to form the top of the ridge. It appears to have textural and physical characteristics similar to those of the upper beds that crop out downslope. The much thicker nature of the lower sandstone unit may indicate that it is part of a lobe of a highly channelized suprafan. The presence of imprints of fossilized wood fragments in the sandstone in Unit 3 (Fig. 26) indicates that deposition took place near land, possibly near a significant shelf slope.

MEASURED SECTION, STOP 5

Rod Club Sandstone Member of the Springer Formation (Caddo Anticline Section)

NE¼NW¼SW¼NW¼ sec. 16, T. 3 S., R. 1 E., Carter County (Springer 7.5′ quadrangle). Measured by LeRoy A. Hemish along the wooded ridge east of the road. Beds strike N. 55° W. and are vertical.

	Thickness (feet)
SPRINGER FORMATION	
ROD CLUB MEMBER	
11. Covered	8.0
10. Sandstone, grayish red (5R4/2), very fine grained, well sorted, subrounded, ferruginous, thin- to medium-bedded, poorly exposed	1.5
9. Covered	16.0
8. Sandstone, grayish red (5R4/2) to dark yellowish orange (10YR6/6), very fine grained, well sorted, subrounded, quartzose, ferruginous, moderately friable, thin- to medium-bedded, some crinkled bedding; soft-sediment deformation features abundant, including dewatering structures; iron oxides outline internal, upward-curved laminae 2–3 in. long; probably scour-and-fill features; upper and lower contacts sharp	2.5
7. Covered interval	10.0
6. Sandstone, description similar to unit 7, but thinner bedded with abundant low-angle cross-laminations, ferruginous, pitted	1.2
5. Covered interval, with rare 1-in.-thick, moderately friable sandstone beds exposed	9.0
4. Sandstone, grayish red (5R4/2), to dark yellowish orange (10YR6/6), very fine grained, quartzose, well sorted, subrounded; very thin to thin, parallel-, wavy-bedded, ferruginous; forms 11-ft-high "wall" in places along outcrop; moderately friable; differential weathering of iron oxide-cemented features causes knobby, ridgy, and boxwork structures to stand out; some shale near middle of unit	10.5
3. Covered interval with sandstone float coming from a medium-bedded, ferruginous sandstone with iron oxide-cemented, low-angle, cross-lamination features; some small imprints of wood fragments noted; rare exposures of sandstone in places; to top of ridge	~45.0
2. Ridge top with weathered dark yellowish orange (10YR6/6) to moderate yellowish brown (10YR 5/4), broken and weathered, very fine grained sandstone littering the outcrop; curved laminations common; load casts and ironstone concretions observed; some Liesegang banding; float appears to be derived from a thin-, parallel-, plane-bedded, moderately friable sand stone bed about 25–30 ft thick	~28.0
1. Covered	30.0
Total	~161.7

Figure 24. Tabular sandstone beds of the Rod Club Sandstone Member of the Springer Formation (Unit 4, Fig. 23) exposed on the Caddo anticline at Stop 5. The beds strike N. 50° W., and are vertical. The top surface of the beds is to the left in the photograph. The highest point on the outcrop is ~11 ft above ground level.

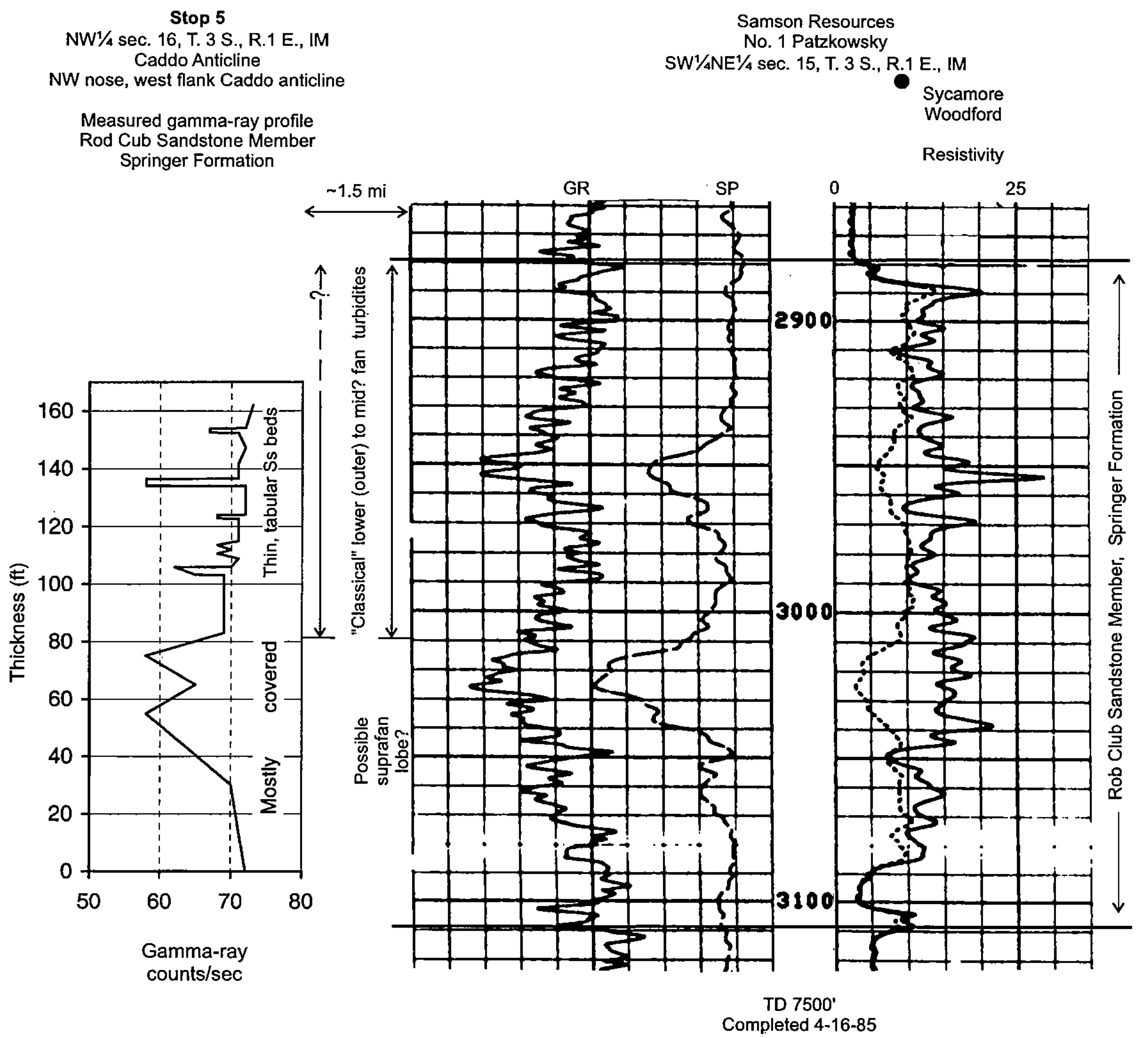
A surface GR profile of the Rod Club interval on the Caddo anticline here at Stop 5 shows similarities to the subsurface GR log (Fig. 27) for the Samson Resources No. 1 Patzkowsky well, which is 1.5 mi due east of this stop. In about the 100–160-ft interval, the surface GR profile shows that the relatively thin upper sandstone units are tabular in nature and have sharp upper and lower contacts with shale. The GR well log shows these same characteristics for sandstone in the Samson well. The spiky GR well log responses in about the 2,900–2,990-ft interval are interpreted as relatively thin sandstone units that have sharp bedding contacts with interbedded shale. Lower on the GR well log for the Samson well (about 2,990–3,090 ft), there are responses interpreted as a thicker sandstone sequence that correlates to the 30–80-ft sandstone interval on the surface GR profile. The lower sandstone unit exposed at the surface is interpreted to be the lobe of a highly channelized suprafan; the lower Rod Club unit in the Samson well may be such a lobe also.

Cuttings from the Beach & Talbot No. 1 Pruitt BB well (located ~3 mi southeast of Stop 5) (Appendix 2; map inside front cover) show that a 140-ft-thick interval consisting mostly of shales with 20–40% thin sandstones and siltstones comprise the Rod Club Member, suggesting a distal relationship from the suprafan facies described at Stop 5. In the Goldsmith & Perkins No. 1 Herman Smith well (located <2 mi southeast of Stop 5) (Appendix 3; map inside front cover), the Rod Club Member is 250 ft thick and has characteristics similar to the outcrops at Stop 5.

Figure 25. One of several thin, tabular beds of the Rod Club Sandstone Member of the Springer Formation (Unit 6, Fig. 23) exposed on the southwest flank of the Caddo anticline at Stop 5.The attitude of the bed is the same as that of Unit 4 (Figs. 23, 24). The top of the bed is to the left in the photograph.

Figure 26. Imprints of wood fragments in sandstone of the Rod Club Sandstone Member of the Springer Formation (Unit 3, Fig. 23). Quarter for scale. Imprints of fragments are pointed out by arrows at 11:00, 1:00, 4:00, and 5:00 o'clock around the coin.

Figure 27 *(below). Left side of figure*—Surface gamma-ray (GR) profile of the Rod Club Sandstone Member of the Springer Formation (Stop 5), measured on the southwest flank of the Caddo anticline. *Right side of figure*—Subsurface well logs from the Samson Resources No. 1 Patzkowsky well for the same stratigraphic interval shown in the surface GR profile. The surface GR profile and the well logs are plotted at the same vertical scale.



STOP 6A

LAKE ARDMORE SANDSTONE MEMBER OF THE SPRINGER FORMATION (MGM Ranch Section)

Location: SE¼SE¼SW¼SE¼ sec. 27, T. 3 S., R. 1 E., and the NE¼NE¼NW¼NE¼ sec. 34, T. 3 S., R. 1 E., Carter County (Springer 7.5′ quadrangle)

This stop is on private property.
Please contact Michael G. McCauley, 2410 N. Commerce, Ardmore, Oklahoma, phone (580) 226-0812 (business) or (580) 223-5872 (home) for permission to visit outcrops.

Directions: From Stop 5, drive 3 mi south along the section road; turn left and drive 0.5 mi east; turn left and travel 0.4 mi north; finally, turn right and drive 1.3 mi east. The Lake Ardmore Sandstone forms a prominent ridge that crosses the driveway to the MGM Ranch, just before it curves to the north.

The resistant Lake Ardmore Sandstone of the Springer Formation (Fig. 28) forms a prominent "wall" (Fig. 29) at this stop. Two units of the member are exposed (Fig. 28, Units 1, 2). The upper 9-ft-thick Unit 2 appears to be in sharp contact with an overlying, covered (probably shale) unit. Unit 2 contains casts of fossil wood fragments (Fig. 30) and well-developed boxwork concretionary structures (Fig. 31). Note the thin-bedded, parallel-bedded, ripple-bedded, burrowed character of the unit (Fig. 32). The stratigraphically lower Unit 1 consists of interbedded shale and sandstone (Fig. 28); it is poorly exposed for ~8 ft just north of the driveway.

This relatively thin sandstone is probably part of a detached bar complex deposited within an inner- to middle-shelf marine environment. The resistant "wall" includes the cleanest and best-cemented sandstone, which constitutes the lower bar facies. This interpretation is based upon the prevalence of thin-, planar- and ripple-bedded sandstone, the absence of interbedded shale, as well as the absence of high-angle cross-bedding. The absence of a central bar facies (upper bar facies) in this outcrop indicates that this offshore bar was deposited in water depths below normal wave base. There was not enough current energy to form well-developed high-angle cross-bedding. Alternatively, the upper bar facies may have been deposited but eroded prior to burial.

Although the strata immediately below the measured section are covered, it is likely that additional sandstone and interbedded siltstone and shale occur below the outcrop. A comparison of the surface GR profile with the GR log for the Lake Ardmore section in the Samson Resources No. 1 Patzkowsky well indicates that a considerable amount of interbedded sandy and silty strata occurs in the transition zone below the principal bar facies (1,406–1,417 ft) (Fig. 33). In the surrounding area, many other wells also have "clean" sandstone that can be correlated to the 1,417–1,470-ft interval in the Samson well.

Stop 6A
Lake Ardmore Sandstone Member of the Springer Formation (MGM Ranch Section)

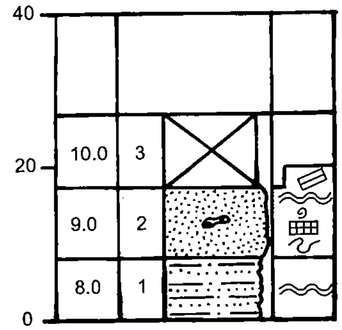


Figure 28. Graphic columnar section of rocks exposed on both sides of the driveway to MGM Ranch at Stop 6A. Explanation of symbols in Appendix 1.

MEASURED SECTION, STOP 6A

Lake Ardmore Sandstone Member of the Springer Formation (MGM Ranch Section)

SE¼SE¼SW¼SE¼ sec. 27, T. 3 S, R. 1 E., and the NE¼NE¼NW¼NE¼ sec. 34, T. 3 S., R. 1 E., Carter County (Springer 7.5′ quadrangle). Measured by LeRoy A. Hemish in the ridge on both sides of the ranch driveway, just before it curves to the north. Beds strike N. 25° W. and dip S. 65° W. at 65°.

	Thickness (feet)
SPRINGER FORMATION	
UNNAMED SHALE (?)	
3. Covered (probably shale)	10.0
LAKE ARDMORE MEMBER	
2. Sandstone, grayish orange (10YR7/4), to dark yellowish orange (10YR6/6), very fine grained, well sorted, subrounded, quartzose, noncalcareous, thin-bedded, ripple-bedded, parallel-bedded, indistinct interference ripples on some surfaces, burrows abundant; ironstone concretions common, with extensive boxwork on the steeply dipping "wall," south side of driveway; sandstone cast of wood fragment (1 × 4 in.) near top of unit on north side of road; sponge spicules present but difficult to find; unit coarsens upwards; upper and lower contacts covered—lower contact probably gradational, while upper contact appears sharp and is presumably a sandstone-shale contact	9.0
1. Shale and sandstone, interbedded, grayish orange (10YR7/4) to moderate yellowish brown (10YR 5/4). Sandstone is similar to Unit 2, and shale is very silty and sandy; slumped and poorly exposed at east side of outcrop, just north of driveway	~8.0
Total	~27.0

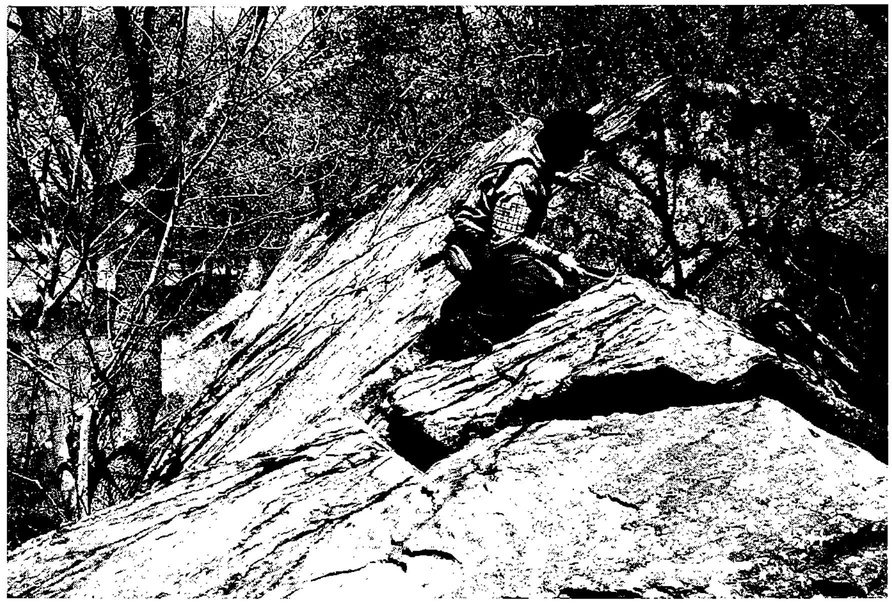


Figure 29. Steeply dipping outcrop of the Lake Ardmore Sandstone Member of the Springer Formation exposed north of the MGM Ranch driveway (Unit 2, Fig. 28). The beds strike N. 25° W. and dip S. 65° W. at 65°. The top surface of the beds is to the left in the photograph.

The measured section and the Samson well are only ~2.7 mi apart.

Cuttings from the Beach & Talbot No. 1 Pruitt BB well (Appendix 2; map inside front cover) confirm the above observations and interpretations. Units 3–6 correlate well with the Lake Ardmore strata in the Samson well and with the strata exposed at Stop 6A. The Lake Ardmore Member is poorly developed in the subsurface ~2 mi north of Stop 6A, where it is mostly siltstone (see Goldsmith & Perkins No. 1 Herman Smith well [Appendix 3; map inside front cover]).

Figure 30. Cast of a fossil wood fragment (1 × 4 in.) in the Lake Ardmore Sandstone Member of the Springer Formation (Unit 2, Fig. 28) at Stop 6A.

Both the surface GR profile of the Lake Ardmore Sandstone at the MGM Ranch and the GR log of the same formation in the Samson well clearly show coarsening-upward textural profiles (Fig. 33). On the surface GR profile, the cleanest sandstone with the best potential as a reservoir occurs at the very top of the sandstone interval, where the GR intensity is less than ~85 cts/sec (Fig. 33, left side). On the GR log from the Samson well, this same "clean" sandstone zone occurs at 1,406–1,417 ft (Fig. 33, center). Based upon analogies of GR responses presented thus far, the strata in the 1,417–1,470-ft interval in the Samson well can be interpreted as planar-, ripple-bedded sandstone interstratified with numerous shale and silty shale partings.

Figure 31. Boxwork concretionary structures exposed on the steeply dipping surface of Unit 2 (Fig. 28) of the Lake Ardmore Sandstone at Stop 6A. Geologic pick for scale.

Figure 32. Cross-sectional view of the thin-bedded Lake Ardmore Sandstone (Unit 2, Fig. 28) exposed at the south side of the driveway to MGM Ranch, just beyond the fence. Note the pits marking fossil burrows. The perspective in this figure is looking down on upturned edges of steeply dipping beds that protrude only a few inches above ground level. Geologic pick for scale.

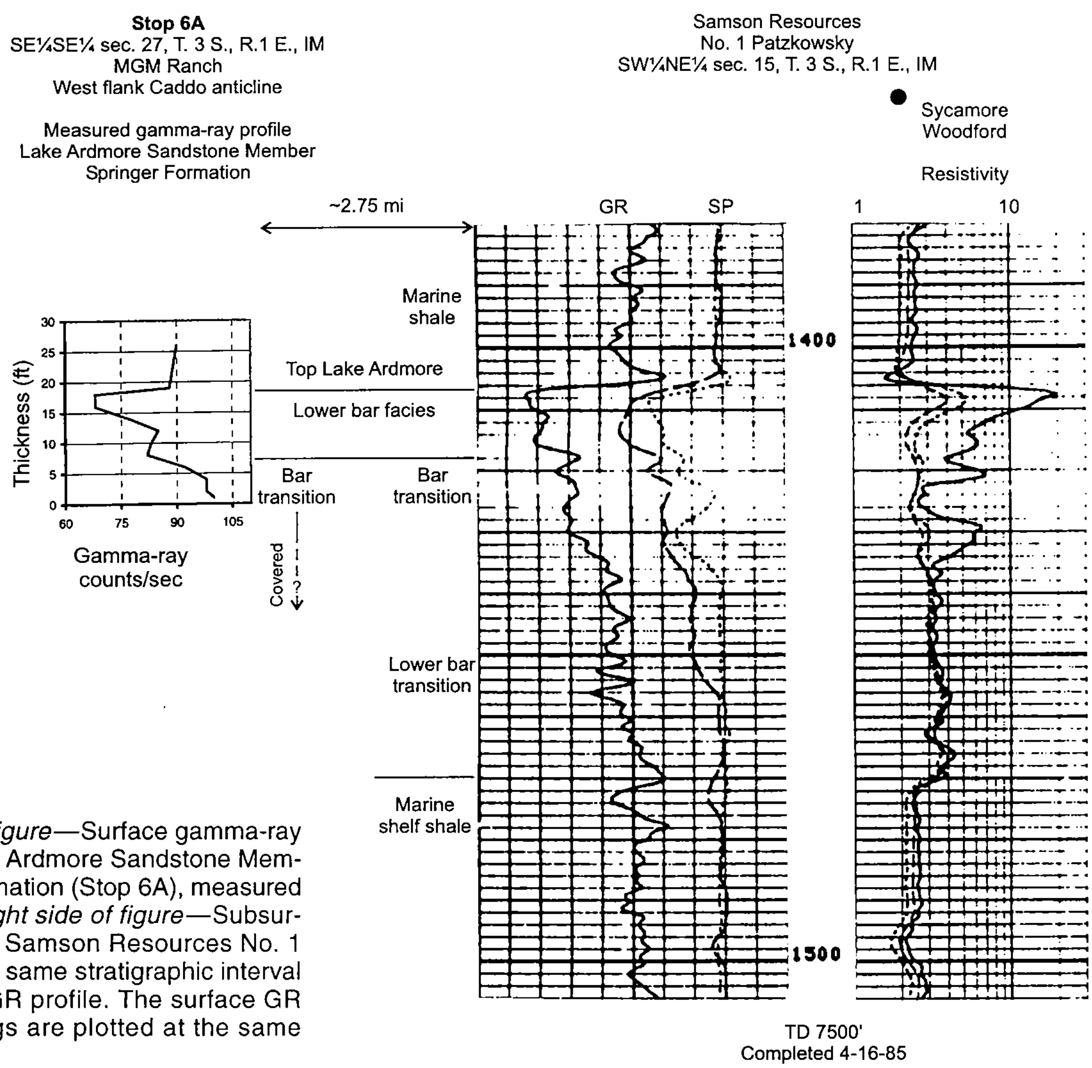


Figure 33. *Left side of figure*—Surface gamma-ray (GR) profile of the Lake Ardmore Sandstone Member of the Springer Formation (Stop 6A), measured at the MGM Ranch. *Right side of figure*—Subsurface well logs from the Samson Resources No. 1 Patzkowsky well for the same stratigraphic interval shown in the surface GR profile. The surface GR profile and the well logs are plotted at the same vertical scale.

STOP 6B

OVERBROOK SANDSTONE MEMBER OF THE SPRINGER FORMATION (MGM Ranch Headquarters Section)

Location: SE¼SE¼SW¼SE¼ sec. 34, T. 3 S., R. 1 E., Carter County (Springer 7.5′ quadrangle)

This stop is on private property.
Please contact Michael G. McCauley, 2410 N. Commerce, Ardmore, Oklahoma, phone (580) 226-0812 (business) or (580) 223-5872 (home) for permission to visit outcrops.

Directions: From Stop 6A, continue on the Trail Ranch driveway for ~0.1 mi to the ranch house; park, and walk south to the exposures on the south side of a small hill, just north of the corral, and to the "wall" east of Rock Creek, just below the corral.

A 54-ft-thick, thin-bedded, ripple-bedded, parallel-bedded, extensively burrowed sandstone is well exposed in a small hill at this stop (Figs. 34–36). The outcrop is on the southwest flank of the Caddo anticline. Beds strike N. 25° W. and dip S. 65° W. at 64°. Note the similarities between this exposure of the Overbrook and Unit 2 at Stop 2, City Lake Spillway Section (Fig. 9). A spectacular "wall" is formed by Unit 4 (Fig. 34), where a blocky, medium- to

MEASURED SECTION, STOP 6B

Overbrook Sandstone Member of the Springer Formation (MGM Ranch Headquarters Section)

SE¼SE¼SW¼SE¼ sec. 34, T. 3 S., R. 1 E., Carter County (Springer 7.5′ quadrangle). Measured by LeRoy A. Hemish in the exposure on the south side of a small hill south of the ranch house and also in the steep "wall" east of Rock Creek, just below the corral. Beds strike N. 25° W. and dip S. 65° W. at 64°.

Thickness (feet)

SPRINGER FORMATION

OVERBROOK SANDSTONE MEMBER

4. Sandstone, light brown (5YR6/4) to moderate orange pink (5YR8/4) with light brown (5YR5/6) staining; very fine grained, well sorted, subrounded, quartzose, well indurated, medium- to thick-bedded, blocky; contains high-angle cross-bedding, some asymmetrical ripples; upper surface has abundant interference ripples; noncalcareous; trace fossils common; includes mud clasts that weather out to form cavities; contains ironstone concretions and boxwork structures on some surfaces; lower contact covered; upper surface forms "wall" in stream valley below dam and is presumably in sharp contact with shale.. 11.0
3. Covered .... ~110.0

Stop 6B
Overbrook Sandstone Member of the Springer Formation
(MGM Ranch Headquarters Section)

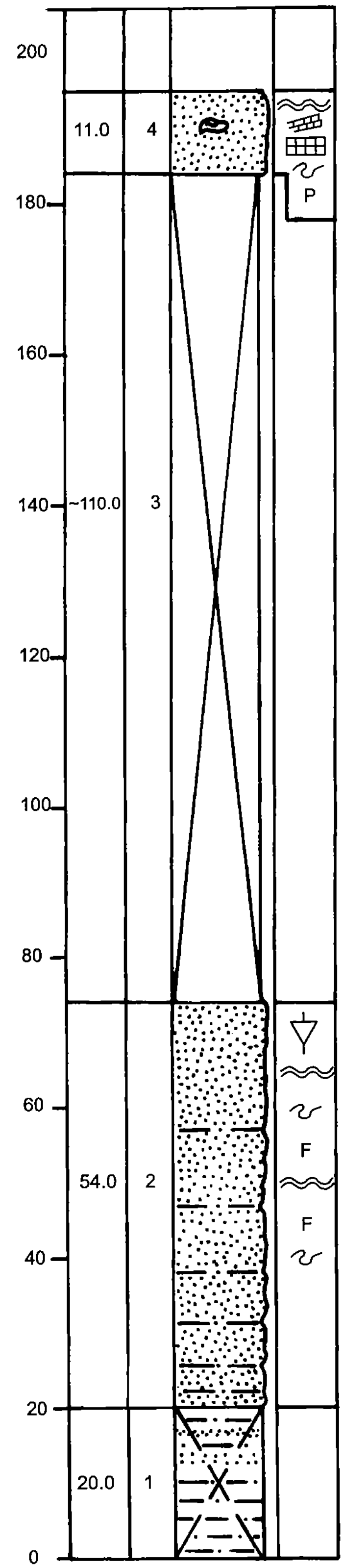


Figure 34. Graphic columnar section of rocks exposed at the MGM Ranch headquarters at Stop 6B. Explanation of symbols in Appendix 1.

Figure 35. Outcrop of the lower unit of the Overbrook Sandstone Member of the Springer Formation (Unit 2, Fig. 34) at Stop 6B. Compare this exposure of the Overbrook Sandstone with Unit 2, Stop 2 (see Figs. 9, 11).

2. Sandstone, very pale orange (10YR8/2) to grayish orange (10YR7/4), to dark yellowish orange (10YR 6/6); includes some 2–3-in.-thick moderate brown (5YR4/4), hard, ferruginous beds; very fine grained; well sorted; rounded; noncalcareous; very thin to thin bedded; ripple-bedded; parallel-bedded; extensively burrowed, both vertically and horizontally; coarsening-upward sequence, with silty shale beds commonly occurring in lower one-half of interval; upper and lower contacts gradational	54.0
UNNAMED SHALE (?)	
1. Covered (probably mostly silty shale, as indicated by float)	~20.0
Total	~195.0

thick-bedded facies of the Overbrook is present just east of the flood plain of Rock Creek (Fig. 37). The surface along the outcrop "wall" contains an abundance of trace fossils, interference ripples (Fig. 38), boxwork concretions, and cavities formed by the weathering out of mud clasts. High-angle cross-bedding can be seen in cross-sectional view (Fig. 39).

The depositional origin of the Overbrook Sandstone at Stop 6B is similar to that of the Lake Ardmore Sandstone at Stop 6A and that of the Overbrook Sandstone at Stop 2. However, here at Stop 6B, the Overbrook has a thin, but laterally extensive, interval of sandstone with well-developed high-angle cross-bedding at the top of the section. The lateral extent of this sedimentary structure and its stratigraphic position indicate that deposition occurred along the crest of the bar (offshore, detached) in very shallow water (probably less than several feet deep). A

Figure 36. Close-up view of the ripple-bedded, parallel-bedded sandstone (Unit 2, Fig. 34) shown in Fig. 35. The photograph is oriented so that the tops of the beds are at the top of the figure.

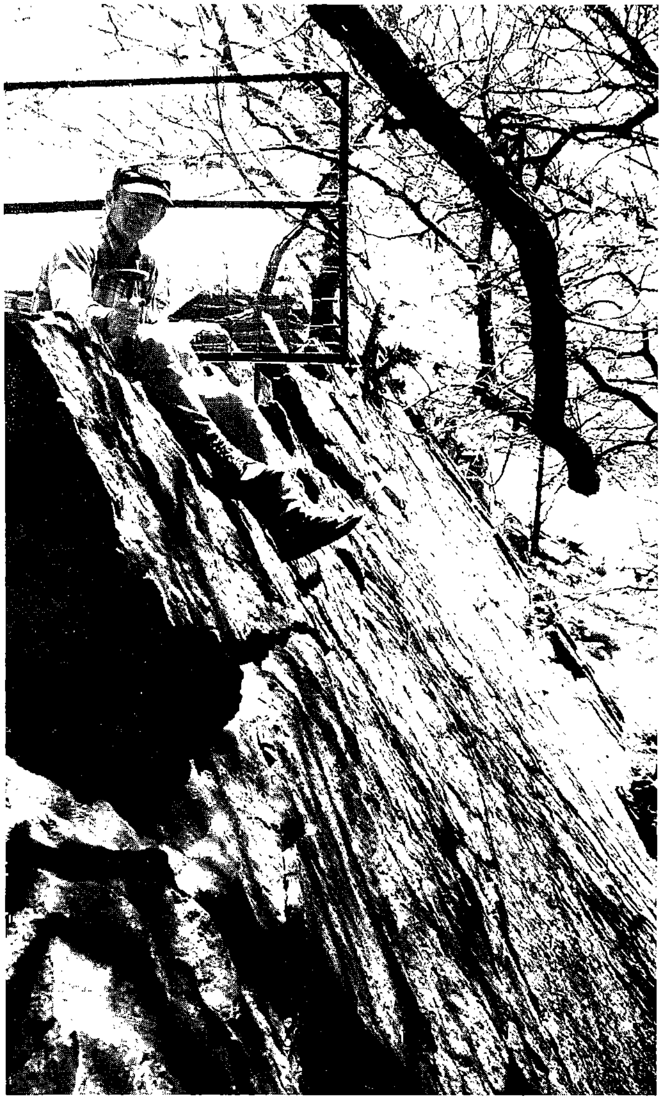


Figure 37 *(left)*. At Stop 6B, the steeply dipping beds of the uppermost sandstone of the Overbrook Member (Unit 4, Fig. 34) form a "wall" below the dam at Scott King Lake and adjacent to the flood plain of Rock Creek.

Figure 38. Interference ripple marks (around the geologic pick) and trace fossils (upper one-third of the photograph and just to the right of the pick handle) on the surface of Unit 4 (Fig. 34) at Stop 6B.

Figure 39. Cross-sectional view of high-angle cross-bedding at the top of the exposure of the upper unit of the Overbrook Sandstone (Unit 4, Fig. 34) at Stop 6B, just west of the corral at MGM Ranch headquarters.

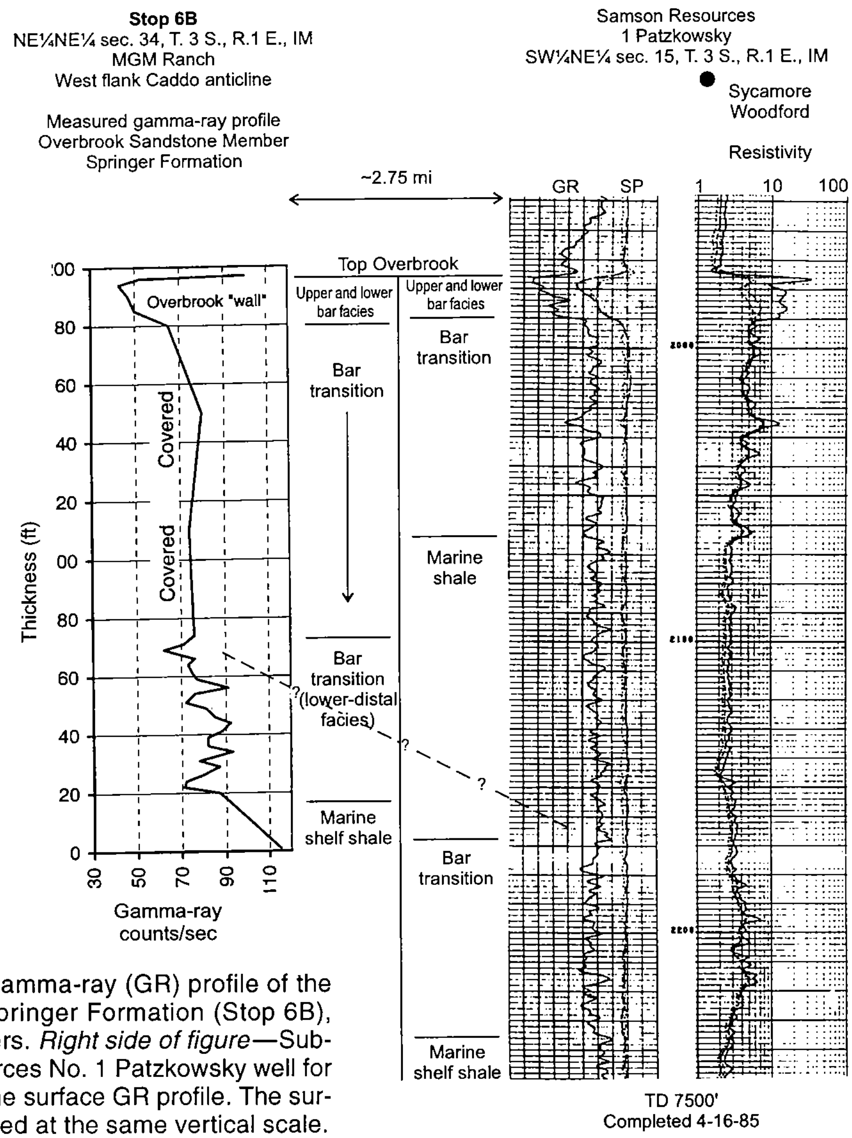


Figure 40. *Left side of figure*—Surface gamma-ray (GR) profile of the Overbrook Sandstone Member of the Springer Formation (Stop 6B), measured at the MGM Ranch headquarters. *Right side of figure*—Subsurface well logs from the Samson Resources No. 1 Patzkowsky well for the same stratigraphic interval shown in the surface GR profile. The surface GR profile and the well logs are plotted at the same vertical scale.

central bar complex (upper bar facies) formed along much of the crest of the bar, which is parallel to depositional strike (parallel to the "wall"). Farther to the north, along the northeast flank of the Caddo anticline, it is doubtful that this facies exists.

A comparison of the measured section and the surface GR profile of the Overbrook Sandstone at Stop 6B with the GR log of the same interval in the Samson Resources No. 1 Patzkowsky well shows similarities in all facies (Figs. 34, 40). The upper and lower bar facies on the surface GR profile, although relatively thin where exposed (about 195–184 ft) can be correlated to the 1,976–1,990-ft interval on the Samson well log (Fig. 40). A thick covered interval on the surface probably correlates to a bar transition and shaly interval identified on the well log at about 1,990–2,168 ft. A lower interstratified sandstone and shale zone in the Samson well (about 2,168–2,234 ft) probably correlates to similar strata exposed at the surface (about 70–20 ft). At the outcrop, this lower unit (Unit 2) is very sandy with numerous shale and siltstone splits, and it is interpreted to be part of a bar transition zone. A comparison of the surface GR profile with the GR profile in the well log indicates, by analogy, that the same lithology probably occurs in the Samson well in the lower bar transition zone as occurs in the surface exposure.

Cuttings from the Goldsmith and Perkins No. 1 Herman Smith well (Units 7–13) (Appendix 3; map inside front cover) indicate that the 160 ft of strata assigned to the Overbrook Member correlate very well with the same interval in the Samson well and also with the exposed Overbrook at Stop 6B, where the Member is 175 ft thick. Although the Overbrook sequence is thinner (60 ft) (Units 8–12) in the Beach & Talbot No. 1 Pruitt BB well, the facies are similar.

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U.S. Geological Survey, 1986, Ardmore, Oklahoma-Texas 30′ × 60′ quadrangle map: U.S. Geological Survey, scale 1:100,000.

Appendixes

Appendix 1

Explanation of Symbols Used in This Guidebook

- Sandstone
- Sandstone, shaly
- Sandstone, siltstone, shale, interbedded
- Siltstone
- Siltstone, shaly
- Shale
- Shale, silty, sandy
- Shale, black
- Limestone
- Ironstone
- Covered interval
- Covered interval with rare exposures of rock type indicated
- Covered interval; lithology suggested by concentration of float

SEDIMENTARY FEATURES

- Plane, parallel stratification
- Amalgamated channels
- Cross-stratification
- Low-angle cross-stratification
- Wavy, rippled, or crinkled
- Lenticular bedding
- Swaly bedding, curved bedding
- Convolute, slumped, or contorted bedding; soft-sediment deformation
- Ripple marks
- Load structures
- Boxwork weathering
- Dewatering structures or dish and pillar
- Plant fossils
- Trace fossils
- Invertebrate fossils
- C Calcareous
- F Ferruginous
- L Liesegang banding
- P Pitted, cavities
- Coarsening-upward sequence

Appendix 2

Upper Part of the Lithologic Subsurface Log from the Beach & Talbot No. 1 Pruitt BB Well, SW¼SE¼SE¼ sec. 23, T. 3 S., R. 1 E., Carter County, Oklahoma. Elevation, 800 ft. Descriptions from cuttings. Explantion of symbols in Appendix 1.

Depth (ft)	Unit Thickness (ft)	Unit No.	Lithology	Description of Units
				SPRINGER FORMATION
				UNNAMED SHALE MEMBER
	220	1		1. Shale, medium dark gray (N4), silty, noncalcareous, with minor grayish red (5R4/2) ironstone.
	200	2		2. No samples.
				LAKE ARDMORE MEMBER
	20	3		3. Sandstone, very light gray (N8) to medium dark gray (N4), very fine grained, subrounded, silty, poorly sorted, noncalcareous; includes abundant moderate reddish brown (10R4/6), very fine grained sandstone, and black (N1) carbonaceous plant fragments from 430 to 440 ft; contains minor medium dark gray (N4) silty shale.
	10	4		4. Shale, medium dark gray (N4), silty, includes ~25% very light gray (N8), very fine grained sandstone.
	10	5		5. Sandstone, very light gray (N8), very fine grained, and shale, medium dark gray (N4), mixed, ~50% each.
	40	6		6. Shale, medium dark gray (N4), silty; includes minor very light gray (N8), very fine grained sandstone.
				UNNAMED SHALE MEMBER
	220	7		7. Shale, medium dark gray (N4), silty, hard, noncalcareous, with minor moderate reddish brown (10R4/6) ironstone; includes some very light gray (N8), very fine grained sandstone laminae from 590 to 600 ft.
				OVERBROOK MEMBER
	20	8		8. Siltstone, medium gray (N5), and shale, silty, medium dark gray (N4); siltstone is laminated and contains some black (N1), carbonized plant fragments; includes minor very fine grained sandstone.
	10	9		9. Sandstone, very light gray (N8), very fine grained, with siltstone (~20%) and shale (~30%).
	10	10		10. Shale, medium dark gray (N4), with ~20% very light gray (N8), very fine grained sandstone.
	10	11		11. Shale medium dark gray (N4), with grayish red (5R4/3) ironstone.
	10	12		12. Shale, medium dark gray (N4), with ~40% interlaminated, light gray (N7), very fine grained sandstone and siltstone.
		13		*UNNAMED SHALE MEMBER*
	600	13		13. Shale, medium dark gray (N4), silty, with grayish red (5R4/2) ironstone; slickensides common.
1,380				*ROD CLUB MEMBER*
	60	14		14. Shale, medium dark gray (N4), with 20–40% medium light gray (N6) interlaminated siltstone and very fine grained sandstone.
1,440	20	15		15. Shale, medium gray (N5), very silty, noncalcareous, with grayish red (5R4/2) ironstone.
1,460	60	16		16. Shale, medium dark gray (N4), with 20–40% medium light gray (N6) interlaminated siltstone and very fine grained sandstone.
1,520				GODDARD FORMATION
				UNNAMED SHALE MEMBER
	880	17		17. Shale, medium dark gray (N4), silty, noncalcareous, with moderate reddish brown (10R4/6) ironstone.
2,000				

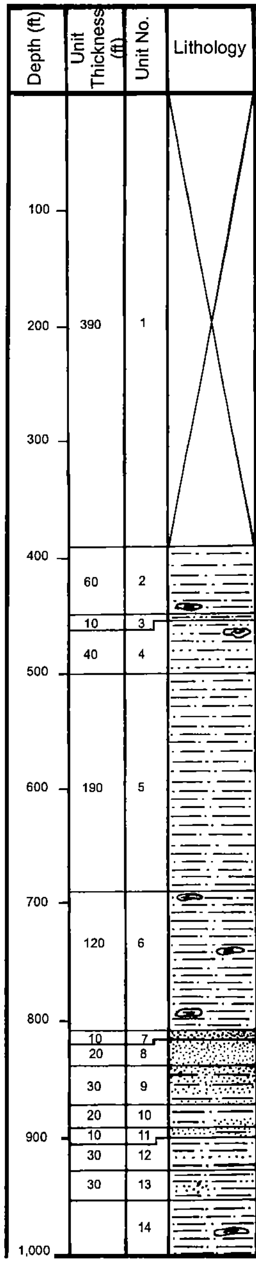
Appendix 2 *(continued)*

Depth (ft)	Unit Thickness (ft)	Unit No.	Lithology	Description of Units
2,100; 2,200; 2,300		17		
2,400–2,500	100	18		18. No samples.
2,500–2,600	100	19		19. Shale, medium dark gray (N4), silty, noncalcareous, with moderate reddish brown (10R4/6) ironstone.
2,600–2,700	110	20		20. No samples.
2,710–2,990 (2,800; 2,900)	280	21		21. Shale, medium dark gray (N4), silty, noncalcareous, with moderate reddish brown (10R4/6) ironstone.
2,990–3,000		22		

Depth (ft)	Unit Thickness (ft)	Unit No.	Lithology	Description of Units
3,030	40	22		22. Shale, medium dark gray (N4), with about 10–30% light gray (N7), very fine grained, well rounded, well sorted quartzose sandstone.
3,100; 3,200; 3,300; 3,400	370	23		23. Shale, medium dark gray (N4), silty, noncalcareous, with moderate reddish brown (10R4/6) ironstone.

Appendix 3

Upper Part of the Lithologic Subsurface Log from the Goldsmith & Perkins No. 1 Herman Smith Well, CSW¼SW¼SE¼ sec. 15, T. 3 S., R. 1 E., Carter County, Oklahoma. Elevation, 946 ft. Descriptions from cuttings. Explantion of symbols in Appendix 1.



Description of Units

1. No samples.

SPRINGER FORMATION

UNNAMED SHALE MEMBER

2. Shale, medium dark gray (N4), silty, noncalcareous, minor moderate red (5R4/6) ironstone at 440 ft.

LAKE ARDMORE MEMBER

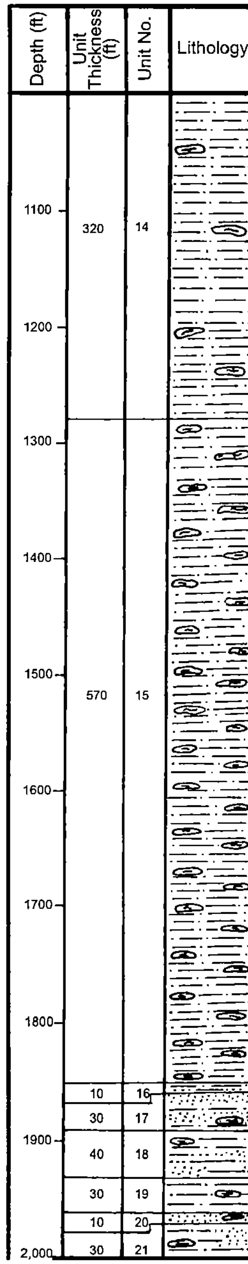
3. Shale and siltstone, medium dark gray (N4), ~50% each.
4. Siltstone, medium dark gray (N4), finely laminated, minor moderate red (5R4/6) ironstone at 470 ft.

UNNAMED SHALE MEMBER

5. Shale, medium dark gray (N4), silty, noncalcareous.
6. Shale, medium dark gray (N4), silty, noncalcareous, with moderate brown (5YR4/4) ironstone.

OVERBROOK MEMBER

7. Sandstone, light gray (N7), very fine grained, well sorted, subrounded, good porosity.
8. Sandstone, light gray (N7) to very light gray (N8), very fine grained, well sorted, subrounded good porosity.
9. Sandstone, very light gray (N8) from 870 to 880 ft, very fine grained; interbedded with medium dark gray (N4) silty shale; includes minor black (N1), carbonized plant fragments; sandstone is medium gray (N5), with minor grayish red (5R4/2) component from 850 to 870 ft.
10. Shale, medium dark gray (N4), silty, noncalcareous; includes some medium gray (N5) very fine grained sandstone from 880 to 890 ft.
11. Sandstone, medium gray (N5) and grayish red (5R4/2), with medium dark gray (N4) silty shale.
12. Shale, medium gray (N5), silty, with minor medium light gray (N6), very fine grained sandstone.
13. Sandstone, siltstone, and shale, medium gray (N5), thinly laminated.



Description of Units

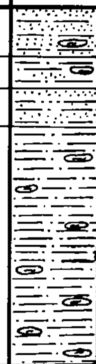
UNNAMED SHALE MEMBER

14. Shale, medium gray (N5), silty, noncalcareous, with minor moderate red (5R4/6) ironstone.
15. Shale, medium gray (N5), silty, noncalcareous, with abundant moderate red (5R4/6) ironstone.

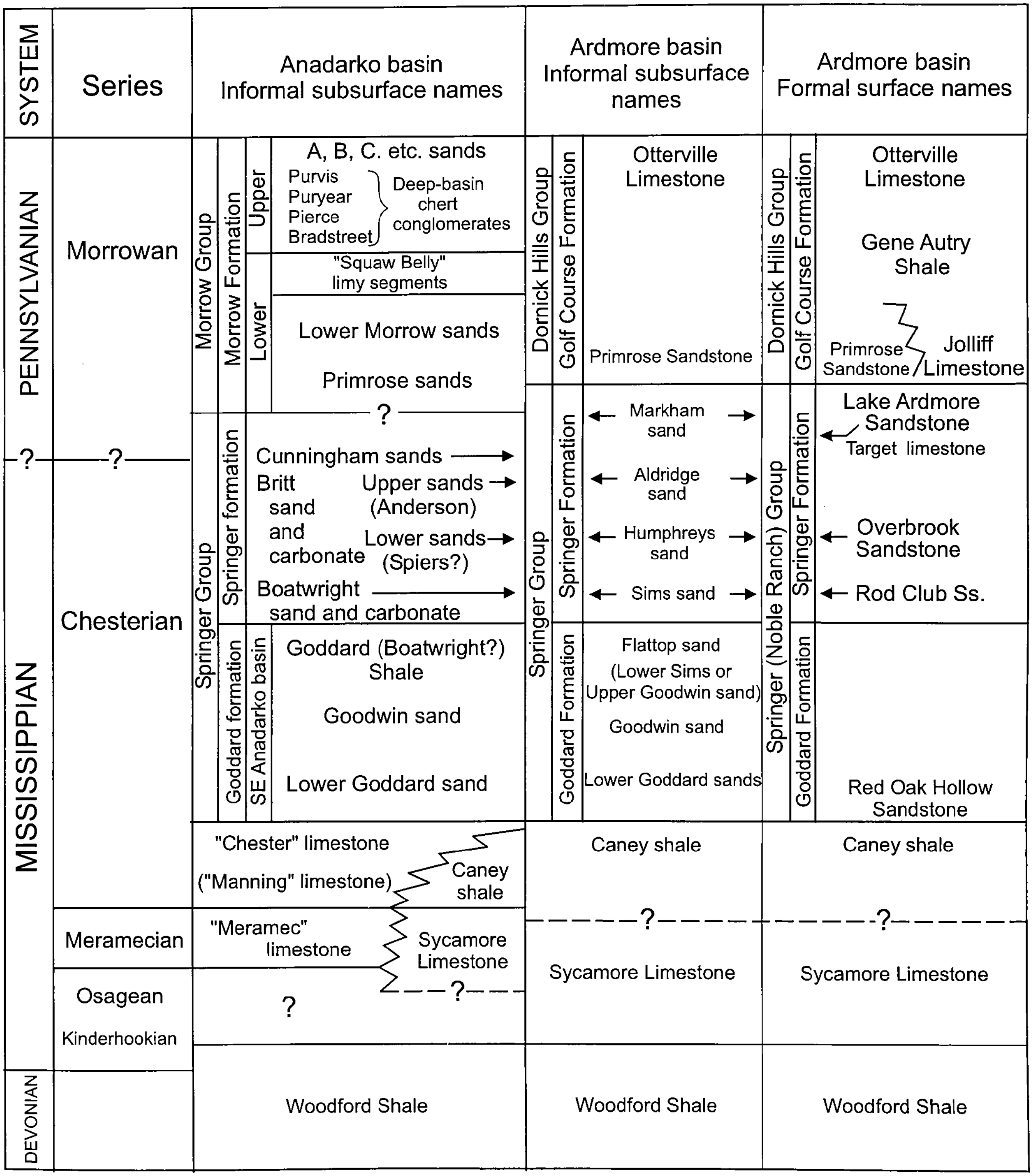
ROD CLUB MEMBER

16. Shale, medium gray (N5), silty, with ~20% medium light gray (N6), very fine grained sandstone and siltstone.
17. Sandstone, medium light gray (N6) to very light gray (N8); interlaminated with medium dark gray (N4) siltstone and shale; includes black (N1), carbonized plant fragments and some grayish red (10R4/2) ironstone.
18. Shale, medium dark gray (N4), silty, with grayish red (10R4/2) ironstone, and 20–30% very light gray (N8), very fine grained sandstone.
19. Shale, medium gray (N5), silty, noncalcareous, with minor grayish red (10R4/2) ironstone.
20. Sandstone, very light gray (N8), very fine grained, well sorted, well rounded, quartzose; includes black (N1), carbonized plant fragments; mixed with minor shale and ironstone.
21. Shale, medium gray (N5), silty, with minor grayish red (10R4/2) ironstone and ~15% very light gray (N8), very fine grained, "clean" sandstone.

Appendix 3 *(continued)*

Depth (ft)	Unit Thickness (ft)	Unit No.	Lithology	Description of Units
	40	22		22. Sandstone, very light gray (N8), very fine grained, well rounded, well sorted, with black (N1) flecks; mixed with medium dark gray (N4), silty shale and minor pale brown (5YR5/2) ironstone.
	30	23		23. Shale, medium dark gray (N4), silty, with minor very light gray (N8), very fine grained sandstone, and pale brown (5YR5/2) ironstone.
2100	30	24		24. Sandstone, light gray (N7), very fine grained; interlaminated with medium dark gray (N4) siltstone and shale; includes black (N1), carbonized plant fragments.
2200	200	25		GODDARD FORMATION *UNNAMED SHALE MEMBER* 25. Shale, medium gray (N5), silty, noncalcareous, with grayish red (5R4/2) ironstone.
2300				

Stratigraphic Nomenclature of the Springer Group and Bounding Strata in the Anadarko and Ardmore Basins in Western Oklahoma



Correlation arrows in the Springer are based on electric log correlations. Modified from Kleehammer (1991), McBride (1986), Peace (1964), and Peace (1989).