OKLAHOMA GEOLOGICAL SURVEY
Charles J. Mankin, *Director*

BULLETIN 126

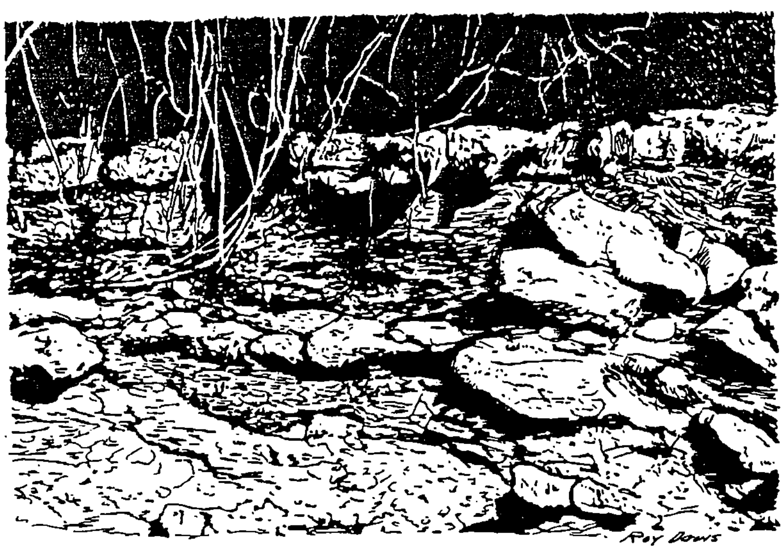
GEOLOGY AND MINERAL RESOURCES OF BRYAN COUNTY, OKLAHOMA

PART I.—AREAL GEOLOGY OF BRYAN COUNTY

GEORGE G. HUFFMAN, THOMAS A. HART, LAURENCE J. OLSON, JOHN D. CURRIER, AND ROBERT W. GANSER

PART II.—OIL AND GAS IN BRYAN COUNTY

GEORGE G. HUFFMAN



The University of Oklahoma
Norman
1978

Title-Page Illustration

Ink drawing by Roy D. Davis from a photograph (fig. 16, p. 24) of alternating beds of clay and nodular limestone in the Duck Creek Member of the Caddo Formation of Cretaceous age, located in the SW¼ sec. 18, T. 5 S., R. 12 E.

This publication, printed by the Transcript Press, Norman, Oklahoma (book), and Stafford-Lowdon Company, Fort Worth, Texas (map), is issued by the Oklahoma Geological Survey as authorized by Title 70, Oklahoma Statutes 1971, Section 3310, and Title 74, Oklahoma Statutes 1971, Sections 231-238. 1,000 copies have been prepared for distribution at a cost to the taxpayers of the State of Oklahoma of $11,105.

Type faces:	Text in 8- and 10-pt. Century Schoolbook, leaded 1 pt. Heads in 10-pt. bold Century Schoolbook Captions in 8-pt. Helvetica, leaded 1 pt. Table heads in 10-pt. large and small caps Century Schoolbook
Presswork:	Miehle TP-29 Perfector
Binding:	Sewn with softbound and hardbound cover
Paper:	Text on 70-lb. Mountie Matte Cover (hardbound) on Gane 8159LV blue cloth on 160-pt. binder's board Cover (softbound) on 65-lb. Hammermill gray, antique finish

DEDICATION

This bulletin is dedicated to the memory of Dr. Carl C. Branson (deceased), former Chairman of the School of Geology (now the School of Geology and Geophysics), The University of Oklahoma, and Director of the Oklahoma Geological Survey, who initiated the study of the geology of Bryan and Choctaw Counties, Oklahoma, and who gave freely of his time, energy, and enthusiasm to the project: During the early part of the investigation, he made frequent trips to the field with the senior author and students. He also provided financial assistance through the Oklahoma Geological Survey. We regret that he did not live to see the project completed.

CONTENTS

Part II.—Oil and Gas

ILLUSTRATIONS

Figures

Plate

TABLES

GEOLOGY AND MINERAL RESOURCES OF BRYAN COUNTY, OKLAHOMA

Abstract—Bryan County encompasses 891 square miles in southern Oklahoma. Boundaries include the Red River on the south, Choctaw County on the east, Johnston and Atoka Counties on the north, and Marshall County on the west. The Washita arm of Lake Texoma separates Bryan and Marshall Counties.

Rocks exposed at the surface range in age from Early Cretaceous (Trinity Group) to Late Cretaceous (Eagle Ford Formation). These are overlain at places by extensive deposits of terrace and alluvium of Pleistocene and Recent age. The Antlers Sandstone (basal Cretaceous) is time-transgressive and represents a nearshore facies of a sea advancing across the surface of eroded Paleozoic rocks. The Trinity Group is represented by the Antlers Sandstone; the Fredericksburg Group by the Goodland Limestone and the Kiamichi Formation; the Washita Group by the Caddo Formation (Duck Creek and Fort Worth equivalents), Bokchito Formation (Denton, Soper, Weno, McNutt, and Pawpaw Members), Bennington Limestone, and the Grayson Marlstone. Woodbine Formation (Upper Cretaceous) rests disconformably on the Lower Cretaceous strata, truncating the Grayson Marlstone northward. The Red Branch Member of the Woodbine Formation separates the Dexter Member (below) from the Lewisville Member (above). The Templeton Member (Upper Woodbine) has been identified and mapped in southern Bryan County where it is overlain by blue-gray, calcareous siltstone and shale of the Eagle Ford Formation (restricted). Four well-developed Pleistocene terrace levels and remnants of a fifth level have been recognized.

Surface structure in Bryan County is relatively simple with a gentle southwestward and northeastward dip into the Cumberland-Kingston Syncline. Several synclines and anticlines plunge southeastward from Marshall County into western Bryan County where they are reflected by the outcrop of more resistant beds within the Lower Cretaceous sequence. Important structures include the Preston Anticline, Kingston Syncline, Madill-Aylesworth Anticline, Cumberland Syncline, and the Cumberland Anticline.

Basement rocks in subsurface include the Tishomingo Granite (Precambrian) and the Colbert Porphyry or Carlton Rhyolite (Middle Cambrian?). Overlying Paleozoic rocks of the Arbuckle facies include the Reagan Sandstone, Honey Creek Limestone, Arbuckle Group, Simpson Group (Joins, Oil Creek, McLish, Tulip Creek, and Bromide Formations), Viola Limestone, Sylvan Shale, Hunton Group, Woodford Formation, Sycamore Limestone, "Caney" Shale, Goddard-Springer Shale, and Dornick Hills Group. The Ouachita facies, which includes the Mazarn Shale, Womble Shale, Bigfork Chert, and Polk Creek Shale of Ordovician age; and the Missouri Mountain Shale and Arkansas Novaculite of Silurian-Devonian-Mississippian age; the Stanley Shale, Jackfork Sandstone, Johns Valley Shale, and "Atoka" Formation of Carboniferous age, appear to have been thrust northwestward onto the Arbuckle facies. Both the Arbuckle and Ouachita facies were truncated by erosion and are unconformably overlain by rocks of Cretaceous age.

Subsurface structures that affect the Paleozoic rocks and control the oil and gas accumulation beneath the onlapping Cretaceous are complicated, consisting of a series of northwest-southeast trending folds and faults that extend from the Arbuckle Mountains, Ardmore Basin, and Criner Hills complex and plunge beneath the Ouachita thrust or grade into the Ouachita facies. These structures are depicted by means of subsurface maps and cross sections. Tectonic features of significance in oil and gas accumulation and in an understanding of the subsurface geology of Bryan County include from northeast to southwest: (1) Clear Boggy Block, (2) Sulphur Fault, (3) Tishomingo-Belton Horst Block, (4) Washita Valley Fault, (5) Ravia Fault Block, (6) Cumberland Fault, (7) Cumberland Anticline, (8) Cumberland Syncline, (9) Madill-Aylesworth Anticline, (10) Kingston Syncline, (11) Preston Anticline, (12) Meers Valley–Wichita–Criner Hills System, and (13) Bryan Basin and Fault (Salient).

Three major oil and gas fields are associated with the above named structures. Aylesworth Southeast is located on the Madill-Aylesworth Anticline where two high-angle faults give rise to approximately 3,000 feet of displacement. Production of the southwest flank is from the Bromide sand; multiple reservoir rocks produce on the northeast flank. Cumberland Field is located on an elongate anticline and produces oil from the Bromide, McLish, and Oil Creek sands. Durant East is on an anticlinal flexure beneath the Cumberland Thrust (Ravia Block) and production is from the Oil Creek, McLish, and Bromide sands. Several small one-well fields are present but are of minor importance.

Nonmetallic mineral deposits yield approximately 3 million dollars per year. The principal products are petroleum, natural gas, stone, sand, and gravel. Abundant water is available, both in subsurface aquifers and in surface lakes. The economy of the county seems to be in excellent condition with numerous industrial plants and an active oil industry. Future drilling is expected to find additional hydrocarbons along the Cumberland and Aylesworth trends and possibly in the Ouachita facies.

Abstract

The geologic and tectonic history of Bryan County includes: (1) faulting of the basement rock and formation of the Southern Oklahoma Geosyncline during Cambrian time, (2) filling of the Southern Oklahoma Geosyncline with early Paleozoic carbonates and late Paleozoic clastics, (3) several episodes of tectonic activity, especially in Pennsylvanian time (Wichita, Arbuckle, and Marathon-Ouachita orogenies), (4) post-Pennsylvanian, pre-Cretaceous erosion and peneplanation, (5) inundation by Cretaceous seas and deposition of the rocks of the Cretaceous System, (6) Tertiary erosion, and (7) formation of extensive Pleistocene terraces and development of modern drainage systems.

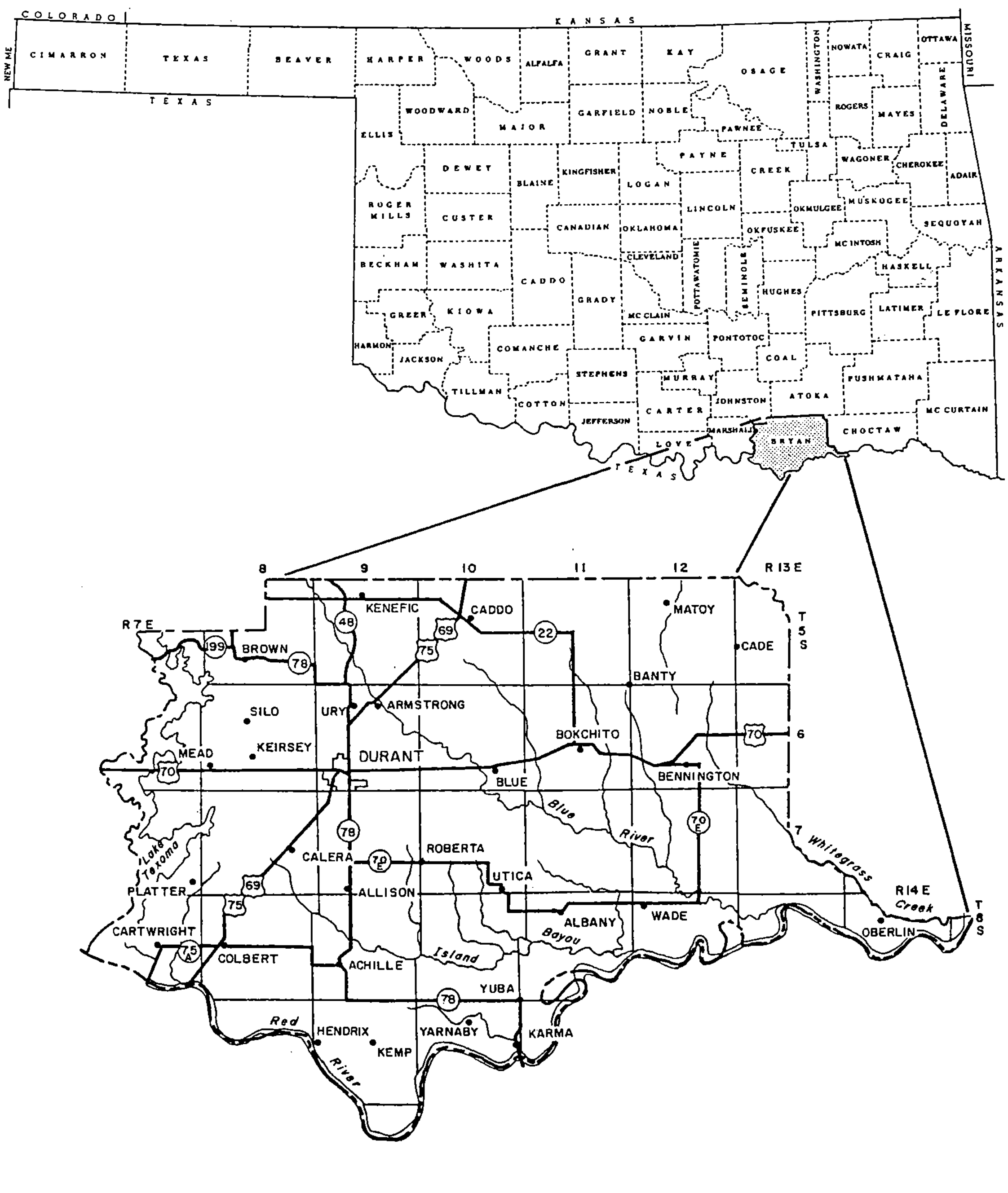


Figure 1. Location map of Bryan County with major highways, cities, and drainages indicated.

PART I.—AREAL GEOLOGY OF BRYAN COUNTY

George G. Huffman,[1] Thomas A. Hart,[2] Laurence J. Olson,[3]
John D. Currier,[4] and Robert W. Ganser[5]

INTRODUCTION

Location and Description

Bryan County, Oklahoma, is in the southern part of the State (fig. 1). It is bounded on the west by Marshall County, on the north by Johnston and Atoka Counties, and on the east by Choctaw County. The Red River forms the southern boundary separating Bryan County from Grayson and Fannin Counties, Texas.

Bryan County is approximately rectangular in shape, measuring about 40 miles from west to east and 25 miles from north to south. Greatest width, 47 miles, is in the southern part where a 10-mile extension occurs between Red River and Whitegrass Creek, the latter separating Bryan and Choctaw Counties. Bryan County includes 891 square miles (570,240 acres).

Purpose and Methods

The primary purpose of the first part of this investigation was the detailed areal mapping of Cretaceous strata and Quaternary deposits in Bryan County. Special attention was given to mapping of extensive Pleistocene terraces adjacent to the Red and Washita Rivers and correlation of these with levels previously established by Frye and Leonard (1963) in Texas.

Graduate students from The University of Oklahoma, working under the supervision of the senior author during 1965–1970, mapped portions of the area. Olson (1965) mapped the eastern one-third, Ganser (1968) and Hart (1970) mapped the northwestern part, and Currier (1968) mapped the southwestern part. The senior author resumed work in the area in the summer of 1972, mapped the south-central part, rechecked the geology of the entire county, and brought the field mapping to completion in 1973.

Aerial photographs taken by the U.S. Department of Agriculture (1963) at a scale of 1:20,000 (approximately 3.2 inches per mile) were used as the base for field mapping, the geology being recorded on acetate overlays taped to the photographs. The base map was compiled from the aerial photographs, using the network of roads and drainages shown. Formational contacts and other data were transferred from the acetate overlays to the base map. The latter was reduced photographically to one inch per mile and final scribing was done by Marion Clark of the Oklahoma Geological Survey.

During the course of the field work, representative stratigraphic sections (Appendix A, p. 87-104) were measured and described. Fossils were collected from several lithic units and photographs were taken of typical exposures. Samples were studied and analyzed at The University of Oklahoma. The project was financed and supported by the Oklahoma Geological Survey under the guidance of C. C. Branson, former director, and C. J. Mankin, present director.

The manuscript was read critically by Frank E. Lozo Jr., Houston, Texas; J. Dan Powell, Grand Junction, Colorado; and Jerome M. Westheimer, Ardmore, Oklahoma. Thomas A. Hart, one of the junior authors, read the completed manuscript and made valuable corrections and comments. Robert O. Fay, Oklahoma Geological Survey, read the manuscript and assisted in its final revision. Illustrations were drafted by Roy Davis, Oklahoma Geological Survey.

[1]Professor of Geology and Geophysics, The University of Oklahoma.
[2]Tennessee Division of Geology, 707 State Office Building, Memphis, Tennessee.
[3]Federal Bureau of Investigation, 50 Penn Place, P.O. Box 25732, Oklahoma City, Oklahoma.
[4]Gulf Oil Corporation, Box 61890, New Orleans, Louisiana.
[5]Gulf Oil Corporation, 1824 Cody Avenue, Casper, Wyoming.

Previous Investigations

According to Thoburn (1916, p. 17–35), many well-known explorers visited Oklahoma and studied the southeastern part of the State during the 18th and early 19th centuries. These explorers include: Bernard de La Harpe (1719–1722), Pierre and Paul Mallet (1739), Fabry de La Bruyere (1741), John Sibley (1805), Captain Richard Sparks (1806), Captain Zebulon M. Pike (1806–1811), Major Stephen H. Long (1817–1820), Thomas Nuttall (1819–1821), and Thomas Say (1823).

Early geographic and geologic investigations along the Red River, which served as a national boundary between French and Spanish possessions in America, have been summarized by Hill (1887a, 1894, 1901), Larkin (1909), Bullard (1928), and Adkins (1932). According to these sources of information, mapping of the Texas side of the Red River of New Spain was compiled from 1799 to 1804 by Baron Friedrich Heinrich Alexander von Humboldt who did not visit the southern Oklahoma area. An early map of Texas was compiled by Stephen F. Austin in 1821 and a later map was issued by Hunt and Randall in 1835. Additional mapping along the Red River in Texas was completed by William Kennedy, an English diplomat to Texas, in 1836 and by a German emigrant agent named G. A. Scherf in 1841. The latter based his mapping on that of Hunt and Randall. Other European investigators were Carl Solms-Braunfels in 1846 and Victor Bracht in 1848.

Early paleontological work was done by S. G. Morton of Philadelphia who in 1834 named and described specimens of *Gryphaea pitcheri* and *Ammonites vespertinus* which he received from near Fort Towson (Choctaw County, Oklahoma). Problems concerning the taxonomy of these specimens have been reviewed by Hill and Vaughn (1898), Adkins (1944), Branson (1965), Stenzel (1959, 1971) and Fay (1975). These species are now assigned to *Texigryphaea pitcheri* (Morton) and *Mortoniceras vespertinum* (Morton).

The first important work on the Cretaceous of the Texas region was by Roemer. He published several papers, the most important being *Die Kreidbildungen von Texas und ihre organischen Einschlüsse* (1852). In 1852 a party under Captain R. B. Marcy traveled from Fort Smith, Arkansas, into what is now Oklahoma. In 1854 Dr. G. G. Shumard, a physician attached to the Marcy expedition, applied the name Washita Limestone to beds near Fort Washita and collected fossils that were identified by Dr. B. F. Shumard and Professor Jules Marcou. Marcou later accompanied a federal expedition to locate a suitable route for a railroad to the Pacific Coast. He described Cretaceous rocks in western Oklahoma and near Tucumcari, New Mexico, and attempted to relate those rocks with Cretaceous strata in the Red River region. Shumard (1886) published his 1855 study of Grayson County, Texas, and included some information concerning the Cretaceous of southern Oklahoma.

The earliest state geological surveys in Texas were established in 1857–1861 (Shumard Survey) and in 1870–1875 (Glenn-Buckley Survey). Neither added much to an understanding of the Cretaceous stratigraphy. A third survey (Dumble Survey) from 1888–1893 issued important reports by J. A. Taff and F. W. Cragin on the Cretaceous. The present Texas survey, known officially as the Bureau of Economic Geology, was established in 1909, and since about 1918, a vast amount of work on the Cretaceous of Texas has been accomplished.

The first notable geological work on the Red River region after Shumard was by Hill (1887a,b,c,) who prepared a careful analysis of the Cretaceous stratigraphic sequence. Hill's monograph (1901) still serves as a standard reference for the Cretaceous of northern Texas and southern Oklahoma. J. A. Taff, working with the U.S. Geological Survey, mapped the Atoka and Tishomingo Quadrangles in Oklahoma (1902 and 1903) and proposed much of the Cretaceous nomenclature used in the area. Stephenson (1918) mapped portions of southern Oklahoma and northeastern Texas.

Detailed studies in Love and Marshall Counties, Oklahoma, were done by Bullard (1925, 1926). Davis (1960) summarized the Cretaceous stratigraphy and prepared a geologic map of southern McCurtain County. Curtis (1956–1961) mapped much of Bryan County, Oklahoma, but the results of his work were not published. Frederickson, Redman, and Westheimer (1965) remapped Love County and reported the results in an Oklahoma Geological Survey Circular. Our understanding of the Woodbine stratigraphy of southern Oklahoma was enhanced by the work of Bergquist (1949) in Grayson and Fannin Counties, Texas. Careful studies of terraces along the Red River by Frye and Leonard (1963) have aided in identification of similar levels in Oklahoma.

Recent investigations concerning the Cretaceous of southern Oklahoma have been completed by graduate students from The University of Oklahoma. These include Heilborn (1949), Skolnick (1949), Gibbs (1950), Prewit (1961), Blau (1961), Hedlund (1962, 1966), Redman (1964), Olson (1965), Jeffries (1965), Manley (1965), Dalton (1966), Alfonsi (1968), Duarte-Vivas (1968), Ganser (1968), Currier (1968), Hart (1970), and Holtzman (1978). Other reports include Oklahoma Geological Survey Bulletin 120 on Choctaw County, Oklahoma, by Huffman, Alfonsi, Duarte-Vivas, Dalton and Jeffries, which was published in 1975, and a report on hydrocarbon accumulation along the Cumberland Thrust in Bryan County by Huffman, which was published in 1976.

Paleontological work by Adkins (1928), Stenzel (1959, 1971), Stephenson (1952), and Young (1957, 1959, 1963) aided in the identification and taxonomic assignment of the fossils collected.

GEOGRAPHY

HISTORICAL BACKGROUND

Oklahoma's recorded history began with the arrival of the early Spanish explorers in search of gold. As a result of explorations of Hernando De Soto and Francisco Vazquez Coronado, Spain laid claim to the southern one-third of the United States including what is now Oklahoma (circa 1541). France laid claim to the interior of North America as a result of the travels of Père Jacques Marquette and Louis Joliet in 1673 and Robert Cavelier Sieur de La Salle who named and claimed the Louisiana Territory in 1682. La Salle, as he is more commonly known, established a colony at the mouth of the Mississippi River in 1684. La Harpe received a grant in 1718 from John Law, president of the French Compagnie d' Occident (Company of the West) for a tract of land on the upper waters of the Red River to the Arkansas River. He traveled through eastern Oklahoma and Arkansas.

France lost claim to her territory in North America as a result of the Seven Years' War (1756–1763). The Treaty of Paris (1763) gave all of the territory west of the Mississippi River to Spain and the area east of the Mississippi River to England. In 1783 Spain recovered Florida from England and retained possession of Louisiana west of the Mississippi River (Morris and McReynolds, 1965, p. 10), and the new United States extended from the Atlantic Ocean west to the Mississippi River.

Following the Treaty of San Ildefonso in 1800, Louisiana Territory was transferred to France with details completed in 1803. In 1803 this territory was sold to the United States for $15,000,000. The transfer included what is now Louisiana, Arkansas, Missouri, Iowa, Minnesota, Oklahoma, Nebraska, Kansas, South Dakota, North Dakota, Montana, Wyoming, and part of Colorado. In 1804 the Province of Louisiana was subdivided into the Territory of Orleans, with New Orleans as the capital, and the Louisiana Territory, north of the 33° parallel, with St. Louis as the capital. The State of Louisiana was admitted to the Union in 1812 with the balance of the Louisiana Purchase becoming the Territory of Missouri. In 1819 the southern part of the Territory of Missouri was designated Arkansas Territory followed by the admission of the State of Missouri into the Union in 1820. In 1828 Indian Territory (later to become Oklahoma) was separated from the Arkansas Territory.

The southern and western boundaries of Oklahoma were fixed by the Spanish Treaty of 1819 as the Red River and the one-hundredth meridian, respectively. The northeastern boundary was established by the Enabling Act of 1820, and the eastern boundary (Choctaw Line) was established in 1825. The Osage Treaty of 1825 established the northern boundary so that by the end of 1825, the United States had acquired title to all of Oklahoma except the Panhandle.

Oklahoma soon became the residence for some 67 Indian tribes, many through the process of removal by the United States Government. Between 1816 and 1840, removal of the Five Civilized Tribes from their homes in Georgia, Alabama, Mississippi, Tennessee, South Carolina, and Florida was completed, and the tribes were relocated in what would become Oklahoma. (See figures 2a and 2b.) The five Indian nations in Oklahoma were the Cherokee, Choctaw, Chickasaw, Seminole, and Creek, each with its own representative government.

Increased pressure from the white man called for opening of Indian Territory to white settlement. By 1890 the original Indian Territory had been divided into two territories, the Oklahoma Territory and Indian Territory (fig. 2c). The Five Civilized Tribes continued to run their own governments and retain their own capitals as before. Meanwhile Oklahoma Territory was settled by the whites, and by 1906 there were 800,000 people living there. Soon the demand for statehood arose with the result that in 1907 the State of Oklahoma was admitted to the Union.

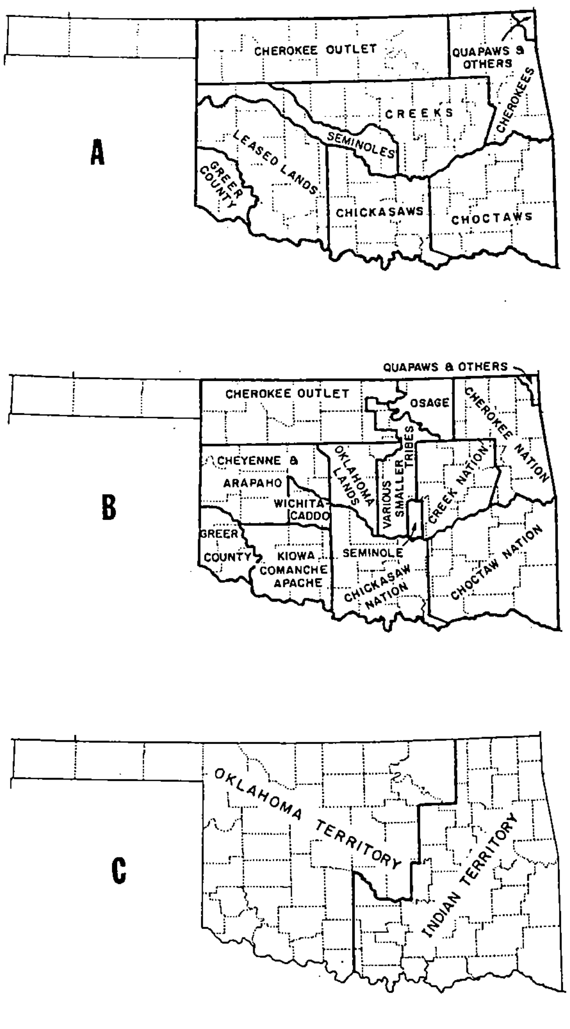


Figure 2. Maps of the development from Indian land to the State of Oklahoma (from Huffman and others, 1963). (A) Indian Country, 1856–1866, (B) Indian Country, 1885, (C) Twin Territories, 1890–1905.

Before Oklahoma statehood in 1907, the area now known as Bryan County (named in honor of William Jennings Bryan) was part of the Choctaw and Chickasaw Nations, all but the western one-fourth being controlled by the Choctaws. The Civilized Tribes established elementary schools and academies for educational purposes. The Choctaws in 1844 established Armstrong Academy near the present site of Bokchito, and the Chickasaws in 1852 founded the Bloomfield Seminary for girls near the present site of Achille (Morrison, 1964).

Many American explorers and traders traveled westward into and across Oklahoma during the period from 1805 to 1853, following the major river systems and using Fort Smith, Arkansas, as their headquarters. They established numerous missions, trading posts, military forts, and homes. Zachary Taylor (later president of the United States) established Fort Washita in 1842, which lasted as a military post until 1865. Remains of the old fort and restorations of it (figs. 3 and 4) make Fort Washita the most historic spot in Bryan County (Lewis, 1975).

Early transportation routes were the Red River and the Texas Road, which ran northward from Colbert's Ferry on the Red River to Fort Washita then northeastward to Fort Gibson. The Butterfield Stage and the Overland Mail Company Route ran northward from Colbert's Ferry through Carriage Point and Nail's Crossing to the Boggy Depot and Atoka then northeastward to Skullypoint where it joined the California Trail. Military roads connected the various forts in Oklahoma. (See fig. 5.)

The earliest railroad, the Katy, was built across the county in 1872. The Frisco system was built from 1901 to 1903 and the Kansas, Oklahoma and Gulf was completed following statehood.

The Choctaws and Chickasaws introduced farming and stock raising in southern Oklahoma, settling along the Red, Blue, and Washita Rivers where their slaves tended the fields of corn and cotton. Bryan County continued to be agriculturally oriented following statehood and by 1920 the population had reached 40,700. Lower cotton prices, followed by the great depression of 1929, caused a decline in population to 32,267 in 1930. Population rose to 38,138 in 1940 only to decline to 28,999 in 1950 and 24,252 in 1960. It rose again to 25,552 in 1970 (table 1).

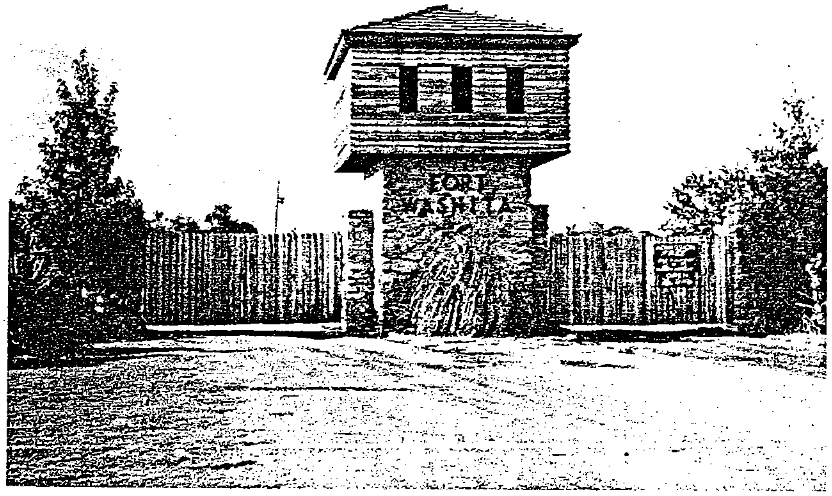


Figure 3. Photo of the entrance to historic Fort Washita, north side of State Highway 199, SW¼ sec. 23, T. 5 S., R. 7 W.

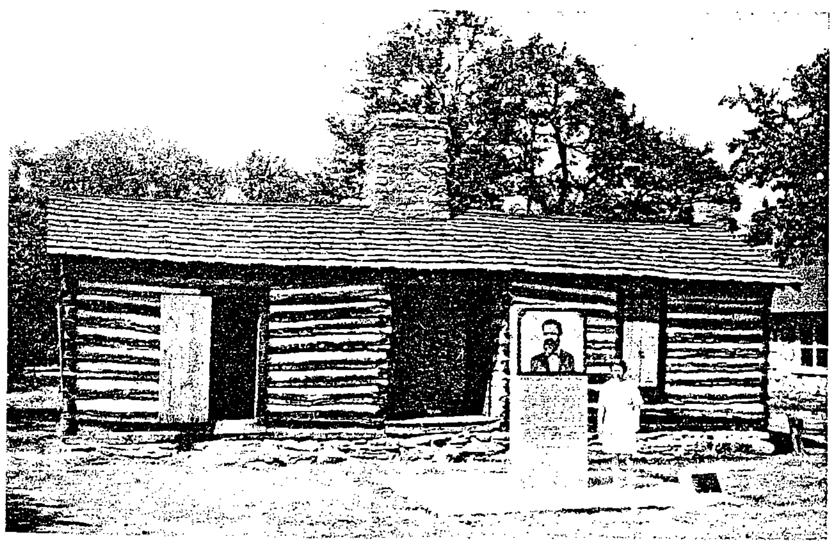


Figure 4. Photo showing restoration of one of the officer's quarters, Fort Washita.

HISTORIC SITES

Bryan County played an important role in the historical development of Oklahoma. The Oklahoma Historical Society has placed roadside markers at or near the site or sites of famous landmarks. Detailed descriptions of these can be found in a booklet published by the Oklahoma Historical Society and edited by Wright and Shirk (1958). Table 2 lists the more important historic sites in Bryan County.

CITIES AND TOWNS

Bryan County has a population of 25,552 according to the 1970 U.S. Census Report. This represents a gain of 1,300 over the 1960 population of 24,252 but a net decline since 1940 of 12,576. Decline has been most rapid in rural areas, and increases have occurred only in Achille, Bokchito, Calera, Colbert, and Durant (table 1).

Durant, county seat of Bryan County, was settled in 1870 on the Dixon Durant

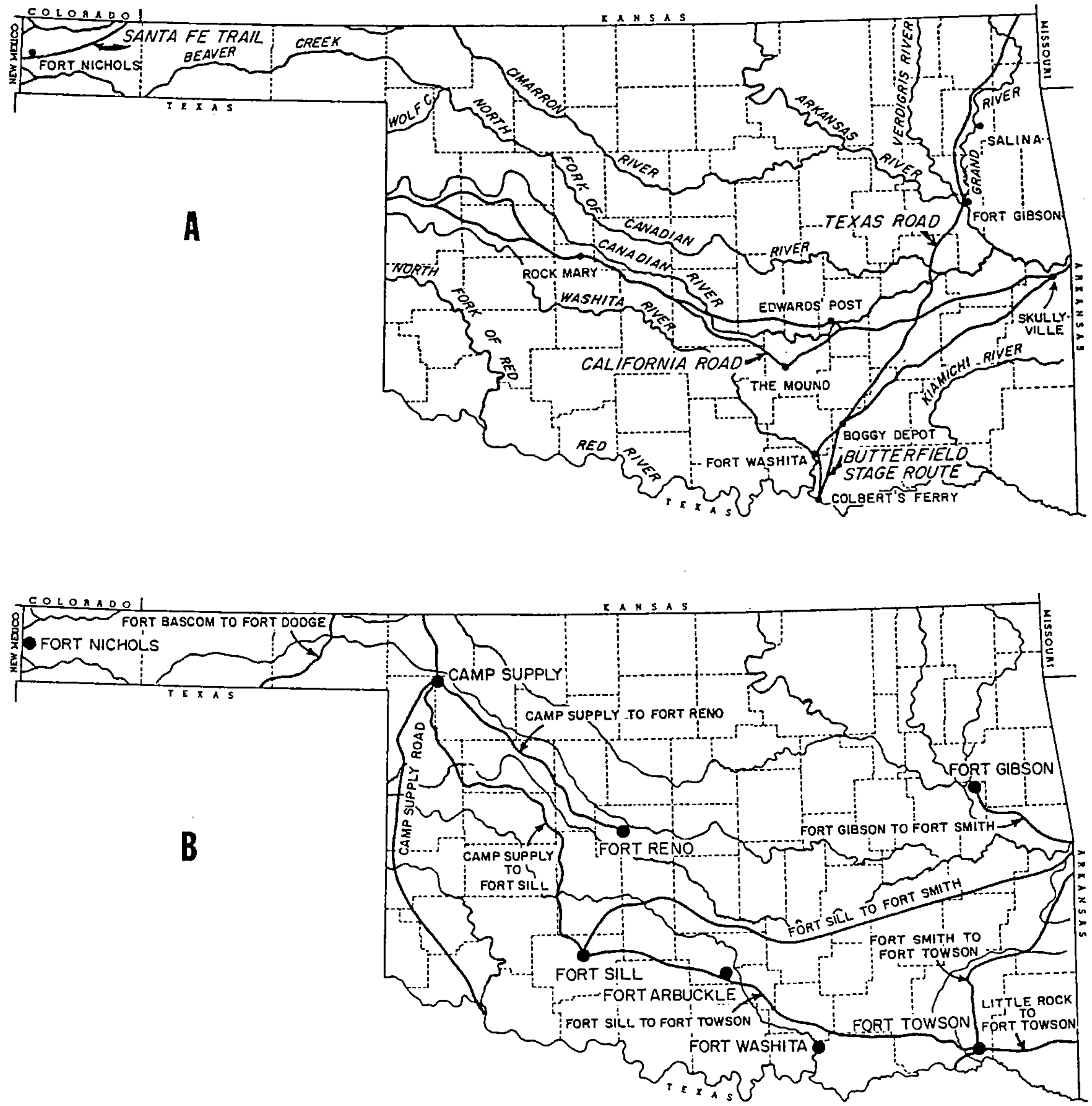


Figure 5. Maps of (**A**) stagecoach routes and trails and (**B**) forts and military roads in Oklahoma (from Morris and McReynolds, 1965, maps 22 and 24).

ranch. It was called *Durant Junction* by the Missouri-Kansas-Texas Railroad in 1872, but the name was shortened to Durant ten years later (Ruth, 1957, p. 378). Durant has an altitude of 643 feet and a population of 11,118 (1970 census). It is the largest town in Bryan County and is the principal retail trade center of the Red River Plains region (Morris, 1954, p. 130).

Durant lies in the heart of a rich farming area. The most recent development in its economy has been in its industrial growth and more than 35 industrial firms are located there. The development of Lake Texoma has made Durant an important center of recreation. Southeastern State University occupies 61 acres along the north side of town. Southeastern is a four-year, state-supported, accredited coeducational institution offering five bachelor degrees and the master of teaching. Enrollment is approximately 4,250 students. Bryan County Memorial Hospital, Robert L. Williams Library, *Durant Daily Democrat*, *Bryan County News*, various civic

TABLE 1.–POPULATION TRENDS OF BRYAN COUNTY[1]

Area or town	1940	1950	1960	1970	Percent change 1940-70
Bryan County	38,138	28,999	24,252	25,552	−32.9
Achille	356	383	294	382	+ 7.3
Bennington	513	361	226	288	−43.8
Bokchito	581	643	620	607	+ 4.5
Caddo	954	895	814	886	− 7.1
Calera	597	643	692	1,063	+78.1
Colbert	602	748	671	814	+35.2
Durant	10,027	10,541	10,467	11,118	+10.8
Kemp	204	158	153	153	−25.0
Kemp City (Hendrix)	145	152	143	117	−19.3
Kenefic	227	115	125	153	−32.6

[1]Source: U.S. Census of Population.

TABLE 2.–HISTORIC SITES IN BRYAN COUNTY[1]

1. Fort Washita, 1842, NW. corner of county, on State Highway 199, and 3 mi. W. of junction with State Highway 78; 14 mi NW. Durant; W½ sec. 23, T. 5 S., R. 7 E. (figs. 3 and 4).
2. Fort McCulloch, 1862; site about 3 mi SW. Kenefic, S. side of Blue River; SW¼ sec. 7, T. 5 S., R. 9 E.
3. Nail's Crossing, 1858 and earlier; Butterfield Station, 1858, E. side Blue River, 2 mi SW. Kenefic; SE¼ sec. 7, T. 5 S., R. 9 E.
4. Carriage Point, known as "Fisher's Station" on Butterfield Route, 1858; site about 4 mi W. of Durant on prairie at head of Mineral Bayou; SW¼SE¼ sec. 34, T. 6 S., R. 8 E.
5. Boiling Springs, 3 mi W. of Carriage Point of Fisher's Station site, and S. of Mead 3 mi; site of court ground and church, Chickasaw Nation, dating from 1850's; precise location not given.
6. Colbert's Ferry, early 1850's and Butterfield Stage crossing (1858–61) on Red River, 3 mi SE. Colbert just below old bridge which was famous in Murray Red River Bridge War, 1932; SW¼ sec. 31, T. 8 S., R. 8 E.
7. Old cemetery at Caddo, E. of town; graves dated 1870's.
8. Mount Pleasant Mission, Presbyterian Church, Rev. C. C. Copeland, founder, 1849; site 14 mi E. of Caddo; sec. 6, T. 5 S., R. 12 E.
9. Armstrong Academy, 1843, Capitol Choctaw Nation, 1863–83; site and ruins 3 mi N. and E. of Bokchito; NW¼ sec. 12, T. 6 S., R. 11 E.
10. Old Presbyterian Church, 1855, about 2¾ mi N. of Bennington; residence just E. of church is original home of Rev. C. C. Copeland who founded church.
11. *Chish Oktok,* noted Presbyterian Church, Indian Presbytery 1854; site about 6 mi SE. of Bennington; sec. 19, T. 7 S., R. 13 E.
12. Site of Bloomfield Seminary, Chickasaw Nation, established 1852; site 2½ mi S. Achille; in woods on hill in field ¼ mi S. is cemetery and noted Holmes Colbert's grave; NW¼ sec. 8, T. 9 S., R. 9 E.
13. Judge Kemp's (Chickasaw) home, pre-Civil War, two-story log house near Kemp.
14. Providence Baptist Church, second site, at Blue, first founded near old Hill (Choctaw County) 1837, SW. of Hugo.
15. Oklahoma Presbyterian College, at Durant, 1890's.
16. "Robbers Roost" noted place, site 1 mi N. Silo in "break" in hills.

[1]Data from Oklahoma Historical Society, 1958, p. 3–4.

clubs, a good school system, an excellent highway system, Eaker Municipal Airport, a golf and country club, many attractive homes and new housing developments make Durant a pleasant place to reside.

Smaller towns in Bryan County include Achille (382), Bennington (288), Bokchito (607), Caddo (886), Calera (1,063), Colbert (814), Kemp (153), Kemp City or Hendrix (117), and Kenefic (153). Unincorporated towns and communities include Albany, Allison, Armstrong, Blue, Brown, Cade, Cartwright, Cobb, Kiersey, Liberty, Matoy, Pirtle, Platter, Roberta, Silo, Ury, Utica, Wade, Wasseta, Yarnaby, and Yuba (fig. 1).

ROADS AND RAILROADS

U.S. Highway 70 traverses Bryan County from west to east, passing through Mead, Durant, Blue, Bokchito, and Bennington. Oklahoma State Highway 78 runs north-south through Durant, northwestward to Tishomingo and southward to Achille, then east to Yuba. U.S. Highways 69 and 75 run diagonally northeastward from Denison, Texas, through Colbert, Durant, and Caddo. Oklahoma State Highways, 70E and 75A serve the southern half of the county (fig. 1).

The St. Louis–San Francisco Railroad runs east-west across the county essentially parallel to U.S. Highway 70, serving the towns of Durant, Bokchito, and Bennington. The Missouri-Kansas-Texas Railroad parallels U.S. Highways 69 and 75 from Colbert through Durant and Caddo; the Kansas, Oklahoma, and Gulf Railroad extends northward from Hendrix through Achille, Durant, and Kenefic.

INDUSTRIES AND MATERIAL RESOURCES

Bryan County is essentially an agricultural area. More than 40 percent of the land area is used for growing crops, 22 percent is used for pasture and range land, 23 percent is covered by forest, and 15 percent is used for other purposes. The number of small farms is steadily decreasing as the number of large farms increases. Important crops include corn, sorghum, wheat, oats, peanuts, hay, cotton, and soy beans.

Livestock production accounts for 50 to 70 percent of the total farm income. In 1964 the sale of livestock and livestock products amounted to $3,323,495 and farm crops yielded $3,211,716 for a total of $6,535,211. In 1969 livestock and livestock products produced $7,399,273 and crops yielded $3,167,147 for a total of $10,566,420. In 1974 farm income was $11,850,000 of which $6,725,000 was from livestock and livestock products and $5,125,000 was from farm crops. Manufacturing was about $2,932,000 in 1964, $6,200,000 in 1967, and $10,300,000 in 1974. Mineral production was $2,588,530 in 1964, $2,522,000 in 1969, and $3,198,000 in 1974. Public assistance for 1963–64 was $2,683,000; in 1969–70 it was $2,131,324; in 1971–72 it was $2,261,454; and in 1973–74 it was reduced to $1,355,953.

Manufacturing and processing plants in operation in Durant in 1974 are listed in table 3.

TOPOGRAPHY AND DRAINAGE

Bryan County lies within the dissected Coastal Plain Province of Oklahoma, a portion of the Gulf Coastal Plain. The region slopes gently southward toward the Red River. Elevations range from 870 feet in northern Bryan County to 450 feet along the Red River. Local relief ranges from 50 to 150 feet.

Southward dipping sedimentary strata give rise to a cuesta and dip-slope type of topography where the more resistant formations are present. The Antlers terrane along the northern border is well dissected and hilly. The overlying Goodland Limestone forms a north-facing escarpment and a gentle dip-slope that passes southward beneath the Kiamichi Formation and the limestone-shale sequence of the Caddo Formation, forming a broad belt of rolling upland prairie. The sands and shales of the Bokchito Formation are deeply dissected and form a belt of sandy soil. The Bennington Limestone caps broad expanses of black, fertile prairie land, especially in the eastern part of the county. The Woodbine terrane ranges from nearly flat or gently rolling to deeply dissected, wooded forest land. Broad expanses of level terrace characterize the southwestern part of the county and broad, flat flood plains parallel the major streams.

Bryan County is drained by the Red River and its tributaries. Damming of the Red River and its major tributary stream, the

TABLE 3.–MANUFACTURING AND PROCESSING PLANTS IN DURANT, OKLAHOMA[1]
(figures in parentheses are for 1967)

ı name	Address	Number of employees
Acme Mattress Factory	N. of City	3
Brooks Produce Co.	36 W. Evergreen	(7)
Bryan County Limestone Co.	901 W. Main	10
C. & S. Printing Co.	115 N. 6th Ave.	3
Carpenter Machine & Supply	105 S. 4th Ave.	4
Chief Trailer Co.	1015 N. 1st Ave.	35
Colvert Dairy Products	401 N. 1st Ave.	23
Crystal Ice Co.	215 N. 3rd Ave.	3
De Leon Peanut Co.	401 Clark	80
Durant Box Factory	N. of City	25
Durant Coca-Cola Co.	202 S. 2nd Ave.	9
Durant Concrete Block Co.	60 E. Evergreen	8
Durant Dress Co.	217 N. 2nd Ave.	95
Durant Electronics Co.	2200 W. Arkansas	64
Durant Marble & Granite Works	E. of City	2
Durant Milling Co.	E. Main and Katy	115
Durant Pub. & Broadcasting Co.	260 West Beech	25
Durant Nursery Co.	N. of City	(45)
Durant Sheet Metal	116 S. 7th Ave.	4
Durant Sign Service	408 E. Florida	1
G. & W. Body Works	S. of City	4
Gold Kist, Inc.	401 Malone Drive	92
Gray's Sawmill	E. of City	10
Hale Manufacturing Co.	N. Katy Street	64
Hale-Halsell Grocery Co.	1800 W. Arkansas	(78)
Hillson Steel Products	Eaker Field, S. of City	40
Linda Dress Co.	2100 W. Arkansas	62
Marathon-Letourneau Inc.	S. of City	125
Oklahoma Vegetable Oil Co.	315 NE 2nd Ave.	10
Peabody Galion Corp.	1855 W. Arkansas	271
Potter Sausage Co.	E. of Hwy. 70	60
Potters Rendering Co.	E. of City	6
Price's Quality Printing	317 W. Cedar	7
R. & S. Leather Mfg.	221 S. 2nd Ave.	16
Rustin Concrete Co.	100 E. Evergreen	(13)
Southeastern Packing Co.	512 N. 1st Ave.	10
Stahl Metal Products Inc.	Eaker Field, S. of City	45
Steelfab Co.	315 NE 2nd Ave.	25
Stewart Feed Mill	E. of City	6
Tate Bros. Mfg. Co.	W. of City	27
Texoma Sash and Door Co.	124 S. 2nd Ave.	14
Thurman Sausage Co.	302 S. 2nd Ave.	5
Vails Redimix Concrete	Cedar and Clark	7
Virden Lighting	Eaker Field, S. of City	8

[1]Data from Human and Material Resources Supplement, 1967; Durant Chamber of Commerce, December 1972; Community Audit for 1972; Oklahoma Directory of Manufacturing, 1974.

Washita River, formed Lake Texoma which lies along the western side of the county. Westward flowing tributaries into Lake Texoma include Sand Creek, Rock Creek, and Newberry Creek.

The central part of the county is drained by the southeastward flowing Blue River which has its headwaters in the northwestern part of the county and which empties into the Red River in the southeastern part of the county. Many tributary streams enter Blue River; these include Bois d'Arc Creek, Little Blue River, Chukwa Creek, Dude Creek, Main Rider Creek, Caddo Creek, Bokchito Creek, and Sulphur Creek. Whitegrass Creek begins near the rural community of Bennington and flows southeastward to form a boundary between Bryan and Choctaw Counties. The northeast corner of Bryan County is drained by Clear Boggy Creek which flows southeastward across Choctaw County. Island Bayou Creek flows along the axis of the Cumberland Syncline southwest of Durant.

DAMS AND RESERVOIRS

In order to make effective use of water, prevent flooding and erosion, generate hydro-electric power, and provide recreational areas, the State of Oklahoma and the Federal Government have completed more than 25 major dams and reservoirs on Oklahoma rivers. Hundreds of small, upstream dams have been built for flood control and thousands of farm ponds dot the surface. In Bryan County, Lake Texoma ranks among the largest and finest lakes. Other projects that will affect part of Bryan County include the Boswell Reservoir, the Albany Dam, and the Durant Dam. More than 4,850 farm ponds cover some 3,800 acres of land (Pyle, Dowell, and Atherton, 1964, p. 12). Small lakes include Eagle Lake, Lake West, Lake Oberlin, and Mossy Lake. Eagle Lake has been drained recently.

Denison Dam and Lake Texoma

Denison Dam, constructed in 1944 on the Red River 16 miles southwest of Durant, created Lake Texoma, a body of water whose power pool covers 91,200 acres with a shoreline of 580 miles and storage capacity of 1,730,000 acre-feet. The flood-control pool covers 144,100 acres, has a shoreline of 1,180 miles, and has a storage of 2,694,000 acre-feet. The lake extends westward on the Red River to within a few miles of Interstate-35 near Marietta and northward on the Washita River to Tishomingo. Drainage area above the dam includes 39,719 square miles.

The dam that creates Lake Texoma is of the earthen-fill type with a length of 15,200 feet, a height of 165 feet above the stream bed, a basal width of 1,145 feet, a top width of 40 feet, and a 2,000-foot wide spillway. Elevation of top of dam is 670 feet, elevation of flood-control pool is 640 feet, and the power-pool level is 617 feet. The dam is a multiple purpose structure built for recreation, flood control, and hydro-electric power (figs. 6 and 7).

Lake Texoma is a popular recreational area with 31 resorts and more than 300 private cottages located on government land adjacent to the lake. Texoma State Park with its lodge, golf course, and other facilities covers 2,300 acres on the Oklahoma side in eastern Marshall County; the 405-acre Eisenhower State Park is on the Texas side near the Denison Dam. The Hagerman and Tishomingo Wildlife Refuges include 31,219 acres along the lake. There are also 19 organized youth and church camps in operation.

Five generators of 35,000 kilowatts capacity each are to be installed. Two are currently in operation and are generating more than 270,000,000 kilowatt hours of electrical energy per year which is enough to serve 100,000 homes at present rate of consumption (data from Corps of Engineers, U.S. Army Engineer District, Tulsa).

Boswell Dam and Reservoir

The Boswell Dam, to be located below the confluence of Muddy Boggy and Clear Boggy Creeks near Soper in Choctaw County, Oklahoma, was authorized by the Flood Control Act of 1946. The reservoir is a multi-purpose project built to supply water, provide recreational facilities, preserve wildlife and control flooding.

The conservation pool comprises 52,740 acres and will store 1,306,000 acre-feet of water. The flood-control pool will inundate 72,480 acres with storage capacity of 1,096,000 acre-feet. Much of the reservoir will be in Choctaw and Atoka Counties

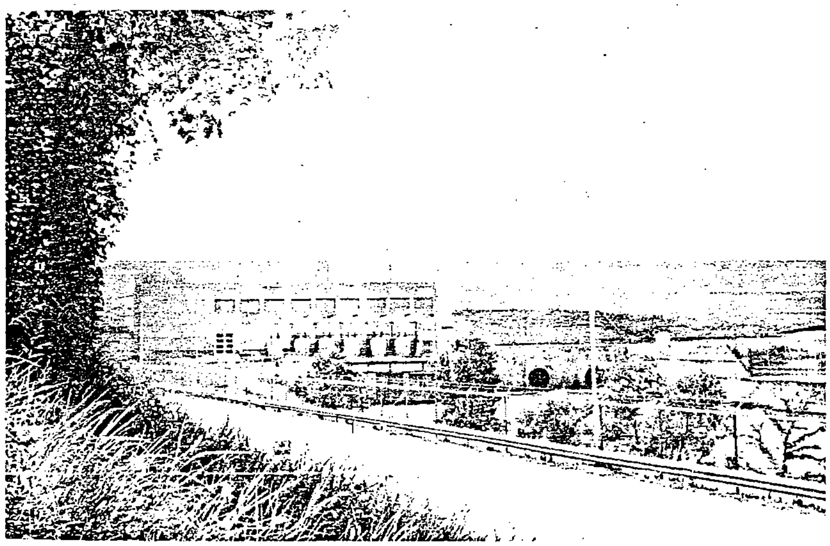


Figure 6. View of east side of Denison Dam, Lake Texoma, sec. 34, T. 8 S., R. 7 E.

Figure 7. View of Red River below Denison Dam, sec. 34, T. 8 S., R. 7 E. during maximum power generation. Note alluvium of flood plain about 12 feet above water level.

(Huffman, 1977a); however, the waters will cover the broad alluvial flat along Clear Boggy Creek in northeastern Bryan County where parts of 10 square miles will be inundated.

Albany Damsite and Lake

Preliminary plans have been made for the construction of the Albany Dam across Island Bayou in sec. 17, T. 8 S., R. 11 E. about 2 miles southeast of Albany. Top of the dam will be at an elevation of 549 feet, top of flood-control pool will be 525 feet, and top of conservation pool will be 517 feet. The conservation pool will have a capacity of 85,200 acre-feet and cover 4,960 acres; the flood-control pool will have a capacity of 45,200 acre-feet and cover 6,480 acres. The lake will be 6.5 miles long (fig. 8).

Durant Damsite and Lake

Preliminary plans have also been made for construction of the Durant Dam on Blue River in secs. 28, 29, and 32, T. 7 S., R. 12 E. (fig. 9) about 10 miles east and 6 miles south of the town of Blue and 1.5 miles north of

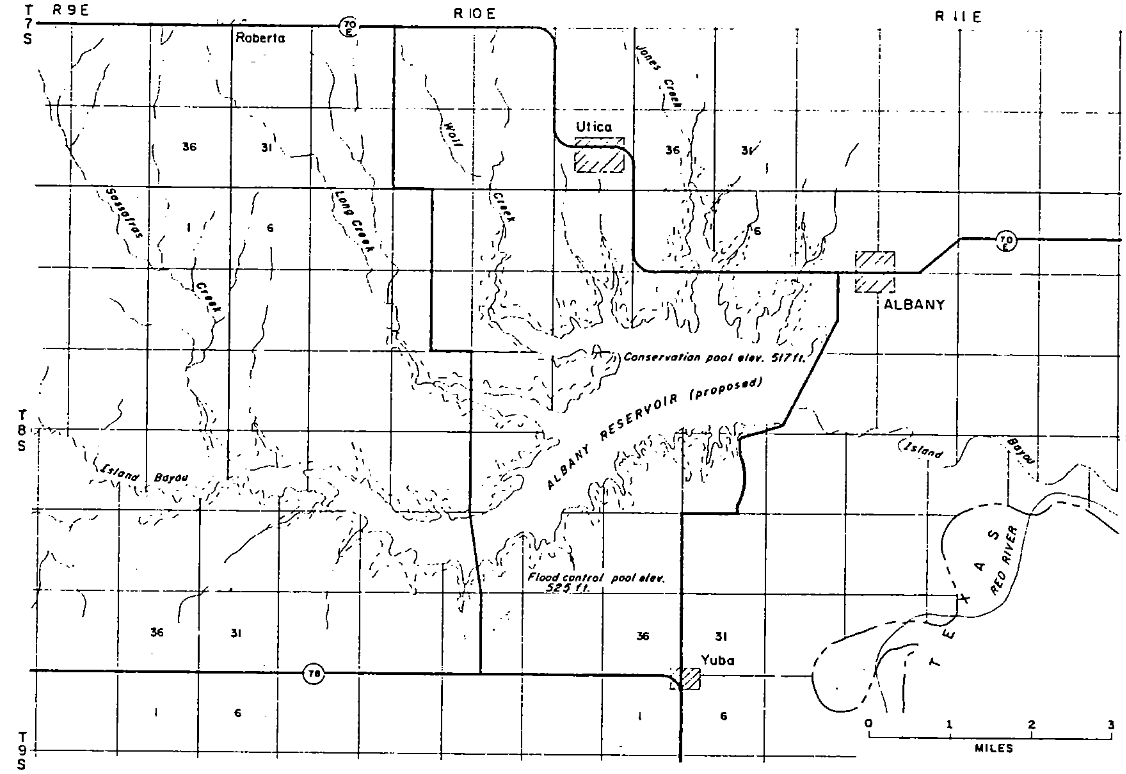


Figure 8. Location map of the Albany Reservoir (proposed).

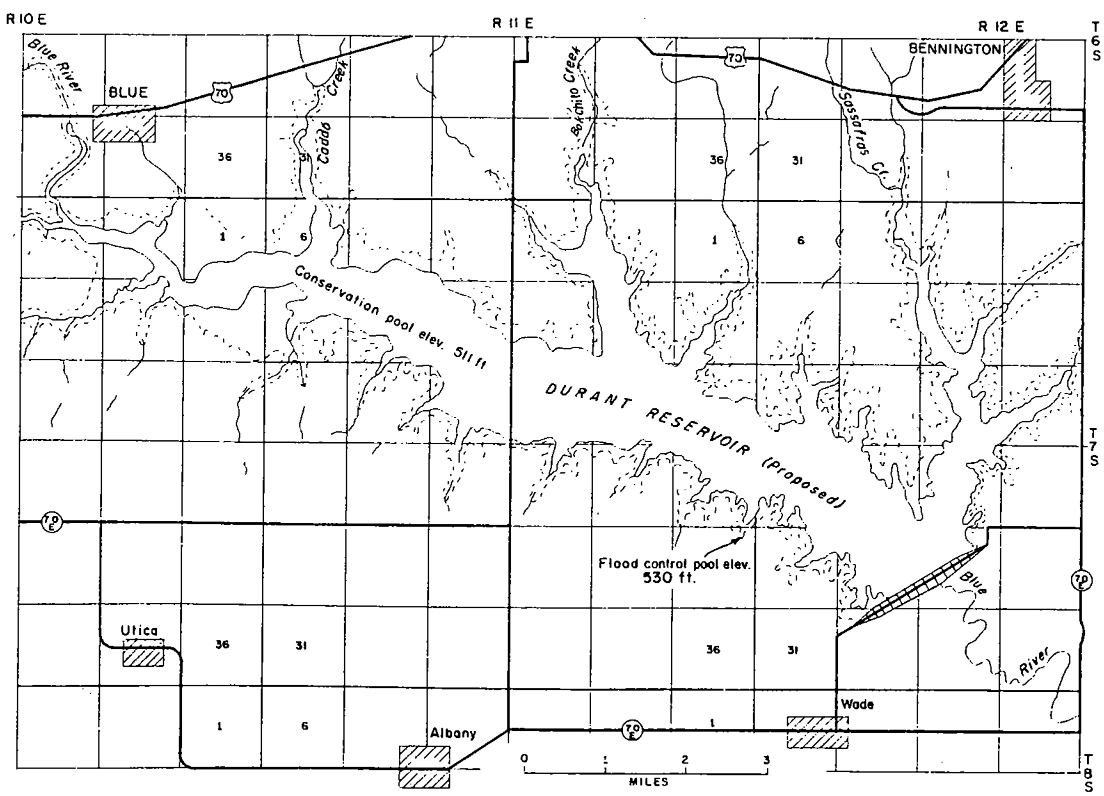


Figure 9. Location map of the Durant Reservoir (proposed).

Wade. Top of the dam will have an elevation of 562 feet, top of flood-control pool will be 530 feet; and top of conservation pool will be 511 feet. The conservation pool will have a capacity of 147,020 acre-feet and cover 8,980 acres; flood-control pool will have a storage of 232,200 acre-feet and cover 15,430 acres. The lake will inundate the flood plain of Blue River northwestward for a distance of 13 miles to the vicinity of Blue in sec. 27, T. 6 S., R. 10 E. Parts of Sulphur, Bokchito, and Caddo Creeks will be flooded.

CLIMATE

Bryan County has a humid, temperate to subtropical climate with warm summers and mild winters. The average annual rainfall is 39.73 inches and the average snowfall is 2.4 inches. Average relative humidity is 66 percent. Rainfall is relatively evenly distributed throughout the year with April, May, and June being the wettest months. The mean maximum temperature is 75.9 degrees F., the mean minimum temperature is 51.5 degrees F., and the average temperature is 63.7 degrees F. Average January temperature is 43.0 degrees F.; August temperatures average 83.6 degrees F. The highest recorded temperature of 118 degrees F. was in August 1936, and the lowest recorded temperature of −6 degrees F. was in January 1930. The growing season averages 234 frost-free days. The first killing frost occurs between November 5 and 10; the last killing frost is between March 25 and April 1. For information concerning temperature and precipitation, see table 4.

TABLE 4.—AVERAGE TEMPERATURES AND PRECIPITATION FOR DURANT, OKLAHOMA, 1931–1960

Month	Average temperature	Annual precipitation
January	43.0	2.26
February	46.7	3.08
March	53.7	2.85
April	63.4	4.41
May	71.0	5.44
June	79.4	3.76
July	83.4	3.04
August	83.6	2.37
September	76.3	3.16
October	65.7	3.23
November	52.8	2.81
December	45.4	2.59
Annual	63.7	39.00

[1]Data from U.S. Weather Bureau. Reproduced from Pyle, L. E., Dowell, C. L., and Atherton, E. P., 1964.

STRATIGRAPHY

STRATIGRAPHIC SUMMARY

Rocks exposed at the surface in Bryan County range in age from Early Cretaceous (Trinity Group) to Late Cretaceous (Woodbine and Eagle Ford Formations). These are overlain at places by extensive deposits of terrace and alluvium of Pleistocene and Recent age. The stratigraphic sequence for Bryan County is shown in figure 10.

The Lower Cretaceous rocks are divided into the Trinity, Fredericksburg, and Washita Groups. The Trinity Group is represented in Bryan County exposures by the Antlers Sandstone; the Fredericksburg Group by the Goodland Limestone and the Kiamichi Formation; the Washita Group by the Caddo Formation (Duck Creek and Fort Worth Members), the Bokchito Formation (Denton-Soper-Weno-McNutt-Pawpaw sequence), the Bennington Limestone and the Grayson Marlstone.

The Antlers Sandstone (Lower Cretaceous) is time-transgressive and represents the nearshore facies of an advancing sea. In subsurface it lies unconformably on eroded Paleozoic rocks and Precambrian granite. Northward in Johnston County, in surface exposures, the Antlers Sandstone rests upon the Tishomingo Granite of Precambrian age (1.35 b.y.).

The Woodbine Formation (Upper Cretaceous) lies disconformably on Lower Cretaceous strata, truncating the Grayson Marlstone northward and eastward. The Red Branch Member separates the Dexter Member (chiefly sandstone) from the Lewisville Member (also sandstone). The Templeton Member, as recognized at its type locality in Grayson County, Texas, has been observed at several localities in southern Bryan County where a sequence of blue-gray to black, fissile shale, previously placed in the Eagle Ford Formation, is mapped and described as the Templeton Member of the

SYSTEM	SERIES	UNIT			LITHOLOGY	THICKNESS (Feet)	DESCRIPTION OF UNITS
QUATERNARY	HOLO-CENE	ALLUVIUM				20-30	Clay, silt, and sand of modern flood plains. Surface 15 to 20 feet above normal water level of Red River.
QUATERNARY	PLEISTO-CENE	TERRACE DEPOSITS				90-120	Sand, silt, clay, and gravels comprising four distinct levels: Qt_1, Qt_2, Qt_3, Qt_4. Overlain by veneer of gravels.
CRETACEOUS	GULFIAN	EAGLE FORD FORMATION				25	Blue-gray, thin-bedded, flaggy, silty limestone; weathers yellow and silty; thin beds of blue, calcareous siltstone and blue, silty shale.
CRETACEOUS	GULFIAN	WOODBINE FORMATION	TEMPLETON SHALE			60-70	Blue-gray to black, fissile shale with thin beds of yellow sandstone, clay ironstone, phosphatic nodules, calcareous concretions, some septaria; weathers brown, iron stained.
CRETACEOUS	GULFIAN	WOODBINE FORMATION	LEWISVILLE SANDSTONE			100-120	Yellow to reddish-brown, ferruginous, glauconitic sandstone interbedded with tan to brown shales. Sandstones typically crossbedded.
CRETACEOUS	GULFIAN	WOODBINE FORMATION	RED BRANCH MEMBER			60-70	Comprises yellow-brown, ferruginous, tuffaceous sandstone, gray-brown to yellow-brown to black, silty shale; thin beds of lignite and coal; thin-bedded to platy siltstones.
CRETACEOUS	GULFIAN	WOODBINE FORMATION	DEXTER MEMBER	RAINBOW CLAY		40	Includes approximately 40 feet of soft, varicolored shales which erode easily.
CRETACEOUS	GULFIAN	WOODBINE FORMATION	DEXTER MEMBER	DEXTER SANDSTONE		85-90	Yellow-brown, ferruginous, fine- to medium-grained, crossbedded sandstone with ferruginous concretions, clay ironstone beds, carbonized wood.
CRETACEOUS	GULFIAN	WOODBINE FORMATION	DEXTER MEMBER	BASAL SHALE		0-37	Includes a maximum of 30 to 35 feet of brown, carbonaceous shale which grades upward into Dexter Sandstone.
CRETACEOUS	COMANCHEAN	WASHITA GROUP	GRAYSON FORMATION			0-27	Olive-gray to light-greenish-gray marlstone with interbeds of white nodular limestone; fossiliferous with abundant *Ilymatogyra arietina* (Roemer) and *Texigryphaea roemeri* (Marcou).
CRETACEOUS	COMANCHEAN	WASHITA GROUP	BENNINGTON LIMESTONE			7-13	Blue-gray, heavy bedded to massive, fine to medium crystalline limestone; weathers yellow-brown, pitted, and honeycombed; fossiliferous with abundant *Ilymatogyra arietina* (Roemer).
CRETACEOUS	COMANCHEAN	WASHITA GROUP	BOKCHITO FORMATION	PAWPAW SANDSTONE		40-45	Yellow to brownish-red, ferruginous sandstone interbedded with gray to brown, sandy shale; grades laterally eastward into shale. Abundant *Protocardia*.
CRETACEOUS	COMANCHEAN	WASHITA GROUP	BOKCHITO FORMATION	McNUTT LIMESTONE		1-20	Gray-brown, sandy, fossiliferous limestone with abundant *Rastellum (Arctostrea) quadriplicatum* (Shumard). (Quarry Limestone of older reports.)
CRETACEOUS	COMANCHEAN	WASHITA GROUP	BOKCHITO FORMATION	WENO SHALE		80-100	Yellow to reddish-brown, ferruginous, sandy shales with abundant molds of *Protocardia* and *Turritella*; selenite crystals common on weathered surface.
CRETACEOUS	COMANCHEAN	WASHITA GROUP	BOKCHITO FORMATION	SOPER LIMESTONE		0-2	Gray, fossiliferous limestone with abundant *Texigryphaea washitaensis* (Hill), *Rastellum (Arctostrea) quadriplicatum* (Shumard) and *Rastellum (Arctostrea) carinatum* (Lamarck).
CRETACEOUS	COMANCHEAN	WASHITA GROUP	BOKCHITO FORMATION	DENTON SHALE		54-60	Blue-gray shale grading upward into beds of fossiliferous marlstone.
CRETACEOUS	COMANCHEAN	WASHITA GROUP	CADDO FORMATION			150-160	Blue-gray to cream-colored limestone and interbedded shale. Includes equivalents of Duck Creek and Fort Worth Limestone of Texas. Marked at lower part by abundance of large cephalopods.
CRETACEOUS	COMANCHEAN	FREDERICKSBURG GROUP	KIAMICHI FORMATION			30-40	Dark-gray to black, fissile shales interbedded in upper parts with thin beds of yellow-gray, fossiliferous limestones forming the "shell beds" composed of abundant *Texigryphaea navia* (Hall).
CRETACEOUS	COMANCHEAN	FREDERICKSBURG GROUP	GOODLAND LIMESTONE			20-25	White, massive-bedded, biomicritic limestone; weathers gray to yellow; lower beds argillaceous and locally nodular, upper beds massive but weather into thin, curved plates.
CRETACEOUS	COMANCHEAN	TRINITY GROUP	ANTLERS SANDSTONE			250-600	White to yellow-brown, ferruginous, crossbedded, unfossiliferous, fine- to medium-grained sandstone, poorly cemented, friable pack sand; interbeds of gray to black to purple, ferruginous clay.

Figure 10. Stratigraphic sequence (columnar section) for Bryan County.

Woodbine Formation. The Eagle Ford Formation is represented by a few feet of blue-gray to yellow, platy, calcareous siltstone, silty limestone, and shale.

Several distinct terrace levels have been differentiated along the Red and Washita Rivers. These have been correlated with corresponding levels as delineated in northern Texas.

Several significant structural features characterize the Cretaceous and older strata in Love and Marshall Counties. These trend southeastward, following the well-established trend of Arbuckle folding and faulting. Named features include the Marietta Syncline (Love County), the Preston Anticline, Kingston Syncline, Madill Anticline, Cumberland Syncline, and Cumberland Anticline (Marshall County). The Preston Anticline continues southeastward into northern Texas. The Madill and Cumberland Anticlines plunge southeastward beneath Cretaceous strata in Bryan County and lose their surface expression. The Cumberland Syncline extends southeastward as a broad, nearly symmetrical structural basin. Sedimentary strata in the northern two-thirds of Bryan County dip gently southwestward into the Cumberland Syncline. Sedimentary strata in southwestern Bryan County are mostly concealed by terrace deposits; however, gentle northeastward dip into the Kingston Syncline is observable. The Kingston and Cumberland Synclines are separated by a local flattening of dip along the upper reaches of Island Bayou. Thickening of Cretaceous sediments in synclines and thinning across anticlinal noses in Love and Marshall Counties have been interpreted by some as the result of draping of Cretaceous sediments over pre-existing structural highs and lows followed by differential compaction; other geologists attribute this phenomenon to renewed growth of pre-existing structures during Cretaceous time.

CRETACEOUS SYSTEM

Comanchean Series

TRINITY GROUP

ANTLERS SANDSTONE

The term *Antlers* was proposed by Hill (1894, p. 303) for the arenaceous section forming the base of the Cretaceous System in Indian Territory (Oklahoma), the name being taken from exposures near the town of Antlers, Oklahoma. Lithologically similar sands had been described by Hill (1887c, p. 296–298) as the "Dinosaur Sands" and as "Paluxy" (1891, p. 510), the later term being applied to exposures of white "pack sand" near the town and creek of Paluxy, Somervell County, Texas. Hill originally assigned the unit to the Fredericksburg Group, but in 1894 (p. 317) he reassigned the Paluxy to the Trinity division.

Taff (1902, 1903) assigned the basal sands of the Cretaceous of Oklahoma to the Trinity Formation and stated that these sands could be traced westward and southward into the region of the Trinity River from which that name had been acquired. Bullard (1925,1926) continued use of the term *Trinity* in reports in Love and Marshall Counties, Oklahoma, and in Cooke and Grayson Counties, Texas (Bullard, 1927, 1931).

In the arcuate outcrop band from southwestern Arkansas to the Trinity River of north-central Texas, the basal Cretaceous division is dominated by fluviatile–brackish water–marine sandy deposits. From Wise County, Texas, southward and from central McCurtain County, Oklahoma, eastward, the section is divided by a fossiliferous, marine, medial limestone wedge into named formations as indicated (Lozo, personal communication, 1977):

Central Wise County Texas	Bryan and adjacent counties Oklahoma	Eastern McCurtain County Oklahoma
Paluxy Sand	Antlers=(Trinity Sand–undivided)	Paluxy Sand
Glen Rose Limestone		De Queen Limestone
Twin Mountains Sand	(may be missing)	Holly Creek Formation

Over the years, since Hill (1894) introduced the provisional name *Antlers,* because of uncertain stratigraphic relations in the Indian Territory central area, usage of Antlers in Oklahoma has been: (1) abandoned as a synonym of Trinity Sand or Formation as shown by Hill (1888) and on the geologic map of Oklahoma (Miser, 1926); (2) replaced by the Paluxy Sand by extension of observed overlap relations to the east and projection of subsurface work, as shown on the geologic map of Oklahoma (Miser, 1954); and (3) most recently revived by workers in Oklahoma and north Texas as valid and appropriate (Barnes, 1966; Barnes, 1967; Frederickson and others, 1965).

The Antlers Sandstone crops out only in the extreme northern part of Bryan County where it is found along streams and in slopes below the overlying Goodland Limestone. Most of the Antlers outcrop is to the north in Johnston and Atoka Counties. A typical exposure of the Antlers is shown in figure 11. The Antlers consists of loosely consolidated, white to yellow, crossbedded, unfossiliferous pack sand and subordinate clays. The sand is fine to medium grained, soft, and friable. The clays are gray to black to dark gray purple, slightly silty, with iron oxide and jarosite(?) staining. The clays and sands offer little resistance to erosion and are exposed in deep ravines and on steep slopes beneath the Goodland escarpment.

The maximum observed thickness in surface exposures of the Antlers in Bryan County is 80 feet; this is in the NW¼NW¼SW¼ sec. 6, T. 5 S., R. 12 E. (Olson, 1965, p. 14). Prewit (1961) listed drilled thicknesses of 235 feet in northern Bryan County and 553 feet southeast of Durant (sec. 21, T. 7 S., R. 10 E.), which indicates southward thickening. (Prewit's thickness of 854 feet in southwestern Bryan County, sec. 16, T. 8 S., R. 8 E., is believed to be excessive.) Frederickson and others (1965, p. 16) noted southward thickening in Love County from 200 to 600 feet; Bullard (1926, p. 21) reported 400 to 600 feet in Marshall County.

A detailed study of the mineralogy of the Antlers in southern Oklahoma was completed by Manley (1965), who reported that the sands are comprised almost entirely of quartz with minor amounts of zircon, rutile, tourmaline, pyrite, leucoxene, and magnetite as accessory minerals. He also reported four major clay-mineral zones in the Antlers, a lower, mixed illite-montmorillonite zone probably derived from the Ouachitas, a middle montmorillonite-illite-kaolinite zone derived from the Ouachita and Arbuckle Mountains and the Arkoma Basin, an upper-middle montmorillonite zone derived from the Anadarko Basin, and an uppermost kaolinite-rich zone possibly derived both from the Appalachian and Wichita Mountains.

The Antlers Sandstone is believed to represent a transgressive, nearshore deposit of the Early Cretaceous sea that encroached upon the land from the south. It rests unconformably on Paleozoic and older rocks, including the Precambrian Tishomingo Granite, and is succeeded conformably by the Goodland Limestone or at places by the fossiliferous marlstone of the Walnut Clay facies.

FREDERICKSBURG GROUP

The term *Fredericksburg* was proposed by Hill (1887c, p. 296–299) for the middle subdivision of the Comanchean Series in honor of Ferdinand Roemer's pioneer study of the rocks and fossils in the namesake locality of Fredericksburg in central Texas. Inasmuch as the Fredericksburg is transi-

Figure 11. Typical exposure of Antlers Sandstone, along country road in NE¼ sec. 8, T. 5 S., R. 12 E.

tional between the underlying Trinity and the overlying Washita divisions, the limiting formations have had varied descriptions and boundaries as personal opinion, area of investigation, and practicality of usage have dictated (Lozo, personal communication, 1977). In Oklahoma and adjoining Texas, the commonly accepted formations of the Fredericksburg Group, in ascending order, are the Walnut Clay, the Goodland Limestone, and the Kiamichi Formation. The bases for differing classifications have been treated by Adkins (1933), Lozo (1959), and Young (1957).

Walnut Clay

The term *Walnut Clay* was proposed by Hill (1891, p. 504, 512) for yellow, laminated clay marls containing abundant "*Exogyra texana*" = *Ceratostreon texanum* (Roemer) overlying the Paluxy Sand and underlying the Comanche Peak Limestone. The type section is near Walnut Springs, Bosque County, Texas.

The Walnut Clay is poorly developed north of the Red River in Oklahoma. Bullard (1926, p. 26), Frederickson and others (1965, p. 18–21), and Ganser (1968, p. 13) recognized thin development of the Walnut Clay facies in Marshall, Love, and Johnston Counties and concluded that it is gradational upward into the Goodland Limestone.

Hart (1970, p. 26–30) reported 1 to 2 feet of marly clay and nodular limestone at this position. He reviewed the literature describing occurrences in Oklahoma of lithologies probably related to the Walnut Clay of Texas and was skeptical that this thin marly zone could be related in a clear way to the Walnut and Goodland (partly marly in Texas). Perkins (1960) has described a Marys Creek Marl Member of the Goodland with which this unit may be correlative. Three localities where the "Walnut Clay" facies is exposed are: (1) SE¼NE¼NW¼ sec. 3, T. 5 S., R. 8 E., along the north creek bank; (2) SE¼NW¼NW¼ sec. 6, T. 5 S., R. 9 E., in a ravine 0.15 mile south of the county line; and (3) NW¼NW¼NE¼ sec. 3, T. 5 S., R. 10 E., on the east creek bank 0.4 mile west-southwest of the farm buildings.

From the exposures listed above, Hart (1970, p. 30–31) collected and identified fauna including the following: *Ceratostreon texanum* (Roemer), *Exogyra plexa* Cragin, *Isocardia medialis* Conrad, *Pecten (Neithea) irregularis* (Böse), *Pecten (Neithea) subalpinus* (Böse), *Tapes aldamensis* (Böse), *Homomya* sp. or *Tapes* sp., *Texigryphaea mucronata* (Gabb), *Barbatia subquadrata* Perkins, *Protocardia* sp., *Cyprimeria texana* (Roemer), *Turritella seriatum-granulata* (Roemer), *Aporrhais tarrantensis* Stanton, *Enallaster mexicanus* Cotteau, and *Hemiaster whitei* (Clark).

The Walnut Clay facies is probably time transgressive and is the lateral equivalent of the lower Comanche Peak Limestone. In Oklahoma the yellow fossiliferous marlstones seem to be more closely related to the overlying Goodland Limestone than to the underlying Antlers Sandstone. It is herein considered a lower, shaly facies of the Goodland with which it has been mapped.

Goodland Limestone

The Goodland Limestone was named by Hill (1891, p. 514) for exposures near the former site of Goodland (now Good), Choctaw County, Oklahoma. Good Station is located near the center of sec. 9, T. 6 S., R. 17 E. about 2½ miles north of Hugo. The exposures and the limestone quarry are located about 1½ miles northwest of Good. (It has been reported that the Presbyterian Goodland Mission, now located in the northeast corner of sec. 6, T. 7 S., R. 17 E., was moved from its original site.)

Hill (1894, p. 303–304) described the Goodland as a "hard, pure white, crystalline limestone" capping the Walnut Clay and concluded that it is a northward continuation of the Edwards and Comanche Peak Limestones of Texas. Taff (1902, 1903) included the Walnut Clay in the Goodland, and in 1905 (p. 309) he described the Goodland as equivalent to the Edwards and Comanche Peak Limestones. Recent workers including Lozo (1959, p. 5), Young (1959, p. 97–98), and Blau (1961) have concurred with the assignment. Blau (p. 3–11) gave a detailed account of the history of nomenclature of the term "Goodland."

The Goodland crops out in a narrow band across the northern edge of Bryan County and southern Johnston Counties and has been traced across Choctaw County from west to east (Huffman and others, 1975, pl. 1). Exposures in northern Bryan County are limited to steep, narrow slopes of valleys and in a prominent north-facing escarpment in

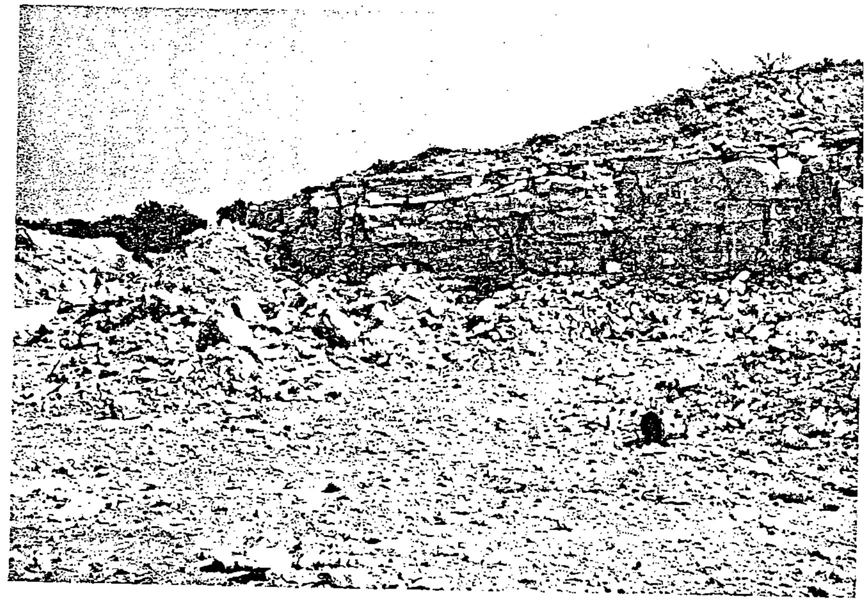


Figure 12. Photo of Bryan County Limestone Company quarry in sec. 1, T. 5 S., R. 8 E. A nearly complete section of Goodland Limestone and the overlying shale of the Kiamichi Formation is shown.

northeastern Bryan County along the bluffs overlooking Clear Boggy River and its tributaries (plate 1 in pocket).

The Goodland is a relatively pure, white, massive, finely crystalline, biomicritic limestone (fig. 12). The lower part of the formation is nodular; fresh surfaces are white but weather gray to buff. The upper part (fig. 13) is a massive, white limestone which tends to exfoliate into thin-curved sheets. The uppermost part weathers with a honeycombed appearance as a result of dissolution of sparry calcite precipitated in voids formerly occupied by fossils.

Chemical analyses (Blau, 1961, p. 38 and table 1) indicate that the Goodland is a nearly pure limestone with an average calcium carbonate content of 97.00 percent. In southern Oklahoma, calcium carbonate content ranges from 91.24 to 98.45 percent; magnesium carbonate from 0.86 to 1.21 percent; and silica, the major contaminant, from 0.25 to 6.16 percent. A sample, taken from the upper 14.8 feet of the Goodland on the Stuart Ranch, SW¼SW¼NE¼ sec. 5, T. 5 S., R. 11 E., Bryan County, yielded 97.02 percent calcium carbonate, 1.05 percent magnesium carbonate, 0.07 percent calcium phosphate, 1.14 percent silica, 0.39 percent iron oxide, and 0.20 percent aluminum oxide. Insoluble residues range from 1 to 19 percent, increasing downward. The average amount of insoluble residue is less than 5 percent of which 99 percent consists of quartz particles with traces of phosphate, glauconite, pyrite, and hematite.

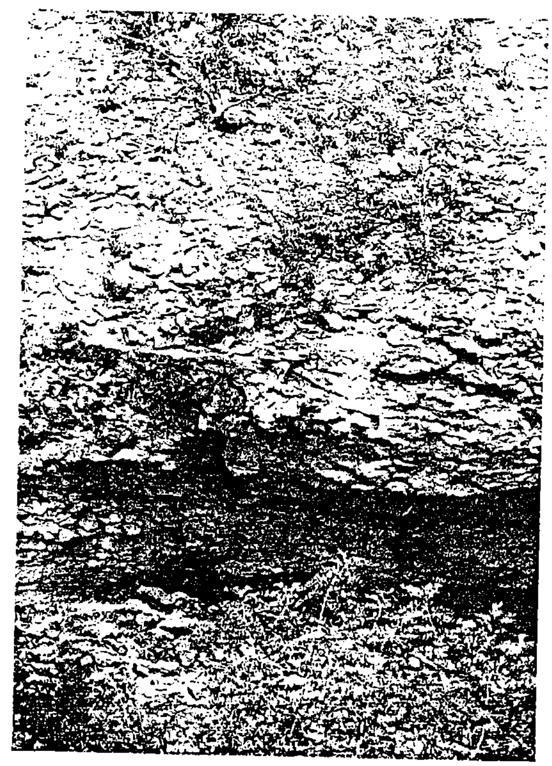


Figure 13. Close-up photo of exposed surface of Goodland Limestone showing the surface weathering into thin, curved plates; near Stuart Ranch, SE¼NW¼ sec. 4, T. 5 S., R. 11 E.

Blau (1961) divided the Goodland into a lower molluscan biofacies coincident with the nodular weathering Comanche Peak lithofacies and an upper rudistid biofacies in the overlying, massively bedded Edwards-type lithofacies; the contact being gradational. Rudistids have been reported in Oklahoma only from the McCurtain County exposures.

The Goodland Limestone, which achieves a thickness of 20 to 25 feet, is resistant to erosion and typically caps a northward facing escarpment.

Stratigraphic relations of the Goodland and underlying Antlers are conjectural. Jeffries (1965), Dalton (1966), Duarte-Vivas (1968), and Alfonsi (1968) postulated disconformable relations based on the absence of typical Walnut Clay facies and a slightly undulating surface on the basal Goodland. Blau (1961) and Frederickson and others (1965) maintained that the contact is gradational and transitional where the basal marly facies (Walnut Clay ?) is present and that no unconformity exists where the Goodland rests directly on the Antlers. The authors of this paper agree with the latter interpretation. The upper contact of the Goodland with the overlying Kiamichi is abrupt and locally undulating but there seems to be little conclusive evidence of emergence and unconformity.

The Goodland Limestone is fossiliferous, but fossils are difficult to collect. Assemblages were collected and identified by both Olson and Hart. Forms listed by Olson (1965, table 1) from T. 5 S., Rs. 11 and 12 E. include *Ceratostreon texanum* (Roemer), *Cyprimeria* sp., *Pecten (Neithea) irregularis* Böse, *Protocardia* sp., *Texigryphaea mucronata* (Gabb), *Lunatia cragini* Stanton, *Turritella* sp., *Tylostoma elevatum* (Shumard), *Tylostoma formosum* Cragin, *Tylostoma kentense* Stanton, *Oxytropidoceras acutocarinatum* (Shumard) and *Enallaster texanus* (Roemer).

Hart (1970, p. 38–39) reported the following collection from sec. 3, T. 5 S., R. 8 E. and sec. 3, T. 5 S., R. 10 E.: *Cyprimeria* sp., *Inoceramus* sp. aff. *I. comancheanus* Cragin, *Lima wacoensis* Roemer, *Pecten (Neithea) subalpinus* (Böse), Pecten *(Neithea) irregularis* (Böse), *Pecten (Neithea) occidentalis* Conrad, *Pecten (Neithea) texanus* Roemer, *Protocardia* sp., *Texigryphaea mucronata* (Gabb), *Texigryphaea* sp., *Tapes* sp. cf. *T. aldamensis* Böse, *Turritella seriatum-granulata* Roemer, *Tylostoma regina* (Cragin), *Manuaniceras carbonarium* (Gabb), *Manuaniceras powelli* Young, *Manuaniceras supani*? (Lasswitz), *Oxytropidoceras acutocarinatum* (Shumard), *Oxytropidoceras salasi*? Young, and *Enallaster mexicanus* Cotteau.

Kiamichi Formation

The term *Kiamichi* (Kiamitia) was applied by Hill (1891, p. 504, 515) to exposures on the plains of the Kiamichi River near Fort Towson, Choctaw County, Oklahoma. Hill originally assigned the Kiamichi to the Washita Group and regarded the Kiamichi as the initial deposit of the Washita depositional cycle. Taff and Leverett (1893, p. 258–262) presented paleontological evidence that supported its assignment to the Fredericksburg Group. There is still no general agreement as to its proper assignment although the U.S. Geological Survey (Imlay, 1944, chart 3) places it in the Fredericksburg Group as does Wilmarth (1938, p. 1091).

The Kiamichi crops out along the northern boundary of Bryan County, forming a nearly continuous band whose width ranges from 0.2 mile to more than 2 miles according to steepness of the associated slope. In general the outcrop belt widens eastward.

The Kiamichi maintains a relatively uniform thickness along the belt of outcrop from Love County to eastern Choctaw County. Frederickson and others (1965, p. 23) reported an average thickness of 30 feet for Love County, Bullard (1926, p. 31) reported 36 feet for Marshall County, Hart (1970, p. 41) measured 36 feet in sec. 6, T. 5 S., R. 9 E. and 40 feet in sec. 1, T. 5 S., R. 8 E. of Bryan County. Thickness in Choctaw County ranges from 28 to 36 feet. A typical exposure is shown in figure 14.

The Kiamichi Formation consists primarily of clay shale ranging in color from dark gray or black to dark brownish green, where fresh, and brownish yellow to gray, where weathered. The very thin basal bed of the Kiamichi is represented in some sections by a calcarenite filled with pelecypod fragments. In other sections, a 2- to 5-inch bed of brown, siliceous limestone marks the base. Succeeding beds are primarily black, fissile shales. Thin beds and lenses of siltstone characterize the lower portion. The upper 17

Figure 14. Distant view of Goodland Limestone and overlying shale of the Kiamichi Formation, Bryan County Limestone Company quarry, sec. 1, T. 5 S., R. 8 E.

feet consist of interbedded limestone layers 0.4 to 0.9 inches thick and dark-gray to brown calcareous shales. The limestone beds are gray, weather yellow gray, and are made up predominantly of shells of the pelecypod *Texigryphaea navia* (Hall). These are the so-called shell beds that are characteristic of the formation throughout its surface extent. The top of the formation is drawn at the top of the uppermost shell bed.

The shell beds give rise to several interesting topographic features. Where streams cross these beds, knickpoints are formed in the stream profile, and waterfalls 3 to 4 feet high are formed. In other cases, the shell beds cap hills and produce extensive, broad dip slopes. Erosion of underlying shales causes the shell beds to break off and slump to form slabs of "edgerock" which may assume any attitude from horizontal to vertical (fig. 15).

The Kiamichi forms a heavy black soil. The steeper slopes support a growth of trees, whereas the broad upland slopes are usually grass covered. Cotton thrives in the upland soil. The upper shell bed is often marked by a tree line, and prickly pear cactus grows on its residual soil.

The contact between the Goodland and Kiamichi appears to be conformable in Bryan County. Gibbs (1950, p. 31) and Duarte-Vivas (1968, p. 26) reported worm burrows in the top of the Goodland that are filled with Kiamichi detritus in eastern Choctaw County. Shelburne (1959, p. 110) and Bishop (1967, p. 163) reported similar burrows and ferruginous and marcasite mineralization at the top of the Edwards in Texas, and Hart (1970, p. 44) reported finding a concentration of marcasite in Bryan County. A local hiatus of short duration may be present in some areas. Contact with the overlying Caddo (Duck Creek) is apparently conformable.

The most abundant fossil in the Kiamichi is *Texigryphaea navia* (Hall) which

Figure 15. Photo of large slabs of *Texigryphaea navia* (Hall) beds (shell beds), top of Kiamichi Formation. Erosion of underlying shale and slumping often place these beds in a nearly vertical position. Location is SE¼NW¼ sec. 4, T. 5 S., R. 11 E.

comprises the bulk of the shell beds. Fossils are difficult to find in the shale sections; however, Hart (1970, p. 46–48) located an exceptionally fresh exposure above the Goodland Limestone in a quarry where he collected and identified the forms listed in table 5 from this and other localities.

WASHITA GROUP

The Washita Group, uppermost subdivision of the Comanchean Series, was named by Hill (1887b, p. 298) for exposures first noticed and described near old Fort Washita, T. 5 S., R. 7 E., Bryan County. In Bryan County, the Washita Group is composed of the Caddo Formation, Bokchito Formation, Bennington Limestone, and Grayson Marlstone. Comparison of Bryan County subdivisions with those of north-central Texas are:

North-Central Texas	Bryan County, Oklahoma
Buda Limestone	missing in Bryan County
Grayson Shale	Grayson Marlstone
Main Street Limestone	Bennington Limestone
Pawpaw Formation	Bokchito Formation —Pawpaw Sandstone Member
"Quarry" Limestone	—McNutt Limestone Member
Weno Clay	—Weno Shale Member (emended)
"Ostrea carinata" bed	—Soper Limestone Member
Denton Clay	—Denton Shale Member (emended)
Fort Worth Limestone	Caddo Formation
Duck Creek Limestone	

CADDO FORMATION

The Caddo was named by Taff (1902, p. 6) for exposures of marls, shales, and limestones in the vicinity of Caddo, Bryan County. Hill (1891, p. 504, 516) had previously applied the names *Duck Creek* and *Fort Worth* to units of comparable age in northern Texas. The Duck Creek includes approximately 100 feet of limestones and marlstones as exposed along Duck Creek near Denison, Grayson County, Texas, and the Fort Worth includes approximately 32 feet of limestone and shale as exposed near Fort Worth, Texas. Separation of the Caddo of Bryan County into two mappable units is impractical because no significant boundary has been established. In general the lower beds of the Caddo resemble those in the Duck Creek, and uppermost Caddo resembles the Fort Worth Limestone.

The Caddo Formation forms a broad, east-west trending outcrop belt ranging from 2 to 5 miles in width across the northern part of Bryan County. Southward projections or "fingers" of the upper Caddo extend for distances of 2 miles beyond the major outcrop belt along southward flowing streams developed on the dip-slope.

Taff assigned a thickness of 150 feet to the Caddo Formation. Hart (1970, p. 53), by means of careful calculations, estimated a thickness of 166 feet for the Caddo along a line from sec. 10, T. 5 S., R. 9 E. to sec. 1, T. 6 S., R. 9 E. Near the town of Caddo, he estimated 131 feet for the Duck Creek part and 29 feet for the Fort Worth. These measurements seem to be in agreement with those of Slocki (1967, p. 189, 194) for northern Texas and Bullard (1925, p. 34; 1926, p. 33–34) for Love and Marshall Counties, Oklahoma.

The Caddo Formation is a sequence of interbedded clays and limestones in varying proportions with shades of gray, blue, yellow, cream, brown, and white. The basal 10 feet consist of light-gray to yellowish clays with subordinate limestones. The interval from 10 to 45 feet is poorly exposed but appears to include gray-blue to yellow-brown shale and clay-ironstone concretions. Beginning about 60 feet above the base is a 10-foot zone of large ammonites including *Eopachydiscus brazoense* (Shumard) in a matrix of light-gray limestone. The succeeding 50 to 60 feet (fig. 16) is predominantly gray, brown, and blue clay with subordinate beds of gray limestone. The upper part of the Duck Creek is marked by a 6- to 8-foot bed of clay.

The Fort Worth equivalent consists of interbedded limestones and clays. The limestones are white or gray and weather yellow. The clays are gray to white, weather yellow, and contain limestone nodules and fucoids. Clays predominate in the basal 10 feet of any 30-foot section of Fort Worth. Limestone beds with thin shale interbeds comprise the interval from 10 to 25 feet above the base whereas the uppermost Fort Worth reveals subequal amounts of limestone and clay.

Limestones in the Duck Creek tend to be blue or gray; those in the Fort Worth are gray to white and weather cream colored. The Caddo forms a rolling topography with heavy black soils above the clay sections and extremely thin soils on resistant limestone beds. Flat lands on the lower Duck Creek form the "twelve mile prairie," a fertile belt of farmland extending across northern Bryan County about 7 miles north of U. S. Highway 70.

TABLE 5.–FAUNULES FROM THE KIAMICHI FORMATION
(modified from Hart, p. 47)

Genus and species	Localities 1a	1b	1c	1d	2	3
Corbis (Mutiella) roblesi? Böse		X				
Cyprimeria texana? (Roemer)			X			
Cyprimeria sp.		X	?			
Inoceramus comancheanus Cragin (juvenile form)					X	
Inoperna concentrice-costellata (Roemer)					X	
Meretrix burkarti? (Böse)		X				
Pecten (Neithea) subalpinus? Böse				X		
Pholadomya sancti-sabae Roemer			X		X	
Plicatula sp.		X				
Protocardia texana? (Conrad)		X				
Tapes whitei Böse)					X	
Tapes gabbi? Böse		X				
Texigryphaea navia (Hall)	X					
Texigryphaea sp. (juvenile form)		X	X			
Aporrhais tarrantensis? Stanton		X				
Turritella sp.			X			
Adkinsites bravoensis (Böse)		X			X	X
Manuaniceras elaboratum var. *lynnense*? Young					X	

Kiamichi localities:

1. South edge SE¼SE¼ sec. 6, T. 5 S., R. 9 E., roadcut and ditches along State Highway 22. **1a**, shell bed; **1b**, siltstone 4 feet below lower shell bed and 20 feet below top of formation; **1c**, siltstone and coquina 2 feet above base of formation; **1d**, main black shale beds.
2. NW¼SE¼NE¼SW¼ sec. 1, T. 5 S., R. 8 E., Bryan County Limestone Company Quarry, southeastern part.
3. NW corner sec. 5, T. 5 S., R. 10 E., float in pasture; shell bed.

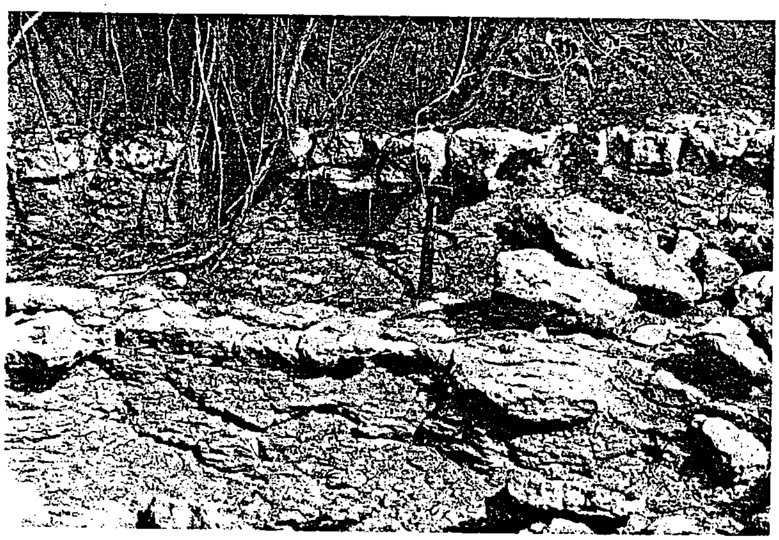


Figure 16. View showing a portion of the Caddo Formation (Duck Creek Member), SW¼ sec. 18, T. 5 S., R. 12 E. Note alternating beds of clay and nodular limestone.

The Caddo rests with apparent conformity on the Kiamichi, and the basal Duck Creek facies shares *Texigryphaea navia* (Hall) and other species with the Kiamichi. The Caddo is succeeded conformably by the Denton Clay Member of the Bokchito Formation.

Both the upper and lower parts of the Caddo are abundantly fossiliferous. Extensive fossil listings have been prepared by Olson (1965, table 1), Ganser (1968, p. 21–22), Currier (1968, p. 16), and Hart (1970, p. 63–68). Forms common to the lower or Duck Creek part include *Mortoniceras* *trinodosum* (Böse), *Eopachydiscus brazoense* (Shumard), *Hamites fremonti* Marcou, *Epiaster whitei* Clark, and *Kingena wacoensis* (Roemer). Fossils common to the upper part or Fort Worth equivalent are *Drakeoceras maximum* (Lasswitz), *Macraster elegans* (Shumard), *Holaster simplex* (Shumard), *Aetostreon walkeri* (White), *Texigryphaea washitanensis* (Hill), and *Rastellum (Arctostrea) carinatum* (Shumard). Fossil listings adapted from Hart (1970) are shown in tables 6 and 7.

Bokchito Formation

The term *Bokchito* was applied by Taff (1902, p. 6) to a sequence of approximately 160 feet of clay, sandy clay, clay-ironstone concretions, arenaceous limestone, and fossiliferous limestones exposed along Bokchito Creek near the town of Bokchito, Oklahoma. Bullard (1925, 1926) recognized three members; in ascending order, these are the Denton, Weno, and Pawpaw. At the top of the Denton is a persistent limestone development commonly referred to as the "*Ostrea carinata*" limestone or the "*Ostrea carinata*" bed. This limestone was used as a marker bed to subdivide the Bokchito Formation and was given member rank by Huffman and others (1975) and named the Soper Member for exposures near the village of Soper, Choctaw County, Oklahoma. At the top of the Weno there is a persistent development of arenaceous limestone referred to as the "Quarry Lime" by previous workers in Texas and Oklahoma. This unit is a useful marker bed within the Bokchito Formation and was given member rank by Huffman and others (1975). The unit has been named the McNutt Member for exposures on the McNutt Ranch southeast of Soper, Choctaw County, Oklahoma. Stratigraphy of the Bokchito Formation in southern Oklahoma has been described by Huffman (1977b).

Denton Clay Member–The Denton Clay was named by Taff and Leverett (1893, p. 272) for exposures along Denton Creek near the town of Denton, Texas. At the type locality, the Denton consists of 40 feet of bluish shales and marls capped by a thin, resistant limestone referred to as the "*Ostrea carinata*" bed.

The Denton Clay Member forms a long, sinuous, and continuous east-west band across northern Bryan County. The width of the band ranges from 0.1 mile to more than 2 miles. It attains a thickness of 54 to 60 feet in Bryan County. Measurements range from 45 to 67 feet in Choctaw County, 46 to 56 feet in Marshall County (Bullard, 1926, p. 36-38), and average 70 feet in Love County (Frederickson and others, 1965, p. 27).

The Denton consists of blue-gray to brownish-gray clay shale. Thin siltstone beds 0.1 to 0.8 inches are common. Selenite crystals have been observed on surface exposures and clay-ironstone concretions are present at places. The Denton becomes increasingly calcareous upward, and beds of fossiliferous marlstone occur immediately below the "*Ostrea carinata*" bed (Soper Limestone) at places. The lower shaly part of the Denton is almost devoid of fossils whereas the upper marlstone beds have yielded abundant *Texigryphaea washitaensis* (Hill), *Pecten (Neithea) texanus* Roemer, *Rastellum (Arctostrea) quadriplicatum* (Shumard), and *Rastellum (Arctostrea) carinatum* (Lamarck). Forms collected and identified by Hart (1970, p. 76–79) are listed in table 8. At locality 3 (table 8) and on p. 24 of his thesis, Hart reported a second limestone bed some 8 to 10 feet below the "*Ostrea carinata*" bed. A typical exposure of the upper part of the Denton and the overlying Soper Limestone is shown in figure 17.

Soper Limestone Member–The Soper Limestone Member was named by Huffman and others (1975, p. 16–17) for an exposure in a railroad cut 1½ miles east of Soper, Choctaw County, Oklahoma. There it consists of a single bed of well-indurated limestone that conformably overlies 2 to 3 feet of yellow, fossiliferous marlstones. These were excluded from the original definition of the Soper Member because they are not everywhere present in exposures, and, where present, they are typically poorly exposed. The hard, compact, resistant Soper Limestone is a persistent marker bed across Choctaw and Bryan Counties and is believed to approximate a time plane. Due to its resistance, it forms a conspicuous ledge along hillsides, across roads, and in stream valleys. Its presence enables one to differentiate between the Denton and Weno Clay Members in the field and to map a boundary between these two members. The Soper Limestone is commonly fossiliferous, containing abundant *Texigryphaea washitaensis* (Hill) and *Rastellum (Arctostrea) quadriplicatum*

TABLE 6.–FAUNULES FROM DUCK CREEK PART OF THE CADDO FORMATION
(adapted from Hart, p. 63–66)

Genera and species	Localities								
	1	2	3	4	5	6	7	8	9
Ceratostreon texanum? (Roemer)				X					
Exogyra plexa Cragin						X			
Homomya sp.					X				
Inoceramus comancheanus? Cragin		X							
Pecten (Chlamys) catherina (Cragin)									X
Pecten (Neithea) bellulus (Cragin)		X							
Pecten (Neithea) sp. *aff. P. longicauda* (d'Orbigny)								X	
Pecten (Neithea) subalpinus (Böse)					X				
Pecten (Neithea) wrighti (Shumard)									X
Plicatula incongrua Böse	X	X	X	X		X	X	X	X
Plicatula subguritis Böse	X	X	X	X		X	X	X	X
Protocardia texana (Conrad)	X						X		
[1]*Rastellum (Arctostrea)* sp. *aff. R. quadriplicatum* (Shumard)							X		
[2]*Texigryphaea corrugata* (Say) = T. pitcheri (Morton)	X	X	X	X	X	X	X	X	X
Texigryphaea navia (Hall)	X								
Texigryphaea washitaensis (Hill)		X			X	X	?	X	X
Loricella? (a chiton)							X		
Adkinites belknapi (Marcou)	X								
[3]*Drakeoceras kummeli*? Young							X		X
[3]*Drakeoceras* sp. *aff. D. lasswitzi* Young							X		
[3]*Drakeoceras* sp. *aff. D. maximum* (Lasswitz)									X
Eopachydiscus brazoense (Shumard)				X					
Goodhallites burckhardti? (Böse)							X		
Hamites intermedius Sowerby	X								
Hamites nokonis Adkins and Winton					X				
Manuaniceras elaboratum var. *lynnense*? Young	X								
[4]*Mortoniceras vespertinum*? (Morton)				X					
[4]*Mortoniceras leonensis* (Conrad)							X		X
[4]*Mortoniceras shumardi*? (Marcou)				X					
[4]*Mortoniceras smedalae* Young					X				
[4]*Mortoniceras* sp. *cf. M. trinodosum* (Böse)									X
[4]*Mortoniceras* sp. *aff. M. whitneyi* Young					X				
Hemiaster (Macraster) elegans Shumard									X
Hemiaster (Macraster) elegans var. *washitae* (Lambert)				X		X			
Hemiaster (Macraster) elegans var. *subobesus*? (Adkins)				X		X			

[1]Following the work of Stenzel (1971), species previously referred to *Ostrea (Lopha)* or *O. (Alectryonia)* belong to *Rastellum (Arctostrea)*.

[2]Fay (1975) considers *Gryphaea corrugata* Say as a *nomen nudum* and recommends that the name be suppressed in favor of *Texigryphaea pitcheri* (Morton).

[3]Assignment of several species to *Drakeoceras* follows the work of Young (1957); however, they bear close resemblance to *Pervinquiera* and hence *Mortoniceras*.

[4]Species referred by Hart to the genus *Pervinquiera* are herein assigned to *Mortoniceras;* however as Branson (1965) noted, the later genus is weakly established.

Duck Creek localities:

1. NE¼NW¼NW¼NE¼ sec. 10, T. 5 S., R. 9 E. Along Simon Creek directly south of State Highway 22. Basal 9 feet of Duck Creek.
2. SE¼NW¼SE¼SW¼ sec. 16, T. 5 S., R. 9 E. In gully 0.15 mile north of intersection of State Highway 48 and side roads; clay 45–53 above base.
3. SW¼SW¼SW¼NE¼ sec. 21, T. 5 S., R. 9 E. Ditch north of State Highway 48; clay 50 feet above base of formation.
4. NW¼NE¼NE¼NW¼ sec. 21, T. 5 S., R. 9 E. State Highway 48 south of section-line road; large ammonite zone 60 feet above base of formation.
5. Near corner NE¼NE¼ sec. 11, T. 5 S., R. 9 E. Roadcut and ditch, State Highway 22; clays and limestones 70–81 feet above base of formation.
6. North edge NE¼NE¼NW¼ sec. 12, T. 5 S., R. 9 E. Roadcuts, south side State Highway 22; clays and limestones 79–105 feet above base of formation.
7. NW¼SW¼SW¼NW¼ sec. 26, T. 5 S., R. 7 E. Gully on west side Cumberland Cut 0.4 mile southeast of bridge; clay and limestone 84–100 feet above base of formation.
8. Same location as 7. Approximately 100–117 feet above Kiamichi in upper 17 feet of Duck Creek.
9. Center SE¼ sec. 8, T. 5 S., R. 10 E. Roadcuts on State Highway 22, northwest side of town of Caddo. Clays and limestones 93–131 feet above top of Kiamichi; includes uppermost 38 feet of Duck Creek and basal Fort Worth.

TABLE 7.–FAUNULES FROM FORT WORTH PART OF THE CADDO FORMATION
(adapted from Hart, p. 66–68)

Genera and species	Localities 1	2	3	4	5	6	7	8
Aetostreon walkeri (White)	X	X			X	X	X	X
Cyprimeria sp. aff. *C. texana* (Roemer)	X							
Lima (Mantellum) blancensis Stanton							X	
Lima (Mantellum) wacoensis quadrangularis Stanton							X	X
Nucula wenoensis? Adkins								X
Pecten (Chlamys) generosus (Cragin)			X	X				
Pecten (Neithea) bellulus (Cragin)					X			X
Pecten (Neithea) subalpinus (Böse)						X		
Pecten (Neithea) texanus Roemer	X			X	X	X	X	X
Pecten (Neithea) wrighti (Shumard)							X	
Plicatula incongrua Böse	X			X	X		X	
Plicatula subgurgitis Böse	X			X	X		X	
[1]*Rastellum (Arctostrea) carinatum* (Lamarck)				X			X	
[1]*Rastellum (Arctostrea) quadriplicatum* (Shumard)	X				X	X		
[1]*Rastellum (Arctostrea) subovatum* (Shumard)	X			X				
Texigryphaea "corrugata" (Say) = *T. pitcheri* (Morton)	X							
Texigryphaea washitaensis (Hill)	X			X	X	X	X	X
[2]*Drakeoceras kummeli* Young	X							
[2]*Drakeoceras lasswitzi* Young		X						
[2]*Drakeoceras maximum* (Lasswitz)						X		X
[2]*Drakeoceras* sp. (juvenile form)				X				X
Goodhallites whitei (Böse)				?		X		
Mortoniceras sp. cf. *M. perarmata* (Hass)	X							
Mortoniceras leonensis (Conrad)				X				
Mortoniceras nodosa (Böse)				X				
Mortoniceras shumardi (Marcou)	X	X						
Prohysteroceras sp. aff. *P. atchisoni* Young							X	
Aporrhais tarrantensis? Cotteau				X				
Enallaster mexicanus? Cotteau	X							
Hemiaster (Macraster) elegans Shumard	X			X				
Hemiaster (Macraster) elegans subobesus (Adkins)	X							
Hemiaster (Macraster) sp.	X							
Holaster simplex Shumard	X			X		X	X	

[1]Plicate Cretaceous oysters formerly assigned to *Ostrea (Lopha)* or *O. (Alectryonia)* are placed in *Rastellum (Arctostrea)* following Stenzel (1971) who assigned *Ostrea carinata* to *Rastellum (Arctostrea) carinatum* (Lamarck).

[2]Again the assignment to *Drakeoceras* is based on the work by Young (1957). These forms appear to be closely related to the genus *Mortoniceras*.

Fort Worth localities:

1. NW¼SW¼SW¼NW¼ sec. 26, T. 5 S., R. 7 E. West side Cumberland Cut, 0.4 mile southeast of bridge in gully; basal 4 feet of Fort Worth.
2. Center SE¼ sec. 8, T. 5 S., R. 10 E. Roadcuts State Highway 22 and pond south of State Highway 22 northwest side of Caddo; limestone and clay in basal 8–9 feet.
3. S½NE¼SW¼SW¼ sec. 28, T. 5 S., R. 9 E. Roadcuts State Highway 48 south of Blue River; about 30 feet below top of Fort Worth.
4. Corner NE¼NE¼SW¼ sec. 16, T. 5 S., R. 10 E. Railroad cuts in Caddo, 0.35 mile southwest State Highway 22 overpass; limestone 11–22 feet above base.
5. NE¼SE¼NW¼NE¼ sec. 34, T. 5 S., R. 9 E. Pasture slopes 0.9 mile northwest of fish hatchery; approximately 30 feet below top of Fort Worth.
6. NW¼NW¼NW¼SW¼ sec. 33, T. 5 S., R. 9 E. East side State Highway 48 near gate. Limestone 15 feet below top of Fort Worth.
7. Corner NE¼NW¼SW¼ sec. 32, T. 5 S., R. 9 E. East side pond; limestone and clay, upper 13–14 feet of Fort Worth.
8. NW¼NE¼SW¼NW¼ sec. 1, T. 6 S., R. 9 E. Creek on Davisson Angus Ranch, 0.3 mile southeast intersection of U.S. Highways 69 and 75 with side road; clay and limestone, upper 4.4 feet of Fort Worth below contact with Denton Clay.

TABLE 8.–FAUNULES FROM DENTON AND SOPER MEMBERS OF THE BOKCHITO FORMATION
(adapted from Hart, p. 76–79)

Genera and species	Localities 1	2	3	4	5	6	7
Aetostreon walkeri? White (juvenile form)		X					
Cardita wenoensis? (Adkins)			X				
Corbula basiniformis Adkins			X				
Corbula wenoensis Adkins			X				
Cyprimeria washitensis Adkins			X				
Gervilliopsis sp.			X				
Inoceramus sp.			X				
Nucula nokonis Adkins			X				
Nucula wenoensis? Adkins			X				
Pecten (Neithea) georgetownensis (Kniker)						X	
Pecten (Neithea) subalpinus (Böse)						X	X
Pinna sp.						X	
Plicatula dentonensis Cragin						X	
Plicatula incongrua Conrad or *P. subgurgitis* Böse				X			
Protocardia multistriata (Shumard)	X						
Protocardia sp. aff. *P. prosogyrata* Perkins			X				
Protocardia texana? (Conrad)			X				
Rastellum (Arctostrea) quadriplicatum (Shumard)			X	X	X	X	X
Texigryphaea washitaensis (Hill)	X	?		X	X	X	X
Trigonia clavigera Cragin				X			
Trigonia emoryi? Conrad						X	
Anchura (Drepanocheilus) mudgeana White			X				
Aporrhais? *subfusiformis*? (Shumard)			X				
Avellana sp.?			X				
Cinulia washitaensis? Adkins			X				
Falsifusus? *gainesvillensis*? Stanton			X				
Natica sp.			X				
Turbo? *gainesvillensis* Stanton			X				
Turritella seriatim-granulata gainesvillensis Stanton			X				
Turritella sp.			X				
Engonoceras sp.		X	X				
Leiocidaris hemigranosus? (Shumard) (spines and plates)				X		X	
Cribratina texana (Conrad)						X	

Localities:
1. NW¼NE¼SW¼NW¼ sec. 1, T. 6 S., R. 9 E. Above creek in Davisson Angus Ranch 0.3 mile southeast of intersection of U.S. Highways 69 and 75 with side road. Siltstone 7 feet above contact with Fort Worth Limestone.
2. SW¼NE¼NE¼NW¼ sec. 6, T. 6 S., R. 10 E. Along creek 0.1 mile south of road on Poole Hereford Ranch; fossils from basal 8 feet of Denton.
3. Center S½NW¼NE¼ sec. 13, T. 6 S., R. 10 E. Above east bank Caddo Creek; pasture road extends to within 0.35 mile to west; fossils between two limestone beds 8 to 10 feet apart.
4. N½NW¼NW¼ sec. 5, T. 6 S., R. 8 E. Localities along pasture road beneath western set of power lines; fossils from "*Ostrea*" bed and associated clay.
5. SE¼NE¼SE¼SE¼ sec. 6, T. 6 S., R. 8 E. Along creek and waterfall, 500 feet west of western set of power lines; unweathered "*Ostrea*" beds and clay.
6. NE¼SE¼SE¼SE¼ sec. 21, T. 6 S., R. 7 E. On shore of Lake Texoma in small embayment. Fossils from below exposed "*Ostrea*" beds and underlying clay.
7. NE¼SW¼NW¼ sec. 1, T. 6 S., R. 9 E. Ridgetop on Davisson Ranch, 0.4 to 0.5 mile south section-line road; "*Ostrea*" bed float.

(Shumard), and an occasional *Rastellum (Arctostrea) carinatum* (Lamarck). Faunally it is closely related to the underlying marlstones in the upper part of the Denton Clay Member. Contact with the overlying Weno Clay Member is conformable but abrupt.

Weno Clay Member–The Weno Clay was named by Hill (1901, p. 121) for exposures near the village of Weno (now abandoned) located northeast of Denison, Grayson County, Texas. The type Weno was described as consisting of 92 feet of ferruginous brown

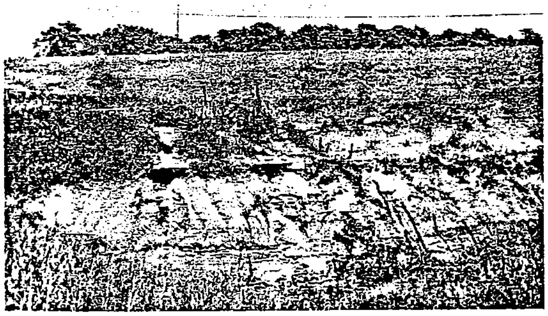


Figure 17. Typical exposure of Denton Member capped by resistant beds of the Soper Member, along creek 3½ miles north of Bokchito in NW¼ sec. 10, T. 6 S., R. 11 E.

clay marls and marly clay. The "Quarry Limestone," a massive arenaceous limestone which oxidizes yellow, was included in the Weno by Hill but was later placed in the lower Pawpaw Sandstone Member by Stephenson (1918, p. 142). Huffman and others (1975, p. 18) renamed the "Quarry Limestone" the McNutt Limestone Member on the basis of its very excellent development and lateral persistence throughout Choctaw County, Oklahoma, especially on the McNutt Ranch south of Soper, Oklahoma. The term *Weno* is emended (restricted) to include the shales and sands between the Soper Limestone and the McNutt Limestone in southern Oklahoma.

The Weno Clay Member forms a sinuous outcrop pattern across northern and western Bryan County. At places, the outcrop belt is more than 1 mile wide; more commonly it is 0.25 to 0.5 mile or less. Long, fingerlike extensions of the Weno project southward along the floors and valley walls of southward flowing streams.

The combined Weno and overlying McNutt Members reach a thickness of 80 to 90 feet or possibly 100 feet in northern Bryan County (Hart, 1970, p. 81) where the basal beds are incompletely exposed. Currier (1968, p. 22) reported 109 feet in southwestern Bryan County, the upper 13 feet being the "Quarry Limestone" or McNutt Limestone Member of this report. Bullard (1926, p. 38) reported thicknesses ranging from 90 to 135 feet in Marshall County; Ganser (1968) corrected the 135-foot measurement to 90 feet and recognized 15 to 20 feet of interbedded arenaceous limestone and shale which he referred to as the "Quarry Limestone." Eastward thinning in Choctaw County gives thicknesses of 30 to 53 feet for the Weno (restricted) and the McNutt Limestone ranges from 2 to 3 feet.

The lower part of the Weno consists of 45 to 50 feet of olive-gray clay with thin interbeds of brown ferruginous sandstone and siltstone. Selenite crystals, limonite, jarosite(?), alunite, marcasite concretions and clay-ironstone concretions have been observed. Weathered slopes are littered with slabby broken fragments of ferruginous concretions.

The Weno between the lower clay unit and the McNutt Limestone contains a lower zone of medium- to thick-bedded, ripple-marked, ferruginous, micaceous sandstone and interbedded clays. The overlying 20 feet consists of clay shales and massive-bedded, yellow to orange, fine-grained, friable, fossiliferous, ferruginous, micaceous sandstones. Uninterrupted sandstone or clay units as much as 17 feet occur in various localities in the section subjacent to the McNutt Limestone Member (fig. 18).

Overlying and interfingering with the clays and sands of the upper Weno are arenaceous limestones ranging in thickness from a few feet to approximately 20 feet. These constitute the "Quarry Limestone" of previous reports which will be discussed under the heading McNutt Limestone Member.

The Weno conformably overlies the Soper Limestone Member and is succeeded conformably by the McNutt Limestone Member with which it intergrades at places. Fossils are rare in the sandstone and clay beds of the Weno. Molds and casts of *Protocardia* sp., *Turritella* sp., *Nucula* sp., and *Corbula* sp. are present in some sandstone layers.

McNutt Limestone Member—The term *McNutt Limestone Member* was applied by Huffman and others (1975, p. 18) to beds previously referred to as the "Quarry Limestone." The name was taken from exposures on the McNutt Ranch 4 miles southeast of Soper, Choctaw County, Oklahoma. The McNutt Member has been mapped across the western two-thirds of Choctaw County where it maintains a fairly constant thickness of 2 feet.

The McNutt is extended into Bryan County to replace the informal name

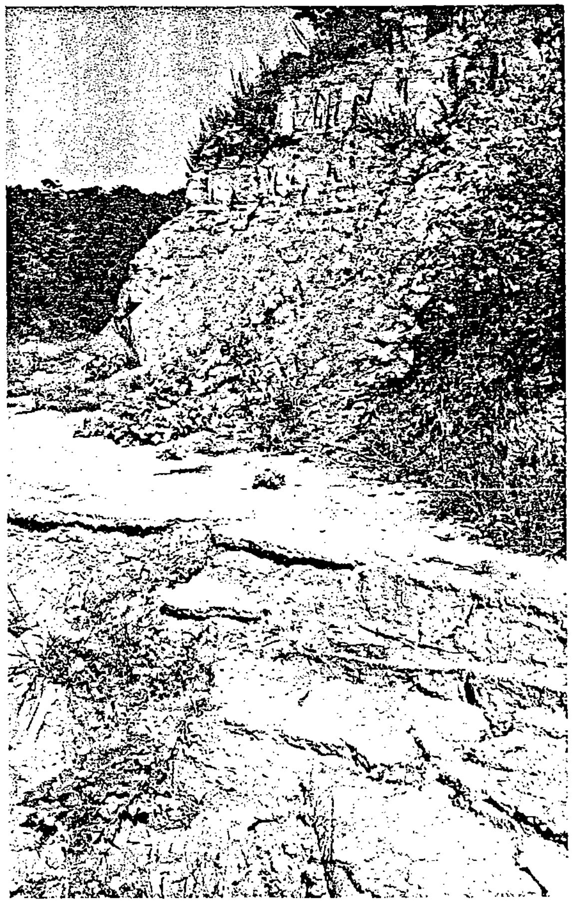


Figure 18. Excellent exposure of the Weno Member, Bokchito Formation, Newberry Creek arm of Lake Texoma, SE¼ sec. 22, T. 6 S., R. 7 E.

"Quarry Limestone" previously applied to arenaceous beds in the upper part of the Weno Shale Member. The McNutt is given member rank in accordance to the rules and regulations of the Code of Stratigraphic Nomenclature (American Commission on Stratigraphic Nomenclature, 1961).

The McNutt Member varies from an arenaceous limestone to a highly calcareous sandstone. At places, as in eastern Bryan County, it consists of a single 2-foot-thick bed. In western Bryan County and adjacent parts of eastern Marshall County, the McNutt thickens by addition of beds in the lower part. At places, two, three, or even four beds are present. These are separated by interbeds of calcareous siltstones, marls, shale, or sandy shale. Thickness ranges from less than 2 feet to a possible maximum of 20 feet. Currier (1968, p. 24) assigned a maximum of 13 feet in southwestern Bryan County; Ganser (1968, p. 28) noted a thickness of 15 to 20 feet; Hart (1970, p. 199), by incorporating a 17-foot section of poorly exposed clay, observed a thickness of 22 feet. The McNutt appears to thicken at the expense of the Weno Clay, and lower units interbed with the upper part of the Weno. It should be pointed out that the McNutt Member reaches maximum development only in areas where the Weno Member is thickest (90–100 feet) and is seldom more than 2 feet thick where the Weno is thin (30–60 feet) as in Love and Choctaw Counties, Oklahoma.

The McNutt limestones are thick-bedded, well-indurated, fine- to medium-grained calcarenites. Insoluble residue data by Currier (1968, p. 24) indicate 76 to 82 percent calcium carbonate and 18 to 24 percent of insoluble silt, clay, and sand, with traces of feldspar, glauconite, and unidentified ferromagnesium minerals.

The McNutt Limestone serves as a reliable marker bed separating the upper Weno sandstones from lithologically similar beds in the overlying Pawpaw Sandstone Member. Although variable in thickness, the McNutt Limestone is almost everywhere present and mappable. The uppermost beds appear to represent a synchronous unit or a time-marker bed.

Fossils are relatively abundant in the limestone beds of the McNutt Member. The most conspicuous fossil is the pelecypod *Rastellum (Arctostrea) quadriplicatum* (Shumard) whose outlines are preserved on weathered surfaces. At places the uppermost bed is a typical coquinite composed of *"Ostrea"* shells. Other forms common to the McNutt include *Texigryphaea washitaensis* (Hill), *Rastellum (Arctostrea) subovatum* (Shumard), *Exogyra* sp., *Pecten (Neithea) subalpinus* Böse, *Lima wacoensis quadrangularis* Stanton, *Protocardia* sp. and small gastropods. A more complete listing was given by Hart (1970, p. 88–89).

Pawpaw Sandstone Member—The name *Pawpaw* was applied by Hill (1894, p. 330) to exposures along Pawpaw Creek near Denison, Grayson County, Texas. There the unit has been described as consisting of fossiliferous, light-drab, thinly laminated clay lying between the Weno Clay and the Main Street Limestone. It was reported as becoming increasingly sandy in northern Texas.

The Pawpaw Sandstone Member in Bryan County is a complex sequence of clay shales, sandstones, and local lenses of very sandy, massive, reefoid limestone. The clay shales are gray to olive gray, platy, and interbedded with thin sandstone and siltstone beds and clay-ironstone concretions. Glauconite and carbonaceous material have been observed. Typical exposures are shown in figures 19 and 20.

The sandstones are gray to brown where fresh but are typically weathered to varying shades of yellow, orange, and reddish brown. The sandstone are fine grained, well sorted, and locally display crossbedding and ripple marks. Mica flakes, chert nodules, hematite grains, glauconite, clay-ironstone concretions, and macerated pelecypod remains are common.

Lateral facies changes and eastward thinning characterize the Pawpaw Member along its present outcrop. In Love County it comprises a basal shale unit (16 feet) and an overlying buff to red sandstone sequence (36 feet) separated by a thin bed of calcarenite (1 foot) for a total of 53 feet (Frederickson and others, 1965, p. 30). In Marshall County the basal clay shale is 22 feet thick and the overlying sandstone is 38 feet for a total of 60 feet (Bullard, 1926, p. 43).

In Bryan County the Pawpaw facies are complex and localized with rapid lateral

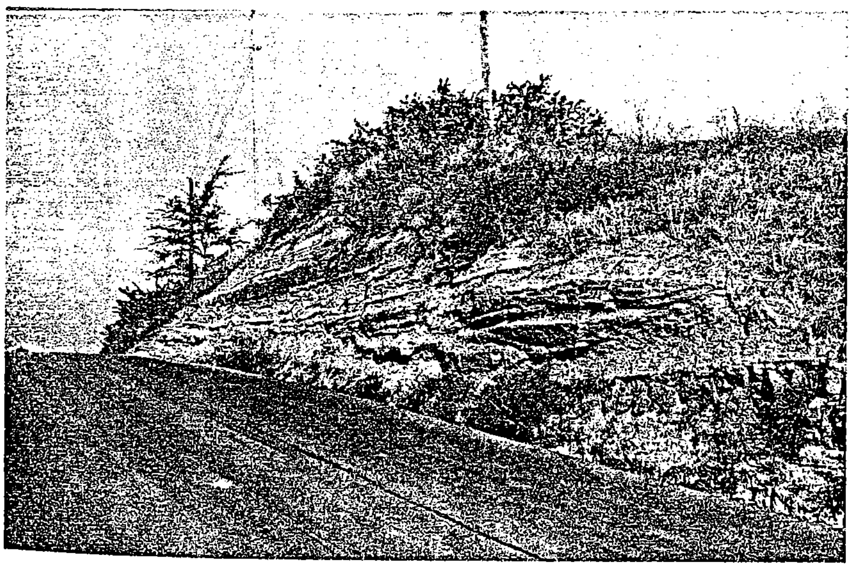


Figure 19. Excellent exposure of Pawpaw Member, Bokchito Formation, west side of U.S. Highways 69 and 75, NE¼SE¼ sec. 17, T. 6 S., R. 9 E.

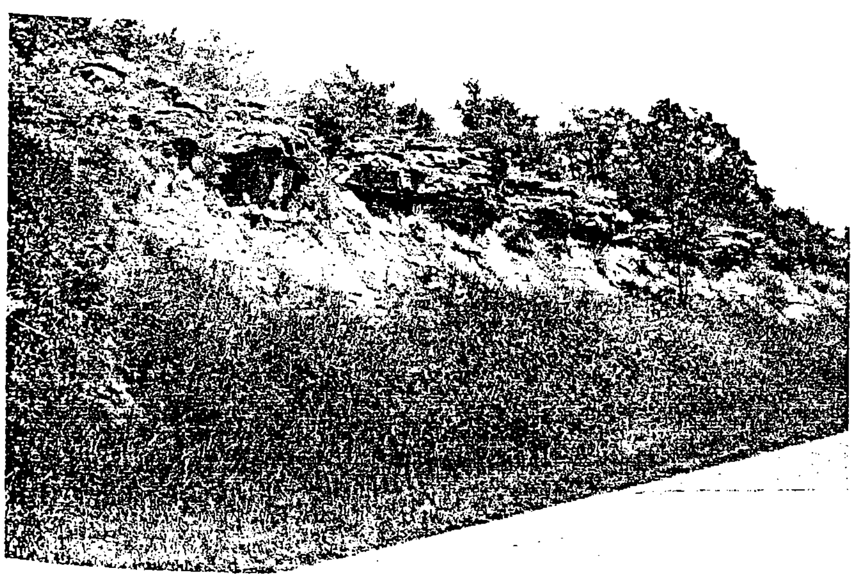


Figure 20. Upper half of the Pawpaw Member, Bokchito Formation, north side of U.S. Highway 70, SW¼SE¼ sec. 27, T. 6 S., R. 10 E. Note Bennington Limestone capping exposure. (See measured section 8, p. 90.)

changes. In the western part of the county, Hart (1970, p. 101) noted that the upper 30 feet of Pawpaw on Newberry Creek (NW¼NW¼ sec. 25, T. 6 S., R. 7 E.) are clay shale. Eastward from there, the Pawpaw is largely sandstone. Excellent exposures are along Chukwa Creek north of Durant (NE¼NE¼ sec. 29, T. 6 S., R. 9 E. and in adjacent sec. 28, T. 6 S., R. 9 E.) and along the west side of State Highway 78 south of the junction with U.S. Highways 69 and 75 (fig. 19). The sandstone facies changes to shale eastward in exposures along Highway 70 east of Blue River (SW¼SE¼ sec. 27, T. 6 S., R. 10 E.). Figure 20 illustrates the nature of the upper Pawpaw along the north roadside. In the cut on the south roadside, a lens of crossbedded calcarenite occurs in the upper part of the Pawpaw (NE¼ sec. 34, T. 6 S., R. 10 E.). This sandy, reefoid mass resembles beds in the McNutt Member and in the Bennington Limestone, suggesting similar environments of deposition. Hart (1970, p. 95–96) mentions other occurrences of limestone within the Pawpaw. Eastward from Blue River, the upper Pawpaw is represented by 34 feet of sandstone as exposed in sec. 25, T. 6 S., R. 10 E.).

In eastern Bryan County the Pawpaw ranges in thickness from 25 to 34 feet and consists predominantly of red to yellow, crossbedded, friable sandstone. The sandstone is poorly sorted and silty. The grains are fine, subangular to subrounded, and coated with iron oxide. Fragments of clay-ironstone litter eroded surfaces.

In Choctaw County the Pawpaw Member consists of red and yellow sandstones interbedded with gray to reddish-purple, sandy clay. The sandstones are friable, poorly indurated, ferruginous and cemented with silty, yellow clay. Sieve analysis of a sample from Choctaw County (Duarte-Vivas, 1968, p. 37) indicates that the grains are in the 3.0 ϕ to 4.0 ϕ range. The member there attains a uniform thickness of 35 feet.

The outcrop pattern forms a narrow, sinuous band along the eastern side of Lake Texoma and eastward to U.S. Highway 69 north of Durant. From there eastward the belt widens to approximately 2 miles with long, narrow "fingers" projecting downdip southward along all major drainage lines.

The Pawpaw rests conformably upon the McNutt Member and is succeeded conformably by the Bennington Limestone except for a small area in T. 6 S., R. 13 E. where basal Woodbine Formation cuts down into the Pawpaw section.

The Pawpaw is sparingly fossiliferous and the fauna consists primarily of molds and casts of pelecypods including *Protocardia* sp., *Nucula* sp., *Cyprimeria washitaensis* Adkins, and *Rastellum (Arctostrea) quadriplicatum* (Shumard). Turritellids are rare in the Pawpaw but were observed by Hart (1970, p. 100).

Bennington Limestone

The Bennington Limestone was named by Taff (1902, p. 6) for exposures of massive, dull-blue limestone exposed near Bennington, Bryan County, where a thickness of 10 feet was reported. The Bennington of Oklahoma is correlative with the Main Street Limestone (restricted) of Texas.

The Bennington Limestone consists of gray to yellow-brown, fine-grained (biomicritic) to medium-crystalline (bioclastic calcarenite), fossiliferous, arenaceous limestone which weathers pitted and honeycombed (fig. 21). Beds of well-indurated limestone alternate with beds of soft, marly limestone in northwestern Bryan County. There the basal beds are 96 percent calcium carbonate, middle layers are 93 percent, and the softer, marly layers are 88 percent (Ganser, 1968, p. 32).

Thickness ranges from 9 to 10 feet in western Bryan County between Lake Texoma and Durant. Hart (1970, p. 103–104) reported a 22-foot section, incomplete at the

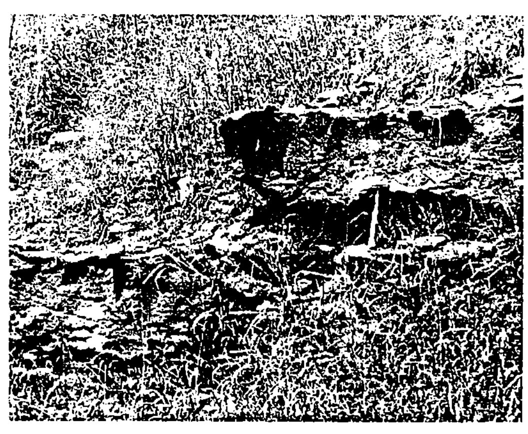


Figure 21. Typical exposure of the Bennington Limestone, railroad cut 0.2 miles east of Bokchito Creek, NW¼NE¼ sec. 26, T. 6 S., R. 12 E.

base, on Kanola Creek, (SW¼NE¼ sec. 36, T. 6 S., R. 9 E.) and 14 feet on the road in SE¼NE¼ sec. 36, T. 6 S., R. 10 E. Olson (1965, p. 30) reported 7 feet or less in eastern Bryan County, the Bennington being locally absent by pre-Woodbine erosion.

The Bennington outcrop is a narrow, sinuous band along the east side of Lake Texoma in western Bryan County. The belt widens abruptly to 2 miles, north of Durant. It narrows again along Chukwa Creek east of Durant but widens to 2 miles within a short distance. From 8 miles east of Durant in the vicinity of Blue, Oklahoma, the outcrop band widens to approximately 3 miles, a width which is maintained from there eastward through Bokchito and Bennington. U.S. Highway 70 traverses the outcrop of the Bennington from 3 miles east of Durant to within 3 miles of the Choctaw-Bryan County line.

The Bennington rests with sharp contact on the shales and sandstones of the Pawpaw Member of the Bokchito Formation. Hart (1970, p. 107–108, 195, 197) noted some exposures containing heavy mineralization and coarse sand and granules at the top of the Pawpaw, suggesting a slight depositional break, but other localities indicated no such features. Contact with the overlying Grayson Marlstone is gradational and transitional, and the boundary is more or less arbitrarily drawn at some exposures.

Fossils are abundant in the Bennington Limestone. The most characteristic forms are *Kingena wacoensis* (Roemer), *Ilymatogyra arietina* (Roemer), *Rastellum (Arctostrea) quadriplicatum* (Shumard), and *Pecten texanus* Roemer. Currier (1968, p. 30–31) listed in addition to these *Cymatoceras texanum* (Shumard), *Plesioturrilites brazoensis* (Roemer), *Holectypus limitus* Böse, *Phymosoma texanum* (Roemer), *Enallaster texanus* Roemer, and *Hemiaster calvini* Clark. Additional but less abundant forms are listed by Olson (1965, table 1) and Hart (1970, p. 109–110).

Grayson Marlstone

The term *Grayson Marl* was applied by Cragin (1894, p. 41–48) to a sequence of yellow, calcareous, fossiliferous marls in the upper part of the Main Street Limestone Member of the Denison Formation in Grayson County, Texas. Hill (1901, p. 114–115, and 280–288) restricted the term *Main Street* to the lower limestone development and followed Cragin's application of *Grayson* to the overlying marly strata.

The Grayson is poorly exposed in the grass-covered slopes above the Bennington Limestone and below the Woodbine Formation. The outcrop tends to be narrow and sinuous and to parallel that of the Bennington. The Grayson Marlstone has been observed in northwestern Bryan County and along streams beneath the terrace cover in southwestern Bryan County. It is absent in eastern Bryan County east of Caddo Creek in sec. 31, T. 6 S., R. 11 E. because of pre-Woodbine erosion. The most completely exposed section is on Little Sand Creek (NE¼NE¼ sec. 11, T. 8 S., R. 7 E.) 2 miles northwest of Colbert (fig. 22). Hart (1970, p. 112–113) described occurrences of Grayson along Newberry Creek (NE¼ sec. 25, T. 6 S., R. 7 E.) 2 miles northwest of Mead and along Chukwa Creek 1 mile northwest of Durant (sec. 19, T. 6 S., R. 8 E.) where good exposures were observed. Thickness ranges from zero to 27 feet.

Currier (1968, p. 32 and section 45, p. 224) divided the Grayson of southwestern Bryan County into four units comparable to

Figure 22. Exposure of the Grayson Marlstone, south bank of Little Sand Creek, SE¼NE¼NE¼ sec. 11, T. 8 S., R. 7 E. (See measured section 45, p. 101.)

those established by Perkins (1960, p. 37) in Tarrant County, Texas. These are: (1) a lower 8-foot-thick, light-gray, nodular limestone and marlstone, interbedded at regular intervals and containing an abundance of fossils, *Ilymatogyra arietina* (Roemer) being the most abundant, accompanied by a few *Texigryphaea roemeri* (Marcou); (2) a 4-foot-thick, very sparsely fossiliferous, olive-gray marl; (3) an 11-foot-thick, olive-gray marl regularly interbedded with nodular limestone sequence containing *Texigryphaea roemeri* (Marcou); and (4) an upper, 4-foot-thick, olive-gray shale containing abundant *Texigryphaea roemeri* (Marcou).

Along Newberry Creek (NE¼ sec. 25, T. 6 S., R. 7 E.), Hart recognized comparable zones in a 22-foot section (incomplete at the base). There the lower Grayson includes approximately 6 feet of interbedded limestone and marly shale succeeded by a 4-foot zone of clay and chalky limestone nodules. Succeeding beds include a 10.5-foot bed of clay with abundant limestone nodules and *Texigryphaea roemeri* (Marcou) and an upper 2-foot bed of clay containing abundant *Texigryphaea roemeri* (Marcou). *Texigryphaea graysonana* (Stanton, 1947) is now generally accepted as a synonym for *Texigryphaea roemeri* (Marcou, 1862) as discussed by Fay (1975). Hart (1970) and others have used the Stanton name for this species in their theses. *T. roemeri* (Marcou) clearly has priority.

The Grayson Marlstone on Chukwa Creek (sec. 19, T. 6 S., R. 8 E.) does not lend itself to the zonation indicated above except for the basal *Ilymatogyra arietina* interval. There the basal shale unit of the Woodbine Formation channels some 22 feet into the Grayson Marlstone (Hart, 1970, p. 117). The Grayson overlies the Bennington conformably and at places their contact is transitional. The Woodbine unconformably overlies the Grayson and truncates the Grayson eastward in T. 6 S., R. 11 E.

Fossils are abundant in the Grayson. Currier (1968, p. 34) listed the following forms: *Serpula* sp., *Trigonia emoryi* Conrad, *Pecten (Neithea) texanus* Roemer, *Ilymatogyra arietina* (Roemer), *Texigryphaea roemeri* (Marcou), *Cyprimeria gigantea* Cragin, *Protocardia texana* Conrad, *Homomya washita* Cragin, *Turritella leonensis* Conrad, *Tylostoma* sp., *Cymatoceras texanum* (Shumard), *Engonoceras* sp., *Plesioturrilites brazoensis* (Roemer), *Holectypus limitus* Böse, *Pseudonanchys completa* (Cragin), *Enallaster texanus*? (Roemer) and *Hemiaster calvini* Clark.

Hart (1970, p. 119–120) also listed those forms that he had collected and identified from the Grayson Marlstone in northwestern Bryan County. Inasmuch as these lists are overlapping, only the Currier list has been presented here.

The most characteristic forms associated with the Grayson in Bryan County are *Texigryphaea roemeri* (Marcou), *Ilymatogyra arietina* (Roemer), *Plesioturrilites brazoensis* (Roemer), *Pecten (Neithea) texanus* Roemer, *Cyprimeria* sp. and *Protocardia texana* (Conrad).

Gulfian Series

Woodbine Formation

The Woodbine Formation was named by Hill (1901, p. 293) for strata cropping out beneath the Eagle Ford Formation near the town of Woodbine, Cooke County, Texas. Taff (1902, p. 6) applied the term "Silo" to partially equivalent beds near the village of Silo, Bryan County, Oklahoma; the term did not gain general acceptance. Hill (1901, p. 297) subdivided the Woodbine into three members (ascending): Dexter, Lewisville, and upper sands and clays (later reassigned to the Eagle Ford in part).

Bergquist (1949) subdivided the Woodbine of Cooke, Fannin, and Grayson Counties, Texas, into four named units of member rank. These are: Dexter Member consisting of 100 to 140 feet of nonmarine white to ferruginous sandstone and silty clay lenses, some carbonaceous clays at base, scattered leaf and wood prints and at the top a persistent bed of varicolored clay (Rainbow Clay); Red Branch Member consisting of lenticular beds of crossbedded tuffaceous sandstone or ferruginous sandstone containing abundant leaf prints, carbonaceous shale, and beds of lignite, total thickness 60 to 70 feet; Lewisville Member composed of 100 to 125 feet of fossiliferous and glauconitic brown sandstones and lenses of shale, some local tuffaceous material, oyster beds with *Crassostrea soleniscus* common; and the Templeton Member consisting of smooth, gray shale with lenses of glauconitic gray and tan sand

and containing large rounded concretions filled with mollusk shells. Below the Dexter Sandstone Member and above the Grayson Marlstone, Bergquist recognized an unnamed shale unit (post-Grayson shale) consisting of 11 feet of gray shale and 6 feet of brown, glauconitic clay which he thought was transitional from Grayson into Woodbine. He indicated the presence of both late Comanchean (Buda-type) pelecypods and arenaceous foraminifera (Woodbine).

The Woodbine crops out over an area of approximately 350 square miles in the southern half of Bryan County. Most but not all of the exposures are south of U.S. Highway 70, which connects Durant, Blue, Bokchito, and Bennington. There are about 25 square miles of Woodbine terrane north of U.S. Highway 70 and west of Durant. Pimple mounds, usually associated with terrace and alluvium, characterize the Woodbine west of Durant. Thick alluvial deposits cover the Woodbine along major streams and Quaternary terrace deposits overlie it in southwestern Bryan County.

The Woodbine Formation of Bryan County is a polylithic sequence consisting of chert pebble conglomerate, shale, siltstone, sandstone, volcanic tuff, calcareous reef sandstone, and lignitic coal beds. Four named members, the Dexter, Red Branch, Lewisville, and Templeton, have been recognized.

Dexter Member—The Dexter Member, as herein mapped and described, includes a basal shale unit of questionable affinities, a thick sandstone (Dexter Sandstone) and the "Rainbow Clay."

At places in western Bryan County, there is a sequence of clay shales separating the Grayson Formation from the overlying sandstones of the Dexter Member. Stratigraphically similar clays were reported by Taff and Leverett (1893, p. 282), Hill (1901, p. 297, 300, 303–305, 307), Bullard (1931, p. 48, 49–51, 55) and Bergquist (1949) at localities in Texas. A detailed discussion of these clay shales and their correlation with rocks in other areas has been presented by Hart (1970, p. 122–129) and will not be repeated here.

The basal shale unit in Bryan County consists of gray to brown, platy clay shale containing carbonaceous fragments. It lies unconformably on and channels into the Grayson Marlstone at places; elsewhere the contact with the Grayson appears to be conformable. The basal shale unit grades vertically upward into and intertongues with the overlying Dexter Sandstone.

The best and most extensive exposure of the basal shale unit is on Newberry Creek in NE¼ sec. 25, T. 6 S., R. 7 E. There the uppermost 2.5 feet of Grayson contains *Gryphaea* specimens mutilated by boring organisms (Hart, 1970, p. 122) suggesting a post-depositional break at the top of the Grayson. The basal shale unit ranges from 29 to 37 feet in thickness on Newberry Creek, and the uppermost 7 to 8.5 feet are interbedded with sandstones of the Dexter type, suggesting close affinity with the Woodbine Formation. Unweathered exposures of the clay shale below the sandy phase range from light gray to brown and dark gray to black, depending on the moisture content of the beds. The brown clay contains sparse black, carbonaceous fragments. The lower 10 feet consist of platy shale with a thin, ferruginous, sandy, clay-ironstone interbed.

Additional exposures were observed along Chukwa Creek in sec. 24, T. 6 S., R. 8 E. approximately 1 mile north of Durant; in gullies in adjacent sec. 23; and in a limited 8-foot exposure in NE¼ sec. 35, T. 6 S., R. 9 E. (Hart, 1970, p. 124). Channeling of the basal shale unit into the underlying Grayson was observed in SW¼ sec. 19, T. 6 S., R. 9 E., also along Chukwa Creek. Currier (1968, p. 69–70) noted a 4.5 foot section of brownish-black, fissile shale between the Woodbine (Dexter Sandstone) and the Grayson Formation on Little Sand Creek, SE¼NE¼NE¼ sec. 11, T. 8 S., R. 7 E. (see measured section 45, p. 101) which may represent this basal shale unit.

Final age assignment and formal naming of these beds awaits additional work on the Bryan County exposures. The senior author has placed them tentatively in the Dexter Member of the Woodbine Formation on the basis of local disconformity at the base and interbedding with typical Dexter type sandstone near the top.

Thickness of the Dexter Member (exclusive of the basal shale unit) ranges from 125 to 130 feet including the "Rainbow Clay." The lower 85 to 90 feet of the Dexter Member consists of sandstones with subordinate amounts of shale. At places a ferruginous, chert pebble conglomerate marks the base. The contact with subjacent beds is unconformable except where the basal shale unit is present; there the contact is gradational and the basal shale overlies the Grayson Marlstone. Sandstones in the Dexter Member are angular to subrounded, fine- to medium-grained quartz with a silt or clay matrix. Ferruginous concretions, clay-ironstone layers, crossbedding, and carbonized wood are common. The sand is typically soft and friable (figs. 23 and 24). The Dexter Sandstone crops out along the northeast flank and the northwest end of the Cumberland Syncline, forming a belt ranging in width from 3 to 6 miles and extending across the county in a northwesterly direction from R. 13 E. to R. 7 E. where it turns abruptly southward and passes beneath terrace cover.

Beds of tuffaceous sandstone occur in the Red Branch Member but are not actually known to exist within the Dexter Member. Hart (1970, p. 140) reported two occurrences where local development of tuffaceous sandstone lenses appear to lie about 10 feet below the base of the Rainbow Clay. These have been reexamined and new information made available by construction of a new highway south of Durant indicates that these exposures are actually part of the Red Branch Member. and are locally channeled into the Rainbow Clay. These exposures are now mapped as isolated remnants of the Red Branch Member, including the exposure along U.S. Highway 70, NW¼ sec. 35, T. 6 N., R. 8 E.

Figure 23. Basal part of the Dexter Sandstone, Woodbine Formation; west side of road through a recent highway cut, approximately 1 mile north of Durant, sec. 19, T. 6 S., R. 9 E.

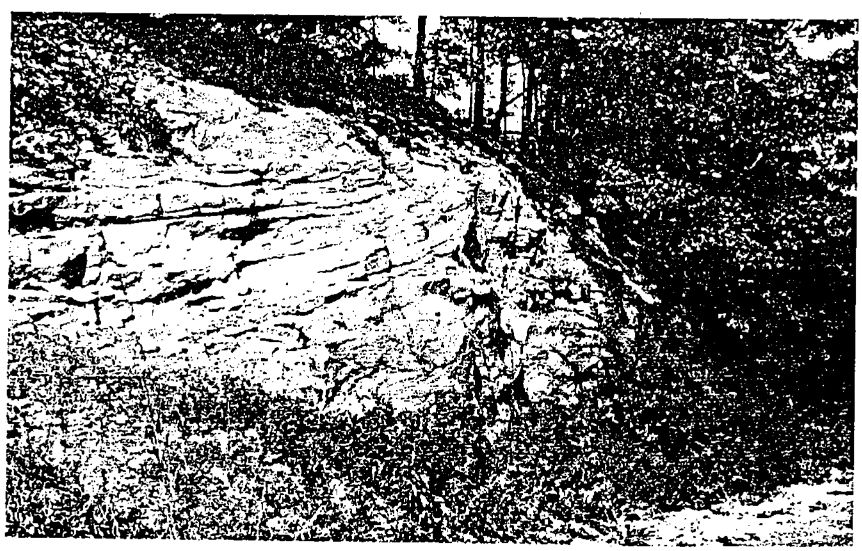


Figure 24. Excellent exposure of the Dexter Sandstone along country road, SE¼ sec. 30, T. 6 S., R. 13 E.

Vertical pipes lined with clay ironstone and filled with soft clayey sand were observed at several localities. Similar structures have been reported in Choctaw County exposures (Huffman and others, 1975).

The upper 40 feet of the Dexter Member comprise the "Rainbow Clay," a unit named for its colorful appearance in weathered outcrop. The clay is gray in fresh exposures but weathers to shades of purple, violet, red, orange, and brown. Tiny pellets of siderite or limonite litter the exposed surfaces of the Rainbow Clay (fig. 25).

Topography on the Dexter Member is typically rolling to hilly. Weathering produces sandy to loamy soils which are loose and subject to wind action unless stabilized by vegetation.

Red Branch Member—The Red Branch Member (fig. 26) consists of tuffaceous sandstones, ferruginous sandstones, carbonaceous shales and lignitic coal. The long, narrow outcrop extends northwestward from the eastern edge of the county (T. 7 S., R. 13 E.) to a point southwest of Durant, then turns abruptly southward along the south limb of the Kingston-Cumberland Syncline. Exposures are somewhat discontinuous, especially along the southern limb where terrace deposits overlap it from the southwest. Island Bayou has cut through the upper Woodbine along the axis of the Kingston-Cumberland Syncline where local flattening of the dip and erosion expose the Red Branch.

The presence of the Red Branch Member in Oklahoma was noted by Curtis (1960) and

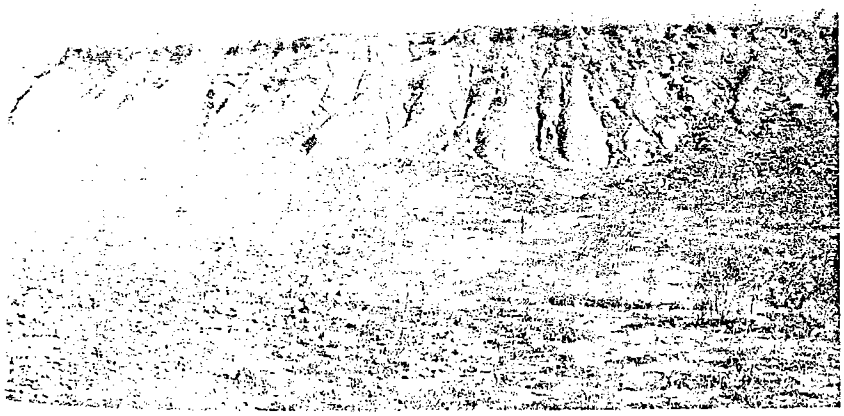


Figure 25. Typical exposure of the Rainbow Clay south of Durant along east side of creek, sec. 1, T. 7 S., R. 8 E. Note let-down terrace gravels at base of exposure.

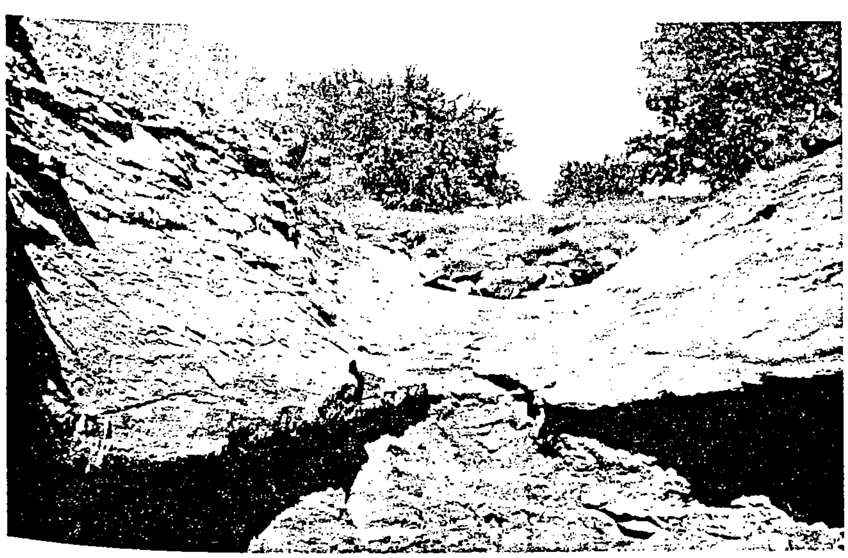


Figure 26. Photo of Red Branch Member, Woodbine Formation, showing large concretionary masses of green calcite-cemented tuffaceous sandstone, small creek, SE¼SE¼ sec. 17, T. 7 S., R. 10 E.

preliminary mapping of the unit was accomplished by him. Hedlund (1962, 1966) measured and collected several sections along the outcrop belt and from a study of the spores and pollens, assigned that part of the Woodbine to the Cenomanian Stage. Olson (1965) remapped the Red Branch Member across eastern Bryan County and measured and described a 24-foot vertical exposure (SE¼ sec. 24, T. 7 S., R. 12 E.) where three lignite beds were observed (fig. 27).

Currier (1968) studied the Red Branch along Island Bayou where it appears that the stream had cut through the upper Woodbine, exposing a sequence of carbonaceous shales and lignitic coals underlying a sandy, calcareous bed carrying a pelecypod assemblage including *Crassostrea soleniscus* (Meek) which probably marks the base of the Lewisville Member. The abundance of coal and plant remains, interbedded with sandstones, siltstones, and silty clays identify these beds as Red Branch. Only the upper 8 to 10 feet are exposed. (See Currier, 1968, p. 39; fig. 28.)

Lewisville Member—The Lewisville Member occupies a large part of the Cumberland-Kingston Syncline, dipping southward north of Island Bayou and northeastward in the area southwest of Island Bayou. It includes beds above the Red Branch lignitic and tuffaceous member and below the shales of the Templeton Member.

Figure 27. Photo of Bred Branch Member, Woodbine Formation along Red Branch Creek, NW¼SE¼ sec. 24, T. 7 S., R. 8 E. Hammer is resting on lignite coal bed.

Figure 28. Small fault cutting low-grade coal beds, Red Branch Member, NE¼ sec. 27, T. 7 S., R. 8 E.

The Lewisville consists of red to yellow, ferruginous, glauconitic sandstones and tan to brown clay shales. Sandstones are fine to medium grained and range from thin-bedded to massive, crossbedded units. Shales alternate with sandstones to produce a gentle escarpment and dip-slope topography with ridges supported by the sandstone layers. Shales predominate in the upper part but are poorly exposed. The best exposures of Lewisville are along Moore Creek south of Calera and in a series of roadcuts along State Highway 70E northeast of Wade in T. 7 S., R. 12 E. Estimated maximum thickness is 100 feet.

Templeton Member—The Templeton Member was named by Bergquist (1949) for exposures along Templeton Branch near Bells, Grayson County, Texas. There it has been described as a sequence of smooth gray shale with lenses of glauconitic, gray and tan, soft shale. Embedded in both the sand and shale are numerous calcareous concretions, some of septarian structure. Phosphatic pebbles characterize the basal shale. The Templeton Member is overlain by sandy limestone flags which mark the base of the Eagle Ford Formation.

Presence of Templeton Shale in Bryan County was noted by Fay in 1970 when he mapped a prominent sandy escarpment south of Island Bayou (Hart, 1974). The senior author independently mapped the Templeton Member in southern Bryan County in 1973 and recorded its position in respect to the Eagle Ford Formation and the associated terrace deposits. He also visited the type locality of the Templeton Member in Texas and made comparisons with the Oklahoma beds. The Templeton Member in Oklahoma is lithologically similar to that in Texas and the units are correlative.

Beds herein assigned to the Templeton were incorrectly mapped as Red Branch by Curtis (unpublished manuscript and map) and as Eagle Ford by Olson (1965). Their true identity and areal extent have now been established.

To date, only five exposures have been observed. Exposed portions consist of soft, gray-black shale which weathers fissile and thin layers of yellow sandstone and clay ironstone. Lower shale beds carry a thin yellow coating of sulfur or jarosite. Phosphatic nodules, calcareous concretions, and septaria are common in lower parts. The upper shales are gray to brown, iron stained, and contain platy partings and thin, reddish-brown, sideritic concretions. Estimated thickness is 60 to 70 feet. The Templeton weathers to form a miniature badland topography devoid of grassland vegetation. Exposed surfaces are covered with a thin blanket of small, gray, fissile shale particles.

The southernmost exposure observed is about 2½ miles east of Kemp and about one-fourth mile west of a small creek in sec. 13, T. 9 S., R. 9 E. A second exposure, along a tributary to Island Bayou on the north side of State Highway 78 in SW¼ sec. 35, T. 8 S., R. 9 E., marks the westernmost known occurrence. A third exposure was observed along a small tributary stream to Island Bayou in secs. 17 and 20, T. 8 S., R. 10 E. A fourth exposure (fig. 29) is on the south wall of Long Creek in SE¼ sec. 16, T. 8 S., R. 10 E. (incorrectly assigned to Eagle Ford by Olson, 1965). A fifth exposure lies immediately below the terrace in NW¼ sec. 19, T. 8 S., R. 11 E. where about 8 feet is exposed. Additional exposures are believed to be present along the walls of Island Bayou and in the lower part of its tributaries.

Contact with the overlying calcareous flagstones of the Eagle Ford was observed in a ravine in the pasture west of the road, SW¼ sec. 27, T. 8 S., R. 10 E. Estimated thickness is 60 feet. The Templeton Member was included in the lower part of the Eagle Ford Formation in earlier reports (Bergquist, 1949).

Figure 29. Photo of Templeton Member, Woodbine Formation in roadcut 0.3 miles south of Long Creek, SE¼ sec. 16, T. 8 S., R. 10 E.

Eagle Ford Formation

The Eagle Ford Formation was named by Hill (1887b, p. 298) from exposures near the town of Eagle Ford, Dallas County, Texas. Adkins (1933, p. 424–426), following unpublished reports by Moreman, divided the Eagle Ford into three members; in ascending order these are: Tarcadia Park Shale. The Tarrant was described as 15 feet of gray and brownish-gray sandy clay and intermittent thin brownish limestone strata and calcareous concretions. The Britton consists of 200–300 feet of blue clay shale with a few flaggy limestone beds. The Arcadia Park Shale, 100 feet thick, consists of blue clay, thin limestone flags, and upper blue shale with calcareous concretions. Bergquist (1949) correlated the Templeton

Member with the Tarrant Member and assigned those strata to the Woodbine Formation.

Strata of Eagle Ford age are believed to be present in southern Bryan County where approximately 25 feet or more of thin-bedded, flaggy limestone and thin beds of blue, calcareous siltstone and blue, silty shale overlie the soft gray shales of the Templeton Member of the Woodbine Formation.

The Eagle Ford Formation is exposed in a series of ravines cut into the frontal edge of a large terrace deposit in southern Bryan County. Basal layers consist of 1-inch beds of blue to brown limestone flags which weather yellow and silty. Succeeding beds are blue to yellow, calcareous, thin-bedded siltstone and blue-gray platy shale. Most of the outcrop is covered by terrace, hence exposures are few in number and are found mainly at the head of ravines cutting back into the terrace cover. Exposures were observed in a gully, NW¼SW¼ sec. 8, T. 9 S., R. 10 E.; in a roadcut between secs. 8 and 9, T. 9 S., R. 10 E.; in a roadcut north of the section line in S½ sec. 27, T. 8 S., R. 10 E.; and in a ravine east of the section line in NW¼ sec. 26, T. 8 S., R. 10 E. Exposures of a thin, platy, yellow siltstone are along State Highway 78, 5 miles west of Yuba in sec. 31, T. 8 N., R. 10 E. and in sec. 6, T. 9 S., R. 10 E. where the beds project above the terrace level.

Similar beds were examined along the south side of Red River where State Highway 78 crosses from Oklahoma into Texas. There basal beds of blue, silty limestone form the lower part of the exposure and blue-gray, blocky, fossiliferous shales comprise the upper part of the exposure. These beds, which are mapped as Eagle Ford in the Sherman Sheet (Barnes, 1967), are lithologically similar and probably equivalent to the beds in Oklahoma. Exposures of Eagle Ford near Bells, Texas, on Templeton Branch were examined and compared with similar strata in Oklahoma.

The large area in southern Oklahoma mapped as Eagle Ford on the Geologic Map of Oklahoma (Miser, 1954) and on the Sherman Sheet (Barnes, 1967) is a terrace deposit lying upon and supported by 15 to 25 feet of relatively resistant limestones and siltstones of the lower part of Eagle Ford. The present areal extent of exposed Eagle Ford is a narrow belt on the northern and southern sides of this terrace.

QUATERNARY SYSTEM

Alluvium and Terrace Deposits

Alluvium

Extensive deposits of alluvium of Quaternary (Holocene) age border all of the major drainage systems. Well-defined flood plains border the Red River (below Denison Dam) and its major tributaries. A 1-mile wide belt of alluvium is along Clear Boggy Creek in the northeast corner of the county where approximately 10 square miles of bottomland parallel Clear Boggy Creek and its tributaries. A narrow band of alluvium parallels Whitegrass Creek and its tributaries for a distance of 20 miles. A 1-mile wide belt of alluvium is along Blue River and narrow bands parallel its tributaries including Sulphur Creek, Bokchito Creek, Little Blue River, Caddo Creek, Bois d'Arc Creek, Mineral Bayou, Kanola Creek, and others. A 1-mile wide belt of alluvium parallels Island Bayou for more than 15 miles; narrower bands parallel its tributaries (Jones Creek, Wolf Creek, Sassafras Creek, and Caney Creek) and extend 8 miles upstream in Island Bayou. A nearly continuous belt of alluvium extends along Red River from Denison Dam to the southeast corner of the county. Upstream from Denison Dam, alluvial deposits of the Red River and the Washita River are beneath the waters of Lake Texoma except in the area of the Cumberland Oil Field in the northwest corner of the county where the river has been rechanneled through the Cumberland Cut and the alluvium is protected by a man-made dike. The flood plain or valley flat surface lies 10 to 15 feet above the Red River channel (see fig. 7).

Flood-plain deposits consist of sand, silt and clay. The surface varies from nearly flat to rolling. At places a "second bottom" or very low 5-foot terrace occurs above a 10-foot level along Red River. The alluvial deposits along Red River (fig. 7) are sandy and belong to the Miller Series of sand and very fine sandy loam (Carter and Patrick, 1914). The surface supports grassland where rolling and soybeans, peanuts, cotton, corn, and alfalfa where level.

Flood-plain deposits along Clear Boggy Creek are composed of the Trinity clay, a black to dark-brown, heavy clay that supports crops such as corn, cotton, and alfalfa as well as a heavy growth of oak, elm, ash, pecan and other trees.

The alluvium along Blue River belongs to the Osage clay soil group in the lower 15 miles and Teller clay in the upper 10 miles of its course. Near the town of Blue, its flood plain consists of fine sand loam of the Verdigris series.

Tributary streams flowing into Blue River have bottomlands composed of the Verdigris sandy loam whereas tributary streams flowing into Island Bayou are on the Osage loam. The lower part of Island Bayou flows through the Osage clay; the upper reaches flow through the Osage loam.

Much of the flood plain of Island Bayou, Blue River, and Clear Boggy Creek will be inundated by the waters of the Albany, Durant, and Boswell Reservoirs. The Albany and Durant Reservoirs have been proposed, the Boswell Reservoir and Dam (in Choctaw County) has been authorized.

As a result of the national meat shortage in 1973, the planting of thousands of acres of peanuts and soybeans on the alluvium and terraces, especially in southern Bryan County, was done to meet increased demands for protein sources. Many of the farms use portable sprinkler-type irrigation systems, taking the water from the Red River.

Terrace Deposits

Several distinct terrace levels can be distinguished along the Red River and its tributaries in Bryan County. The best developed terraces, and the most extensive, are in southern and southwestern Bryan County where multiple levels can be observed. Numerous "patches" of terrace gravel characterize the upper part of Blue River from the vicinity of Armstrong northward and discontinuous terrace deposits occur along the east side of Lake Texoma on the Washita arm in northwestern Bryan County.

Stephenson (1918, p. 132) was one of the first geologists to recognize multiple levels along the Red River. He observed the present flood plain of Red River, a well-defined river terrace 45 to 75 feet above low-water level of the Red River, a terrace plain 140–160 feet above water level, and remnants of surficial deposits at higher elevations.

Terrace deposits along the Red River, especially on the Texas side, were differentiated by Frye and Leonard (1963) into five levels ranging in age from Wisconsinan to Nebraskan. Their classification is based on fossil assemblages of molluscans as well as physiographic expression. The terrace levels and their elevations above the Red River channel in counties in northern Texas are:

Level	*Elevation (in feet)*
Nebraskan Terrace = Qt_5	150–160
Hardeman Terrace (Kansan) = Qt_4	90–110
Intermediate Terrace (Illinoian) = Qt_3	65–70
Ambrose Terrace (early Wisconsinan) = Qt_2	30–45
Cooke Terrace (late Wisconsinan) = Qt_1	18–20

Five levels were designated by the Texas Bureau of Economic Geology on the Texarkana Sheet (Barnes, 1966) and the Sherman Sheet (Barnes, 1967). These were extended into southern Oklahoma to "square-out" the boundaries of these maps. These extensions into southern Oklahoma have clearly delineated the terraces in southern McCurtain, Choctaw, and Bryan Counties, Oklahoma. The levels designated by the Texas Bureau of Economic Geology for the Red River basin are: Qt_1 (Wisconsinan), 17 ± 3 feet above flood-plain level; Qt_2 (Wisconsinan), 30 ± 5 feet above flood-plain level; Qt_3 (Illinoian), 65 ± 10 feet above flood-plain level; Qt_4 (Kansan), 110 ± 10 feet above flood-plain level; and Qt_5 (Nebraskan), surface of residual gravels 160 ± 10 feet above modern flood plains. A sixth category of *Qt* was used for those terraces whose deposits were not assigned to any of the above levels.

The senior author (summer 1973) projected the Texas mapping onto his base for southern Bryan County. The designated levels were also projected onto a topographic base for elevation control and were checked on aerial photographs and in the field. Field differentiation is made difficult by dissection of the terraces, especially Qt_3 and Qt_4 and partial modification of their frontal edges into long, gentle slopes.

Four well-developed terrace levels, some minor intermediate levels, and possible remnants of a fifth level have been recognized in Bryan County.

Cooke Terrace (Qt_1)—The late Wisconsinan Cooke terrace is a well-defined surface approximately 15 feet above the flood-plain level and 25–30 feet above the channel floor of the Red River. It is well-developed along the north side of Red River immediately above the flood plain. The surface is relatively flat, poorly to adequately drained, and devoid of pimple mounds. Most of this terrace level is under cultivation. Two small areas of Cooke Terrace are in extreme southeastern Bryan County where they cover less than 4 square miles. Other areas include 10 square miles south of Wade, 11 square miles south of Yuba, about 3 square miles south of Hendricks, 1–2 square miles south of Colbert along the Red River. Peanuts, soybeans, alfalfa, sudan grass, and pasture grow on its sandy surface.

Ambrose Terrace (Qt_2)—The early Wisconsinan Ambrose Terrace is well developed in Bryan County. Along the Red River this terrace level is 10 to 15 feet above the Cooke Terrace, 30 feet above flood-plain level, and 40 to 45 feet above the Red River channel.

The Ambrose Terrace is composed of gravel, sand, silt, and clay. Gravels are well sorted and crossbedded, grading into and interbedded with sands and silty clay. The associated soils tend to be sandy and to belong to the Teller very fine sandy loam and the Brewer very fine sandy loam. The surface is characterized by a few pimple mounds, especially where the terrace surface is in pastureland.

The Ambrose Terrace (Qt_2) level is relatively flat and undissected and most of it is under cultivation. Important crops include peanuts, sorghum, corn, cotton, alfalfa, sudan grass, and soybeans. Irrigation water from the Red River is applied by portable sprinkler units.

The Ambrose Terrace occupies approximately 2 square miles, east of the Denison Dam; 5 square miles, southeast of Colbert (fig. 30); less than 1 square mile, south of Hendrix; 5 square miles, south and east of Liberty; 5 square miles, from Yuba southwestward to beyond Yarnaby; three small areas east of Wade; and about 5 square miles, near Oberlin. Two small areas on Blue River are tentatively assigned to the Ambrose level; they may actually be part of an older terrace level (Qt_3).

Intermediate (Illinoian) Terrace (Qt_3)—The Illinoian or Intermediate Terrace level is extensively developed in parts of Bryan County. Deposits include gravel, sand, silt, and clay. The Intermediate level is 30 to 40 feet above the Ambrose (Qt_2) level, 70 to 75 feet above the flood-plain level, and 80 to 85 feet above the present Red River channel.

Soils developed on the Intermediate Terrace include the Teller fine sand, the Teller very fine sandy loam, Brewer very fine sandy loam, and the Brewer silt loam. The surface varies from flat to somewhat irregular and dissected. The frontal edge may be rock defended or slope uniformly toward the Qt_2 level. The back side may abut against the bedrock surface or pass beneath the "slumped" frontal edge of Qt_4.

A large expanse of Qt_3 parallels the Red River from south of Colbert southeastward through Hendrix to the vicinity of Liberty, encompassing more than 15 square miles. The surface is level except where major drainage has dissected it. The terrace level supports excellent crops of cotton, peanuts, and soybeans. The dissected areas are in grassland.

A second area extends from west of Albany through the Wade area, covering ap-

Figure 30. View of broad expanse of level farmland developed on the Ambrose Terrace (Qt_2 on geologic map), southeast of Colbert, junction of secs. 5, 6, 7, and 8, T. 9 S., R. 8 E.

proximately 15 square miles. The surface is gently rolling and is mainly in grassland. Six smaller scattered exposures overlie the Woodbine in the southeastern part of the county.

The Intermediate level appears to extend along the Washita arm of Lake Texoma where it rises slightly above power pool level of 617 feet. Hart (1970, p. 151–152) noted that two Qt_3 sublevels are present along the lake. Extensive deposits tentatively assigned to the Qt_3 level occur along Blue River and its tributaries from south of U.S. Highway 70 northward through the vicinity of Armstrong to the county line. Gravels of these deposits have been quarried extensively, and numerous small pits characterize these scattered exposures.

Hardeman Terrace (Qt_4)—The Hardeman Terrace (Kansan) consists of 30 feet or more of gravel, sand, silt, and clay. Important soil types related to its upper surface include Teller very fine sandy loam (high terrace phase), Teller loam, Teller fine sandy loam, Durant very sandy loam, Brewer very fine sandy loam, Susquehanna very fine sandy loam, and Durant loam.

The most extensive development of the Hardeman Terrace is in the Colbert-Platter-Achille area where approximately 75 square miles of relatively level terrace surface is present. This area is farmed extensively in the Colbert-Platter area. Southeastward from there, the surface becomes more dissected (fig. 31), and, from Achille to Kemp, the Hardeman surface is rolling, dissected, and devoted to grassland.

A second large area currently assigned to the Hardeman level extends along the northeast side of Island Bayou south of Allison. Here the surface is gently rolling and well dissected. The surface is covered by abundant pebbles of chert, quartz, quartzite, and igneous rocks which probably were from a higher, now essentially removed, surficial level. Distribution of the pebbles conforms to irregularities of the present surface rather than to a distinct level of older terrace. The Hardeman surface south of Allison is about 80 feet above the alluvium of Island Bayou. Several smaller patches of questionable Qt_4 have been mapped along the north side of Island Bayou on the basis of flatness of the surface, the sandy nature of the soil, and scattered gravels and pebbles.

Additional deposits of the Qt_4 level are associated with the Washita arm of Lake Texoma in northwestern Bryan County. One of the better exposures is at Cumberland Cut where sands and gravels of Qt_4 channel into the bedrock of the Caddo Formation.

A large area of 20 square miles, bisected by State Highway 78 east of Achille and previously mapped as Eagle Ford Formation on the Oklahoma Geologic Map (Miser, 1954) and the Geologic Atlas of Texas—Sherman Sheet (Barnes, 1967), is herein mapped as terrace and assigned to the Hardeman level. This large flat area is supported by the Eagle Ford flagstones and consists of 20 to 30 feet of

Figure 31. Dissection of the Hardeman Terrace at the head of a small ravine, southeast of Colbert, NE¼ sec. 27, T. 8 S., R. 8 E.

sands, gravels, and clay. The base of the terrace slopes from an elevation of 600 to 560 feet from west to east. Higher elevations are about 120 feet above the Red River channel. The surface is relatively flat except near the dissected margins. Related soils include the Durant loam, the Grayson silt loam, and the Susquehanna very fine sandy loam.

Nebraskan Terrace (Qt_5)—One or more terrace levels are represented by small patches near Fort Washita where they consist of silt and pebbles of ferruginous sandstone and clay ironstone (Hart, 1970, p. 153).

Undifferentiated Terrace Deposits (Qt)—A few isolated patches of terrace gravels and sands occur at places in Bryan County where ~~the~~ specific level was not readily determinable. These are simply mapped as Qt without attempting to correlate them with levels established elsewhere where the necessary control was available.

Residual gravel deposits—In addition to the terrace and alluvial deposits that have been described, there are scattered lag gravels which were from reworking of previous surfaces, possibly from the Tertiary Ogallala Formation. The material consists of deposits of coarse residual gravels composed of pebbles of chert, quartzite, quartz, and igneous rocks. These are especially common in the southern part of Bryan County but may be found in other parts of the county. North of Island Bayou, they seem to have been laid down on deposits mapped as Qt_4. South of Durant along Mineral Bayou, these residual pebbles lie on the Rainbow Clay (lower Woodbine) and are weathering out of the soil zone above the clay. No mappable areas were identified, and the gravels appear to have random distribution on the surface or to occur as thin, discontinuous beds in the upper part of the soil profile where they parallel the present topographic surface rather than any distinct terrace level.

Remapping of Marshall County, Oklahoma, on 7½-minute quadrangle maps is in progress. Careful study of the extensive terrace deposits along the Red River and the Washita arm of Lake Texoma is expected to yield information which will allow a more precise dating of the terrace remnants along the lake in western Bryan County. The Marshall County report will be published as a bulletin of the Oklahoma Geological Survey.

STRUCTURAL GEOLOGY

REGIONAL TECTONIC SETTING

Knowledge of the general regional tectonic features of southeastern Oklahoma and the relationship of Paleozoic structures to the overlying Cretaceous strata is essential in understanding the structure and areal distribution of Cretaceous strata in Bryan and adjacent counties. Bryan County is part of the Coastal Plain Province. In this province strata of Cretaceous age dip gently southward at a rate of approximately 50 feet per mile. This gentle homoclinal dip is interrupted at places in western Bryan County and Marshall County by southeastward-plunging anticlines and synclines that are superimposed over major fault blocks and associated flexures in the underlying Paleozoic rocks. These are in turn related to nearby tectonic features of regional magnitude. A short summary of the principal tectonic features is included here.

Arbuckle Mountains

The Arbuckle Mountain complex is northwest of Bryan County in Carter, Johnston, and Pontotoc Counties. There the Paleozoic sequence has been folded into northwest-trending segments known as the Arbuckle Anticline, Tishomingo Anticline, Mill Creek Syncline, Belton Anticline, and Hunton Anticline (Ham, 1969, fig. 13). These structures are separated by major northwest-trending faults which postdate the folding. Mississippian and Morrowan uplifts occurred in the southeastern end of the Arbuckle complex and Early Pennsylvanian (post-Morrowan) movement uplifted the Hunton Anticline and deformed Arbuckle Mountain strata. Close folding of the Arbuckle Anticline and adjacent Ardmore Basin with overturning and thrusting occurred during two or more major pulsations in Virgilian time, producing the Collings Ranch and the Vanoss Conglomerates. The major faults are post-Collings Ranch and pre-Early Vanoss (late Virgilian). The Arbuckle faults extend southeastward beneath Cretaceous strata where they become associated with subsurface anticlines and horst blocks which control production in Marshall and Bryan Counties. These structures are reflected at the surface as minor, southeastward-plunging folds in Cretaceous beds (fig. 32).

Ardmore Basin

The Ardmore Basin is between the Arbuckle Mountains and the Criner Hills–Wichita Mountain trend of folding and faulting. In pre-Pennsylvanian time, the Ardmore Basin was part of a much larger feature, the Southern Oklahoma Geosyncline, which received more than 17,000 feet of pre-Pennsylvanian sediments (Ham, 1969, p. 19). Continued subsidence, accompanied by tectonic movements, resulted in approximately 13,000 feet of pre-Virgilian Pennsylvanian beds. These are succeeded by two orogenic conglomerates, the Collings Ranch and Vanoss. The Ardmore Basin continues northwestward into the Anadarko Basin and southeastward into Kingston and Cumberland Synclines.

Caddo Anticline

The Caddo Anticline is a northwest-trending structure north of Ardmore in the center of the Ardmore Basin. It is a doubly plunging fold 9 miles long and 3 miles wide. It has trapped petroleum in Goddard sands, Sycamore Limestone, Woodford Shale, Hunton lime, Viola Limestone, and the third Bromide sand. The Caddo Anticline is parallel to the Madill-Aylesworth Anticline and associated faults and is separated from them by the Berwyn Basin. The uplift formed in Late Pennsylvanian Arbuckle Orogeny (post-Hoxbar, early Virgilian).

Criner Hills

The Criner Hills uplift is a complexly folded and faulted structure comprising the eroded Criner Hills Anticline, Brock Anticline, Pleasant Hill Syncline, Hickory Creek Syncline, and Overbrook Anticline. The Overbrook Fault is on the north and the Criner-Meers Fault on the south, dipping steeply southwestward. The Criner axis extends northwestward into the Wichita-Amarillo Arch and southeastward into northeastern Cooke County, Texas, northwestern Grayson County, Texas, and into southern Marshall County. Deformation is Morrowan (Wichita Orogeny) to post-Hoxbar (Arbuckle Orogeny).

Marietta Basin

The Marietta Basin is a southeast-plunging synclinal flexure lying between the Muenster or Red River Arch and the Criner Axis. It was initiated during the Wichita Orogeny (Morrowan) and received a thick section of Deese (Desmoinesian) and Hoxbar (Missourian) sediments. The axis of the syncline plunges southeastward into Cooke and Grayson Counties, Texas, where it becomes the Sherman Basin.

Ouachita Province

The Ouachita Province comprises a complex system of folds and faults which occupy 4,250 square miles in southeastern Oklahoma and more than 700 square miles in southeastern Marshall and southern Bryan Counties. The known Ouachita facies includes Womble, Bigfork, Polk Creek, Missouri Mountain, Arkansas Novaculite, Stanley, and Jackfork formations and consists largely of clastics derived from the east and southeast. Significant orogenic and epeirogenic movements during Deese (Desmoinesian) and Hoxbar (Missourian) deposition gave rise to the Devils Kitchen Conglomerate and similar but later conglomerates on the east side of Lake Murray. Ouachita structures are concealed beneath Cretaceous cover in southern Bryan County. Where drilled, the Ouachita rocks are cherty, siliceous, and dark gray to black and are in sharp contrast with normal marine carbonates, sandstones, and fissile shales of the Arbuckle facies except near facies boundaries where it is difficult to distinguish the two facies.

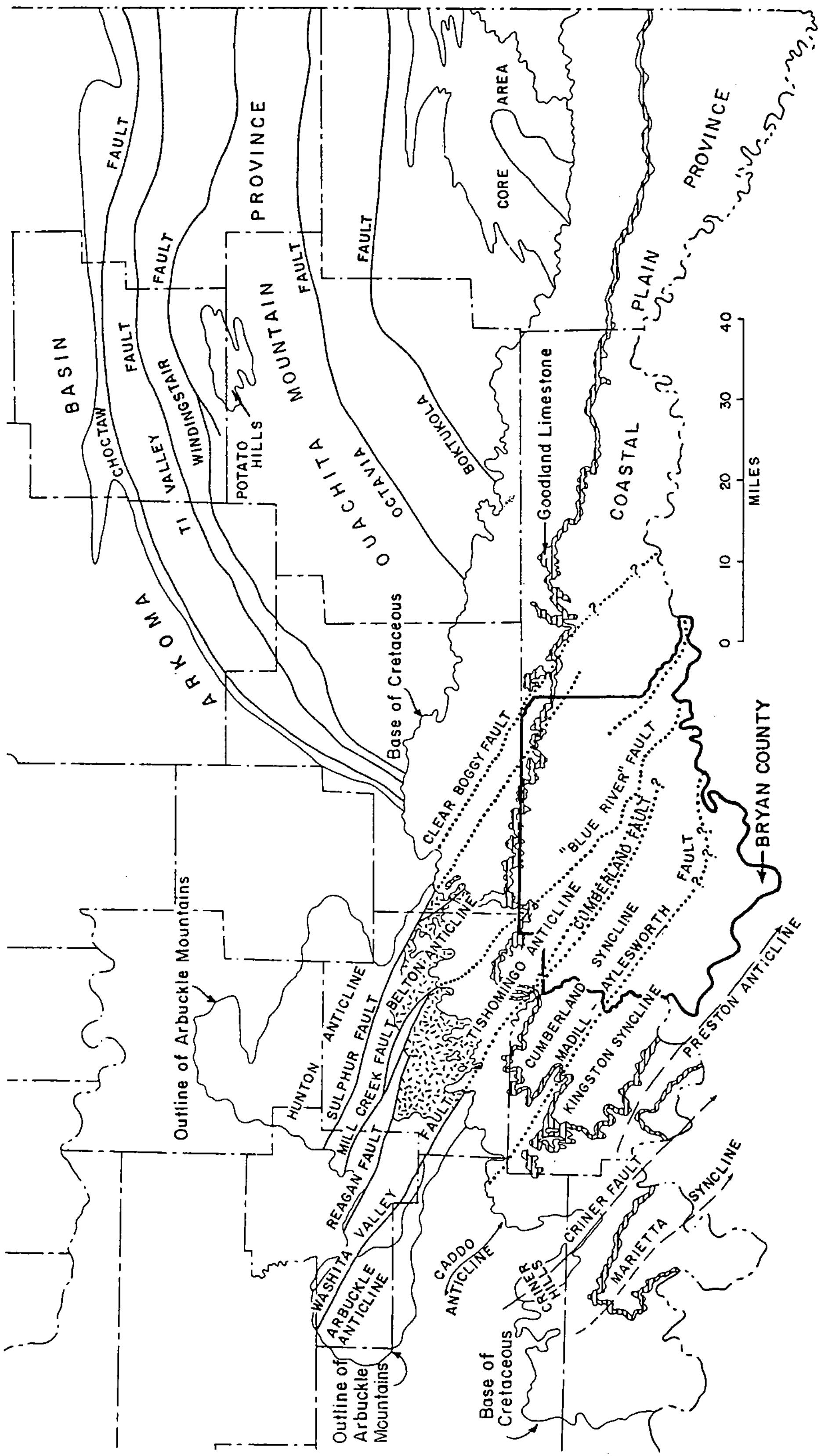


Figure 32. Map of principal tectonic features of southeastern Oklahoma.

From Cambrian through Morrowan time, the area northeast of the Arbuckle Mountain region received Ouachita sediments which were later uplifted to form part of the Ouachita structures. This basin is herein referred to as the *Atoka Basin*. A second basin located southeast of the Arbuckle Mountain complex also received typical Ouachita facies which were later thrust northwestward to form a series of thrust sheets in southern Bryan County. This is called the *Bryan Basin*.

The terms *Atoka Basin* and *Bryan Basin* were suggested to the writer by Robert O. Fay for use in this bulletin. The Atoka Basin is an area of Ouachita rocks northeast of the Tishomingo-Belton Horst Block and the Bryan Basin is an area of Ouachita rocks on the southeast side of the Tishomingo-Belton Horst Block. Both the Atoka Basin and the Bryan Basin rocks were thrust northward and northwestward to their present position by late Virgilian tectonic movements.

Arkoma Basin

The Arkoma Basin lies adjacent to the frontal Ouachitas, separating that area from the Ozark Mountains to the northeast and the Arbuckle Mountains to the southwest. During the Atokan and Desmoinesian, the Arkoma Basin was the foredeep into which thousands of feet of clastics derived from the Ouachita Uplift or areas to the east were deposited. Major structural deformation appears to be post-Boggy and later.

LOCAL SURFACE STRUCTURE

Several prominent synclines and anticlines characterize the Cretaceous rocks in Marshall County. These are known to extend northwestward in subsurface to the Arbuckle, Ardmore, Criner, and Marietta structures. Southeastward in Bryan County, they plunge beneath sedimentary cover and all but lose their identity as surface features. Major faults and late Paleozoic folds in the subsurface underlie the principal Cretaceous structures.

Preston Anticline

The Preston Anticline extends from southeastern Love County through southern Marshall County into Texas in the vicinity of Gober. It borders the Marietta Syncline on the northeast and the Kingston Syncline on the southwest. Its relationship to deep Paleozoic structures is unknown to the writer. The southwestern limb dips at approximately 80 feet per mile; the northeastern limb dips 30 feet per mile (Prewit, 1961, p. 49).

Kingston Syncline

The Kingston Syncline is a broad, shallow structure separating the Preston Anticline from the Madill-Aylesworth Anticline. The axis of the syncline is delineated at the surface in eastern Marshall County by a row of hills capped by Woodbine Formation. The Kingston Syncline passes northward into the larger Ardmore Basin.

Madill-Aylesworth Anticline

The Madill-Aylesworth Anticline separates the Kingston Syncline and the Cumberland Syncline. It trends northwest-southeast and plunges gently southeastward at 20 to 40 feet per mile (Bullard, 1926, p. 52). The Madill-Aylesworth Anticline is nearly symmetrical with dips of 60 to 90 feet per mile. The Madill-Aylesworth Anticline continues northwestward into the Mannsville Anticline and then into Carter County, being nearly parallel to the Caddo Anticline but separated from it by the Berwyn Basin. Several small cross faults cut the Aylesworth-Madill-Mannsville structure and are of significance in trapping of hydrocarbons in the various fields. The Aylesworth Anticline is cut by two large faults which effectively trap the oil and gas in both Aylesworth and Aylesworth Southeast Fields.

Cumberland Syncline

The Cumberland Syncline is a broad, shallow, asymmetrical depression between the Madill-Aylesworth Anticline and the Cumberland Anticline. It appears to be a southeastward extension of the northern part of the Ardmore Basin. Its axis in Bryan

County plunges gently southeastward and appears to pass beneath Ouachita rocks.

Cumberland Anticline and Related Faults

The Cumberland Anticline is a low, asymmetrical structure which lies immediately southwest of the extension of the Washita Valley Fault and a sliver fault, the Cumberland. The Cumberland structure is reflected at the surface by the outcrop of the Goodland Limestone in Marshall and Johnston Counties. Much of the producing structure lies below the alluvium of Washita River.

Unnamed Syncline and Anticline

Northeast of the Cumberland Anticline is a small, unnamed syncline bordered on the northeast by an apparent anticline as indicated by outcrop pattern along Blue River. It is suggested that a fault enters the area from the north and determines the course of the Blue River for several miles (Blue River Fault).

Clear Boggy Alignment

The Sulphur Fault of the Arbuckle Mountains passes southeastward through Bryan County, parallel to and about 3 miles southwest of the Clear Boggy Creek which forms the boundary of the northeastern corner of Bryan County. It is a normal fault with 8,000–9,000 feet of displacement. The course of Clear Boggy River across the Cretaceous sediments apparently follows the Clear Boggy Fault. The Clear Boggy Fault is a normal fault, down to the northeast, with 3,000 feet or more of displacement (Fay, personal communication, 1978).

SUBSURFACE STRUCTURE

Subsurface structures in Bryan and adjacent counties have been described by Beckman and Sloss (1966), Harlton (1966, 1976), Gahring (1959), Cram (1948), Womack (1956), Godfrey (1956), Prewit (1961) and Huffman (1976).

Basically the subsurface structures which have trapped hydrocarbons are controlled by closure along the major southeast-trending faults which extend from the Arbuckle Mountain complex and the Ardmore Basin, passing beneath the Cretaceous overlap and in southern Bryan County beneath and into the Ouachita rocks. The major faults which control hydrocarbon accumulation are (1) Washita Valley (Ravia) System, (2) Cumberland Fault, and (3) Aylesworth Fault. The East Durant Field produces from an anticlinal flexure which lies beneath the Cumberland Thrust Plate. The Cumberland Field is on an anticline immediately southwest of the Cumberland Fault. Production in the Aylesworth Southeast Field is structurally controlled with closure on both sides of the Mannsville-Madill-Aylesworth Fault System.

GEOLOGIC HISTORY

The geologic and tectonic history of southern Oklahoma and the Midcontinent region has been summarized by various authors including Tomlinson and McBee (1958), Huffman (1959), and Ham and Wilson (1967). For a more complete understanding of the regional history, the reader is referred to these publications. The following is a brief summary of the history of southern Oklahoma as it pertains to Bryan County.

During the Paleozoic, two distinct geosynclines characterized the southern Midcontinent area. One of these, the Ouachita-Marathon System, extended northeast-southwest across southern Arkansas, southeastern Oklahoma, and central Texas, passing between the Tishomingo-Belton Prong and the Texarkana Platform, then southward beyond the Llano Uplift, and thence southwestward to the Marathon region of West Texas. From the Cambrian through the Morrowan, two prominent arms or embayments of this geosyncline extended into southeastern Oklahoma. The area northeast of the Arbuckle Mountains (Tishomingo-Belton Horst Block), the *Atoka Basin,* received thick Ouachita sediments. A second embayment, the *Bryan Basin* located southeast of the Tishomingo-Belton Horst Block, also received Ouachita rocks. The Bryan Basin and the Atoka Basin were the sites of deposition of thick clastics and colloidal silica to form the dark-gray shales, cherts, and sandstones of the Ouachita facies. In Mississippian and Early Pennsylvanian time, growth faulting was initiated around the edges of the basins and the Atoka Basin became the site of maximum deposition of the pre-Stanley, Stanley, Jackfork, and Johns Valley sediments. Tectonic activity in post-Morrowan time shifted the axis of maximum deposition northward into the Arkoma Basin where thick Atoka and later beds were deposited. Renewed uplift occurred in the Desmoinesian (post-Boggy) and later produced highlands in the Ouachita Province; these became the source area for the chert pebble conglomerates in the Thurman and later rocks. The Bryan Uplift during Boggy (Desmoinesian) and later deposition was probably the source for the conglomerates in the Devils Kitchen, Rocky Point, and later Deese and Hoxbar units in the Ardmore Basin. A culminating pulse of late Virgilian age produced the thrust faults which characterize the present Ouachita Province and caused the apparent overriding of the "Ouachita facies" upon the Arbuckle segment. This movement may coincide with or be slightly earlier than the Marathon Orogeny of West Texas. Final movement in latest Pennsylvanian time produced a set of joints whose orientation pattern was used by Melton (Ham and Wilson, 1967, p. 387) to postulate a late episode in the Ouachita Province. Pre-orogenic sediments (pre-Mississippian) are 10,000 feet thick in the Arkansas portion of the Ouachitas whereas late Paleozoic beds (Stanley, Jackfork, Johns Valley and "Atoka") have a maximum thickness of 42,000 feet (Ham and Wilson, 1967, p. 383).

The second Paleozoic geosyncline in the Midcontinent region was the northwest-trending Southern Oklahoma Geosyncline (variously referred to as the Wichita Trough, Arbuckle Geosyncline, Harrisburg Trough, and ancestral Anadarko-Ardmore Basin). This intracratonal rift valley was bordered on the southwest by the Texas Craton and on the northeast by the Tishomingo-Belton Horst Block and the stable cratonal shelf.

The northwest-trending Southern Oklahoma Geosyncline apparently connected the Rocky Mountain Geosyncline (Cordilleran) to the northwest and the Bryan Basin portion of the Ouachita Geosyncline to the southeast. The geosyncline is characterized throughout much of its trend by great thicknesses of Paleozoic rocks—37,500 feet (Late Cambrian through Permian) in the western or Anadarko Basin and 30,000 feet (Late Cambrian through Pennsylvanian) in the Ardmore-Bryan Basin. According to Ham and Wilson (1967, p. 393), sedimentation in the Southern Oklahoma Geosyncline was accomplished in two depositional sequences, a Late Cambrian–Early Devonian stage of carbonate deposition (11,000 feet) and a Late Devonian–Permian stage of clastic deposition (27,000 feet maximum). The carbonate sequence is often referred to as the "Arbuckle facies" of the Ardmore and Anadarko Basin. The areas of maximum thicknesses for each formation do not coincide but reach their maximum along the depoaxis of the basin that lies northeast of the Wichita front (Huffman, 1959).

Major orogenic movements in the Southern Oklahoma Geosyncline began in Mississippian time, giving origin to the reworked and "exotic" boulders of Arbuckle rocks in the Delaware Creek (Caney) Shale. Three major episodes of folding and faulting characterize the Pennsylvanian history. The first of these, the Wichita Orogeny, produced the Wichita-Criner Hills line of folding, elevated the Hunton Anticline and the Pauls Valley Uplift, and initiated many of the hydrocarbon-bearing structures of southern Oklahoma.

The second episode of deformation is early to middle Desmoinesian (Ham and Wilson, 1967, p. 398). Conglomerate-bearing beds of the Arbuckle facies of the Deese and Hoxbar Groups unconformably overlie older rocks in the Arbuckle Mountains and Criner Hills. In the Ardmore Basin, Devils Kitchen and Rocky Point Conglomerates of Desmoinesian age record important movements in the Bryan Basin (Bryan Uplift). The final and culminating deformation was one of strong compression. Most of the folding in the Arbuckle Anticline, Criner Hills, and Ardmore, Marietta, Bryan, and Anadarko Basins originated at this time (Ham and Wilson, 1967, p. 398). Orogenic conglomerates, the Collings Ranch and Vanoss (Pontotoc), indicate two phases of the Arbuckle Orogeny, one in middle Virgilian and one in late Virgilian. The major northwest-trending faults of the Arbuckle complex are post-Collings Ranch and pre-late Virgilian Vanoss (Pontotoc) inasmuch as these faults die out in the Vanoss (Ham, 1969, p. 18).

In the third episode, rocks of the Marathon-Ouachita tectonic belt were uplifted and thrust northwestward onto rocks and structures of the Arbuckle segment. In the Atoka Basin, the Ouachita facies appear to have been thrust northward, north of the Potato Hills area, and southward, in the Broken Bow Uplift area, with the Lynn Mountain Graben between (Fay, personal communication, 1978). Growth faults parallel to the Tishomingo-Belton segment may have some lateral, northwestward movements. In southeastern Ardmore Basin, rocks of the Bryan Basin (Ouachita facies) appear to have been moved northwestward into the downdropped block between the Bryan Fault, which passes southwest of and parallel to the Madill-Aylesworth flexure, and the Criner Hills faults. Locally the "Ouachita Front" may coincide with a line of rapid facies change between Arbuckle and Ouachita facies.

The Ouachita-Marathon Province, the Arbuckle Mountains, and surrounding areas remained high during the Permian and supplied sediments to the still subsiding Anadarko Basin and the Oklahoma Platform where Permian sediments reach a maximum of 6,800 feet. Erosion and peneplanation characterized Triassic and Jurassic time in southern Oklahoma where beds of these ages are missing.

A shallow sea in Early Cretaceous time advanced into southern Oklahoma from the south, depositing the Antlers Sandstone (and older units in McCurtain County) upon the pre-Cretaceous erosion surface. With subsequent standstill of the sea, deposition of the carbonates and shales of the Goodland, Kiamichi, and Caddo Formations occurred. Renewed uplift in the source area or a minor depression of the basin introduced the clastics of the Bokchito Formation. Marine inundation and standstill resulted in deposition of the Bennington Limestone and the Grayson Marlstone. Post-Grayson withdrawal was followed by transgression of the Late Cretaceous (Woodbine and Eagle Ford) sea to complete the depositional history of Bryan County. Nearby volcanoes, probably in Arkansas, supplied abundant tuffaceous material to the Woodbine Formation. Thickening and thinning of Cretaceous units across the Paleozoic synclines and anticlines (Prewit, 1961) is probably due to a combination of factors including differential compaction across pre-existing structures and renewed adjustment along the lines of Paleozoic folding and faulting (Frederickson and others, 1965, p. 47).

Post-Eagle Ford and pre-Pleistocene deposits are not known to be present in Bryan County. Extensive development of terrace deposits and downcutting of these during the Pleistocene and Recent complete the geologic history of the county.

ECONOMIC GEOLOGY

Bryan County is moderately well endowed with economic resources. Nonmetallic mineral products yielded more than $3,000,000 in 1974 (table 9), and the value of oil and gas reached an all time high of $3,531,750 in 1975. The principal economic products are (1) petroleum, (2) natural gas, (3) stone, and (4) sand and gravel. In addition, there is an abundance of fresh water from surface lakes and streams as well as several ground-water aquifers. No metallic deposits have been reported.

OIL AND GAS

Seven oil and gas fields have been discovered in Bryan County. Of these, only three are of commercial significance. These are (1) Cumberland (2/3 of the wells are in Marshall County), (2) Aylesworth Southeast, and (3) Durant East. Production is mainly from Paleozoic rocks, especially the oil sands of the Simpson Group (Ordovician). The oil and gas fields will be discussed in detail in Part II of this report. Cumberland Field produces from the Bromide, McLish, Oil Creek, and Arbuckle Formations on a large, asymmetrical, faulted anticline located on the downthrown side of the Cumberland Fault, a late Paleozoic structure. One hundred thirty-nine wells have produced 70,605,432 barrels of oil (as of 1-1-77) and 1,275,759 Mcf (thousand cubic feet) of gas (as of 1-1-75). Aylesworth Southeast produces from 22 wells in the Bromide, Oil Creek, Woodford, and "Meisner" formations on an anticlinal flexure on the Aylesworth Fault Zone. 1,857,006 barrels, and gas production is 13,916,895 Mcf (as of 1-1-75). Durant East produces from an anticlinal flexure beneath the northeast-dipping Cumberland Thrust Fault. Production is from Simpson sands. Cumulative production (as of 1-1-77) is

651,401 barrels of oil. Cumulative gas production (as of 1-1-75) is 25,635,366 Mcf (thousand cubic feet) from 15 wells. In addition, there are several small one- or two-well fields such as Durant North, Durant Northwest, Durant West, and Silo (new). From 1960 through 1970, 10 oil wells, 9 gas wells, and 36 dry holes were drilled in Bryan County. Additional wells are being drilled in Aylesworth Southeast.

STONE

Limestone for agricultural lime, road material, concrete aggregate, and building stone is abundant in Bryan County. The principal source is the Goodland Limestone which crops out along the northern edge of the county. The Goodland has been quarried extensively in sec. 1, T. 5 S., R. 8 E. by the Bryan County Limestone Company (now abandoned). New quarrying operations are being conducted in SW¼ sec. 5, T. 5 S., R. 9 E. by the Lattimore Material Company of Denison, Texas. The principal use is for making crushed rock for concrete aggregate.

In addition to the Goodland, limestones of the Bennington and Fort Worth (upper Caddo) have been quarried in the past. The "Quarry Limestone" (McNutt Member of Bokchito Formation) has been quarried for building stone in Texas.

The Kiamichi shell beds were used in construction of the buildings of Fort Washita; some are still standing after more than 120 years.

SAND AND GRAVEL

Sand and gravel occur in abundance in the terrace deposits along the major streams. Sand and gravel are being taken at the H. C. Rustin pits in terrace deposits along Blue River north of Armstrong. Much of the current production comes from pits near the town of Colbert in southwest Bryan County. Recent operations were observed in the second terrace level 2 miles southeast of Yarnaby in sec. 11, T. 9 S., R. 10 E.

Hart (1970, p. 175) discussed the possibility of using the Antlers Sandstone for glass-manufacture foundry sand, filtration, and chemical processes but suggested that it probably could not compete with presently established glass-sand plants producing from the Simpson sands of the Arbuckles.

COAL AND LIGNITE

Small amounts of coal and lignite have been observed in the Red Branch Member of the Woodbine Formation. These are too thin and poorly developed to warrant commercial production and should be limited to very local usage.

CLAYS

Numerous clay shales are present in the Cretaceous sequence and should be tested for use in making brick and tile. Shales occur in

TABLE 9.–MINERAL PRODUCTION FOR BRYAN COUNTY[1]

Year	Total Value (in dollars)	Products in Order of Importance			
1960	2,243,494	petroleum	natural gas	stone	sand and gravel
1961	2,141,883	petroleum	natural gas	stone	sand and gravel
1962	2,072,764	petroleum	natural gas	stone	sand and gravel
1963	2,509,351	petroleum	natural gas	sand and gravel	stone
1964	2,588,530	petroleum	natural gas	sand and gravel	stone
1965	2,291,519	petroleum	natural gas	sand and gravel	stone
1966	2,243,730	petroleum	natural gas	sand and gravel	stone
1967	1,897,000	petroleum	natural gas	sand and gravel	stone
1968	2,527,000	petroleum	natural gas	sand and gravel	stone
1969	2,522,000	petroleum	natural gas	stone	sand and gravel
1970	2,370,000	petroleum	natural gas	stone	sand and gravel
1971	3,010,000	petroleum	natural gas	sand and gravel	stone
1972	2,195,000	petroleum	natural gas	sand and gravel	stone
1973	2,231,000	petroleum	natural gas	stone	sand and gravel
1974	3,198,000	petroleum	natural gas	stone	sand and gravel

[1]Data from Bureau of Mines Minerals Yearbook, United States Department of the Interior.

the Kiamichi, Caddo, Bokchito, and Woodbine Formations. One of the most prominent clays, the Denton, was sampled and analyzed by the Oklahoma Geological Survey from an exposure near the town of Soper in adjacent Choctaw County. The presence of the clay mineral montmorillonite and the high shrinkage factor of the fired material render this clay unfit for making high quality brick.

WATER

One of the greatest resources of Bryan County is the abundant supply of water. Lake Texoma provides water for hydroelectric power at Denison Dam. Water is taken from the Red River below the Denison Dam for irrigation purposes. The city of Durant uses water from Blue River for its water supply. Construction of the proposed reservoirs on Blue River and on Island Bayou will add large additional water supplies. Abundant ground water is available from the Antlers and Woodbine Sandstones and shallow supplies are present in terrace sands and alluvium. The towns of Achille, Bennington, Bokchito, Caddo, Calera, Colbert, and Kenefic obtain their water from wells drilled into the Antlers Sandstone. Hendrix and Kemp obtain their water from wells drilled into the alluvium of Red River.

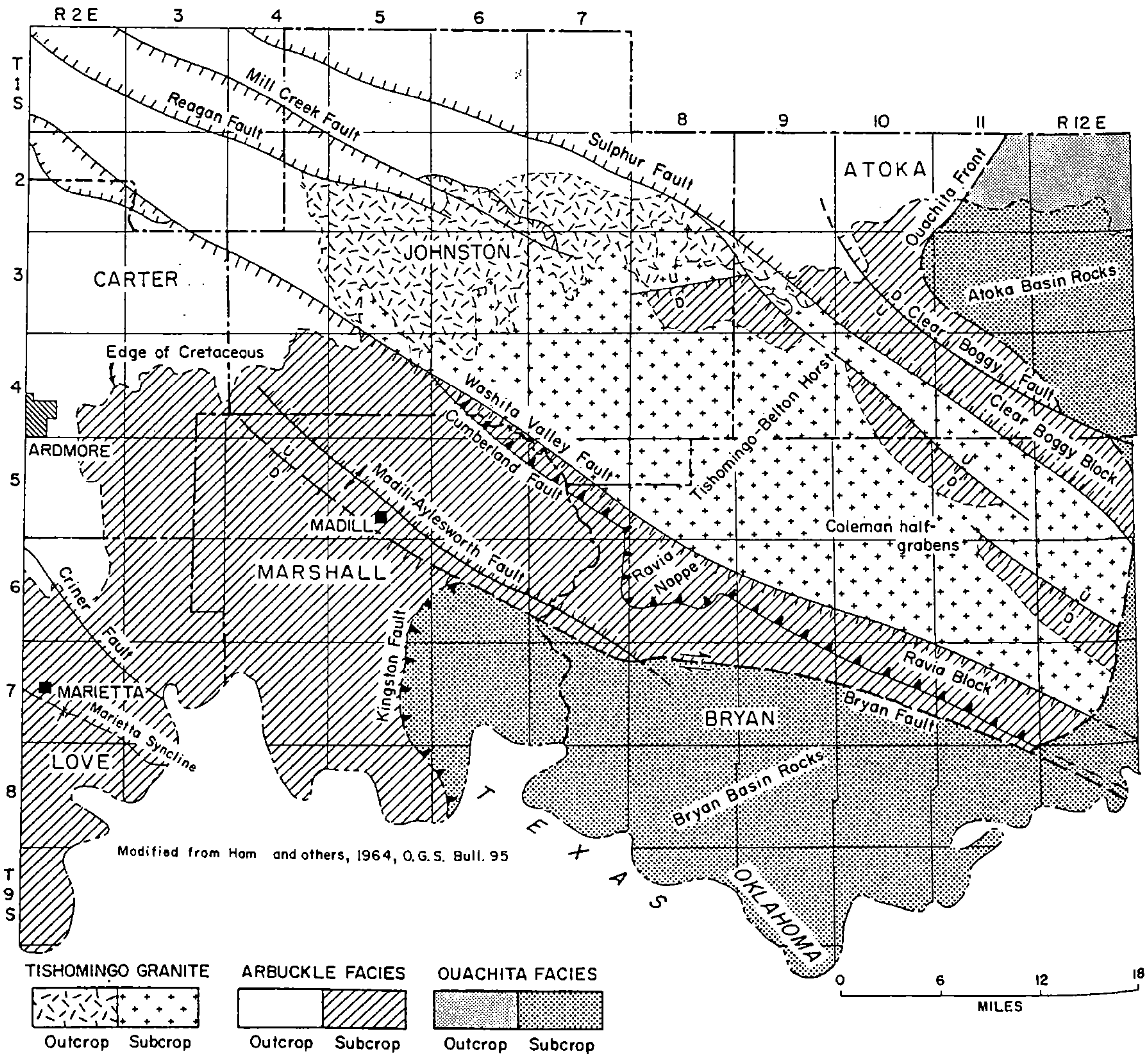


Figure 33. Map of pre-Cretaceous rocks and structures.

PART II.—OIL AND GAS IN BRYAN COUNTY

GEORGE G. HUFFMAN[1]

INTRODUCTION

Bryan County is in the Coastal Plain Province of southern Oklahoma. Surface rocks are Cretaceous in age and dip gently into the Kingston-Cumberland Syncline. Cretaceous strata are superimposed over pre-existing Paleozoic folds and faults which control the hydrocarbon accumulation. The folds and faults trend southeastward from the Arbuckle Mountains, Ardmore Basin, and Criner Hills. Draping of Cretaceous strata across these older structures and subsequent adjustment along these structures have only slightly deformed Cretaceous strata. In northern Bryan County, Cretaceous rocks overlie the Tishomingo Granite; in western Bryan County, Cretaceous beds lie unconformably on eroded rocks of the Arbuckle facies; and in southern Bryan County Cretaceous rocks directly overlie rocks of "Ouachita" facies (fig. 33).

Several major oil producing structures in Marshall County extend southwestward into western Bryan County where production has been established in the Cumberland and Aylesworth Southeast Fields. Durant East Field is on an anticline beneath the Cumberland Thrust. Several small, one-well fields are northwest of Durant.

Numerous articles cover parts of the production in northwest Bryan County but none have included a detailed subsurface interpretation. Articles concerning the subsurface geology of Bryan County include those by Cram (1948), Godfrey (1956), Gahring (1959), Prewit (1961), Beckman and Sloss (1966), Harlton (1966, 1976) and Huffman (1976). P. A. Chenoweth and B. K. Reed made helpful suggestions during the compilation of the report; Craig Wright and Stewart Hoge supplied valuable information; J. A. E. Norden shared seismic information; and Jerome M. Westheimer and Robert O. Fay reviewed the manuscript. Their assistance is deeply appreciated.

[1]Professor of Geology and Geophysics, The University of Oklahoma.

SUBSURFACE STRATIGRAPY

BASEMENT ROCKS

Precambrian

According to Ham and others (1964), approximately 10 townships in northern and northeastern Bryan County are underlain by the Tishomingo Granite which occupies a large horst block (Tishomingo Horst) lying between the Sulphur Fault and the Washita Valley Fault.

Medium- to coarse-grained, pink granite, in part strongly porphyritic and locally with a gneissoid fabric, is the dominant rock type in both outcrops and subsurface of the Eastern Arbuckle Province, which includes Bryan County. Also present are dikes and sills of diabase and biotite-hornblende diorite (Ham and others, 1964).

The Tishomingo Granite is well exposed in a large domal mass in NE¼ sec. 3, T. 3 S., R. 5 E. in Johnston County where the rock was quarried for construction stone for the lower floors of the State Capitol Building at Oklahoma City. Thin-section examination (Ham and others, 1964) indicates that microcline-perthite comprises 50 percent of the rock, oligoclase forms 20 percent, quartz 22 percent, and biotite, 2 to 5 percent. Accessory minerals are magnetite, apatite, zircon and sphene that occur together with epidote and fluorite of hydrothermal origin. Radiometric dating based on zircons containing isotopes of uranium, thorium, and lead indicate an age of 1.35 billion years for the granite (Ham, 1969, p. 45).

Several wells have penetrated the igneous complex in Bryan County, and three penetrated thicknesses of 3,600, 3,800, and 11,800 feet (Ham and others, 1964, p. 127). The deepest penetration is the Phillips 1 Matoy, sec. 24, T. 5 S., R. 11 E. Here the coarse-textured granite that predominates in the well is injected by sills of diabase and biotite-hornblende gneiss ranging in thickness from 20 to 270 feet. A Rb^{87}/Sr^{87} determination on biotite from the diorite in the

Matoy well gave an age of approximately 1.2 billion years, thus assigning the intrusive rock to the Precambrian.

Cambrian (?)

Southwest of the Washita Valley Fault and the Tishomingo Uplift, the basement rock has been assigned to a much younger division of rock including flows of rhyolite and basalt cut by irregular plutons of gabbro and granite. The most widespread rock is the Carlton Rhyolite (equivalent to the Colbert Porphyry of the Arbuckles) which attains a thickness of more than 4,500 feet and underlies more than 7,000 square miles in southern Oklahoma. A radiometric age determination of 525 million years (Ham, 1969, p. 7) indicates that the main body of rhyolite is Middle Cambrian.

The rhyolites of the Wichita Mountain Province extend from the Muenster-Waurika Fault on the southwest to the Washita Valley Fault on the northeast. According to Ham, Denison, and Merritt (1964, p. 127), the Carlton Rhyolite flows were bounded on the northeast by an upthrown block of Precambrian granite which formed a scarp against which the flows were terminated. Depth to the rhyolite in southwestern Bryan County would range from 11,100 feet to more than 30,000 feet.

CAMBRIAN-ORDOVICIAN ROCKS

Reagan Sandstone

The Reagan Sandstone is the basal unit of the sedimentary section of Oklahoma. Named for exposures near the town of Reagan in Johnston County, the Reagan ranges in thickness from 75 to 450 feet and is absent around local granite islands that stood in the Late Cambrian sea. The Reagan is a feldspathic, glauconitic sandstone assigned to the Dresbachian Stage of the Upper Cambrian Croixan Series. The Reagan Sandstone has been identified in several wells southeast of Durant where its thickness ranges from 90 to 160 feet.

Honey Creek Limestone

The Honey Creek Limestone includes about 100 feet of gray, pelmatozoan limestone which grades into fossiliferous, sandy dolomite (Ham, 1969, p. 8). Several wells southeast of Durant have reported thicknesses ranging from 135 to 188 feet.

Arbuckle Group

In the Arbuckle Mountains, the Arbuckle Group includes a maximum of 6,700 feet of gray, fossiliferous, shallow water carbonates. A thickness of 8,700 feet has been reported along the Wichita Axis in Healdton Field, Carter County. Included in the Arbuckle are thin carbonate mudstones, calcarenites, stromatolites, laminated dolomites, shales, and anhydrite. Cram (1948, p. 348) described the upper 686 feet in Cumberland Field as "buff, light and dark brown, granular to dense dolomite with some beds of buff to brown limestone." Womack (1956, p. 381) described the upper part of the Arbuckle as consisting of 600 feet of "white to brown, very finely crystalline, commonly cherty, dolomitic limestone with some white, medium-grained, tightly cemented sandstone." Wells southeast of Durant penetrated approximately 2,500 feet of Arbuckle; many of these wells are faulted and the true thickness of the Arbuckle is not known. A maximum of 4,500 feet was drilled in the Ravia Nappe.

Joins Formation

The Joins Formation, basal division of the Simpson Group, consists of 160 to 211 feet of white to brown, finely crystalline limestone which may be slightly dolomitic and sandy. Pure Oil Company 2 Little 210, located in the SW¼SE¼NW¼ sec. 34, T. 5 S., R. 7 E. (Cumberland Field) penetrated 211 feet of dolomite, limestone, and sandstone with a basal sandstone unit 14 feet thick.

Oil Creek Formation

The Oil Creek Formation ranges in thickness from 500 to 1,000 feet. According to Womack (1956, p. 381), the upper 800 feet is predominantly green shale and thin-bedded limestone in Aylesworth Field. The shales (in contrast to the emerald-green shales above) are dull gray green and can be identified by the ubiquitous presence of the ostracod

Aparchites (Westheimer, personal communication, 1977). The limestones are white to brown, fine to medium crystalline, slightly dolomitic and sandy. The basal 200 feet consists of medium-grained, rounded quartz sandstone with calcareous cement, changing to sandy limestone in the upper 25 feet. In the Cumberland Field (Cram, 1948, p. 347), the upper part of the Oil Creek Formation consists of 465 feet of coarsely crystalline limestone and green shale. Underlying this is the first Oil Creek sand which averages 180 feet and carries oil and gas shows. Below the first Oil Creek sand is a 30-foot limestone which overlies a 30-foot bed of tight, calcareous sandstone. The second Oil Creek sand is 210 feet thick, is composed of well-rounded quartz grains and produces oil. In Pure Oil Company 2 Little 210 located in the SW¼SE¼NW¼ sec. 34, T. 5 S., R. 7 E., the Oil Creek Formation consists of 890 feet of limestone, green shale, and sandstone. The Oil Creek averages 700 feet in Durant East Field.

McLish Formation

The McLish Formation ranges in thickness from 475 to 575 feet. The upper 450 feet consists of thin, interbedded, white, gray, and brown limestones, green shales, and fine-grained, tight to loosely cemented, argillaceous sandstone. The limestones in this formation are generally more coarsely crystalline than those above and below (Westheimer, personal communication, 1977). The "basal McLish" is a fine- to medium-grained, porous, massive sandstone with thin streaks of green shale (Womack, 1956, p. 381). Thickness ranges from 100 to 125 feet. The "basal McLish" produces oil in North Madill, Southeast Mannsville, and Cumberland Fields but carries water at Aylesworth (Godfrey, 1956, p. 120). In Pure Oil Company 2 Little 210 (Cumberland Field), the McLish includes 497 feet of calcareous sandstone, green shale, and limestone with 114 feet of oil sand at the base. Thickness is 400–575 feet in Durant East Field.

Tulip Creek Formation

The Tulip Creek Formation averages 315 feet in the Aylesworth Field (Womack, 1956, p. 380). The upper 110 feet consists of green shales and interbedded limestones which overlie a 65- to 135-foot sandstone known as the second Bromide sand. The second Bromide sand is fine to medium grained, subangular, interbedded with subordinate amounts of green shale, and carries oil in several fields. Directly below the second Bromide sand is a dense, white to buff, slightly dolomitic limestone ranging in thickness from 5 to 50 feet (Womack, 1956, p. 380). Below this limestone is the third Bromide or Tulip Creek sand which is a main producing horizon. It is described as a fine- to medium-grained, tightly to poorly cemented, subangular to rounded sand, carrying oil shows, and interbedded with green shale. The third Bromide is a major producer at Aylesworth and Cumberland.

Bromide Formation

The Bromide Formation is approximately 350 feet thick in the Aylesworth Field according to Womack (1956, p. 380). There it consists of three units: an uppermost white to buff limestone (100 feet) commonly referred to as the Bromide dense (Pooleville Member); 150 to 250 feet of green, waxy shales and coarsely crystalline to dense, white to brown limestone, locally sandy (Upper Mountain Lake Member); and the first Bromide sand, 120 to 135 feet thick, comprising fine-grained, thin-bedded, oil-stained sand interbedded with green shale (Lower Mountain Lake Member).

In the Pure Oil Company 2 Little 210 (Cumberland Field), combined thickness of the Bromide and Tulip Creek Formations is 486 feet.

Viola–Fernvale Limestone

The coarsely crystalline, white to brown, cherty, crinoidal, fossiliferous Fernvale Limestone is 25 to 30 feet thick. It overlies 500 to 600 feet of white to brown, finely crystalline, cherty, dolomitic limestone with a lowermost section of dark-brown limestone. In Cumberland Field in the Pure Oil Company 2 Little 210 well, located in sec. 34, T. 5 S., R. 7 E., thickness of the Viola Limestone is 440 feet. In Durant East Field, average thickness is 500 feet.

Sylvan Shale

The Sylvan Shale ranges in thickness from about 280 feet in Cumberland Field to 330 feet in Aylesworth Field. Average thickness in the area is 300 feet. The upper part (175 feet) is described as a pale-gray-green, non-sandy shale whereas the lower part (125 feet) is light- to dark-brown, dolomitic shale with a bed consisting of 20 to 30 feet of finely crystalline, graptolitic dolomite near the base (Womack, 1956, p. 378). Pure Oil Company 2 Little 210 in Cumberland Field had 253 feet of brown and green shale with a dolomitic shale at the base. Average thickness in Durant East Field is 250 feet.

SILURIAN—DEVONIAN

Hunton Group

The Hunton Group, consisting of four formations, ranges in thickness from zero to 300 feet. It is absent where pre-Woodford erosion occurred along the Madill-Aylesworth trend (Godfrey, 1956, p. 126).

In Cumberland Field (Cram, 1948, p. 344–345), the Hunton Group includes the Bois d'Arc Limestone (100 feet), the Haragan Marlstone (145 feet), the Henryhouse Shale (25 feet, top eroded), and the Chimneyhill Limestone (30 feet) containing the typical crinoidal, glauconitic, and oolitic members. Combined thickness of the Hunton Group in the Pure Oil Company 2 Little 210 well, located in sec. 34, T. 5 S., R. 7 E., is 315 feet and includes oolitic, glauconitic, crinoidal, and cherty limestones and shale.

Only the basal part of the Hunton is present on the northeast flank of the Aylesworth-Aylesworth Southeast flexure. Thickness in the Durant East Field ranges from 200 to 300 feet and averages approximately 250 feet.

Woodford Formation

The upper part of the Woodford Formation has been described as consisting of 70 feet of hard, dark-brown shale with thin beds of dark-brown chert. The underlying 280 feet is composed of hard, coffee-brown shale with abundant "spores" (probably *Tasmanites)*. The basal 40 feet is green, silty shale (Gahring, 1959, p. 280). The Woodford Formation has a thickness of 236 feet in Pure Oil Company 2 Little 210 well, located in sec. 34, T. 5 S., R. 7 E. in Cumberland Field. Thickness in the area southeast of Durant ranges from 228 to 328 feet; at Aylesworth, thickness is approximately 380 feet.

On the northeast flank of the Madill-Aylesworth structure, the "Mannsville Dolomite" occurs below the base of the Woodford and carries oil in an updip wedgeout (Beckman and Sloss, 1966, p. 1359). According to Westheimer (personal communication, 1977), "the 'dolomite' is often a conglomerate with chert pebbles (not Woodford) and coarse, rounded quartz grains. It appears to have been deposited during the erosional interval between the Woodford and underlying Hunton (or Sylvan where the Hunton is missing) and may be similar to the 'Misener' of parts of Oklahoma north of the Arbuckle Mountains."

MISSISSIPPIAN ROCKS

Sycamore Limestone

The Sycamore Limestone overlies the Woodford Shale in normal sequence. The Sycamore includes 175 to 275 feet of light-brown, finely crystalline, very silty, micaceous limestone or calcareous siltstone, often referred to by subsurface geologists as the "Mayes." The Sycamore has a thickness of 247 feet in Pure Oil Company 2 Little 210 (Cumberland Field).

Caney Shale

The Caney Shale is a brownish-black, fissile shale ranging in thickness from 200 to 500 feet and averaging 400 feet. It is currently assigned to the Meramecian and Chesterian Series (Mississippian). In the Pure Oil Company 2 Little 210 well (Cumberland Field), the Caney has a recorded thickness of 335 feet and consists of black shale and thin limestones. (The term *Caney* has been replaced by *Delaware Creek* for surface nomenclature but is retained on subsurface logs and scout tickets for subsurface use only.)

Springer-Goddard Shale

Resting disconformably (?) on the Caney

Shale and older rocks is a sequence of dark-gray, sideritic shales and lenticular beds of sandstone ranging in thickness from zero to more than 2,500 feet. These have been referred to as Caney, Goddard, and Springer formations by various geologists and assigned to both the Mississippian and Pennsylvanian Systems. The term *Goddard* is now applied to those shales below the first sandstone marker bed at the base of the Springer (restricted) and succeeding beds are classed as Springer. The Goddard is assigned to the Mississippian (Chesterian), and the Springer to the Mississippian by some and to the Pennsylvanian by others. Beckman and Sloss (1966) postulated a major unconformity and channeling at the base of the Goddard and assigned thicknesses of approximately 4,000 feet to the Goddard. Other geologists do not accept this interpretation and explain this abnormal thickness as structure control.

In Cumberland Field the Goddard-Springer sequence ranges in thickness from 1,800 to 2,800 feet with the thickest portions on the flanks. According to Westheimer (personal communication, 1977), "Morrowan shales may overlie the Goddard in the Cumberland Oil Field with Springer equivalents missing." The author has not studied this particular problem. In North Madill Field in Marshall County, Gahring (1959, p. 280) assigned a thickness of 700 to 1,200 feet to the Goddard Formation which he described as gray, fine-textured shale with interbeds of gray, fissile shale and siderite concretions. He recognized 1,200–1,300 feet of light-gray shale that he assigned to the Springer Formation. Godfrey (1956) recognized 2,000 feet of Goddard in the Aylesworth Field.

PENNSYLVANIAN ROCKS

Lower Dornick Hills Group
(Golf Course Formation)

The lower Dornick Hills Group has been recognized by several writers in the area. In the Ardmore Basin, the lower Dornick Hills (Golf Course Formation) includes the Primrose Sandstone Member, Jolliff and Otterville Limestone Members, and associated shales. North of the Arbuckles, the Union Valley and Wapanucka Formations are correlated with the Golf Course Formation and are considered to be Morrowan in age.

Gahring (1959, p. 276) described the lower Dornick Hills as consisting of 700 to 1,700 feet of light-gray, fine-textured shales with thin beds of siderite and a thick bed of gray, glauconitic shale near the base. According to Godfrey (1956, p. 117) the lower Dornick Hills reaches a thickness of 4,000 feet on the northeast side of the Madill-Aylesworth Anticline and is present on the southwest flank of the Cumberland Field. Its presence in northwest Bryan County has been noted in California 1 Nelson (sec. 20, T. 6 S., R. 8 E.) and in the Sinclair 1 Archibald (sec. 24, T. 6 S., R. 8 E.).

Upper Dornick Hills Group
(Lake Murray and Big Branch Formations)

The upper Dornick Hills (Godfrey, 1956, p. 117) includes 2,100 feet of fine- to medium-grained, calcareous sandstone alternating with gray, calcareous, silty, micaceous shale and a few beds of gray-brown, fossiliferous limestone. It appears to be present on both flanks of the Aylesworth Anticline and in the Cumberland Syncline southwest of Cumberland Field. Its southeastward extension into western Bryan County is indicated by Godfrey (1956, p. 127, pl. 3). It appears to be present in wells in northwestern Bryan County that include California 1 Nelson (sec. 20, T. 6 S., R. 8 E.) and Sinclair 1 Archibald (sec. 24, T. 6 S., R. 8 E.).

Deese Group

Deese sediments are present in the Cumberland and Kingston Synclines both northeast and southwest of the Madill-Aylesworth Anticline (Godfrey, 1956, pl. 3). The Deese consists of fine- to coarse-grained, calcareous, glauconitic sandstone alternating with gray, calcareous, micaceous, silty shale. It is not known to extend into Bryan County but may be present in the thick Pennsylvanian shale sections west of Durant.

OUACHITA FACIES

The Ouachita facies is represented by a sequence of metamorphosed beds lying between the Arbuckle facies and the overlapping Cretaceous (fig. 33). Ouachita rocks are present in eastern and southern Bryan County. The Tishomingo Horst acted as a buttress against which the Ouachita thrust sheet was moved. Wrench faulting along pre-existing growth faults allowed the northeast, or Atoka, salient and the southwest, or Bryan, salient of the Ouachita thrust sheet to move northwestward to their present positions. Earlier movement in the Bryan embayment (Desmoinesian and later) had produced uplifts which supplied chert pebbles for the Devils Kitchen and Rocky Point Conglomerates in the Ardmore Basin (Fay, personal communication, 1978).

The Ouachita facies includes the Womble Shale, Bigfork Chert, and Polk Creek Shale of Ordovician age; the Missouri Mountain Shale and the Arkansas Novaculite of Silurian-Devonian-Mississippian age; and the Stanley Group, Jackfork Group, Johns Valley Shale and "Atoka" Formation of Carboniferous age. Correlation of the Ouachita rocks with those of the Arbuckle facies has been made by Harlton (1966, p. 1372, fig. 4); these remain somewhat tentative inasmuch as both structural and stratigraphic relations of the Arbuckle facies and the Ouachita facies, especially in the Ardmore Basin, are not clearly understood.

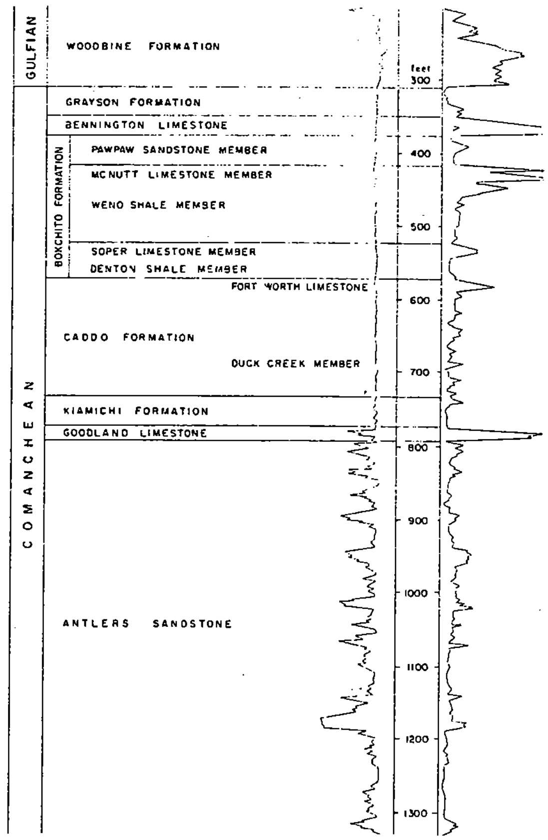


Figure 34. Type log for the subsurface Cretaceous, Bryan County (redrawn from Atlantic 1 Fee Oklahoma well, sec. 31, T. 7 S., R. 9 E.).

CRETACEOUS SYSTEM

Lower Cretaceous Strata

Lower Cretaceous strata in ascending order are: (1) Antlers Sandstone (200–600 feet), (2) Goodland Limestone (20–25 feet), (3) Kiamichi Formation (30–35 feet), (4) Duck Creek Member of the Caddo Formation (100 feet), (5) Fort Worth Member of the Caddo Formation (40–50 feet), (6) Bokchito Formation including Denton, Soper, Weno, McNutt, and Pawpaw Members (140–150 feet), (7) Bennington Limestone (7–13 feet), and (8) Grayson Marlstone (0–27 feet). (See fig. 34.)

Upper Cretaceous Strata

Upper Cretaceous beds include in ascending order: (1) Woodbine Formation composed of the Dexter, Red Branch, Lewisville, and Templeton Members (approximate thickness 425 feet) and (2) Eagle Ford Formation (25 feet).

QUATERNARY SYSTEM

Pleistocene and Holocene Deposits

Cretaceous strata are overlain by a varying thickness of Pleistocene clay, sand, and gravel belonging to several levels of terrace deposits and Holocene alluvium. (See Part I of this report.)

SUBSURFACE STRUCTURE

MAJOR TECTONIC ELEMENTS

The subsurface structure that affects the Paleozoic rocks and controls the oil and gas accumulation beneath the onlapping Cretaceous is very complicated, consisting of a series of northwest-southeast-trending folds and faults extending from the Arbuckle Mountains, Ardmore Basin, and Meers Valley–Criner Hills–Wichita complex and passing beneath and at places interfingering with the Ouachita facies. These relations are shown in figures 32 and 33.

The major regional tectonic features as well as those structures reflected in exposed Cretaceous strata were discussed in Part I of this report and will not be treated in detail here; this part of the report is restricted to those structures that relate specifically to oil and gas production in Bryan County. Much of this was discussed by Ham and others (1964) and Harlton (1966, p. 1342–1365).

Tectonic features (figs. 32 and 33) of importance to oil and gas production in Bryan County include from northeast to southwest: (1) the Clear Boggy Block and Fault, northeast of the Sulphur Fault, (2) the Sulphur Fault, (3) the Tishomingo-Belton Horst Block including the Tishomingo Uplift, Coleman Syncline, and Belton Uplift, (4) Washita Valley Fault, (5) Ravia Fault Block, (6) Cumberland Fault, (7) Cumberland Syncline, (8) Madill-Aylesworth Anticline and related fault system, (9) Kingston Syncline, (10) Preston Anticline, (11) Meers Valley–Criner Hills Fault System, and (12) the Bryan Salient of the Ouachita System.

Clear Boggy Block, Northeast of Sulphur Fault

A downdropped block of Arbuckle facies extends from Clear Boggy Creek to the Sulphur Fault, the basement being displaced 8,000 to 9,000 feet downward on the north side of the Sulphur Fault. A second fault along Clear Boggy Creek is downthrown to the northeast and has a displacement of 3,000 feet. Northeast of this fault are growth faults which include Ouachita facies of the Atoka Embayment. Some wrench faulting and overthrusting has taken place along these growth faults (R. O. Fay, personal communication, June 1978). The Arbuckle facies includes the Arbuckle Group (4,500 feet), Simpson Group (1,400 feet), Viola-Fernvale Limestone (370 feet), Sylvan Shale (30–175 feet), Hunton Group (0–154 feet), Woodford Shale (310–450 feet), Sycamore Limestone (350–530), Caney Shale (250 feet), Goddard Formation (1,100 feet), Cromwell Sandstone (470 feet), Wapanucka Shale (770 feet), Wapanucka Limestone (185 feet), and Atoka Formation (5,000+ feet). Ouachita rocks are possibly sheared parallel to growth faults north of Clear Boggy Creek. Relationships of the rocks of the Clear Boggy Block to the Ouachita facies of the Atoka Embayment are not understood.

Sulphur Fault

The Sulphur Fault is a high angle fault which dips northeastward and extends from its exposed surface trace in sec. 6, T. 1 S., R. 4 E. into the subsurface for a distance of more than 60 miles where it passes beneath or intersects the Ouachita Thrust Plate in T. 5 S., R. 13 E.

Tishomingo-Belton Horst Block

The term Tishomingo-Belton Horst Block is herein used to denote a massive block of granite. It includes three tectonic belts, the Belton Uplift, the Coleman Syncline, and the Tishomingo Uplift. This huge horst block is believed to have originated in the Precambrian (Ham and others, 1964) and to have remained a stable buttress since that time. It is bounded on the northeast by the Sulphur Fault and on the southwest by the northeastward dipping Washita Valley Fault. The Precambrian block plunges southeastward beneath Ouachita rocks (Flawn, 1961, pl. 2). The Arbuckle facies is preserved in half-grabens (Coleman Syncline Complex) as shown by Ham, Denison, and Merritt (1964, pl. 2). The Mill Creek and Reagan Faults, which trend northwest-southeast through the Arbuckle Mountains, are shown to terminate in the northwest corner of T. 3 S., R. 7 E. (Ham and others, 1964). Jordan (1962, 1965) shows other faults extending from T. 3 S., R. 7 E. to T. 7 S., R. 12 E. where they pass beneath the Ouachita rocks. The present study suggests that the Reagan–Mill Creek Fault System continues southeastward along the present course of the Blue River where it intersects the Washita Valley Fault southeast of Durant.

Washita Valley Fault

The Washita Valley Fault is a high-angle, reverse fault which extends southeastward from the southwest corner of T 1 N., R. 1 W. in the western Arbuckles to the southeast corner of T. 7 S., R. 12 E. where it passes beneath or cuts the Ouachita rocks. It may be continuous across the Red River into Texas (Harlton, 1966, p. 1367), a total distance of more than 96 miles. The Washita Valley Fault separates the Tishomingo Horst Block from a smaller block, the Ravia. Immediately northeast of the Washita Valley Fault, Cretaceous rocks rest on Precambrian granite; southwest of the fault, they lie on disturbed Paleozoic rocks of the Arbuckle facies which in turn rest on Precambrian basement rocks at depths of 5,000 to 7,000 feet. Recent earthquake tremors have been recorded along this line of faulting.

Ravia Fault Block

The Ravia Fault Block is a slender fault slice lying between the Washita Valley and Cumberland Faults. The Ravia Block is approximately 35 miles long (Harlton, 1966, p. 1371) and 1–2 miles wide except in the area between Cumberland Field and Durant East Field where the Cumberland Fault flattens and a large nappe or decke (Ravia Nappe) brings a sheet of Simpson and Arbuckle rocks to lie on the Springer-Goddard sequence to form a flat thrust sheet nearly 5 miles long and 3 miles wide (fig. 35 and discussions on cross-sections *C–C′*, fig. 38; *D–D′*, fig. 39; and *E–E′*, fig. 40). Wells drilled in the Ravia Fault. Block encountered a section of lower Paleozoic rocks beneath the Cretaceous and above the Tishomingo Granite. Wells penetrating the Cumberland Thrust Fault in the Ravia Nappe (T. 6 S., R. 8 E.) pass from the overthrust Arbuckle Limestone into Springer Shale or the Caney-Sycamore Formations, thence downward through a normal section of Paleozoic rocks including the Woodford, Hunton, Sylvan, Viola, Bromide–Tulip Creek, McLish, Oil Creek, Joins, and the top of the Arbuckle. Basement rocks in the Ravia Block are of the Tishomingo Granite facies and lie 5,000 to 8,000 feet below the surface. Durant East Field is on an anticlinal flexure beneath the Ravia Fault Block and the Cumberland Thrust Fault, and wells in the field drill through the Ravia Block to reach their objective. (See discussions on cross-sections *G–G′*, fig. 42, and *H–H′*, fig. 43.)

Cumberland Fault

The Cumberland Fault bounds the Ravia Block on the southwest, paralleling the Washita Valley Fault for more than 35 miles. It merges with the Washita Valley Fault in T. 4 S., R. 5 E. and extends southeastward into T. 7 S., R. 12 E. where it passes beneath or possibly cuts Ouachita rocks. The Cumberland Fault is a high-angle, reverse or thrust fault that dips northeastward beneath the Ravia Block. Locally, as in T. 6 S., R. 8 E., the Cumberland Fault flattens and forms the sole of the Ravia Nappe, a thrust sheet approximately 3 miles wide and 5 miles long (fig. 35). The Cumberland Fault passes northeast of the Cumberland Field and trends southeastward through the Durant East Field, thence beneath the Ouachita Thrust Sheet.

Cumberland Syncline

The Cumberland Syncline is a broad, asymmetrical syncline which occupies a block between the Cumberland Fault and the Aylesworth flexure. Compressional folding and underthrusting along the Cumberland Fault has produced the Cumberland Anticline and the Durant East flexure on which the major oil fields are located. Between these major anticlines, the rocks fractured and the Ravia Nappe was thrust southwestward over the rocks of the Cumberland Syncline. Wells drilled through the Ravia Nappe pass through a thick section of early Paleozoic rocks and the Arbuckle Limestone is thrust upon the Springer-Goddard shale section. Structural complexities, curvature of fault planes, and thrusting cause repetition of strata in wells in the Ravia Nappe. The basement rocks southwest of the Cumberland Fault in the Cumberland Syncline are believed to lie at depths of −14,000 to −18,000 feet (Ham and others, 1964, pl. 2).

Madill-Aylesworth Anticline

The Madill-Aylesworth Anticline is a northwest-trending fold which separates the Cumberland and Kingston Synclines. It is characterized by major faulting that controls oil production. The Madill-Aylesworth flexure extends from the vicinity of Mannsville (T. 4 S., R. 4 E., Johnston County) southeastward through the north side of Madill, through the Aylesworth Field, thence across

Lake Texoma through the Aylesworth Southeast Field in Bryan County. There it bends southeastward into T. 7 S., R. 8 E.

The Madill-Aylesworth flexure is reflected at the surface in the vicinity of Madill where the outcrop of the Goodland Limestone makes an abrupt swing to the southeast (fig. 32). In subsurface the Madill-Aylesworth flexure and related faults pass beneath or cut the Ouachita rocks in T. 7 S., R. 8 E. Its presence is reflected in the basement rock by two elongate closures with estimated depths of −12,000 feet (Ham and others, 1964, pl. 2).

Local flattening of dip southwest of Calera in the upper reaches of Island Bayou, a small three-foot fault in sec. 27, T. 7 S., R. 8 E. (fig. 28), and the general alignment of Island Bayou suggest that post-Cretaceous adjustment along an extension of the Madill-Aylesworth structure may be reflected in modern drainage patterns and that a low structural axis separates the Cumberland and Kingston Synclines near Calera.

The Madill-Aylesworth flexure is cut by one or more southeast-trending faults. The major fault, known as the Aylesworth Fault, extends the entire length of the structure and is downthrown to the northeast with displacement ranging from 2,000 to 3,000 feet. The Aylesworth Fault controls production in four major fields, Southeast Mannsville, Madill, Aylesworth, and Aylesworth Southeast (Godfrey, 1965, p. 121). A second but somewhat smaller fault parallels the major fault. It too is downthrown to the northeast and has a displacement of 300 to 900 feet. This fault is not everywhere present but locally controls the oil production on the northeast flank of the structure. Combined displacement on the two faults averages 3,000 feet. Production southwest of the major fault is primarily from the Simpson; that on the northeast side of the fault system is from Simpson, Woodford-Misener, and Sycamore. Several small cross faults trend northeast-southwest dividing the producing structure into several smaller segments, each segment being a significant producing structure.

Kingston Syncline

The Kingston Syncline is a broad, shallow structure lying between the Madill-Aylesworth Anticline and the Preston Anticline. The axis of the syncline, as delineated by surface exposures, passes through a row of hills capped by the Woodbine Formation. The axis trends northwestward through T. 6 S., Rs. 5 E. and 6 E., approximately 3 miles southwest of and parallel to the Madill-Aylesworth Anticline. The Kingston Syncline is part of the southeastward extension of the Ardmore Basin; however, the Ardmore Basin axis as reflected by the configuration of the basement rock lies approximately 3 miles southwest of the surface expression of the Kingston Syncline (Ham and others, 1964, pl. 2).

Preston Anticline

The Preston Anticline is a prominent structural feature in Cretaceous rocks of southern Oklahoma and Texas. It extends from southeastern Love County along the Red River south of Bryan County into Texas in the vicinity of Gober, Fannin County, Texas. The Preston Anticline, known primarily from its effects on Cretaceous strata, is generally north of the Meers Valley–Criner Hills line of folding and faulting. The crest is also north of the Overbrook Fault Block which controls production in the Handy Field of Texas and extends southeastward across southeastern Marshall County into southern Bryan County. In subsurface a large sheet of Ouachita rocks, herein referred to as the Bryan Salient, underlies the Cretaceous and overlies Paleozoic rocks of the Arbuckle facies. Earlier deformation of the Bryan Salient (Desmoinesian and later) may have furnished clastics for the Devils Kitchen and Rocky Point Conglomerates to the northwest (Lake Murray area). Final movement of the Bryan Salient probably took place in late Virgilian.

Meers Valley–Criner Hills Fold and Fault System

The Meers Valley–Criner Hills line of folding and faulting enters Oklahoma from the Texas Panhandle, trends southeastward along the frontal Wichitas through the Duncan area and the Criner Hills, and continuing southeastward through Love County and southern Marshall County into northern Texas, crossing the Red River in T. 7 S., Rs. 3 to 5 E. The Meers Valley–Criner Hills system passes immediately south of Bryan County and is south of the Preston Anticline. Much of the oil production in southern Oklahoma and northern Texas is related to this complex system of folding and faulting.

Bryan Salient of the Ouachita System

As previously mentioned, a large body of Ouachita rocks lies south of the Madill-Aylesworth Anticline in southern Bryan County and extends westward into Marshall County and southward into Texas. Little is known about the structure of this body although it appears to consist of a series of imbricate thrust slices that moved northwestward in late Virgilian time. Recent discoveries of oil in the Ouachita facies near Isom Springs in Marshall County may shed new information concerning the structure and history of this great enigma. The Kingston Fault marks the northwest end of the Bryan Salient of Ouachita rocks; the Bryan Fault is the northeast side. The Bryan Fault extends northwestward through central Marshall County with 10,000 feet of displacement on the Viola Formation.

DESCRIPTION OF MAPS AND CROSS SECTIONS

In addition to the structure contour maps drawn to illustrate the subsurface structure on top of the Viola Limestone in Cumberland, Aylesworth Southeast, and Durant Fields (see figs. 44, p. 74; 46, p. 76, p. 77), a detailed map of the northwest one-fourth of Bryan County was constructed as well as eight cross sections drawn at right angles to the Cumberland Fault and related structures. These are shown in figures 35–43, with a brief description of each cross section given.

Subsurface Map

This map (fig. 35) was drawn to show the location and relationship of the major oil fields together with the regional structure of northwestern Bryan County as indicated by contours drawn on the top of the Viola Limestone.

The northeastern one-third of the area is occupied by the Tishomingo-Belton Horst, a large block of Precambrian Granite overlain by Cretaceous sediments. The Tishomingo Block is bounded on the southwest by the Washita Valley (Ravia) Fault, a major thrust fault dipping to the northeast. Adjacent to the Washita Valley Thrust Fault is the Ravia Block of early Paleozoic rocks overlain by the Cretaceous. These early Paleozoic rocks are intensely disturbed and are thrust southwestward onto late Paleozoic rocks along the Cumberland Fault. A large mass of rock, the Ravia Nappe, occupies approximately 12 square miles between Cumberland and Durant East Fields.

The Cumberland Syncline lies immediately southwest of the Cumberland Fault. The axis of the syncline extends southeastward from sec. 6, T. 6 S., R. 7 E. to sec. 7, T. 7 S., R. 9 E., where it passes beneath the Ouachita Thrust Sheet. The syncline plunges southeastward, reaching a depth of −10,500 feet on top of the Viola in sec. 7, T. 7 S., R. 9 E. The northeast flank of the Cumberland Syncline passes beneath the Cumberland Thrust Fault where it is locally folded into the Cumberland and Durant East Anticlines. Between these two anticlinal flexures is the Ravia Nappe where Arbuckle Limestone is thrust upon the Springer-Goddard sequence. A normal section of Paleozoic rocks lies beneath; these sediments are only slightly deformed with minor folding and normal faulting. A prominent structural nosing in T. 6 S., Rs. 8 and 9 E. is cut by several small, normal faults to control production in several one-well fields as shown. A north-south normal fault was drawn to account for differences in elevation of the top of the Viola Limestone on the east flank of this structure.

Southwest of the Cumberland Syncline is the Aylesworth–Aylesworth Southeast Anticline. As previously discussed, this fold is continuous for many miles, controlling production in many major oil fields. The anticline is cut by two major, nearly vertical faults which have a total displacement of 3,000 feet. Production on the southwest limb of the Aylesworth structure is from the Bromide Formation of the Simpson Group; production on the northeast (downthrown) block is from several horizons including Springer, Woodford-Misener-Hunton, Bromide, and McLish. The anticline and related faults enter the map area in sec. 18, T. 6 S., R. 7 E. and continue southeastward into T. 7 S., R. 8 E., where they pass beneath or into the Ouachita rocks.

Southwest of the Aylesworth Anticline is the Bryan Salient of the Ouachita Thrust Sheet, a large mass of rocks which has been thrust northwestward and possibly northeastward to lie on Arbuckle rocks and pre-Desmoinesian structures. Very little is known concerning Ouachita rocks in this area although production has been established in Ouachita "cherts" near Isom Springs in Marshall County. The Bryan Uplift, involving Bigfork Chert through Arkansas Novaculite, supplied angular cherts for the Devils Kitchen and Rocky Point Conglomerates (Desmoinesian). Later movements (Virgilian) moved the Bryan Salient to its present position.

CROSS-SECTION *A–A′*

Cross-section *A–A′* (fig. 36) is a southwest-northeast line drawn at right angles to the axis of the Cumberland Anticline. Pure 1 Stewart 113 (sec. 33, T. 5 S., R. 7 E.) was drilled on the southwest flank of the structure. It encountered a normal section of pre-Goddard sediments, topping the Viola Limestone at 4,578 (−3,952) feet. It failed to establish production in the Simpson sands.

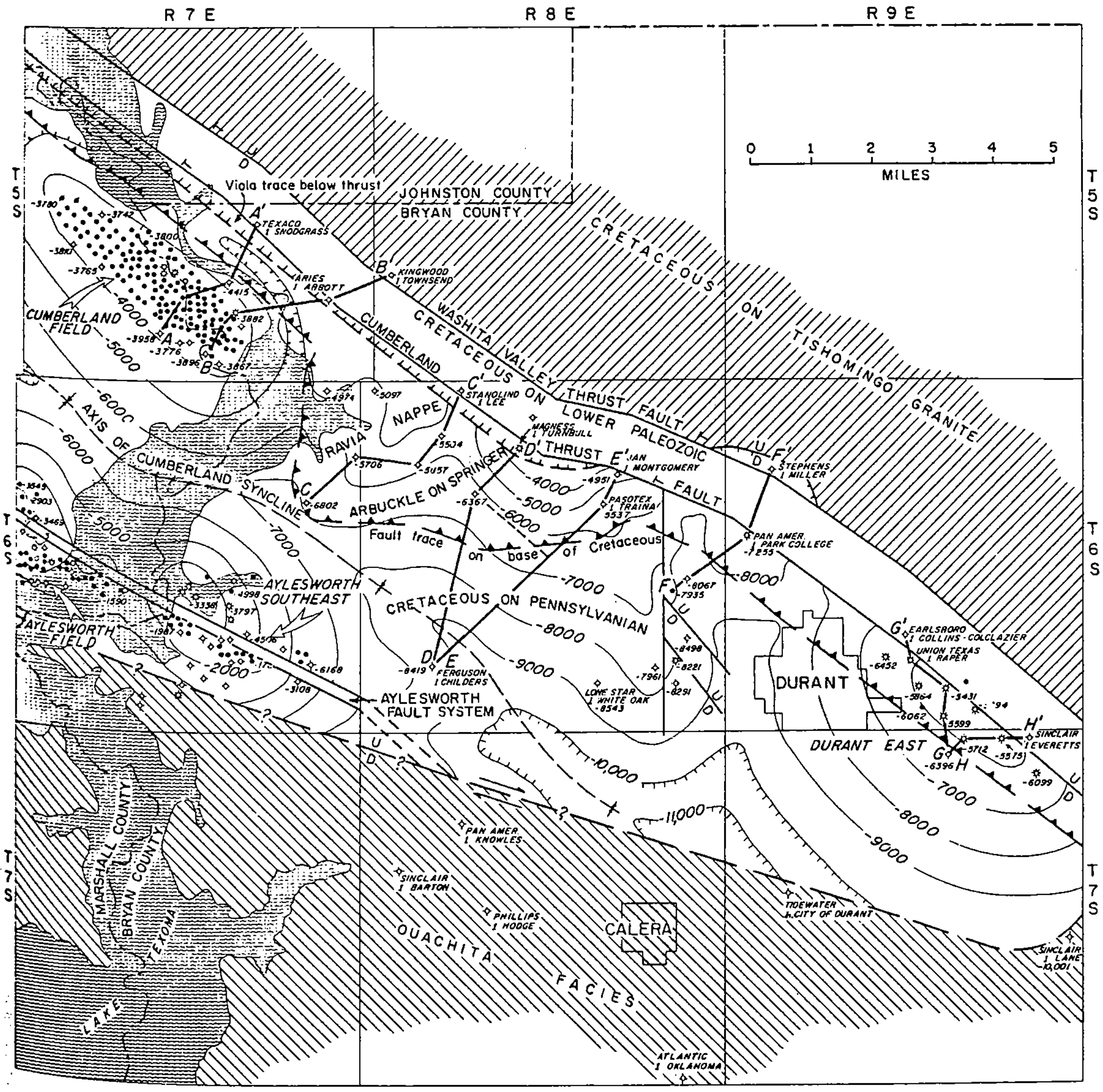


Figure 35. Subsurface-structure map of northwestern Bryan County; contours are (in feet) drawn using the top of the Viola Limestone. Location of cross-sections (figs. 36–43) are shown.

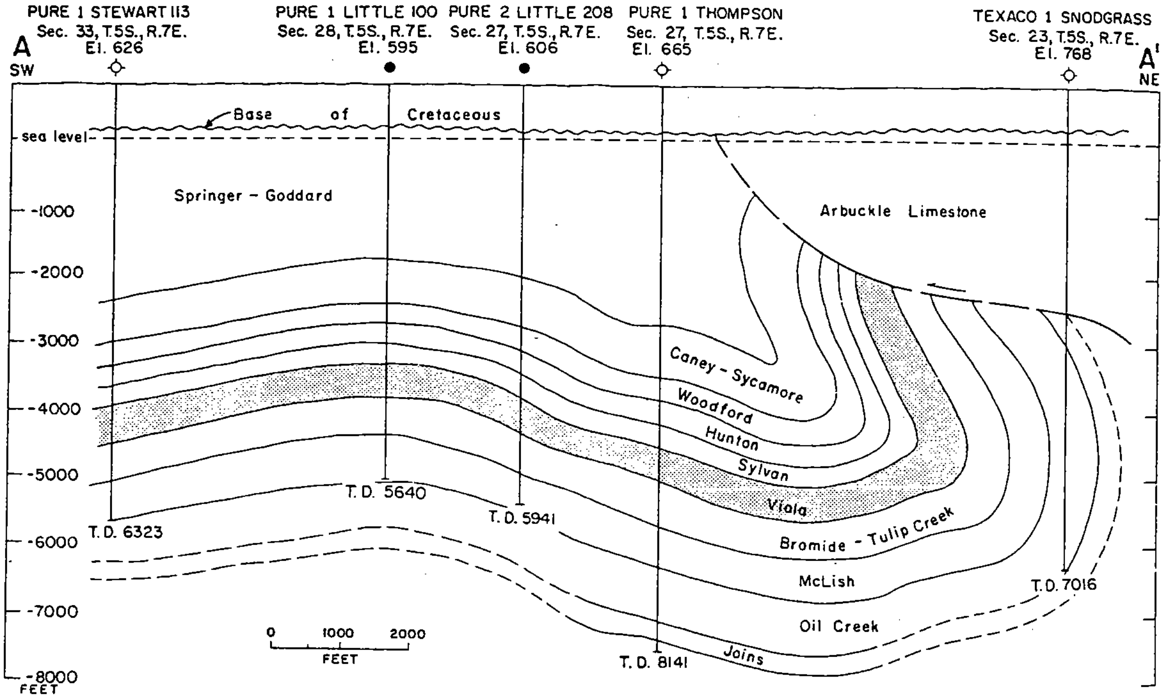


Figure 36. Cross-section *A–A′*, Cumberland Field (sec. 33, T. 5 S., R. 7 E. to sec. 23, T. 5 S., R. 7 E.).

Pure 1 Little 100 (sec. 28, T. 5 S., R. 7 E.) and Pure 2 Little 208 (sec. 27, T. 5 S., R. 7 E.) were completed as oil wells in the Bromide and McLish sands. Pure 1 Thompson (sec. 27, T. 5 S., R. 7 E.) was located too low on the structure to establish production. A small fault is believed to separate this well from producing wells in the Cumberland Field; however, its position can be explained by steep dip on the northeast limb of the anticline. In all four wells mentioned above, Cretaceous strata rest uncomformably on shales of the Springer-Goddard sequence.

In Texaco 1 Snodgrass (sec. 23, T. 5 S., R. 7 E.), Cretaceous strata rest on the Arbuckle Limestone. The well encountered the Joins Formation at 3,284 (−2,516) feet and the Oil Creek Formation 340 feet below. The Oil Creek, which is normally about 700 feet thick, was drilled from 3,625 (−2,857) feet to total depth of 7,016 (−6,248) feet, indicating nearly vertical dip as indicated on the cross section. The Cumberland Thrust Fault is believed to pass between the Arbuckle Group and the Joins Formation as indicated, bringing the Arbuckle in the thrust block to lie upon the upturned edges of strata ranging from Joins to Springer-Goddard. These strata are vertical to slightly overturned beneath the Cumberland Thrust.

CROSS-SECTION *B–B′*

Cross-section *B–B′* is a southwest to northeast section across the southeast end of the Cumberland Field, extending from Pure 1 Meyers 213 (sec. 34, T. 5 S., R. 7 E.) to the Kingwood 1 Townsend (sec. 30, T. 5 S., R. 8 E.). The Pure-Meyers well is a dry hole near the southeastern end of the field and is separated from production by one or more small normal faults. Pure 3 Little 120, Pure 3 Little 211, and Pure 2 Park College 200 produce oil and gas from the Simpson sands and are located on the Cumberland Anticline.

In the Aries 1 Abbott (sec. 25, T. 5 S., R. 7 E.) well, the Cretaceous rests on the Bromide–Tulip Creek section. The Joins Formation was encountered at 2,680 (−1,953) feet, and Arbuckle Limestone was drilled to 4,100 (−3,373) feet, where it crossed the Cumberland Thrust Fault into overturned McLish. The third Bromide sand (Tulip Creek) was penetrated at 5,240 (−4,513) feet, McLish at 5,440 (−4,713) feet, Oil Creek Formation at 5,995 (−5,268) feet, Joins Formation at 6,860 (−6,133) feet and Arbuckle Limestone at 7,070 (−6,344) feet. (Data are from Research Oil Reports.) The Ravia Block is interpreted as a thrust sheet

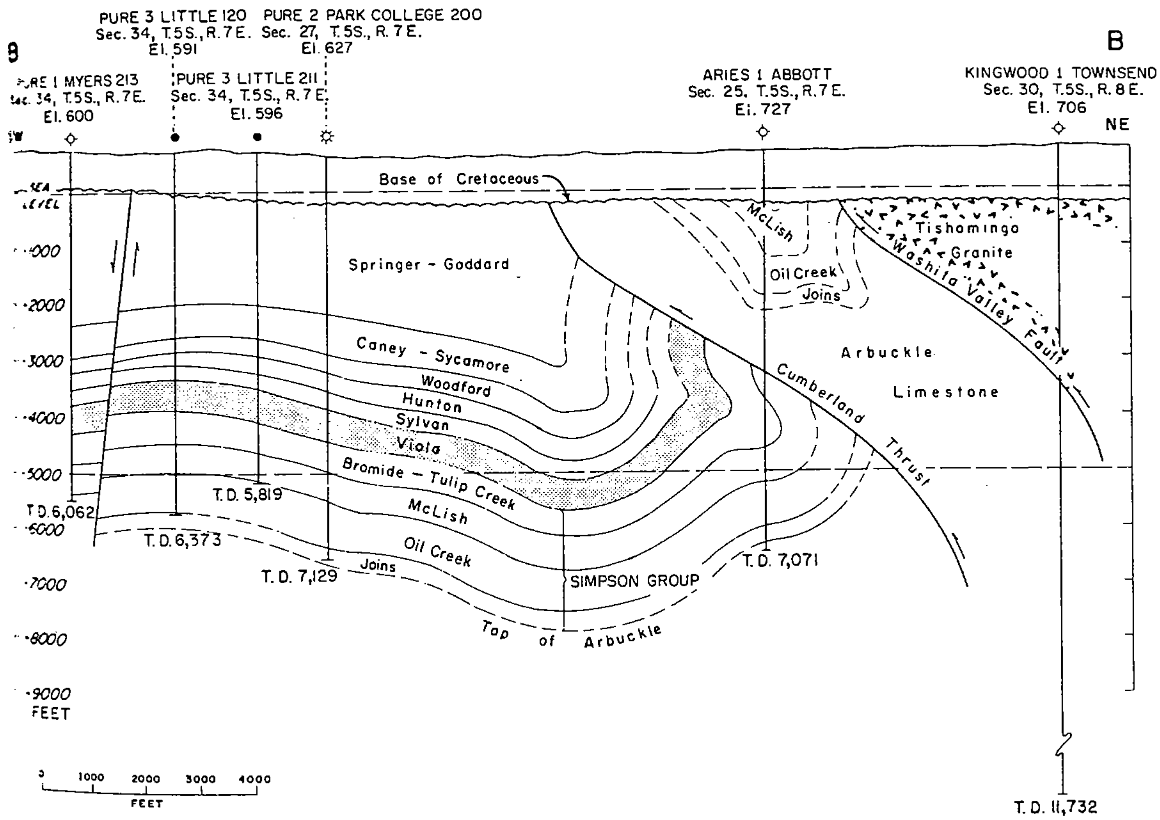


Figure 37. Cross-section *B–B′*, Cumberland Field (sec. 34, T. 5 S., R. 7 E. to sec. 30, T. 5 S., R. 8 E.).

of Arbuckle and Simpson lying upon the upturned edges of vertical to overturned strata ranging from Joins into Springer-Goddard as indicated.

In drilling the Kingwood 1 Townsend (sec. 30, T. 5 S., R. 8 E.) the well went from Cretaceous into the Tishomingo Granite (Precambrian), crossed the Washita Valley Thrust at 4,230 (−3,584) feet, and drilled Arbuckle Limestone to total depth of 11,732 feet.

CROSS-SECTION *C–C′*

Cross-section *C–C′* (fig. 38) is drawn at right angles to the regional strike and includes five wildcat wells drilled southeast of Cumberland Field. It extends from Little 1 Little (sec. 13, T. 6 S., R. 7 E.) to Stanolind 1 Lee (sec. 5, T. 6 S., R. 8 E.).

In the Little 1 Little well, the Cretaceous is on Arbuckle Limestone. It crossed a thrust fault at 4,442 (−3,645) feet and entered overturned Hunton and Woodford. A second thrust fault was found at 4,673 (−3,876) feet, passing from Woodford into the Springer-Goddard Shale. Then a normal section from Caney Shale through the Oil Creek sand was drilled to a depth of 10,064 feet.

The Cretaceous was also on Arbuckle Limestone in Superior 1 Turvell (sec. 12, T. 6 S., R. 7 E.) well. Arbuckle Limestone was drilled to a depth of 4,885 (−4,138) feet where the Springer-Goddard shale section was encountered beneath the Cumberland Thrust Fault. A normal section of pre-Goddard beds was drilled to the basal Oil Creek sand and a total depth of 8,828 feet. The Arbuckle has a thickness of more than 4,000 feet in the thrust block (Ravia Nappe).

Stanolind 1 Barakat (sec. 7, T. 6 S., R. 8 E.) cut the main Cumberland thrust at 5,200 (−4,403) feet with Arbuckle Limestone resting on Caney Shale. A normal section of pre-Caney strata through the Oil Creek sand underlies the thrust fault. The plate above the thrust fault has been constructed to agree with that in the Superior 1 Turvell with approximately 4,400 feet of Arbuckle Limestone. No Simpson strata were recognized in the upper plate.

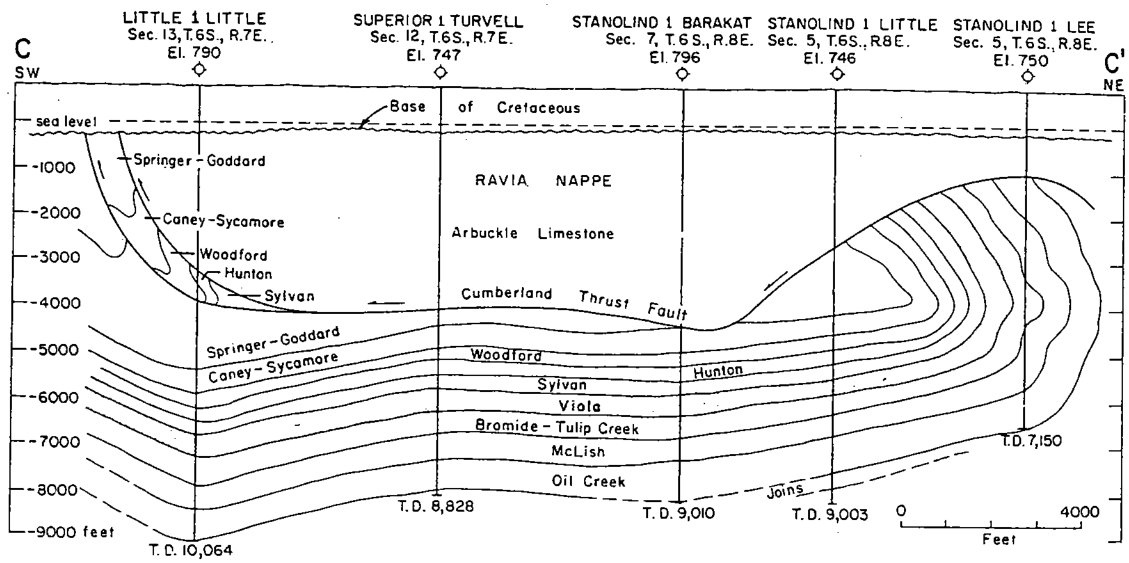


Figure 38. Cross-section *C–C′*, Cumberland Field (sec. 13, T. 6 S., R. 7 E. to sec. 5, T. 6 S., R. 8 E.).

Stanolind 1 Little (sec. 5, T. 6 S., R. 8 E.) has Cretaceous resting on Arbuckle. The main Cumberland Thrust was found at 3,440 (−2,694) feet with Arbuckle resting on the Springer-Goddard Shale. A normal section of pre-Springer beds was encountered below the thrust fault and drilled to a total depth of 9,003 feet in Arbuckle Limestone.

Stanolind 1 Lee (sec. 5, T. 6 S., R. 8 E.) encountered Cretaceous on Arbuckle at 854 (−104) feet and entered the base of overturned Oil Creek at 1,800 (−1,050) feet. The top of overturned Oil Creek was at 2,750 (−2,000) feet; base of overturned Bromide-Tulip Creek at 4,000 (−3,250) feet; Bromide was drilled to approximately 5,000 (−4,250) feet; top of normal McLish was at 5,000 (−4,250) feet; top of normal Oil Creek at 6,400 (−5,650) feet; basal Oil Creek was drilled to total depth of 7,150 feet. The structure below the Cumberland Thrust is an overturned syncline like that discussed in the previous two cross sections.

CROSS-SECTION *D–D′*

Cross-section *D–D′* (fig. 39) extends northeastward from sec. 29, T. 6 S., R. 8 E. to sec. 9, T. 6 S., R. 8 E. In the southwesternmost well, Ferguson 1 Childers, Cretaceous rests on the Pennsylvanian shale section at 1,082 (−321) feet, and reportedly the Springer-Goddard was drilled to a depth of 7,838 (−7,077) feet where the top of the Caney was established. This extremely thick section (6,756 feet) of Pennsylvanian shale may be due in part to overturning of the northeastern flank of the Cumberland Syncline ahead of the Ravia Nappe (Cumberland Thrust) and to the postulated presence of strata of the Dornick Hills Group. A normal section of pre-Caney beds was drilled through the Oil Creek sand to a total depth of 11,118 feet.

Sunray 1 Beal (sec. 8, T. 6 S., R. 8 E.) cut the Cumberland Thrust at 3,524 (−2,679) feet with Arbuckle on Springer-Goddard Shale. The Caney was found at 5,780 (−4,935) feet, Woodford at 6,364 (−5,519) feet, Hunton at 6,628 (−5,783) feet, Sylvan at 6,950 (−6,107) feet, Viola at 7,210 (−6,367) feet, Bromide at 7,770 (−6,925) feet, McLish at 8,310 (−7,465) feet, and Oil Creek at 8,824 (−7,979) feet. Total depth was 9,645 feet in the Oil Creek Formation.

In Magness 1 Turnbull (sec. 9, T. 6 S., R. 8 E.), the Cretaceous was on top of the Arbuckle Formation at a depth of 850 feet. The Arbuckle section was reportedly thrust onto a section of shale identified by the operator as Springer Shale at 2,075 (−1,239) feet. A second fault reportedly brings this anomalous shale section to lie on overturned McLish at 2,440 (−1,602) feet. This thin wedge of "Springer" lying between two thrust faults is difficult to visualize and impossible to explain. The writer has not seen the samples from this well and suggests that

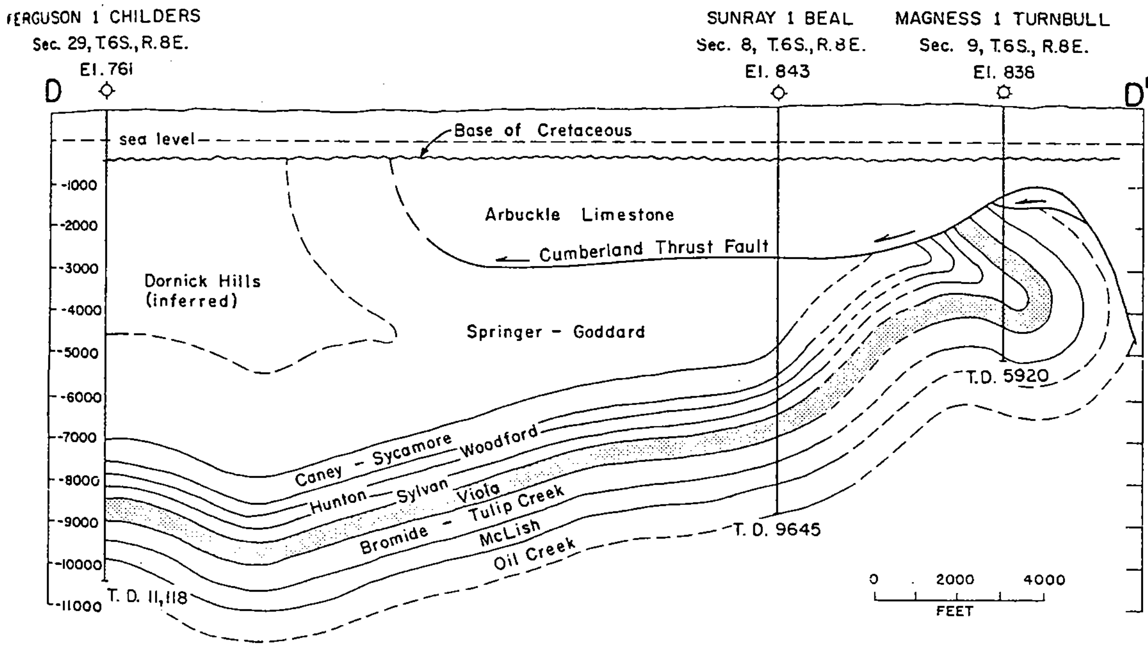


Figure 39. Cross-section *D–D'*, between Cumberland Field and Durant East Field (sec. 29, T. 6 S., R. 8 E. to sec. 9, T. 6 S., R. 8 E.).

the shale has been misidentified and that it probably is a wedge of Simpson. Below this shale bed, the well drilled an overturned section of McLish, Bromide–Tulip Creek, Viola, and Sylvan. The Sylvan Shale has twice its normal thickness and is in the core of an overturned syncline. Below the Sylvan is a normal section of Viola at 4,317 (−3,479) feet, Bromide at 4,840 (−4,002) feet, McLish at 5,890 (−5,052) feet. The well bottomed in the McLish Formation at a depth of 5,920 feet. The beds in the Magness 1 Turnbull occupy an overturned syncline which lies beneath the Cumberland Thrust Fault. The Cumberland Thrust Sheet here comprises the Ravia Nappe as shown in figure 35.

CROSS-SECTION *E–E'*

Cross-section *E–E'* (fig. 40) extends northeastward from the Ferguson 1 Childers (sec. 29, T. 6 S., R. 8 E.) to the Jan 1 Montgomery (sec. 11, T. 6 S., R. 8 E.). Sunray 1 Beal was moved onto the line of section and hence creates a slight distortion.

As previously noted in the discussion of cross-section *D–D'*, approximately 6,750 feet of beds of Pennsylvanian age have been assigned to the Springer-Goddard sequence. The writer suggests that some of this may represent the Dornick Hills Group which has been recognized in a nearby well, California 1 Nelson (sec. 20, T. 6 S., R. 8 E.). The well is located near the axis of the Cumberland Syncline. Caney Shale was reported at 7,838 (−7,077) feet and a normal section of pre-Caney through the Oil Creek Formation was encountered. The Sunray 1 Beal well crossed the Cumberland Thrust passing from the Arbuckle to Springer-Goddard at a depth of 3,524 (−2,679) feet. The so-called "false Caney" was found at 5,780 (−4,935) feet, and a normal section from Caney downward through the Oil Creek was drilled. The well bottomed in the base of the Oil Creek at a depth of 9,645 feet.

According to the Research Oil Reports, the Pasotex 1 Traina (sec. 15, T. 6 S., R. 8 E.) found Cretaceous on probable McLish at 920 (−116) feet. The McLish was underlain by the Oil Creek Formation at 1,270 (−466) feet and the Joins Formation at 2,250 (−1,446) feet. The top of the Arbuckle was reported at 2,510 (−1,706) feet and the Cumberland Thrust Fault at 4,347 (−3,543) feet, bringing the Arbuckle Limestone to rest on Springer-Goddard. A normal section of Caney through Oil Creek was drilled to a total depth of 8,688 feet. On the cross section, the Simpson strata are shown to form a

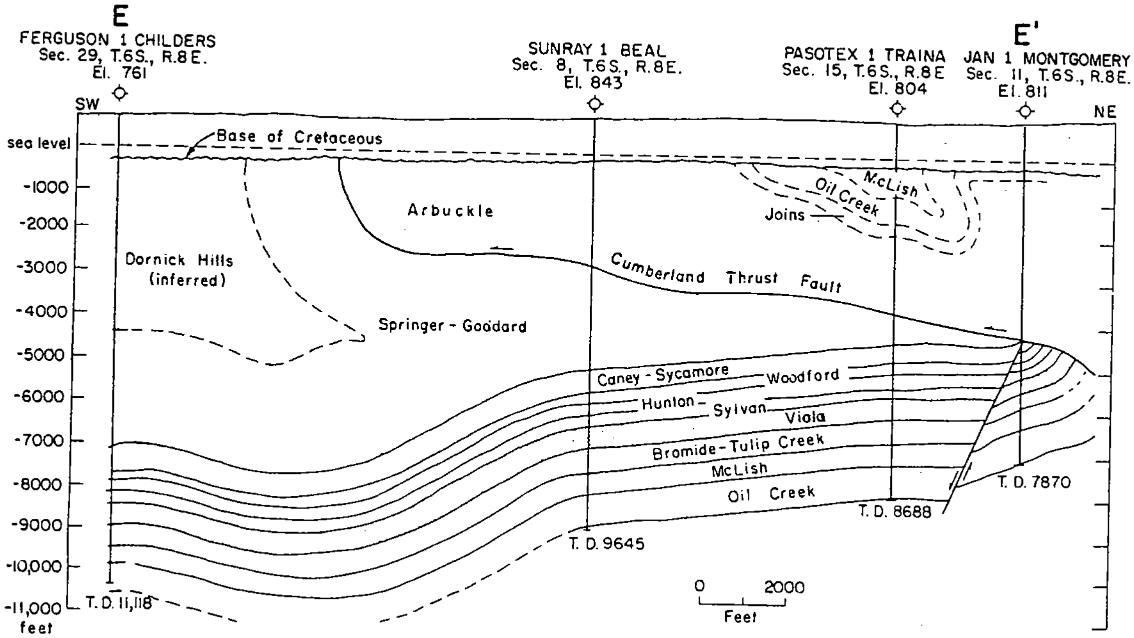


Figure 40. Cross-section *E–E'*, between Cumberland Field and Durant East Field (sec. 29, T. 6 S., R. 8 E. to sec. 11, T. 6 S., R. 8 E.).

small, overturned syncline or downfold within the rocks of the Ravia Nappe.

In the Jan 1 Montgomery (sec. 11, T. 6 S., R. 8 E.) well, the Cretaceous was reported on the Joins Formation at 855 (−44) feet. The Arbuckle was reported at 1,110 (−299) feet and was drilled to 4,862 (−4,051) feet, resulting in a thick section of Arbuckle, possibly due to folding and steepened dips. The major Cumberland Thrust Fault was found at 4,862 (−4,051) feet where the Arbuckle Limestone lies on the Springer-Goddard Shale. A small fault (250 feet displacement) was cut at 5,252 (−4,441) feet near the top of the Woodford as indicated. Below the fault is a normal section of Woodford through the Oil Creek to a total depth of 7,870 feet.

CROSS-SECTION *F–F'*

Cross-section *F–F'* (fig. 41) is a southwest-northeast trending section drawn from sec. 24, T. 6 S., R. 8 E. to sec. 7, T. 6 S., R. 9 E. and at right angles to the trace of the Cumberland Fault. Sinclair 1 Archibald (sec. 24, T. 6 S., R. 8 E.) logged "Pennsylvanian" shale from the base of the Cretaceous at 1,050 (−355) feet to a depth of 4,520 (−3,825) feet. Dornick Hills limestones were logged from 4,520 to 5,150 (−3,835 to −4,455) feet where the top of the Springer-Goddard sequence was encountered. Below the Goddard Shale is a normal sequence of Paleozoic strata including (in descending order) the Caney, Sycamore, Woodford, Hunton, Sylvan, Viola, Bromide–Tulip Creek, McLish, and Oil Creek Formations. Production is from the Bromide sand.

In the Sinclair 1 Hauk (sec. 24, T. 6 S., R. 8 E.), the "Pennsylvanian" shale section was drilled from the base of the Cretaceous to the top of the Caney Formation at a depth of 7,500 (−6,809) feet. Below the Caney Shale is a normal section of strata from the Sycamore downward through the Oil Creek Formation to a depth of 10,577 feet.

The Pan American 1 Park College (sec. 18, T. 6 S., R. 8 E.) found the Cretaceous on the Oil Creek Formation. Top of the Joins Formation was reported at a depth of 1,670 (−966) feet and top of the Arbuckle Limestone was found at 1,783 (−1,079) feet. The Arbuckle Limestone was drilled to 6,014 (−5,310) feet where the well crossed the Cumberland Thrust Fault and entered the Springer-Goddard section. A normal section of pre-Goddard strata includes beds from the Caney Shale downward through the Oil Creek sand to a total depth of 9,634 feet. A small fault appears to cut the Viola section at a depth of 8,070 (−7,364) feet. The well produces gas from the McLish sand through per-

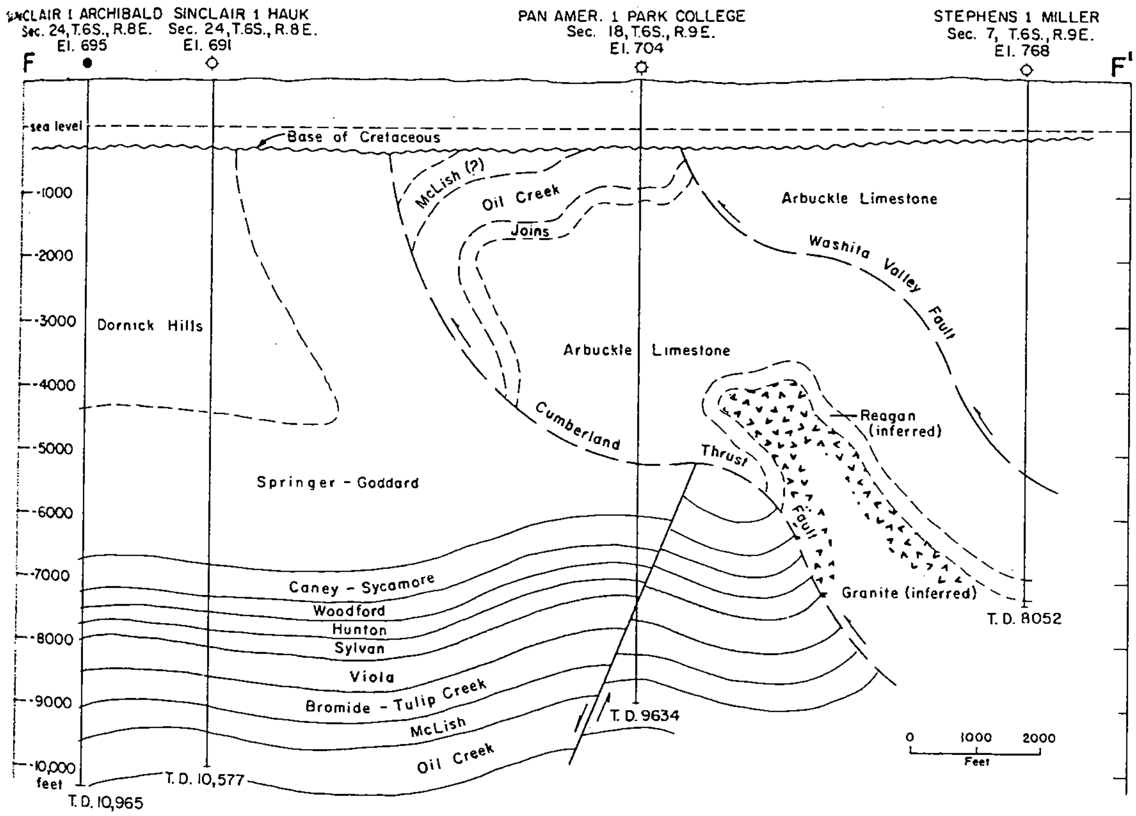


Figure 41. Cross-section *F–F′*, northwest of Durant (sec. 24, T. 6 S., R. 8 E. to sec. 7, T. 6 S., R. 9 E.).

forations at 9,152–9,184 feet.

In the Stephens 1 Miller (sec. 7, T. 6 S., R. 9 E.) well, steeply dipping Arbuckle Limestone was drilled from the base of the Cretaceous to a depth of 6,201 (−5,433) feet where the well cut a fault (personal communication, Stephens Production Company, November 1975). This is believed to be the Washita Valley Fault as previously depicted in cross-section *B–B′*. The well went through glauconitic sand (Reagan) from 7,800 (−7,032) to 8,020 (−7,252) feet where it encountered about 28 feet of weathered granite (granite wash). Fresh, unweathered granite was found at 8,040 (−7,280) feet and the well bottomed in granite at 8,052 feet.

The structure shown in cross-section *F–F′* suggests that two major thrust faults, the Cumberland and Washita Valley, are involved. The nappe-like structure demonstrated by previous cross sections is no longer apparent and the Cumberland and Washita Faults appear to be rather high-angle thrusts. Geology within the Ravia Block between the two thrusts has been inferred from limited data. Strata below the Cumberland Thrust are gently folded into the Cumberland Syncline, and a small syncline north of the Pan American 1 Park College is cut by a small normal fault as shown.

CROSS-SECTION *G–G′*

Cross-section *G–G′* (fig. 42) is a north-south section through Durant East Field, extending from Sinclair 1 House (sec. 3, T. 7 S., R. 9 E) to the Earlsboro 1 Collins-Colclazier (sec. 27, T. 6 S., R. 9 E.). The Sinclair 1 House well was drilled through an abnormally thick section of Springer-Goddard shale from the base of the Cretaceous at 1,080 (−436) feet to the top of the Caney Shale at 5,895 (−5,261) feet. Below the Springer-Goddard sequence is a normal section from Caney downward into the Oil Creek, the latter being drilled to a total depth of 8,650 feet.

The section through the Sinclair 1 Anderson-Mayhue (sec. 34, T. 6 S., R. 9 E.) well shows the Arbuckle Limestone thrust upon the Springer-Goddard Shale at 4,050 (−3,381) feet. The pre-Goddard section in-

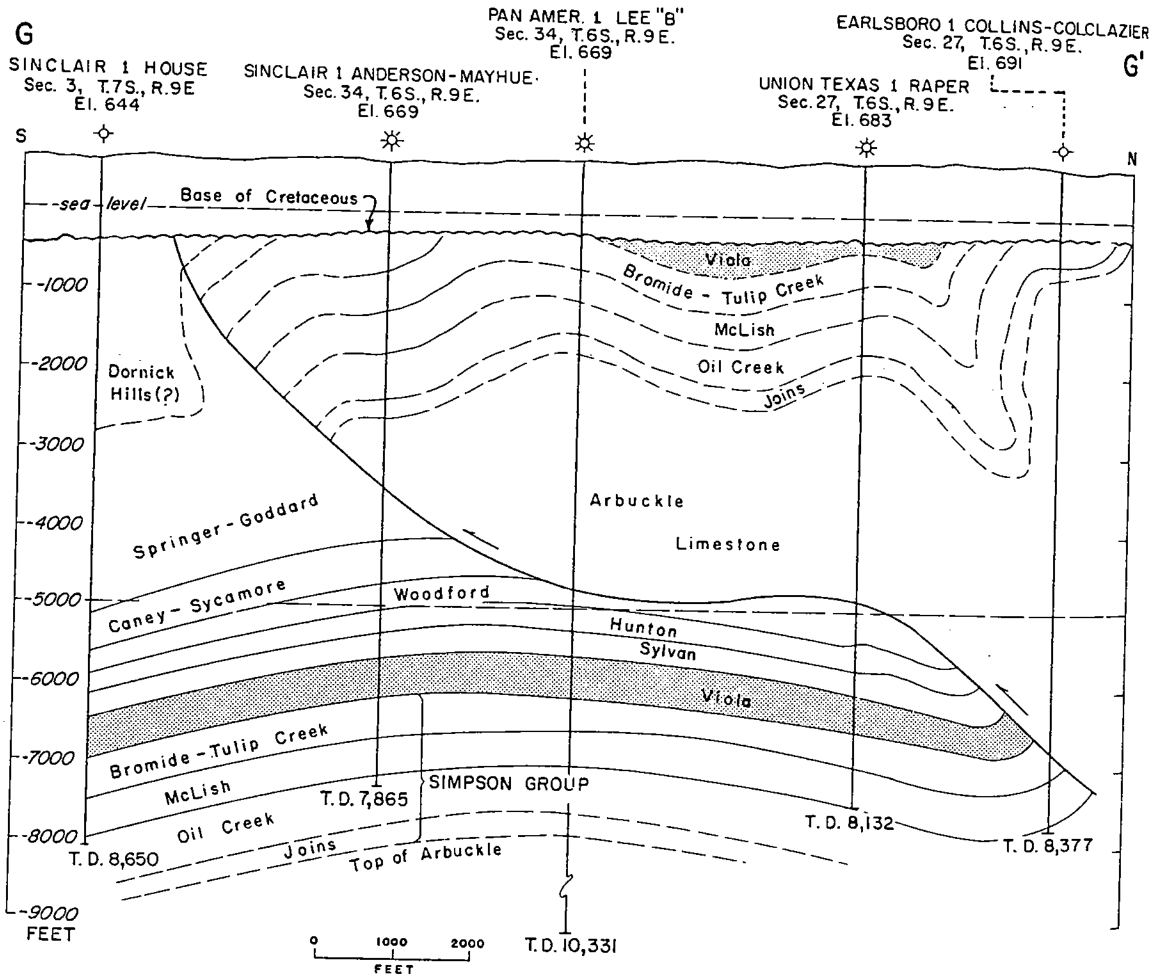


Figure 42. Cross-section G–G′, Durant East Field (sec. 3, T. 7 S., R. 9 E. to sec. 27, T. 6 S., R. 9 E.).

cludes strata from the Caney Shale to the Oil Creek. Gas production was established in the Bromide and McLish Formations. Structure below the Cumberland Thrust is anticlinal and production is controlled in the Simpson sands by anticlinal trapping. Rocks encountered in the upper thrust plate include Viola, Simpson, and Arbuckle. Sample tops secured through Dr. P. A. Chenoweth (personal communication, January 1976) show the Viola Limestone at 1,080 (−411) feet lying beneath the Cretaceous, the Bromide at 1,370 (−701) feet, and the Arbuckle Limestone at 3,303 (−2,634) feet.

The Pan American 1 Lee "B" (sec. 34, T. 6 S., R. 9 E.) well shows the lower Paleozoic section overlain by the Cretaceous and thrust upon the Woodford Formation at 5,390 (−4,721) feet. A normal section of Hunton, Sylvan, Viola, Bromide–Tulip Creek, McLish, Oil Creek, and Joins was drilled. The top of the Arbuckle Limestone was encountered at a depth of 8,570 (−7,901) feet, and the well was drilled to total depth of 10,331 feet. The upper thrust plate appears to include strata from Arbuckle through the Viola as indicated.

The Union of Texas 1 Raper (sec. 27, T. 6 S., R. 9 E.) drilled Arbuckle Limestone from 2,250 (−1,867) to 5,520 (−4,837) feet. The overlying Joins, Oil Creek, McLish, Bromide, and Viola have been reconstructed (inferred) to comprise the thrust plate. The well crossed the Cumberland Thrust at 5,520 (−4,837) feet, passing from Arbuckle Limestone into rocks that are probably Mississippian in age. The top of the Woodford is 5,880 (−5,197) feet, Hunton is 6,145 (−5,462) feet, Sylvan is 6,455 (−5,772) feet, Viola is 6,735 (−6,052) feet, Bromide is 7,130 (−6,447) feet,

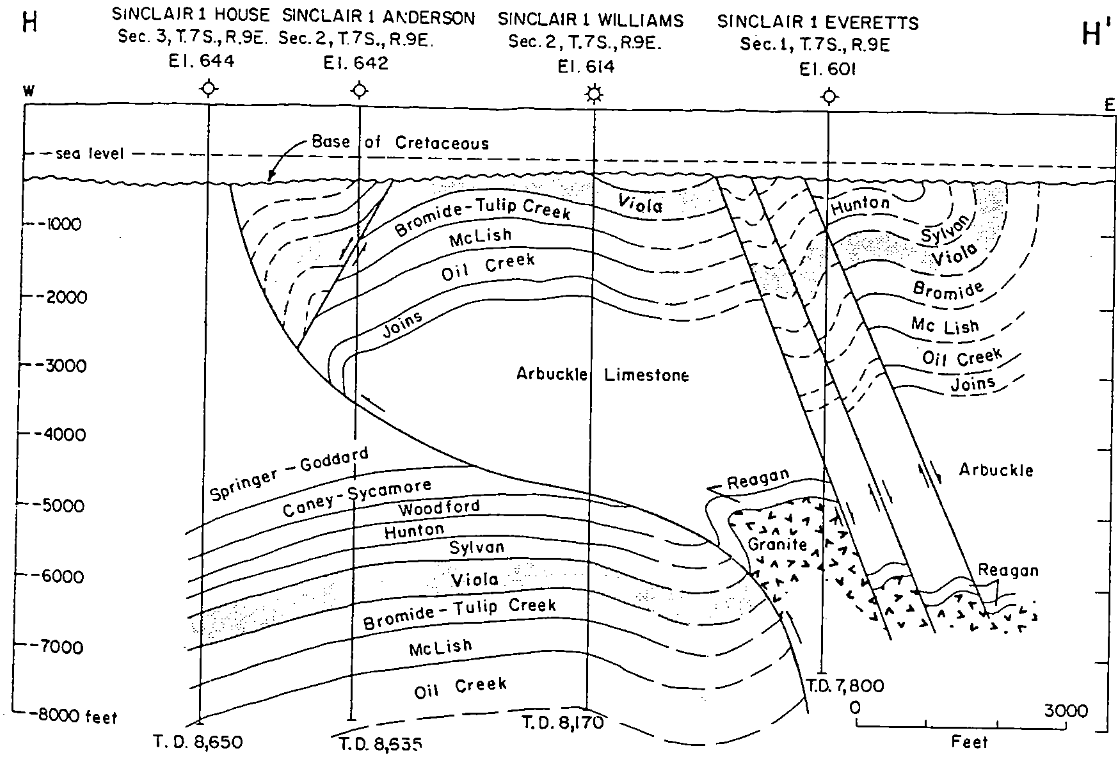


Figure 43. Cross-section *H–H'*, Durant East Field (sec. 3, T. 7 S., R. 9 E. to sec. 1, T. 7 S., R. 9 E.).

and McLish is 7,959 (−7,276) feet. The well was completed in second Bromide and McLish sands; total depth is 8,125 feet.

In the Earlsboro 1 Collins-Colclazier (sec. 27, T. 6 S., R. 9 E.), Oil Creek sand was encountered below the Cretaceous from 946 to 1,254 feet. The Joins Limestone was found at 1,254 (−563) feet and the top of the Arbuckle at 1,316 (−625) feet. The Arbuckle is deformed and steeply dipping to a depth of 7,397 (−6,706) feet where it is thrust onto the Bromide Formation. The McLish was topped at 7,803 (−7,112) feet and the Oil Creek at 8,331 (−7,640) feet. The well was dry and abandoned at a total depth of 8,377 feet.

The structure is interpreted to involve the Cumberland Fault (Ravia Block) thrust southward across gently folded Paleozoic rocks to form a gentle anticlinal flexure which is terminated on the north by the thrust fault. Production in the Simpson sands is controlled by anticlinal trapping.

CROSS-SECTION *H–H'*

Cross-section *H–H'* (fig. 43) is a west-east section across the south end of the Durant East Field. The westernmost well in the section is the Sinclair 1 House (sec. 3, T. 7 S., R. 9 E.). After drilling approximately 4,800 feet of Springer-Goddard Shale (probably folded and overturned beneath thrust), the well encountered a normal section of rocks from the Caney Shale to the top of the Oil Creek Formation. Total depth is 8,650 feet.

Basal Cretaceous is on Woodford at 1,060 (−418) feet in Sinclair 1 Anderson (sec. 2, T. 7 S., R. 9 E.). The Sylvan was reported at 1,208 (−566) feet, Viola at 1,600 (−958) faulted against the Bromide at 1,900 (−1,258) feet, "Birdseye" McLish at 2,570 (−1,928) feet, Oil Creek at 2,630 (−1,988) feet, Joins at 3,135 (−2,495) feet, and Arbuckle at 3,340 (−2,698) feet. Originally abandoned at 4,050, the well was reentered and drilled deeper to be completed as a shut-in gas well. The well crossed the Cumberland Thrust Fault at 4,150 (−3,508) feet with Arbuckle Limestone on Springer-Goddard Shale. A normal section from Caney Shale downward to the Oil Creek Formation was drilled, and the well was completed in the Bromide and McLish sands. Total depth is 8,635 feet.

Sinclair 1 Williams (sec. 2, T. 7 S., R. 9

E.) found the Viola Limestone at 1,050 (−259) feet below the base of the Cretaceous. The Bromide was found at 1,405 (−791) feet, McLish at 1,691 (−1,071) feet, Oil Creek at 1,985 (−1,371) feet, Joins at 2,433 (−1,809) feet, and the Arbuckle at 2,632 (−2,018) feet. The well cut the Cumberland Thrust Fault at 5,312 (−4,698) feet and encountered the Woodford Shale. A normal section of Hunton, Sylvan, Viola, Bromide, McLish, and Oil Creek was drilled below the thrust fault and production was established in the McLish sand. Total depth is 8,190 feet.

The easternmost well in the section is the Sinclair 1 Everetts, a dry hole drilled to a depth of 7,800 feet. Drillers reportedly logged Woodford Shale at 1,003 (−402) feet immediately below the base of the Cretaceous. Three small, normal faults appear to cut the lower Paleozoic section as shown—one cutting the Viola-Sylvan section at 1,546 (−945) feet, a second passing between the McLish and Oil Creek Formations at 3,503 (−2,899) feet, and a third one (postulated) within the Arbuckle Limestone about 300 feet above the Reagan Sandstone. The direction and trend of these small faults are not known to the author and were established only in this well. The Joins was reported at 3,860 (−3,259) feet, the Arbuckle at 4,050 (−3,449) feet, the Reagan Sandstone at 5,250 (−4,649) feet, and granite was drilled from 5,340 (−4,739) feet to total depth of 7,800 feet. No production was established in this well. The Cumberland Thrust Fault is believed to pass below the bottom of this hole.

The Arbuckle Limestone was found at 3,397 (−2,787) feet, Reagan Sandstone at 5,148 (−4,538) feet, and the Tishomingo Granite at 5,417 (−4,807) feet in the Earlsboro 1 Smith (sec. 1, T. 7 S., R. 9 E.) well, not shown on this cross section. The well cut the Cumberland Thrust at 5,417 (−5,104) feet, passing from granite into the Sycamore. Pre-Sycamore strata were drilled in normal order. Total depth was 8,830 feet, and the well was completed in Bromide and McLish sands. This well confirms the position of the Cumberland Fault as shown in figure 35.

OIL AND GAS DEVELOPMENT

HISTORY OF PRODUCTION

The history of oil and gas development in Bryan County is closely related to that in Marshall County inasmuch as the producing structures that control oil and gas accumulation in Marshall County extend southeastward into Bryan County. Early development in the area occurred in Marshall County.

Oil and gas seeps had long been known to exist in the region north of Madill where "Seneca Oil" was bottled from an oil spring on Oil Creek in SE¼ sec. 34, T. 4 S., R. 5 E.; production was from 10 feet below the top of the Antlers Sandstone (Hutchison, 1911, p. 64). The presence of these seeps led to the drilling of the first commercial well in 1906. In March 1909, the Mal-Millan Oil Company 1 Arbuckle well, in SW¼ sec. 25, T. 5 S., R. 5 E., was completed in the "Arbuckle Sand" producing more than 400 barrels per day. Production was from the basal 50 feet of the Cretaceous (Antlers Sandstone). By late April 1909, eight wells had been drilled and five had found production. The field, originally called "Arbuckle Field," was later incorporated in the Madill Field. Subsequent drilling in secs. 13 and 24, T. 5 S., R. 5 E. and sec. 30, T. 5 S., R. 6 E. led to completion of more than 50 wells on the flank of the Madill Anticline producing from a lenticular sandstone (possibly Deese) of Pennsylvanian age.

The next major discovery in Marshall County was the Enos Gas Field located 7 miles south of Kingston, Oklahoma. Production was from the Cretaceous (Antlers Sandstone) near the crest of the Preston Anticline at depths ranging from 500 to 1,480 feet (Bullard, 1926, p. 55–57). More than a dozen wells were completed by 1918. The nearby Isom Springs Field produces from the basal Cretaceous (Antlers Sandstone) and underlying Paleozoic strata. Approximately 60 wells have been drilled. Recent drilling has established production in the Stanley Formation, the Arkansas Novaculite, and Bigfork Chert.

Deeper drilling was commenced in 1939 when Johnson and Kemnitz drilled 1 Neff-Godfrey (SW¼SE¼NW¼ sec. 14, T. 6 S., R. 6 E.) to the top of the Arbuckle Limestone. Shows of oil and gas were encountered in the Simpson Group of Ordovician age (Godfrey, 1956, p. 116). This led to the discovery in 1942 of the Aylesworth Field by the Samedan 1 Neff-Godfrey (SW¼ sec. 13, T. 6 S., R. 6 E.). Approximately 86 wells have produced more than 10 million barrels of crude oil from the Bromide sand on the Madill-Aylesworth Anticline. Production on the northeast flank is from the "Misener (?) Dolomite."

Production was extended southeastward into Bryan County by the discovery of Aylesworth Southeast Pool (secs. 27 and 28, T. 6 S., R. 7 E.) in 1945. There the Bromide sand produces on the southwest flank of the faulted Madill-Aylesworth Anticline. Production was established on the northeast flank in 1957 from Springer, Sycamore, Woodford, Hunton, Bromide, and McLish Formations. Production in the narrow fault block in the center of the field was established in 1976 in the Oil Creek sand in sec. 21, T. 6 S., R. 7 E.

Cumberland Field was discovered by Pure Oil Company 1 Little 100 (SE¼ sec. 28, T. 5 S., R. 7 E). The well flowed oil on drill stem test from the Bromide sand (Cram, 1948, p. 341). Production was obtained on an elongate anticline located by reflection seismograph.

East Durant Field, discovered by Amoco 1 Callahan-Lee (sec. 34, T. 6 S., R. 9 E.) in 1961, produced oil and gas from Simpson sands on an anticlinal flexure beneath the Cumberland Fault Block (figs. 42, 43).

Several small (1-well) fields have been discovered in recent years. These include Durant North (1967), Durant Northwest (1968), and Silo (1973). Drilling continues in the area west and northwest of Durant, and additional discoveries can be anticipated.

DESCRIPTION OF INDIVIDUAL OIL FIELDS

Cumberland Field

Cumberland Field was discovered by Pure Oil Company in 1940 when production was established in the Bromide sand on an elongate northwest-trending anticline located by reflection seismograph (Cram, 1948, p. 341). One hundred fifty oil wells, one gas well, and nine dry holes were drilled during field development (Cram, 1948, p. 358).

The Cumberland Anticline is located on the downthrown side (southwest) of the northwest-trending Cumberland Thrust Fault. The fold is approximately 4 miles long and 2 miles wide; production is from an area 3 miles by 1 mile. Seismic records indicated a closure of more than 1,000 feet; effective closure on top of the Bromide Formation is 550 feet (Cram, 1948, p. 348). The anticline is slightly asymmetrical with the steeper limb on the northeast side. One or more cross faults cut the southern end with 200–300 feet of displacement.

The oil reservoirs are sandstones of the Bromide, McLish, and Oil Creek Formations of the Simpson Group (Ordovician). There are three producing sands in the lower part of the Bromide; each sand is more than 100 feet in thickness. The basal McLish Sandstone is 100 feet thick; the first Oil Creek sand is 185 feet thick; the second Oil Creek sand is 210 feet thick. Original bottom hole pressures were normal hydrostatic: 2,210 psi (pounds per square inch) at 4,800 feet in the Bromide; 2,542 psi at 5,300 feet in the McLish; and 2,940 psi at 6,200 feet in the second Oil Creek. Gravity is 35° API. According to Cram (1948, p. 355–358), the Bromide sand produced oil from 1,250 acres in 41 wells; the McLish produced from 2,000 acres in 74 wells with a 320-acre gas cap; the first Oil Creek produced from under 2,000 acres in 5 wells; and the second Oil Creek produced from 600 acres in 31 wells. New gas production has been established recently in the West Spring Creek (Arbuckle) in Union Oil Company 104-14 Chrisman, sec. 20, T. 5 S., R. 7 E. (completed 1-16-77).

A structural map drawn on top of the Viola Limestone is shown in figure 44, and a typical electric log of the stratigraphic sequence is shown in figure 45.

Today 132 oil wells and one gas well are producing. The 1976 production was 329,428 barrels of oil; cumulative production (to 1-1-77) was 70,605,432 barrels. Gas production for 1974 (latest year available) was 224,273 Mcf (thousand cubic feet); cumulative gas production (to 1-1-75) was 1,275,759 Mcf (see tables 10 and 11). Approximately one-third of the wells are in Bryan County; the remainder are in Marshall County.

Aylesworth and Aylesworth Southeast Fields

Aylesworth and Aylesworth Southeast are located on the Madill-Aylesworth flexure, an elongate, faulted anticline extending more than 25 miles across Marshall and Bryan Counties. Four major oil fields, Southeast Mannsville, Madill, Aylesworth, and Aylesworth Southeast, are on this structure.

The first two wells drilled on the Aylesworth Anticline were Johnson-Kemnitz 1 Neff-Godfrey, in the SW¼SE¼ sec. 14, T. 6 S.,

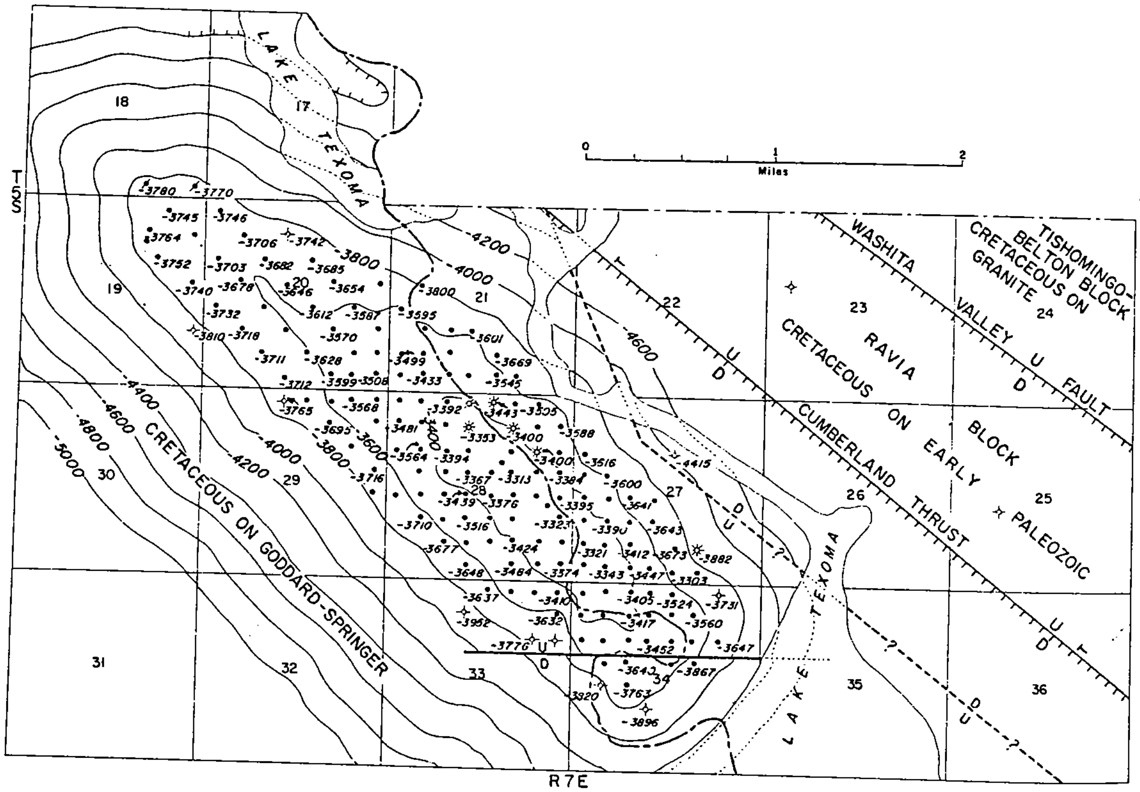


Figure 44. Subsurface structure map, Cumberland Field, Bryan and Marshall Counties. Contours (in feet) are drawn using the top of the Viola Limestone.

R. 6 E. (total depth is 5,860 feet in Arbuckle Limestone) in 1939 and Marshall-Kubat 1 McCormick, in the SE¼SE¼ sec. 4, T. 6 S., R. 6 E., in 1942. Both wells were abandoned after encountering numerous oil and gas shows in the Simpson sands (Womack, 1956, p. 376).

The discovery well of Aylesworth Field, Samedan Corporation 1 Neff-Godfrey (NE¼SW¼ sec. 13, T. 6 S., R. 6 E.), was completed in 1942 for 100 bopd (barrels of oil per day) from the Bromide sand. Approximately 78 wells were drilled and production was established from 1,800 acres extending from sec. 4, T. 6 S., R. 6 E. to sec. 21, T. 6 S., R. 7 E. on the upthrown block southwest of the Aylesworth Fault Zone. The field is terminated northwestward in sec. 4, T. 6 N., R. 6 E. by a small cross fault and southeastward by a saddle that separates it from Aylesworth Southeast (fig. 46). Production on the southwest flank is primarily from the second and third Bromide or Tulip Creek sands. The McLish and Oil Creek sands tested salt water. Approximately 1,200 feet of closure is present against the Aylesworth Fault. The stratigraphic sequence is shown in figure 47.

The northeast segment of Aylesworth Field was developed in 1957–59 with production in the Woodford-Misener zone and the Sycamore Limestone. Twenty-nine oil wells and one gas well (Simpson) were drilled east of the Aylesworth Fault Zone. Two major, high-angle, faults, both downthrown to the northeast, have a displacement of approximately 3,000 feet along the crest of the Aylesworth Anticline.

Eighty four oil wells and two gas wells are currently listed as producers; all are in Marshall County. Production for 1976 was 134,519 barrels; cumulative production (to 1-1-77) was 10,036,330 barrels. Gas production for 1974 was 26,017 Mcf; cumulative gas production (to 1-1-75) was 3,310,836 Mcf (see tables 10 and 11).

Aylesworth Southeast is in western Bryan County on the Madill-Aylesworth flexure. Here again the major anticlinal structure is cut by two high-angle faults, both downthrown to the northeast with maximum displacement of about 3,000 feet. Production on the upthrown block southwest of the fault zone is from the Bromide sand. Pro-

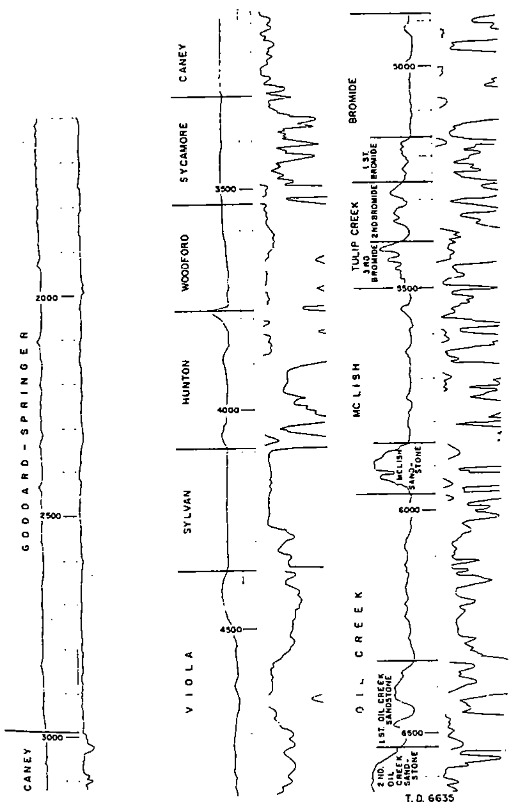


Figure 45. Electric log for Cumberland Oil Field, Bryan and Marshall Counties, showing stratigraphic sequences in Pure 4 Meyers 110, sec. 34, T. 5 S., R. 7 E. Depths in feet.

TABLE 10.–OIL PRODUCTION IN BRYAN COUNTY[1]

Field name	Producing wells	Discovery date	1976 (barrels)	Cumulative (barrels) 1-1-77
Aylesworth Southeast	16	4/45	39,710	1,857,006
Durant East	9	8/61	17,998	651,401
Durant North	1	6/67	0	10,036
Durant Northwest	1	1/68	3,818	82,115
Silo	2	9/73	2,285	9,537
Cumberland	132	4/40	329,428	70,605,432

[1]Data from Petroleum Information Corporation Report for 1976.

TABLE 11.–GAS PRODUCTION IN BRYAN COUNTY[1]

Field name	Producing wells	Discovery date	1974 (MCF)	Cumulative (MCF) 1-1-75
Aylesworth Southeast	5	4/45	1,677,513	13,916,895
Durant East	11	5/58	1,944,040	25,635,366
Durant North	1	6/67	21,383	830,235
Durant Northwest	1	1/68	—	—
Silo	2	9/73	—	—
Mead West	1	1964	shut in	shut in
Cumberland	1	4/40	224,273	1,275,759

[1]Data from International Oil Scouts Association Year Book for 1974, Part II, v. XLV.

duction on the northeast flank was established in 1957 when oil and gas were found in several reservoirs including the Springer, Woodford-Misener-Hunton, Bromide, and McLish Formations. Gas production has been established recently in the basal Oil Creek sand in the narrow fault zone in the center of the field (Westheimer, personal communication, 1977). Producing wells are Cleary 1 Godfrey (sec. 21, T. 6 S., R. 7 E.) and Hanover 1 State (sec. 27).

Discovery well for Aylesworth Southeast was drilled in April 1945 to establish Simpson production on the west side of the flexure. Today 16 wells produce oil and five produce gas in Aylesworth Southeast. Production for 1976 (tables 10 and 11) was 39,710 barrels; cumulative production (to 1-1-77) was 1,875,006 barrels. Gas production in 1974 was 1,677,513 Mcf; cumulative gas (to 1-1-75) was 13,916,895 Mcf. Two typical oil-well operations in Aylesworth Southeast are shown in figure 48.

Durant East

Durant East is a small field located on an anticlinal flexure beneath the Cumberland Thrust Sheet (fig. 49). Production is from the Bromide, McLish, and Oil Creek Formations (Simpson Group) on the downthrown block. The fault plane dips northeastward beneath the Ravia Block. Gas was discovered in 1958 in the Sinclair 1 Anderson well, originally completed as a dry hole in 1953. Oil was first reported in the Pan American (now Amoco) 1 Callahan-Lee well which flowed 246 bopd from the McLish Formation and tested at the rate of 10,926 Mcfgd (thousand cubic feet of gas per day) with 4.06 barrels distillate per million cubic feet of gas from the Bromide. According to Corporation Commission records, this well was completed August 16, 1961.

Today 11 wells are producing oil, gas, and condensate. The 1974 gas production was

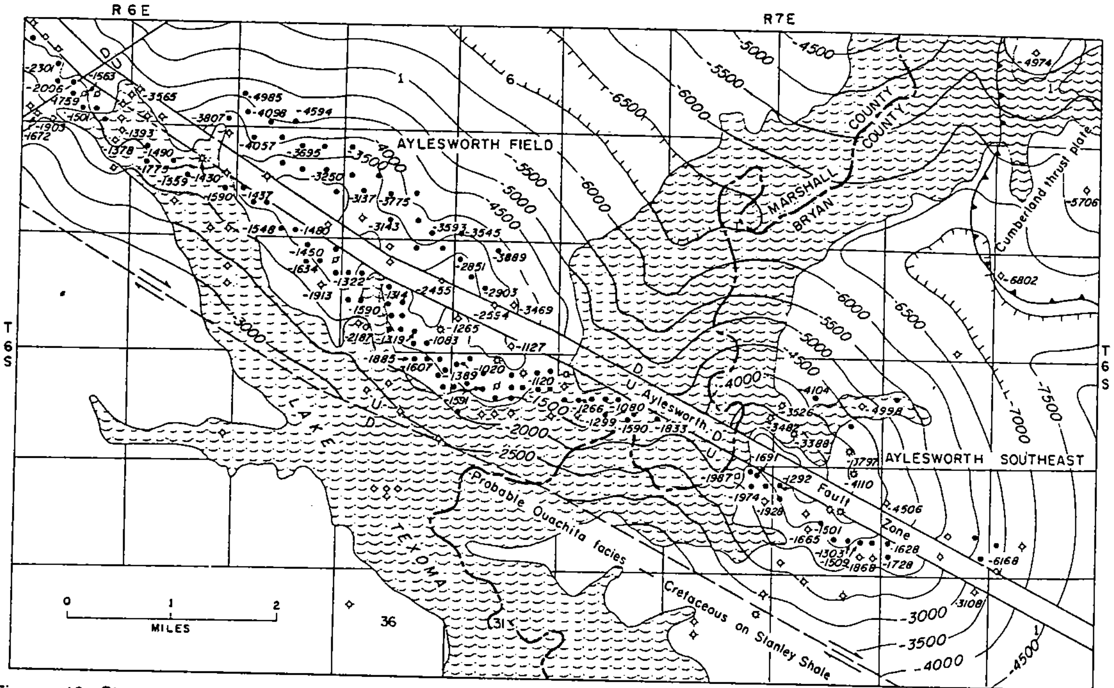


Figure 46. Structure map of Aylesworth-Aylesworth Southeast, Bryan and Marshall Counties. Contours (in feet) are drawn using the top of the Viola Limestone.

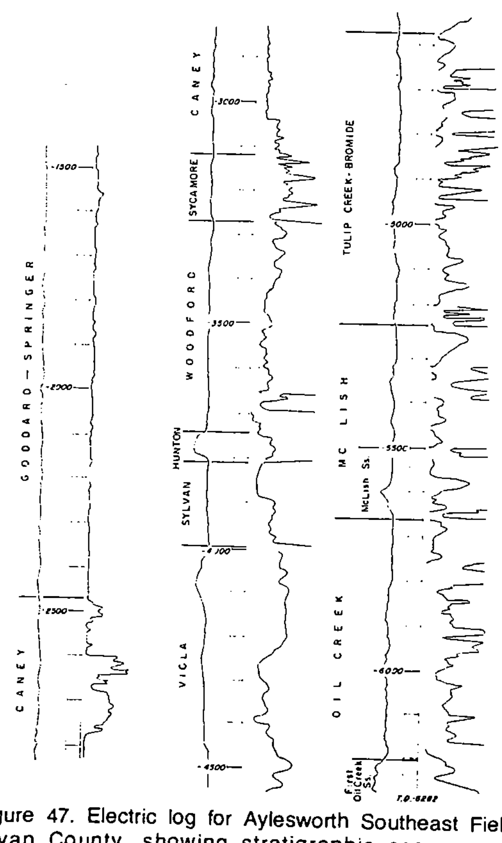


Figure 47. Electric log for Aylesworth Southeast Field, Bryan County, showing stratigraphic sequence in Amerada 1 Neff-Godfrey, sec. 22, T. 6 S., R. 7 E. Depths in feet.

1,944,040 Mcf; cumulative production (to 1-1-75) was 25,635,366 Mcf. During 1976, 17,998 barrels of liquid hydrocarbons were produced for a cumulative production (to 1-1-77) of 651,401 barrels.

Durant North

Durant North is a one-well field discovered by Pan American (now Amoco). This well, the Pan Amer. 1 Park College unit, located in NE¼SW¼ sec. 18, T. 6 S., R. 9 E. and completed August 26, 1965, and produced gas from the McLish Formation. The well produced 10,036 barrels of fluid hydrocarbons (to 1-1-77) and in 1974 produced 21,383 Mcf of gas for a cumulative total (to 1-1-75) of 830,235 Mcf.

Durant Northwest

Durant Northwest is a one-well field discovered by Sinclair (now Atlantic Richfield). This well, the Sinclair 1 Archibald, was drilled in 1968 in NW¼SW¼ sec. 24, T. 6 S., R. 8 E.; production was from the second and third Bromide (Tulip Creek) sands. It produced 3,818 barrels in 1976 for cumulative production (1-1-77) of 82,115 barrels. No statistics on gas production are available, and no gas is currently being produced.

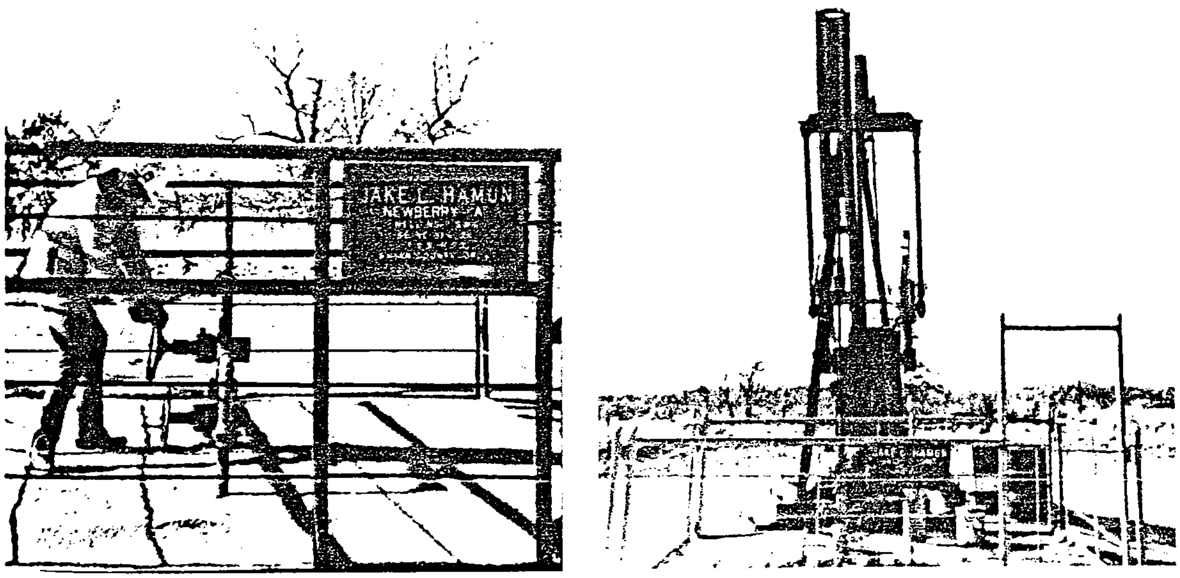


Figure 48. Two typical oil-well operations in Aylesworth Southeast Field.

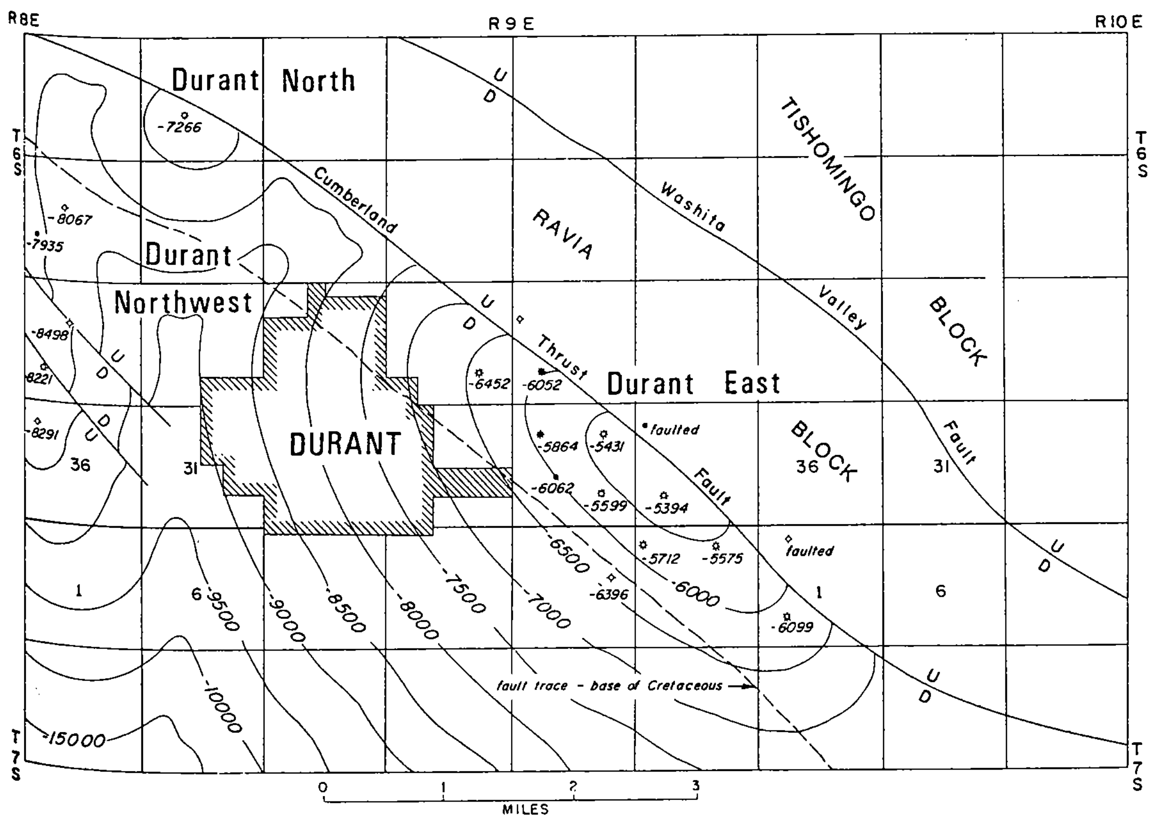


Figure 49. Structure map of the Durant Oil Fields, Bryan County. Contours (in feet) are drawn using the top of the Viola Limestone.

Silo Field

Silo, a one-well field, (the Magness Petroleum 1 Turnbull, in sec. 9, T. 6 S., R. 8 E.), was discovered in 1973. It produced 2,285 barrels of oil in 1976 for a cumulative total (to 1-1-77) of 9,537 barrels. Production is from the Bromide sand. Perforations from 2,733 to 2,801 feet tested 124 bopd and 200 Mcfgpd for a new discovery well.

Durant West

Durant West is an abandoned one-well field (Pasotex 1 State of Oklahoma in sec. 25, T. 6 S., R. 8 E.) discovered in 1956 by PasoTex Petroleum. This well was completed in the McLish sand through perforations from 9,640 to 9,712 feet for a calculated open flow of 2,900 Mcfgpd with 60 barrels of distillate. The well reportedly made only 379 barrels of condensate before abandonment.

Mead West

Mead West is a one-well gas field (Texaco 1 Elliott) discovered by Texaco in 1964. Located in the SE¼NE¼ sec. 33, T. 6 S., R. 7 E., the well tested 301 Mcfgpd in perforations from 798 to 816 feet in the Cretaceous sand. It is shut in as a noncommercial well.

FUTURE POSSIBILITIES

Exploration for oil and gas continues in the Bryan County area with recent drilling of several wells in Aylesworth Southeast. Future exploration will probably center around two areas: (1) beneath the Cumberland Thrust Plate, where additional Simpson production is believed possible, and (2) along the southeastern extension of the Aylesworth Anticline and fault system and in the central fault block of Aylesworth Southeast. Drilling beneath the Bryan Salient of the Ouachita rocks on a broad regional basis is not encouraged. However, additional testing along the projection of the Aylesworth structure and the Preston Anticline should be considered. Recent discoveries in the Ouachita rocks on the Preston Anticline near Isom Springs in Marshall County should lead to additional study of possibilities in Ouachita rocks. Geophysics should be used to confirm the presence of Arbuckle facies at depth.

TECTONIC HISTORY AND HYDROCARBON ACCUMULATION

INTRODUCTION

In this section the depositional and tectonic history of Bryan County and vicinity is summarized even though some of the material presented in Part I of this report under the heading Geologic History may be repeated. The approach here is from how deposition and tectonics relate to hydrocarbon accumulation. Previous studies on regional tectonics and history of southern Oklahoma have been included by Tomlinson and McBee (1959), Huffman (1959), Ham and others (1964), Ham and Wilson (1967), Ham (1969), and others. A geologic history of the Mansville-Madill-Aylesworth area was prepared by Godfrey (1956) and modified by Beckman and Sloss (1966).

PALEOZOIC GEOSYNCLINES AND SEDIMENTATION

The Southern Oklahoma Geosyncline formed in late Precambrian or Early Cambrian time. In keeping with the concepts of continental drift and plate tectonics, it is herein postulated that the crust of southern Oklahoma split along the Washita Valley Fault and the area between that fault and the Waurika-Muenster Arch opened to form a broad rift valley. This geosyncline was bordered on the northeast by the Tishomingo-Belton Horst block, which formed part of the northeastern craton, and on the southwest by the Waurika-Muenster Arch, a part of the Texas craton. The geosyncline consisted of a northwest-trending deep basin with en echelon bordering and intrabasinal uplifts with structural relief reaching a maximum of 40,000 feet on the present basement rock surface (Ham and Wilson, 1967, p. 396). The western portion of the geosyncline is now the Anadarko Basin which is bordered on the southwest by the Wichita Uplift. The southeastern part of the old geosyncline is now the

Marietta and Ardmore-Bryan Basins, separated by the Criner Hills Uplift. The Marietta Basin is bordered on the south by the Waurika-Muenster Arch, and the Ardmore Basin is bordered on the northeast by the Arbuckle Anticline which lies southwest of and adjacent to the Tishomingo-Belton Horst block. Deformation is mainly Pennsylvanian in age.

Ham (1969, p. 7) divided the Paleozoic rocks of the Southern Oklahoma Geosyncline into four major lithostratigraphic units: (a) Late Cambrian to Early Devonian marine sediments, mainly carbonates; (b) Late Devonian and Mississippian black shales; (c) Pennsylvanian dark shales, sandstones, thin marine limestones, and local conglomerates; and (d) Permian red shales, sandstones, and evaporites. These were deposited on more than 7,000 feet of Middle Cambrian Rhyolite flows of the Carlton and Colbert Formations (these rocks are 525 million years old as determined by radioactive dating).

The greatest thickness of Paleozoic rocks is in the Anadarko Basin, where 38,000 feet of Late Cambrian to Late Permian beds are present. A similar section of Paleozoic rocks is present in the Ardmore Basin segment where 34,000 feet of Late Cambrian through Late Pennsylvanian are preserved. Strata thin towards the margins of the geosyncline and are 10,000 feet thick on the adjacent cratonal shelf areas (Ham, 1969, p. 7). Cambrian-Ordovician carbonates are limestone in the geosyncline and dolomite on the craton; the Mississippian is composed of dark shales in the geosyncline and carbonates on the craton; the Pennsylvanian is composed of shale and sandstones in the geosyncline and shales and limestones on the craton.

Southern Oklahoma was the site of abnormally thick sedimentation during the Pennsylvanian with the Southern Oklahoma Geosyncline receiving from 15,000 to 17,000 feet of clastic sediments. The Ardmore Basin received more than 13,000 feet of post-Springer deposits including 3,000 feet of Dornick Hills Group, 6,000 feet of Deese Group, and 4,000 feet of Hoxbar. Virgilian sediments are missing except for post-orogenic conglomerates that encircle the Arbuckle Uplift.

TECTONIC HISTORY

The Southern Oklahoma Geosyncline remained relatively stable during the early Paleozoic. Active deposition and continuous subsidence occurred during Late Cambrian to Middle Devonian as indicated by the thick accumulation of carbonates. The diastrophic history began with epeirogenic movements in pre-Woodford time followed by intermittent orogenic movements during the Pennsylvanian and reaching a culmination in Late Pennsylvanian with the folding of the Arbuckle Mountains and final thrusting of the Ouachita rocks.

Post-Hunton, Pre-Woodford Epeirogeny

The first major Paleozoic crustal movement, following the initial rifting in Early Cambrian time and subsequent emplacement of the Middle Cambrian rhyolite prophyry (Colbert), occurred during the Middle Devonian (post-Hunton, pre-Woodford) when the floor of the Southern Oklahoma Geosyncline was uplifted and subjected to erosion. Removal of the Hunton Group from the Mannsville-Madill-Aylesworth Anticline suggests local warping followed by extensive erosion. The Oklahoma Ozarks, Seminole Uplift, and other similar uplifts were tilted or arched at this time. The pre-Woodford unconformity is one of the major erosion surfaces in the Midcontinent, truncating the rocks in many places where the Woodford Shale lies on successively older beds of the Hunton Group, Sylvan Shale, and Viola Limestone. Production in the Hunton Group along the eastern shelf of the Anadarko Basin is due to truncation of the Hunton and overlap by the Woodford Shale. The Woodford is succeeded conformably by the Sycamore Limestone and the Delaware Creek (Caney) Shale.

Late Mississippian–Early Pennsylvanian Movements

Early Mississippian movements in the Southern Appalachian Mountains and "Llanoria" east of the Southern Oklahoma Geosyncline have been documented by the thick sequence of Stanley, Jackfork, and Johns Valley clastics derived from a rising source to the east (Morris, 1977, p. 155–156). The effect of this movement and related movements in the Southern Oklahoma

Geosyncline are difficult to evaluate. The Tishomingo-Belton Horst block was probably uplifted to supply the exotic boulders in the Caney and Johns Valley Formations. A paleogeologic map drawn by Godfrey (1956, pl. 4) suggests that the Goddard rests unconformably upon early Paleozoic beds ranging in age from Ordovician (Simpson Group) to Mississippian (Caney Shale) along the Madill-Aylesworth Flexure. Actually these relations can be explained by faulting and change in dip of the fault planes. Beckman and Sloss (1966, p. 1348–1359), by means of cross sections and a pre-Goddard paleogeologic map, attempted to show deep channeling of the pre-Goddard surface with thick Goddard resting on beds as old as the Arbuckle and Simpson along the crest of the faulted anticline. Other geologists attribute this thick section of Goddard to faulting and throw doubt on the Beckman-Sloss interpretation. Elsewhere in Oklahoma, the Goddard is conformable with the Delaware Creek (Caney) Formation.

Both Godfrey (1956) and Beckman and Sloss (1966) postulated an unconformity above the Goddard, marked by thinning of the Goddard and absence of Springer beds on the crest of the Madill-Aylesworth Anticline. Womack (1956) stated that this relationship resulted from post-Goddard folding and faulting followed by pre-Cretaceous erosion. The Golf Course Formation (Dornick Hills) appears to be absent on the Aylesworth and Cumberland structures but has been recognized in the Cumberland Syncline where it is represented by thick shales with brown limestone interbeds.

Early Pennsylvanian–Wichita Orogeny

The Early Pennsylvanian–Wichita Orogeny is well documented in the Southern Oklahoma Geosyncline by marginal and intrabasinal uplifts (Ham and Wilson, 1967, p. 397). The Wichita Orogeny is well demonstrated in the Wichita Mountains where rapid uplift and erosion produced a thick sedimentary section known as the "Granite Wash." The most precise dating of the Wichita Orogeny is in the Criner Hills where the Jolliff Conglomerate Member (Early Morrowan) and later the Bostwick Conglomerate Member of Early Desmoinesian (Atokan) age were deposited. This orogeny is recorded throughout much of Oklahoma by a widespread unconformity. Late Morrowan and Early Desmoinesian (Atoka) rocks are represented by shales in the Cumberland Syncline and appear to be absent because of post-Pennsylvanian, pre-Cretaceous erosion across the Aylesworth Southeast, Cumberland, and Durant East structures.

Middle Pennsylvanian–Desmoinesian Movements (Bryan Uplift)

The second episode of Pennsylvanian deformation occurred in Desmoinesian time when the Wichitas were re-elevated and parts of the Ouachita System including the Bryan Basin were uplifted to become the source of stream transported chert pebbles incorporated in the Devils Kitchen and Rocky Point Conglomerates of the Lake Murray region. Careful sample analysis by Saether (1976) suggested that the conglomerate pebbles came from a nearby source. Pre-Cretaceous erosion has stripped most of the Desmoinesian (Deese) rocks from the Bryan County area.

Late Pennsylvanian–Arbuckle Orogeny

The major deformation in the Southern Oklahoma Geosyncline occurred in Early Virgilian when the folding of the Arbuckle Anticline and structural deformation in the Ardmore and Marietta Basins, Criner Hills, and other major structures occurred. The folding and subsequent faulting that control oil accumulation in Bryan County is believed to have occurred at this time as strong compressional forces from a northeastward moving plate attempted to close the Southern Oklahoma Geosyncline. Compressional forces from the southwest folded and faulted the rocks in the Bryan County area, forcing them against the rigid buttress of the Tishomingo-Belton Horst Block, creating underthrusting of the Cumberland plate beneath the Cumberland and Washita Valley Faults, and creating the Cumberland and Durant East Anticlines. The Aylesworth Southeast structure was re-elevated and the faults rotated to their present position. Dating of these structures can only be said to be post-Dornick Hills, pre-Cretaceous, but all of the evidence leads one to believe that the oil producing structures in Bryan County are simply a southeastward extension of the Arbuckle Mountain System. This system was dated by Ham (1969, p. 17–18) to be post-Hoxbar and pre-Early Vanoss (Pontotoc) because the faults that cut the folds also preserve the down-dropped Collings Ranch Conglomerate but pass beneath the Vanoss (Pontotoc) Conglomerate. The Vanoss Conglomerate was dated as Late Pennsylvanian, post-Arbuckle folding in age.

Final Orogenic Movements–Marathon-Ouachita Tectonic Province

Shortly after or perhaps in part contemporaneous with formation of the Arbuckle Mountain structures and the major faults which cut the Arbuckle rocks, strong compressional forces, probably from the southeast, moved the rocks of the Bryan Basin northwestward to their present position. The unusual shape of the Ouachita Front in Bryan and adjacent counties has been explained in at least two different ways: (1) erosion of the Ouachita rocks from the stable Tishomingo-Belton Horst block and (2) large scale wrench faulting on both sides of the Tishomingo-Belton Horst block along growth faults and pre-existing high-angle faults with the Bryan Basin rocks and the Atoka Basin rocks being carried to their present positions. Evidence to prove conclusively either of these hypotheses is lacking, and the answer probably involves both concepts.

The Atoka Formation is the youngest rock known in the Ouachita facies. Thus early Desmoinesian uplifts could have preceded the Virgilian movements in the Ouachita System. Final thrusting of the Ouachita rocks onto the Arbuckle facies produced a southeast dipping joint system in the Arbuckle Mountains.

Pre-Cretaceous erosion beveled the Late Pennsylvanian structures to a surface of moderate relief upon which the Cretaceous sediments were deposited. Differential compaction and subsequent adjustment along pre-existing faults and folds caused gentle folding of Cretaceous beds. Such structures as the Preston Anticline, Kingston Syncline, Aylesworth Anticline, and Cumberland Syncline are reflected in the outcrop of Cretaceous beds. Microfracturing of Cretaceous and underlying rocks along major faults provided easy avenues for the development of post-Cretaceous drainage lines.

The Late Cretaceous Laramide Orogeny had little or no effect on the rocks of Bryan County although Cretaceous seas withdrew from the area. Tertiary time was one of erosion whereas in the Quaternary (Pleistocene) several terrace levels developed during the interglacial ages and renewed downcutting occurred during the pluvial stages associated with ice accumulation in regions to the north of Oklahoma.

TIME OF OIL ACCUMULATION

Oil accumulation and entrapment in Bryan County are believed to be largely Late Pennsylvanian in age and to have occurred after the folds and faults of the Arbuckle System had been formed. Final uplift and migration of hydrocarbons in Aylesworth Southeast, Cumberland, and Durant East Fields are believed to date from this time inasmuch as the producing structures seem to be closely related to the Arbuckle movements. Overturning of fault planes and northeastward underthrusting of the Cumberland Syncline beneath the Ravia Block appear to be Late Pennsylvanian events.

Oil and gas in nearby fields from "stray" Pennsylvanian sands enclosed in Pennsylvanian shale are believed to have accumulated during Pennsylvanian time. Shallow accumulations in basal Cretaceous sands may be the result of leakage upward from underlying faults and fractures which cut pre-Cretaceous beds.

REFERENCES CITED

Adkins, W. S., 1928, Handbook of Cretaceous fossils: University of Texas Bulletin 2838, 385 p.

———, 1933, The geology of Texas, pt. 2, The Mesozoic systems in Texas: University of Texas Bulletin 3232, v. 1, pt. 2, p. 239–518 (1932).

———, 1944, *Mortoniceras vespertinum* (Morton), Lower Cretaceous ammonite genotype (abs): Dallas Digest, p. 102.

Alfonsi, P. P., 1968, Lithostratigraphy and areal geology of east-central Choctaw County, Oklahoma: University of Oklahoma unpublished M.S. thesis, 57 p.

American Commission on Stratigraphic Nomenclature, 1961, Code of stratigraphic nomenclature: American Association of Petroleum Geologists Bulletin, v. 45, p. 645–665.

Barnes, V. E. (project director), 1966, Geologic atlas of Texas, Texarkana sheet: University of Texas Bureau of Economic Geology, scale 1:250,000.

(project director), 1967, Geologic atlas of Texas, Sherman sheet: University of Texas Bureau of Economic Geology, scale 1:250,000.

Beckman, W. A., Jr., and **Sloss, L. L.**, 1966, Possible pre-Springeran unconformity in southern Oklahoma: American Association of Petroleum Geologist Bulletin, v. 50, p. 1342–1364.

Bergquist, H. R., 1949, Geology of the Woodbine formation of Cooke, Grayson, and Fannin Counties, Texas: U.S. Geological Survey Oil and Gas Investigations Preliminary Map 98, scale 1 inch = 1 mile, 2 sheets.

Bishop, B. A., 1967, Stratigraphic study of the Kiamichi Formation of the Lower Cretaceous of Texas, *in* Hendricks, Leo, ed., Comanchean (Lower Cretaceous) stratigraphy and paleontology of Texas: Permian Basin Section, Society of Economic Paleontologists and Mineralogists, Publication 67-8, p. 159–180.

Blau, P. E., 1961, Petrology of Goodland Limestone (Lower Cretaceous), southeastern Oklahoma: University of Oklahoma unpublished M.S. thesis, 148 p.

Branson, C. C., 1965, Holotype of type species of *Mortoniceras:* Oklahoma Geology Notes, v. 25, p. 252–256.

Bullard, F. M., 1925, Geology of Love County, Oklahoma: Oklahoma Geological Survey Bulletin 33, 77 p.

———, 1926, Geology of Marshall County, Oklahoma: Oklahoma Geological Survey Bulletin 39, 101 p.

———, 1928, Lower Cretaceous of western Oklahoma: Oklahoma Geological Survey Bulletin 47, 116 p.

———, 1931, Geology of Grayson County, Texas: University of Texas Bulletin 3125, 72 p.

Bybee, H. P., and **Bullard, F. M.**, 1927, Geology of Cooke County, Texas: University of Texas Bulletin 2710, p. 5–61.

Carter, W. T., Jr., and **Patrick, A. L.**, 1914, Soil survey of Bryan County, Oklahoma: U.S. Department of Agriculture, series 1914 (16th Rept.), p. 2165–2212, map.

Cragin, F. W., 1893, A contribution to the invertebrate paleontology of the Texas Cretaceous: Texas Geological Survey, Annual Report, v. 4, pt. 2, p. 139–296.

Cram, I. H., 1948, Cumberland oil field, Bryan and Marshall Counties, Oklahoma, *in* Structure of typical American oil fields: American Association of Petroleum Geologists, v. 3, p. 341–358.

Currier, J. D., 1968, Stratigraphy and areal geology of southwestern Bryan County, Oklahoma: University of Oklahoma unpublished M.S. thesis, 76 p.

Curtis, N. M., 1960, Lignite in the Red Branch member, Woodbine formation, Oklahoma: Oklahoma Geology Notes, v. 20, p. 240–244.

Dalton, R. C., 1966, Stratigraphy and areal geology of central Choctaw County, Oklahoma: University of Oklahoma unpublished M.S. thesis, 68 p.

Davis, L. V., 1960, Geology and ground-water resources of southern McCurtain County, Oklahoma: Oklahoma Geological Survey Bulletin 86, 108 p.

Duarte-Vivas, Andrew, 1968, Geology of eastern Choctaw County, Oklahoma: University of Oklahoma unpublished M.S. thesis, 70 p.

Fay, R. O., 1975, The type species of *Mortoniceras* and the holotype specimens of Lower Cretaceous *Texigryphaea* of the southwestern United States: Oklahoma Geology Notes, v. 35, p. 43–57.

Flawn, P. T., 1961, The Ouachita System: University of Texas Publication 6120, 173 p.

Forgotson, J. M., Jr., 1957, Stratigraphy of Comanchean Cretaceous Trinity group: American Association of Petroleum Geologists Bulletin, v. 41, p. 2328–2363.

———, 1963, Depositional history and paleotectonic framework of Comanchean Cretaceous Trinity stage, Gulf Coast area: American Association of Petroleum Geologists Bulletin, v. 47, p. 69–103.

Frederickson, E. A., **Redman, R. H.**, and **Westheimer, J. M.**, 1965, Geology and Petroleum of Love County, Oklahoma: Oklahoma Geological Survey Circular 63, 91 p.

Frye, J. C., and **Leonard, A. B.**, 1963, Pleistocene geology of Red River basin in Texas: University of Texas Bureau of Economic Geology Report of Investigations 49, 48 p.

Gahring, R. R., 1959, History and development of North Madill field *in* Petroleum geology of southern Oklahoma, v. II: American Association of Petroleum Geologists, Ardmore Geological Society Symposium, p. 274–286.

Ganser, R. W., 1968, Geology of the Cumberland area, Bryan, Johnston, and Marshall Counties, Oklahoma: University of Oklahoma unpublished M.S. thesis, 60 p.

Gibbs, H. D., 1950, A field study of the Goodland limestone and the Washita group in southeastern Oklahoma: University of Oklahoma unpublished M.S. thesis, 72 p.

Godfrey, J. M., 1956, The subsurface geology of the Mannsville-Madill-Aylesworth anticline: University of Oklahoma M.S. thesis published in Oklahoma City Geological Society, Shale Shaker, v. 6, p. 7–12, 15–24, 27–30.

Ham, W. E., 1969, Regional geology of the Arbuckle Mountains, Oklahoma: Oklahoma Geological Survey Guidebook 17, 52 p.

Ham, W. E., **Denison, R. E.**, and **Merritt, C. A.**, 1964, Basement rocks and structural evolution of southern Oklahoma: Oklahoma Geological Survey Bulletin 95, 302 p.

Ham, W. E., and Wilson, J. L., 1967, Paleozoic epeirogeny and orogeny in the central United States: American Journal of Science, v. 265, p. 332–407.

Harlton, B. H., 1966, Relation of buried Tishomingo uplift to Ardmore basin and Ouachita Mountains, southeastern Oklahoma: American Association of Petroleum Geologists Bulletin, v. 50, 1365–1374.

———, 1976, Salient features of the Arbuckle uplift, the adjacent Ardmore basin and the Ouachitas: Gulf Coast Association of Geological Societies, Guidebook for 1976 Field Trip, October 15–17, 1976, p. 46–57.

Hart, D. L., Jr., 1974, Reconnaissance of water resources of the Ardmore and Sherman quadrangles, southern Oklahoma: U.S. Geological Survey and Oklahoma Geological Survey, Hydrological Atlas 3.

Hart, T. A., 1970, Areal geology and Cretaceous stratigraphy of northwestern Bryan County, Oklahoma: University of Oklahoma unpublished M.S. thesis, 215 p.

Hedlund, R. W., 1962, Palynology of the Red Branch Member of the Woodbine Formation (Upper Cretaceous) in Bryan County, Oklahoma: University of Oklahoma Ph.D. dissertation, 146 p., 9 pl.

———, 1966, Palynology of the Red Branch Member of the Woodbine Formation (Cenomanian), Bryan County, Oklahoma: Oklahoma Geological Survey Bulletin 112, 69 p.

Heilborn, George, 1949, Stratigraphy of the Woodbine formation, McCurtain County, Oklahoma: University of Oklahoma unpublished M.S. thesis, 48 p.

Hill, R. T., 1887a, Present knowledge of the geology of Texas: U.S. Geological Survey Bulletin 45, 95 p.

———, 1887b, The Texas section of the American Cretaceous: American Journal of Science, v. 34, ser. 3, no. 202, p. 287–309.

———, 1887c, The topography and geology of the Cross Timbers and surrounding regions in northern Texas: American Journal of Science, v. 133 (3d series, v. 33), p. 291–303.

———, 1888, The Trinity formation of Arkansas, Indian Territory and Texas: Science, v. 11, p. 21.

———, 1891, The Comanche Series of the Texas region: Geological Society of American Bulletin, v. 2, p. 503–528.

———, 1894, Geology of parts of Texas, Indian Territory, and Arkansas adjacent to Red River: Geological Society of America Bulletin, v. 5, p. 297–338.

———, 1901, Geography and geology of the Black and Grand Prairies, Texas: U.S. Geological Survey 21st Annual Report, pt. 7, 666 p.

Hill, R. T., and Vaughn, T. W., 1898, Lower Cretaceous Gryphaeas of Texas: U.S. Geological Survey Bulletin 151, 139 p.

Holtzman, Alan M., 1978, The areal geology and Cretaceous stratigraphy of northwest Marshall County, Oklahoma: University of Oklahoma unpublished M.S. thesis, 97 p.

Honess, C. W., 1930, Atoka, Pushmataha, Bryan, and Choctaw Counties, *in v. 3 of* Oil and gas in Oklahoma: Oklahoma Geological Survey Bulletin 40, p. 83–108. (Originally published in 1927 as Oklahoma Geological Survey Bulletin 40-R).

Huffman, G. G., 1959, Pre-Desmoinesian isopachous and paleogeologic studies in central Mid-Continent region: American Association of Petroleum Geologists Bulletin, v. 43, p. 2541–2574.

———, 1976, Hydrocarbon accumulation along the Cumberland thrust, Bryan County, Oklahoma: Gulf Coast Association of Geological Societies, Guidebook for 1976 Field Trip, October 15–17, 1976, p. 65–82.

———, 1977a, New water resources for Choctaw and Atoka Counties, Oklahoma: Oklahoma Geology Notes, v. 37, p. 159–166.

———, 1977b, Stratigraphy of the Bokchito Formation (Cretaceous) in southern Oklahoma: Oklahoma Geology Notes, v. 37, p. 11–18.

Huffman, G. G., Alfonsi, P. P., Dalton, R. C., Duarte-Vivas, A., and Jeffries, E. L., 1975, Geology and mineral resources of Choctaw County, Oklahoma: Oklahoma Geological Survey Bulletin 120, 39 p.

Huffman, G. G., Cathey, T. A., and Humphrey, J. E., 1963, A guide to the state parks and scenic areas in the Oklahoma Ozarks: Oklahoma Geological Survey, Guidebook 12, 95 p.

Hutchison, L. L., 1911, Preliminary report on the rock asphaltite, petroleum, and natural gas in Oklahoma: Oklahoma Geological Survey, Bulletin 2, 256 p., 13 pls., 30 figs.

Imlay, R. W., 1944, Correlation of Lower Cretaceous formations of the Coastal Plain of Texas, Louisiana, and Arkansas, 1944: U.S. Geological Survey Oil and Gas Investigations Preliminary Chart 3.

International Oil Scouts Association, 1976, Yearbook for 1975, v. XLV, part II.

Jeffries, E. L., 1965, Areal geology of western Choctaw County, Oklahoma: University of Oklahoma unpublished M.S. thesis, 51 p.

Larkin, Pierce, 1909, A preliminary report on the Cretaceous of Oklahoma: University of Oklahoma unpublished B.A. thesis, 141 p.

Lewis, Kenneth E., ed., 1975, Fort Washita from past to present, an archeological report: Oklahoma Historical Series in Anthropology, no. 1, 287 p., 89 figs.

Lozo, F. E., 1959, Stratigraphic relations of the Edwards limestone and associated formations in north-central Texas, *in* Lozo, F. E., and others, Symposium on Edwards limestone in central Texas: University of Texas Publication 5905, p. 1–20.

Manley, F. H., Jr., 1965, Clay mineralogy and clay mineral facies of the Lower Cretaceous Trinity Group, southern Oklahoma: University of Oklahoma unpublished Ph.D. dissertation, 116 p.

Marcou, Jules, 1856, Reports of explorations and surveys to ascertain the most practical and economic route for a railroad from the Mississippi River to the Pacific Ocean, made under the direction of the Secretary of War, 1853-54: Washington, D.C., U.S. 33d Cong. 2d. sess., H. Ex. Doc. 91, v. 3, 175 p.

Maxwell, R. W., 1959, Post-Hunton, pre-Woodford unconformity in southern Oklahoma, *in* Petroleum geology of southern Oklahoma, v. II: American Association of Petroleum Geologists, Ardmore. Geological Society Symposium, p. 101–126.

Miser, H. D., 1926, Geologic map of Oklahoma: U.S. Geological Survey Geologic Atlas of the United States, State of Oklahoma, scale 1:500,000.

———, 1954, Geologic map of Oklahoma: U.S. Geological Survey and Oklahoma Geological Survey, scale 1:500,000.

Morris, J. W., 1954, Oklahoma geography: Harlow Publishing Company, Oklahoma City, 154 p.

Morris, J. W., and McReynolds, E. C., 1965, Historical atlas of Oklahoma: University of Oklahoma Press, 70 plates and text.

Morris, R. C., 1977, Petrography of Stanley-Jackfork Sandstones, Ouachita Mountains, Arkansas, *in* G. G. Stone, ed., Symposium on the geology of the Ouachita Mountains, Arkansas Geological Commission, v. 1, p. 146–157.

Morrison, J. W., 1964, Historical statement, Bryan County *in* Pyle, L. E., Dowell, C. L., and Atherton, E. P., An overall development program for Bryan County, Oklahoma: County Program Planning and Resource Development Council, 99 p.

Morton, S. G., 1834, Synopsis of the organic remains of the Cretaceous group of the United States: Key and Biddle, Philadelphia, 88 p., 19 pls.

Oklahoma Historic Sites Committee, 1958, Oklahoma historic sites survey: Oklahoma Historical Society, Oklahoma City, 32 p.

Olson, L. J., 1965, Geology of eastern Bryan County, Oklahoma: University of Oklahoma unpublished M.S. thesis, 64 p.

Peach, W. N., and **Poole, R. W.**, 1965, Human and material resources of Bryan County—a profile for growth and development: Southeastern State College, Technology Use Studies Center, Durant, Oklahoma, 129 p.

Perkins, B. F., 1960, Biostratigraphic studies in the Comanche (Cretaceous) series of northern Mexico and Texas: Geological Society of America, Memoir 83, 138 p.

Petroleum Information Corporation, 1977, Report for 1976 (formerly Vance-Rowe Reports), v. 2.

Prewit, B. N., 1961, Subsurface geology of the Cretaceous coastal plain, southern Oklahoma: University of Oklahoma unpublished M.S. thesis, 82 p.

Pyle, L. E., **Dowell, C. L.**, and **Atherton, E. P.**, 1964, An overall economic development for Bryan County, Oklahoma: County Program Planning and Resource Development Council, 99 p.

Redman, R. H., 1964, Post-Mississippian geology of Love County, Oklahoma: University of Oklahoma unpublished M.S. thesis, 73 p.

Roemer, F. V., 1846, A sketch of the geology of Texas: American Journal of Science, v. 52 (2d. series, v. 2), p. 358–365.

———, 1848, Contributions to the geology of Texas: American Journal of Science, v. 56 (2d. series, v. 6), p. 21–28.

———, 1852, Die Kriedebildungen von Texas und ihre organische Einschlüsse (The Cretaceous formations of Texas and their organic remains): Adolph Marcus, Bonn, Germany, 100 p.

Ruth, Kent, and staff of University of Oklahoma Press, eds., 1957, Oklahoma—A guide to the Sooner State (revised edition): University of Oklahoma Press, 532 p.

Saether, Ola M., 1976, Depositional history of the Devils Kitchen sandstones and conglomerates in the Ardmore basin: University of Oklahoma unpublished M.S. thesis, 95 p.

Shelburne, O. B., Jr., 1959, A stratigraphic study of the Kiamichi Formation in central Texas, *in* Lozo, F. E., and others, Symposium on Edwards limestone in central Texas: University of Texas Publication 5905, p. 105–119.

Shumard, B. F., 1860, Observations upon the Cretaceous strata of Texas: St. Louis Academy of Sciences Transaction, v. 1, p. 582–590.

ous strata of Texas: St. Louis Academy of Sciences

Transaction, v. 1, p. 582–590.

Shumard, G. G., 1853, Remarks upon the general geology of the country passed over by the exploring expedition to the sources of Red River, under command of Captain R. B. Marcy, U.S.A., *in Appendix B* of Marcy, R. B., and McClellan, G. B., Exploration of the Red River of Louisiana in the year 1852: Robert Armstrong, Public Printer, Washington, D.C., p. 179–195.

———, 1886, A partial report on the geology of western Texas with an appendix giving a detailed report on the geology of Grayson County: State Printing Office, Austin, 145 p. appendix 123–145.

Skolnick, Herbert, 1949, the lithology and stratigraphy of the Tokio formation of McCurtain County, Oklahoma: University of Oklahoma unpublished M.S. thesis, 35 p.

Slocki, S. F., 1967, Physical stratigraphy of the Georgetown Limestone equivalent in Tarrant, Denton, and Cooke Counties, *in* Hendricks, Leo, ed., Comanchean (Lower Cretaceous) stratigraphy and paleontology of Texas: Permian Basin section, Society of Economic Paleontologists and Mineralogists, Publication 67–8, p. 182–216.

Stanton, T. W., 1928, The Lower Cretaceous or Comanchean Series: American Journal of Science, v. 216 (5th series, v. 16), p. 399–409.

———, 1947, Studies of some Comanchean pelecypods and gastropods: U.S. Geological Survey Professional Paper 211, 256 p.

Stenzel, H. B., 1959, Cretaceous oysters of southwestern North America *in* Kellum, L. B., chairman, El Sistema Cretácico—un symposium sobre el Cretácico en el Hemisferio Occidental y su correlación mundial: Mexico City, 20th International Geological Congress, v. 1, p. 15–37.

———, 1971, Oysters, *v. 3 of* Bivalvia, *pt. N of* Moore, R. C., ed., Treatise on invertebrate paleontology: Geological Society of America and University of Kansas Press, p. 953–1224.

Stephenson, L. W., 1918, A contribution to the geology of northeastern Texas and southern Oklahoma: U.S. Geological Survey Professional Paper 120-H, p. 129–163.

———, 1927, Notes on the stratigraphy of the Upper Cretaceous formations of Texas and Arkansas: American Association of Petroleum Geologists Bulletin, v. 11, p. 1–17.

———, 1952, Larger invertebrate fossils of the Woodbine Formation (Cenomanian) of Texas: U.S. Geological Survey Professional Paper 242, 226 p.

Taff, J. A., 1902, Description of the Atoka quadrangle (Indian Territory): U.S. Geological Survey Geologic Atlas, Folio 79, 8 p.

———, 1903, Description of the Tishomingo quadrangle (Indian Territory): U.S. Geological Survey Geologic Atlas, Folio 98, 8 p.

———, 1905, Portland cement resources of Texas: U.S. Geological Survey Bulletin 243, p. 307–312.

Taff, J. A., and **Leverett, S.**, 1893, Report on the Cretaceous area north of the Colorado River *in* Fourth annual report of the Geological Survey of Texas, 1892, pt. 1, p. 241–354.

Thoburn, J. B., 1916, A standard history of Oklahoma: American Historical Society, Chicago and New York, 5 vols., 2192 p.

Tomlinson, C. W., and **McBee, Wm., Jr.**, 1959, Pennsylvanian sediments and orogenies of Ardmore district, Oklahoma, *in* Petroleum geology of southern

Oklahoma, v. II: American Association of Petroleum Geologists, Ardmore Geological Society, p. 3–52.

U.S. Bureau of Mines, Minerals Yearbooks for 1960–1974.

Vanderpool, H. C., 1928, A preliminary study of the Trinity Group in southwestern Arkansas, southeastern Oklahoma, and northern Texas: American Association of Petroleum Geologists Bulletin, v. 12, p. 1069–1094.

Wilmarth, M. G., 1938, Lexicon of geological names of the United States: U.S. Geological Survey Bulletin 896, 2396 p.

Womack, J. L., 1956, Aylesworth Field *in* Petroleum geology of southern Oklahoma, v. I: Ardmore Geological Society, p. 373–391.

Wright, M. H., and **Shirk, G. H.**, eds., 1958, Oklahoma historical marker—mark of heritage: Oklahoma Historical Society, 24 p.

Young, Keith, 1957, Upper Albian (Cretaceous) Ammonoidea from Texas: Journal of Paleontology, v. 31, p. 1–33.

———, 1959, Edwards fossils as depth indicators *in* Lozo, F. E., and others, Symposium on Edwards limestone in central Texas: University of Texas Publication 5905, p.97–104.

———, 1963, Upper Cretaceous ammonites from the Gulf Coast of the United States: University of Texas Publication 6304, 373 p.

APPENDIX A.—MEASURED STRATIGRAPHIC SECTIONS

1. Southwest of Durant: large gullies, 0.25 mile east of overpass over new U.S. Highways 69 and 75. Near south line SE¼SE¼ sec. 36, T. 6 S., R. 8 E., and in adjacent part of sec. 1, T. 7 S., R. 8 E. (Hart, 1970, p. 187).

	Thickness (ft)
WOODBINE FORMATION	
Red Branch Member	
Sandstone, clayey, medium-orange matrix; sand, fine- to medium-grained, subrounded to subangular, moderately well cemented; rock, moderately well sorted. Clay and sand subequal. Locally one bed 1.0 foot thick, other beds 0.2 to 0.3 foot thick	1.4
Dexter Member ("Rainbow Clay")	
Clay, poorly exposed, light- to medium-gray where fresh, darker shades where wet; weathering pastel shades of purple, red violet, medium to dark red, and light brown, with medium orange being most common. Pastel weathered colors in spots are several inches in diameter and in points visible under magnification. Coloration more prominent in lower part, decreasing upward with encrusted purple masses in lower part; top 5 feet red in color. Platy in good exposures which are rare	38.0
Clay, fairly well exposed, weathers dull pastel purple; irregularly platy. Abundant clay ironstone, tending to sheety form, in places standing vertically out of the soil, adjacent is yellow coloration because of iron oxides, many black carbonized wood fragments	1.6

2. Northwest edge of Durant: Roadcut along Washington Street (section-line road), several hundred feet south of Chukwa Creek. NE¼SE¼SE¼ sec. 19, T. 6 S., R. 9 E. (Hart, 1970, p. 188. This section was independently measured and described by Currier; see measured section 46, this report.)

	Thickness (ft)
WOODBINE FORMATION	
Dexter Member (Dexter Sandstone unit)	
Sandstone, yellow-orange to orange, medium- to fine-grained, becoming fine upward, very well sorted, subrounded, soft and friable; stringers of well-cemented ferruginous sandstone. Beds range from 0.1 to 3.0 feet thick, are subparallel, some dipping 5 to 10 degrees southward. Some clay, especially in upper 10 to 12 feet, gray, in bands or lenses as much as 1 foot thick and 5 to 10 feet long, often interbedded with sand	34.7
Clay and sandsone: clay, light-gray to yellow-orange (both fresh and weathered); blocky. Clay and sandstone irregularly interbedded; gray clay streaks occur in the sandy layers	6.0
Clay, light-gray, darker when dry, weathering dark pink and orange; platy, clay ironstone bed 0.3 foot thick near middle	12.0
Sandstone, similar to underlying unit, gray sandstone beds form stringers of irregular shape and size	13.3
Sandstone, main rock dark-reddish-orange with mottled masses of moderately light gray, medium-grained near base, becomes fine upward, very well sorted, subrounded. Some gray, clayey sandstone (sticky when wet); both types moderately soft and friable. Gray sandstone is less resistant and characterized by rounded "pipes." Upper contact irregular	6.0
Dexter Member (Basal Shale unit)	
Clay, sandy, gray to red; sticky and firm when wet; fine-grained sand; much finely divided carbonaceous material in clay, upper contact irregular	0.8
Covered	7.4
GRAYSON MARLSTONE	
Clay, very light gray, weathering yellow; massive; one irregular bed of coquinitic limestone, with very fine, dense matrix. *Ilymatogyra arietina* and other pelecypods	2.5
Covered	2.6
BENNINGTON LIMESTONE (not measured).	

3. Northwest of Mead: high bank along sharp bend in Newberry Creek, about 0.4 mile west-northwest of right-angle turn in road. NE¼SW¼SW¼NE¼ sec. 25, T. 6 S., R. 7 E. (Hart, 1970, p. 189).

	Thickness (ft)
WOODBINE FORMATION	
Dexter Member (Dexter Sandstone unit)	
Sandstone, largely light-brown, weathering orange brown; medium grained, well to very well sorted, soft and friable; various parts are well cemented by dark-red hematite and dark-green glauconite. Crossbedding in wedge sets with truncation between sets, grades downward and laterally into clay	8.5
Dexter Member (Basal Shale unit)	
Clay, very poorly exposed, weathers light brown. Contains irregular spots of carbonaceous material. Section of 20 feet passes laterally into sandstone in upper part	20.0
Clay, gray-black, carbonaceous, weathers lighter; platy; orange coating, possible jarosite(?) on plate surfaces	7.5

Sandstone, fine- to medium-grained; crumbly to hard; ferruginous, locally containing vitreous yellow crystalline material, some fragile pelecypod remains, bed cuts into underlying clay section 0.1
Clay, moderately dark gray (dark-gray when wet), weathers lighter; platy; limonite coating on plates; occasional satinspar and selenite crystals; rare pelecypod remains 9.1
Clay, Black, limonitic stains, locally crumbly limonitic material; minute vitreous yellow crystals (siderite ?) 0.6

GRAYSON MARLSTONE
Clay, moderately dark to dark-gray; fissile to platy, *Texigryphaea* and other pelecypods in lower 1.1 feet. fragmented, some pockmarked by boring organisms 2.0
Limestone, light-gray; very fine and compact; fossils locally comprise 30 to 50 percent of rock, especially at top; nodular and irregularly bedded, clay interbeds, abundant pelecypods, some marked by boring organisms 0.5
Clay, irregularly platy, subordinate limestone nodules 0.6
Limestone, nodular to thin-bedded, minor amounts of clay 0.3
Clay with minor amounts of limestone nodules 0.2
Limestone, nodular to thin-bedded, minor amounts of clay 0.6
Clay with minor nodules of limestone. Abundant pelecypods, grades laterally into nodular limestone 0.7
Limestone and clay, subequal; limestone, nodular-bedded, minor amounts of clay, abundant *Texigryphaea roemeri* (Marcou) 0.8
Clay, medium gray (moderately dark when wet); massive; minor amounts nodular limestone; fucoids, one cherty; abundant pelecypods and fossil fragments 0.5
Clay with limestone: clay, moderately dark gray, unfossiliferous; limestone, very fine to dense, in nodular masses, often attached; locally abundant *T. roemeri* (Marcou) and other pelecypods 0.2
Clay, gray to medium-dark-gray, massive 0.6

4. High Bank on Newberry Creek, on half section line, usually approached from the east. NW¼SW¼NE¼ sec. 25, T. 6 S., R. 7 E. (Hart, 1970, p. 191).

Thickness (ft)

WOODBINE FORMATION
Dexter Member (Basal Shale unit)
Clay, very light gray, weathering light brown, appears massive, unfossiliferous 6.0
Covered (interval probably includes dark-gray clay shale) 8.6

GRAYSON MARLSTONE
Clay, very light gray, mostly complexly fractured, a few *Texigryphaea roemeri* (Marcou) 2.2
Clay and limestone: clay, light-gray to very light gray, massive to slightly platy; limestone nodules in great abundance, white, very fine to dense, concentrated in lower 1 foot and in 10 beds mostly about 1 foot apart through section. Many *T. roemeri* (Marcou) found in abundance with large specimens of *Pecten texanus*, without preferred orientation 10.5
Clay, light-greenish-gray to slightly greenish gray, slightly platy, fractured, unfossiliferous 3.3
Clay and limestone: clay, light-gray, fractured; abundant limestone in nodular masses, some large fucoids; limestone weathers white to yellowish, chalky, very fine to dense, occasional pelecypods 0.3
Clay, light-gray (moderately dark when wet), fractured, few fossils 0.3
Limestone, gray-white to light-gray, very fine to dense, chalky. Passes laterally into nodular limestone and clay interbeds; clay, light-gray. *Texigryphaea roemeri* (Marcou), *Pecten*, not too abundant, convex upward 0.6
Clay, light-gray to moderately gray, fissile; abundant *Pecten*, some *Ilymatogyra arietina*, and *Mariella (Plesioturrilites) brazoensis*, and other turrilitids 0.4
Limestone, light-gray, very fine to dense. Some *I. arietina, Pecten, M. (P) brazoensis* and other turrilitids 0.5
Clay with limestone, light-gray to moderately light gray, bluish, massive to slightly fissile. Locally 20 percent composed of fossils, especially *Ilymatogyra arietina* and *Pecten*, without preferred orientation. Limestone in nodules, very light gray, weathering white, very fine to dense, some fossils embedded in nodules, fucoids present 1.8
Limestone, light-gray, very fine to dense. Abundant fossils with *Ilymatogyra arietina* and *Pecten*, usually oriented convex upward or on its side. Top undulating 0.5
Clay, medium-gray (moderately dark when wet); massive to thinly bedded. Abundant *I. arietina*, occasional *Pseudananchys completa* oriented with bedding 0.4
Limestone, light-gray to moderately light gray, very fine to dense. Concentrations of *I. arietina* on upper surface give hummocky appearance; some show convex downward orientation 0.4
Limestone, exposed below water level in creek 1.1

5. Ledges along Chukwa Creek, about 500 feet west of Washington Street (section-line road). NE¼SE¼SE¼ sec. 19, T. 6 S., R. 9 E. (Hart, 1970, p. 193–194).

	Thickness (ft)
GRAYSON MARLSTONE	
Clay, marly, poorly exposed, white, fossils on weathered slope, especially *Texigryphaea roemeri* (Marcou)	3.0
Limestone, white, weathers yellowish white, very fine grained to dense, in flattened nodular masses. Locally consists of 40 to 50 percent fossils, especially *Ilymatogyra arietina*	0.3
Clay, marly, poorly exposed, white to light-gray, abundant *I. arietina*, discontinuous limestone bed 0.3 foot above base	2.0
Limestone, white to light-gray, very fine grained to dense, in irregular nodular masses. Marly zone 0.1 to 0.3 foot thick in middle, abundant *I. arietina*	0.7
Clay, marly, white to light-gray, massive	2.4
Limestone, white, weathers cream colored, very fine grained to dense, bed in nodular masses	0.2
Clay, white to light-gray, weathers light brown, massive, *Ilymatogyra arietina* common	0.4
BENNINGTON LIMESTONE	
Limestone, white to brown, weathers brown, matrix very fine grained to dense; in most places 20 to 40 percent fossils, in rough angular beds separated by shale breaks, *I. arietina* common	1.5
Limestone and clay: limestone white, weathers light brown, very fine to dense; clay weathers light brown, crumbly. Some fossils, mostly in fragments	0.8
Limestone, white, weathers light dull brown, very fine grained to dense, interbedded with streaks of clay; fossils comprise 15 to 20 percent of rock, especially *I. arietina*	0.3
Clay, moderately light gray, thickness variable, contact undulating, fossils, especially *I. arietina* comprise 10 to 15 percent of rock	0.3
Limestone, light-gray to white, weathers light yellow brown, very fine grained to dense. Two irregular beds of clay, 0.1 to 0.2 foot thick with undulating surfaces, clay moderately light gray, crumbly, unfossiliferous	2.0
Clay, medium-gray, weathers very light gray and light brown, irregular bedding, subordinate amounts of marly limestone. Some pelecypods. Interbeds with underlying unit	1.1
Limestone, white to very light gray, fine-grained to dense matrix, interbeds with thin, marly limestone, fossiliferous with *Rastellum quadriplicatum*, *Pecten*, and *Ilymatogyra arietina*	1.6
Limestone, white, weathers light brown, very fine grained to dense, locally marly, splits into very thin beds	0.2
Limestone, white, weathers light brown, very finely crystalline to dense, abundant fossil fragments, *Rastellum quadriplicatum* abundant at top	1.5
BOKCHITO FORMATION	
Pawpaw Member	
Clay, moderately light gray, platy, irregular with undulating surfaces; plate surfaces sandy. Sand, yellow-orange and orange, very fine grained, very well sorted, subrounded; top of unit undulatory like other contacts in section, probably conformable	2.1
Sandstone, green-black, very fine grained, very well sorted, subrounded, moderately soft and friable; contains chert nodules and hematite concretions, highly glauconitic, abundant fragile pelecypod fragments	1.0
Clay, green-black, massive, pebble-sized galls contain fossils; chert pebbles and chert nodules present; abundant fragile pelecypod remains	0.3
Sandstone, light-brown, weathers medium orange, very fine grained, very well sorted, subrounded grains, soft and friable, firmly packed, massive	2.6

6. High bank along creek, 0.15 mile south of intersection of U.S. Highway 70 and side road. SE¼NE¼SE¼ sec. 25, T. 6 S., R. 10 E. (Hart, 1970, p. 195)

	Thickness (ft)
BOKCHITO FORMATION	
Pawpaw Member	
Sandstone in excellent but inaccessible exposure, all float indicates same lithology as in bed below	14.0
Sandstone (or sand), mostly cream-colored to very light yellow, very fine grained, very well sorted, subrounded, soft and friable to hardly coherent; locally orange or moderately dark red; the red sandstone being moderately friable. Numerous clay inclusions and very thin shale, breaks along bedding surfaces. Crossbedded, including wedge sets and tabular to lenticular sets; major sets are 1 to 3 feet thick; ripple marks, essentially oscillatory	18.0
Clay, medium-gray (moderately dark when wet), weathers dark red on exterior and along bedding surfaces; platy, bands of brightly colored, medium-yellow clay near top; thin	

beds and stringers of dark-red or medium-gray sandstone; very fine grained, very well sorted, subrounded, friable 2.0

Note: This section was taken a few feet below the Bennington Limestone.

7. South bank of creek about 300 feet south of U.S. Highway 70. NE¼NW¼SW¼ sec. 30, T. 6 S., R. 11 E. (Hart, 1970, p. 196).

	Thickness (ft)
BOKCHITO FORMATION	
McNutt Member	
Limestone, sandy, only partially exposed	10.0
Limestone, sandy, white, weathering brown to red; fine-grained, crystalline; fine sand visible. Beds about 0.1 foot thick form units 0.6 to 1.0 foot thick, some crossbedding with truncated wedge sets	6.4
Calcarenite, composed of light-brown to brownish-orange grains consisting of sand-sized, rounded, fossil fragments in a ferruginous matrix	1.1

Note: Several feet lower are two beds of limestone which resemble the McNutt lithology. Hart (personal communication, 1977) remains of the opinion that these limestones should be considered a local facies of the Weno.

8. North roadcut, U.S. Highway 70, a few hundred feet east of Blue River; lowest described section is in a small gully closer to river. Located in SW¼SE¼ sec. 27 T. 6 S., R. 10 E. (Hart, 1970, p. 196–197).

	Thickness (ft)
BENNINGTON LIMESTONE	
Limestone, very light gray; very fine and dense, hard; abundant pelecypods	0.5
Clay (poorly exposed), chalky; abundant pelecypods, though fewer than in limestones	0.6
Limestone, very light gray; very fine and dense, hard; with *Rastellum quadriplicatum*, *Ilymatogyra arietina*, other pelecypods	2.0
Limestone, very light gray; very fine, chalky, 5 to 10 percent sparry calcite grains; many pelecypods	2.9
BOKCHITO FORMATION	
Pawpaw Member	
Sandstone, highly mineralized, massive, brown-black, probably very fine grained, minor coarse sand and granules (feldspar, quartz); bands of black ferruginous cement and green glauconite crystals, masses of limonite; fragile pelecypod remains	0.6
Clay, light-gray (medium-gray wet), weathering lighter; platy and weathering flaky; selenite gypsum crystals on plate surfaces	4.6
Clay, dark-red, fresh and weathered; moderately hard; fracturing irregularly; masses of gray and glauconitic green clay included	0.2
Clay, dark-gray, weathering lighter; platy, fine sand and minute selenite grains on plate surfaces; thin ironstone concretionary laminae here and there, some with gray clay internally	4.8
Sandstone, partly orange, soft and friable, partly dark-red, moderately well cemented ferruginous; very fine grained, very well sorted; pelecypod specimens and molds, mostly fragmentary. Passes laterally into clay like overlying unit	1.5
Clay, dark-gray, weathering lighter; platy, very fine sand and minute selenite grains on plates. Interval laterally includes as much as 0.4 foot of sandstone, light-yellow-brown; very fine grained, very well sorted; ferruginous cement; laminated with ferruginous stains on partings	1.5
Clay, medium-gray, weathering light brown; platy and blocky. Black carbonaceous fragments and specks on plate surfaces	2.8
Covered	3.2
Sandstone, light-yellow-brown; very fine grained; very well sorted, mostly soft and friable. Upper 2.8 feet contain hard, ferruginous, cemented stringers. Irregular lower contact, unit varies from 3.4 to 4.2 feet in thickness	3.8
Poorly exposed; clay, bright-medium-gray, weathering light brown	1.4
Sandstone, orange-brown, weathering light brown; very fine grained, very well sorted, subrounded, soft and friable	0.3
Clay, as in next overlying clay bed	0.3
Sandstone, as in next overlying sandstone bed	0.3
Covered interval (about)	16.0
Clay, medium-gray; platy; some plates show very fine sand, other minute selenite grains on surfaces; chert nodules in lower 1.5 feet; masses of limonite. Two small lenses of sandstone, limonitic yellow, weathering yellow-orange, very well sorted, subrounded, with abundant fragile pelecypods. Gully is filled with slabs resembling the McNutt Limestone which may be included in lower part of interval. Slump has probably extended interval here	7.7

Note: In the south roadcut, about 13 to 27 feet below the Bennington, are large masses of calcareous sandstone reefoid material. The sandstone is light yellow brown to medium orange, weathering light brown; fine grained, very well sorted, subrounded, mostly moderately well cemented; *Rastellum quadriplicatum* (Shumard), barnacles, *Gryphaea, Exogyra drakei, Nucula* sp.

9. East side of a hill below pond and road. Near the center N½SE¼NE¼ sec. 12, T. 6 S., R. 7 E. (Hart, 1970, p. 198–199).

	Thickness (ft)
BOKCHITO FORMATION	
McNutt Member	
Limestone, gray, very sandy, weathers dark red: 40 to 80 percent composed of fossil material, mainly coarse sand and small gravel-sized fragments; abundant whole pelecypods, probably tending parallel to bedding. Small spots of fine, subrounded sand visible	0.7
Limestone, gray, sandy, weathers reddish brown, scattered fossils	2.1
Limestone, gray, sandy, ferruginous, weathers light brown to light orange brown; sand, fine- to medium-grained, subangular to subrounded; very hard. Abundant pelecypods and large fragments, largely found in concentrations, not aligned to bedding	0.7
Clay, poorly exposed, partly covered; where visible light or very light gray, weathering light orange brown; platy and flaky	17.0
Limestone, weathers very sandy; sand, very fine to fine-grained, subangular to subrounded. Many pelecypods, often in concentrations, whole and large fragments in various orientations; abundant fucoids. Grades directly from underlying unit	1.5
Weno Member	
Sandstone, light-yellow-orange to light-brown, very fine to fine-grained, subangular to subrounded, soft and friable. Pelecypod casts	1.0
Sandstone, light-yellow-orange to orange; fine-grained, subangular to subrounded, soft and friable; trace of muscovite; bands and streaks of gray clay and clay ironstone, especially about 0.7 to 1.0 foot above base	3.5
Sandstone, medium-orange to medium-brown; fine- to medium-grained, subangular to subrounded, very well sorted, soft and friable; a few percent muscovite; exposure rounded in aspect, very vague beds 0.2 to 0.3 foot thick. At varying levels, 1 to 3.5 feet above base, zone containing flakes of very light gray clay and clay ironstone molds; some of the molds are of pelecypods, *Nucula, Corbula, Remondia* and the brachiopod *Kingena*	8.2

10. Heights above Lake Texoma, embankment facing west, behind trees in NW¼NE¼NW¼ sec. 22, T. 6 S., R. 7 E. (Hart, 1970, p. 200-201).

	Thickness (ft)
BOKCHITO FORMATION	
McNutt Member	
Limestone, sandy, fossiliferous, light-gray, weathering light brown and orange; limestone matrix probably very fine grained and dense; sand, fine-grained with a few medium grains, moderately well sorted, subrounded to subangular. Abundant *Rastellum quadriplicatum, R. subovatum* tending to be oriented *concave* upward	0.8
Covered	9.0
Limestone, sandy, fossiliferous, very light gray, weathering yellow brown and orange; sand, fine- to very fine grained, moderately well sorted, subrounded to subangular. Abundant *R. quadriplicatum* and other pelecypods, oriented concave up. Two beds 0.4 to 0.7 foot and 1.6 feet thick	3.0
Weno Member	
Covered	11-12
Sandstone, medium- to dark-orange; very fine grained, very well sorted, subrounded, soft and friable; horizontal beds, 0.2 to 0.3 foot thick, breaking into blocks. Minor light-gray clayey streaks	3.5
Sandstone, yellow-orange to orange; very fine grained, very well sorted, subrounded, soft and friable. Laminated, with clay partings, except for three beds 0.1 to 0.2 foot thick; well indurated sand next to partings	3.1
Sandstone, resembles underlying unit except in bedding. Major beds various thicknesses, forming inclined, truncated laminated sets, all dipping in same direction, steeper dips in thicker beds	3.8
Sandstone, light-yellow to medium-orange, fine-grained to medium-grained, very well sorted, subrounded to near subangular, soft and friable. Bedding horizontal or indiscernible; major beds 1.0 to 1.5 feet thick, locally divided into two or three thinner beds. Beds of siltstone, light-gray, weathering yellow orange; 0.1 to 0.2 foot thick, near top. Minor amounts of light-gray clay; platy to fissile	6.7
Clay, fair to poor exposure; clay, medium-gray to moderately light gray. Streaked with very fine sand and silt, small sandstone lens included	3.5
Sandstone, light-orange to medium-orange; very fine grained, very well sorted, subrounded, extremely soft and friable, less soft when darker; ferruginous cemented sheets through unit; horizontal to slightly	

inclined lamination. This is maximum thickness, contacts undulatory, wedging out laterally 2.3

Clay and sandstone: clay moderately dark gray; sandstone as in underlying unit. Clay and sand laminated, sandstone also in small lenses. Contacts undulatory, especially upper one 0.7

Sandstone, silty, light-yellow-brown; fine sand and coarse silt; very well sorted, subrounded, extremely soft and friable except where grading into hard ferruginous laminae, which are probably clayey. Uniform inclined bedding, except horizontal near top. Probably matches highest sandstone unit in measured section 11 ...... 3.0

Clay, fair to poor exposure, medium-gray, weathering light brown; fissile, partially interspersed very fine sand. Top of unit undulatory 2.0

Sandstone, medium-orange or dull-medium-brown (when wet); very well sorted, subrounded, mostly soft and friable; interlaminated with well-cemented ferruginous material 0.4

Clay, poorly exposed, medium-gray to moderately dark gray (when wet), weathering light brown. Traces of very fine sand and silt, perhaps on partings 4.0

11. Cut on headland, facing south, Lake Texoma, NW¼NE¼NW¼ sec. 22, T. 6 S., R. 7 E. (Hart, 1970, p. 201-202).

Thickness (ft)

BOKCHITO FORMATION

McNutt Member (not measured)

Weno Member

Covered 37.0

Sandstone, yellow-orange to medium-orange; very fine grained, very well sorted, subrounded to slightly subangular; soft and friable, except in local ferruginous occurrences. Believed to match fourth unit from base of measured section 10 ...... 2.5

Clay, silty, poorly exposed, dark-gray; platy. Small splotches of silt 1.8

Siltstone, yellow-orange to orange; very well sorted; partings on clay-ironstone. Top has features resembling tiny complex ripple marks, the waves being ¼ inch apart 0.1

Covered, apparently dark-gray clay under sandstone float 7.5

Clay, light-gray to moderately dark gray, weathering light brown; irregular and bedding fracture. Includes 0.1 to 0.2 foot of siltstone, yellow-orange, very well sorted, soft and friable 5.1

Siltstone, sandy, light-brown, faint orange weathering; coarse silt and finest sand; very well sorted, subrounded, soft and friable 0.3

Clay, light-gray to very dark gray, weathering light brown, shade of gray not according to wetness; lower part (approximately 7 feet) platy, upper part blocky with conchoidal fracture, bedding fracture increasingly noticeable near top. Minor siltstone bed near base; also ironstone concretions; scattered selenite crystals, some more than 1 inch in dimension 14.8

Water level, elevation probably near 615 feet.

12. Cuts along creek, about 0.1 mile south of section-line road, Poole Ranch. SW¼NE¼NE¼NW¼ sec. 6, T. 6 S., R. 10 E. (Hart, 1970, p. 203).

Thickness (ft)

BOKCHITO FORMATION

Denton Member

Clay, moderately light gray (moderately dark when wet), also weathering gray, occasionally pink. Small lenses (largest 0.2 foot thick) and plates of siltstone, light-yellow; a few poorly preserved pelecypod remains 7.0

Siltsone, medium-gray, weathering light yellow; grains indiscernible with 12X hand lens; locally broken by clay. Abundant poorly preserved juvenile *Texigryphaea* on undersurface 0.1

Clay, moderately light gray (moderately dark when wet), weathering yellow brown; platy, often irregularly, and fracturing 2.2

Siltstone, light-gray, weathering yellow; grains indiscernible; this or next higher siltstone has small fucoids 0.2

Clay, moderately light gray (moderately dark when wet); a few percent silt, trace of very fine sand (with mica), some samples much more silty. Irregular fracture. Scattered plates of siltstone included 5.6

CADDO FORMATION

Fort Worth Member

Limestone, light-gray, very fine and dense, irregular top (not measured).

13. Above creek on the Davisson Ranch, about 0.3 mile south-southeast of intersection of U.S. Highways 69 and 75 and side road. NE¼SW¼NW¼ sec. 1, T. 6 S., R. 9 E. (Hart, 1970, p. 203–204).

Thickness (ft)

BOKCHITO FORMATION

Denton Member

Clay, light-gray (darker when wet); bed of clay ironstone, 0.1 foot thick; selenite gypsum crystals 4.0

Siltstone, light-gray, weathering light brown; laminated, yellow, very fine grained, sandy partings 0.3

Clay, light-gray (darker wet), weathering light brown; platy and flaky; tiny gypsum crystals 1.4
Siltstone, moderately light gray, weathering brown; well indurated 0.1
Clay, light-gray (moderately dark when wet), weathering light brown; massive to blocky. Thin siltstone or fine sand bed near base 1.2
Clay, poorly exposed, medium-gray (darker when wet), weathering brown 2.4
Siltstone, sandy, light-gray, weathering yellow; laminated, fine or medium sand on partings, occasional ferromagnesian and feldspar grains. Many juvenile *Texigryphaea* and fucoids on surface, may not be laterally persistent 0.8
Clay, moderately light gray (darker when wet); massive or blocky, weathered material becoming platy. Rare pelecypods doubtfully belong here. Base indistinct 6.4

CADDO FORMATION
Fort Worth Member
Clay, moderately light gray (darker when wet); massive, weathering platy. Common *Texigryphaea washitaensis* and other pelecypods 0.4
Limestone, moderately light gray, lighter weathered; very fine, marly, locally very clayey. Grades into overlying and underlying unit. Abundant pelecypods and fragments in concentrations 0.6
Clay, as in lower units. Pelecypods very abundant locally 0.4
Limestone, light-gray, fresh and weathered; very fine grained and dense; clay breaks through unit in places. Abundant fossils and sand- and gravel-sized fragments, not aligned, in concentrations 0.7
Clay, moderately dark gray, weathering lighter; flaky and crumbly. Scattered limestone nodules. Abundant pelecypods. Irregular contacts 0.4
Limestone, as in lower units. Upper part contains 15 to 20 percent very fine sand sized grains, probably fossil material. Undulatory clay zone, 0.1 to 0.2 foot thick, in middle. Abundant pelecypods, juvenile *Drakeoceras* 1.3
Clay, gray; irregularly flaky. Intermingled with limestone nodules and fucoids, grading laterally into limestone. Fossils as in adjacent beds 0.6
Limestone, light-gray to very light gray; very fine grained and dense, with a few percent sparry grains; irregular bedding. *Texigryphaea washitaensis*, other pelecypods 0.4

14. Railroad cuts in the town of Caddo, about 0.35 mile southwest of State Highway 22 overpass. Located in the NE¼NE¼SW¼ sec. 16, T. 5 S., R. 10 E. (Hart, 1970, p. 209–210).

Thickness (ft)

CADDO FORMATION
Fort Worth Member
Limestone, very light gray, weathering light yellow brown; very fine and dense. Lower part some pelecypods, upper part 40 to 50 percent composed of pelecypods and gravel- and sand-sized fragments of them; fossils are at all orientations 2.4
Clay, with fucoidal limestone 0.1
Limestone, very light gray, weathering light yellow brown and yellow orange; very fine grained and dense; rough, irregular bedding, laced with clay. Some pelecypods, with little preferred orientation. Lower 1.5 feet nearly a distinct unit, in two beds; concentrations of fossils. Clay streaks light-gray or moderately light gray, flaky 5.0
Clay, moderately light gray, weathering lighter; flaky and crumbly. Near top, fucoids 0.5
Limestone, light-gray to white, some yellowish weathering; very fine grained and dense, hard; four very irregular beds. Between beds and in breaks clay, moderately light gray, weathering lighter; flaky. Limestone and clay contain *Texigryphaea* and other pelecypods, with local concentrations; also concentrations of sand-sized fossil fragments 3.3
Clay, poorly exposed at base.

15. Roadcuts and ditches, State Highway 22, on northwest side of town of Caddo; around the C SE¼ sec. 8, T. 5 S., R. 10 E. (Hart, 1970, p. 206–208).

Thickness (ft)

CADDO FORMATION
Fort Worth Member
Concealed. Heavy limestone float weathered light yellow; very fine and dense. *Texigryphaea* and other pelecypods, at top about 50 percent fossil content 1.7
Covered, apparently clay 3.3
Limestone, weathered light brown; very fine grained and dense; some pelecypods, at all orientations 0.7
Covered, probably mostly clay, weathering yellow brown 1.9
Limestone, probably light-gray, fresh, weathered yellowish and light brown; very fine-grained and dense. Many pelecypods and echinoids, in concentrations; locally 10 to 15 percent composed of sand-sized fossil fragments 0.7

Duck Creek Member
Covered, gray clay soil under cover 8.0
Limestone, as below 0.5
Concealed. Dark-gray clay soil under yellowish cover and limestone float 2.4
Limestone, light-gray, bluish under dim light; very fine grained and dense; shattered; unfossiliferous 0.4

Covered. Some clay, very dark gray, weathered 2.2
Limestone, as below; unfossiliferous 0.3
Clay, weathered, very dark gray; apparently platy 1.2
Limestone as below; unfossiliferous except for a few ammonites 0.5
Clay, weathered dark gray and light-brown; flaky 0.5
Limestone, very light to light-gray, bluish under weak light; very fine grained and dense; shattered. A few pelecypods, somewhat oriented convex upward 0.3
Clay, weathered dark gray; very flaky. Two thin siltstones, one light-blue-gray, other light-yellow 6.8
Limestone, light-gray, weathering yellowish; three beds. Locally up to 40 to 50 percent composed of *Texigryphaea* shells, often oriented convex *downward*. Sand-sized fossil fragments near top 0.6
Clay, medium-gray to moderately dark gray (when wet), weathering light gray; flaking very thin 3.6
Limestone, moderately light gray, weathering very light gray and light brown; very fine grained and dense; irregular thin beds, weathering shattered. Abundant *Texigryphaea* and other pelecypods, many ammonites ....
Clay, medium-gray (when wet), weathering light brown; platy and weathering fissile 0.9
Limestone, very light gray; very fine and dense; weathering into rounded masses, and then shattering. Abundant *Texigryphaea* sp. and other pelecypods 0.4
Clay, weathered light gray and light brown; platy and flaky. Some fossils, large ammonite near top 1.6
Limestone, as below. Medium-sized fucoids. Possibly clay in middle 0.8
Clay, as below 1.5
Limestone, very light gray, weathering light yellow; very fine grained and dense, slightly chalky. *Texigryphaea* and other pelecypods, at all orientations, ammonites, echinoids 0.2
Clay, weathered light gray and light brown 5.4

16. Roadcut, south side of State Highway 22, below house with red roof in 1969. North edge NE¼NE¼NW¼ sec. 12, T. 5 S., R. 9 E. (Hart, 1970, p. 208-209).

Thickness (ft)

CADDO FORMATION
Duck Creek Member
Clay, very poorly exposed, moderately light gray, weathering medium brown; chalky specks 2.0
Limestone, light-gray, weathering light yellow; very fine grained and dense, hard; complexly fractured, abundant pelecypods, with ammonites; small fucoids 0.4
Clay, very poorly exposed, light-gray, weathering light brown; white chalky spots 5.5
Limestone, white, weathering very light yellow brown; very fine, soft and chalky. Grades locally into hard limestone, moderately light gray; very fine and dense; composed 10 to 40 percent of fossils 0.4
Clay, poorly exposed, blue-gray, chalky spots near top 4.1
Limestone, chalky, white, very soft and powdery 0.3
Clay, light-gray or blue-gray, weathering very light brown; platy 1.6
Limestone, white, weathering very light brown; very chalky; fossiliferous 0.5
Clay, light-gray or blue, weathering very light brown; blocky and platy 7.6
Limestone, white, weathering very light yellow; very fine and dense. Gradational with clays above and below 0.3
Clay, very poorly exposed, light-blue-gray, weathering very light brown; apparently platy and flaky 3.3
Exposure heavily littered with fossils.

17. Roadcut and ditch, State Highway 22. Along north side NE¼NE¼ sec. 11, T. 5 S., R. 9 E. (Hart, 1970, p. 209-210).

Thickness (ft)

CADDO FORMATION
Duck Creek Member
Clay, moderately light gray, weathering light brownish orange; white chalky spots; probably abundantly fossiliferous 2.0
Limestone, very light gray, weathering cream colored; very fine and dense; somewhat nodular appearance 0.4
Clay, medium-gray, weathering light yellow; platy 1.7
Limestone, marly, cream-colored, weathers yellowish, very fine and dense; platy to thin-bedded. Somewhat fossiliferous 0.3
Clay, moderately light gray, weathering moderately light brown; mostly blocky, slight platiness. Unfossiliferous 2.0
Clay, very marly, cream-colored; platy, weathering flaky. Some *Texigryphaea* shells 0.3
Clay, dark-gray, weathering lighter gray, bluish, and medium-brown; platy; unfossiliferous 1.9
Limestone, very marly, intergrading light-blue and light-yellow; very fine and dense; platy 2.3
Fossil shells litter surface. Section calculated to be 70 to 80 feet above the Kiamichi Formation.

18. Gully, 0.15 mile north-northwest of intersection of State Highway 48 and side road (east of highway). NW¼SE¼SW¼ sec. 16, T. 5 S., R. 9 E. (Hart, 1970, p. 210).

	Thickness (ft)
CADDO FORMATION	
Duck Creek Member	
Clay, perhaps moderately dark gray fresh, mainly seen as light-blue or very light yellow brown, the yellow-brown in zones through the exposure, 0.3 to 1.0 foot thick; mostly irregularly fractured, platy and flaky in spots; probably silty; ironstone concretions. A few limestone nodules, cream-colored, very fine and dense. Pelecypods abundant, noticeable in matrix	8.0
Limestone, weathering light brown; somewhat marly	0.6
Section calculated as about 45 to 50 feet above Kiamichi Formation.	

19. Small exposure on Simon Creek, just south of State Highway 22, NW¼NW¼NE¼ sec. 10, T. 5 S., R. 9 E. (Hart, 1970, p. 210–211).

	Thickness (ft)
CADDO FORMATION	
Duck Creek Member	
Clay, light-gray, weathering brownish. A few masses of limestone, probably nodules, forming thin beds. Abundant *Texigryphaea* and other pelecypods	4.5
Limestone, very light gray, weathering cream colored, very fine and dense; bed somewhat undulatory. Unit relatively unfossiliferous	0.4
Clay, moderately light, weathering yellowish. Not noticeably fossiliferous	0.4
Limestone, light-gray, weathering yellowish; very fine and dense. Along top of unit in spots is a layer of *Texigryphaea* coquina, 80 percent or more composed of fossils, grading laterally into fossiliferous clay	0.6
Clay, moderately light gray, weathering light brown; platy. Contains limestone locally. Some pelecypods and fragments. Resting on or near top of underlying unit are specimens of *Adkinsites belknapi* and *Manuaniceras elaboratum lynnense?*	1.0
Limestone, very light gray, weathering yellowish; very fine and dense; unfossiliferous	0.2
Clay, moderately light gray, weathering light brown; platy. *Texigryphaea* shells and fragments concentrated in top 0.1 foot	1.9
KIAMICHI FORMATION	
Limestone, coquinoidal, light-gray, weathering light yellow; about 70 percent composed of *Texigryphaea* shells, matrix very fine and compact, hard. *Texigryphaea navia* (Hall), ammonites (Adkinsites, Manuaniceras, etc.) noted. Breaks into slightly abutting large, irregular slabs (not measured).	

20. Road ditches along several hundred feet extent, roadcut at east end of stretch on north side, State Highway 22. Along south edge SE¼SE¼ sec. 6, T. 5 S., R. 9 E. (Hart, 1970, p. 211–212).

	Thickness (ft)
KIAMICHI FORMATION	
Limestone, coquinoidal, light-gray, weathering medium gray, orange brown, dark red; matrix very fine and dense, hard; composed predominantly of *Texigryphaea navia* (Hall)	0.5
Covered, forms clay soil	10.0
Shale, dark-gray, weathering lighter gray and brown; upward poorly exposed	5.0
Limestone, coquinoidal, weathering light brown and orange brown; matrix may be clayey or silty; irregular fracture; composed predominantly of *Texigryphaea navia* (Hall)	0.9
Shale, medium-gray, exterior black; platy; alunite on breaks. Siltstone at top, light-brown; very finely sandy	4.1
Siltstone, light-gray, weathering rusty brown and cream colored; alunite and jarosite(?) on partings, *Adkinsites bravoensis, Pholadomya sancti-sabae,* several poorly preserved pelecypods	0.1
Shale, shiny black, weathering dark gray, lighter gray, and eventually brown, very platy, papery when weathered; selenite gypsum crystals, jarosite(?) and limonite on partings; chert nodules. Parts of section poorly exposed	15.0
Siltstone, light-brownish-gray, with rusty brown weathering stains; laminated. Cobbles of soft sandstone included. Top surface covered with shell fragments	0.1
Shale, weathering gray or light brown; platy, becoming fissile where weathered	0.7
Calcarenite and silt: calcarenite, light-gray-white, silt, light-gray. Minor angular granules of ironstone. Only top readily visible	0.2
Covered	0.5
Limestone, medium-gray, weathering moderately dark orange brown; fine grained, crystalline	0.1
Covered: appears to be black shale	0.1
GOODLAND LIMESTONE	

21. Southeast part of Bryan County Limestone Company quarry, and hill to south. Lower Kiamichi exposed in gently sloping pavement of clay. Recorded as SE¼NE¼SW¼ sec. 1, T. 5 S., R. 8 E., may be farther to southeast. (Hart, 1970, p. 213–214).

KIAMICHI FORMATION	Thickness (ft)
Limestone, coquinoidal, matrix very light gray, weathering light yellow, medium orange, dark red; very fine grained and dense; 70 to 80 percent of rock material in specimens of *Texigryphaea navia* (Hall)	0.4
Covered	17.0
Limestone, coquinoidal, as above, except matrix perhaps more clayey	0.8
Shale, moderately light gray, weathering light brown; poorly exposed	4.4
Shale, light- to medium-gray, weathering light brown; platy, some alunite coating rock surface, with jarosite, alunite, and hematite in streaks and stringers. Minor siltstone in very small lenses and plates	7.0
Siltstone and shale: siltstone, light-yellow, moderately well cemented, in two beds each 0.1 foot; shale interbeds, moderately light gray; platy; abundant satinspar gypsum	0.4
Shale, moderately light to dark gray; platy; jarosite and hematite at breaks, hematite in a bed 0.1 foot thick; alunite, satinspar, glauconite	3.6
Shale, medium-gray to moderately light gray; platy. Abundant plates of siltstone, weathering light yellow and medium orange; moderately well cemented	0.5
Shale, black grading upward to moderately light gray; platy, except massive or breaking only to 0.1-foot layers near middle; jarosite, alunite, limonite and pyrite. Silty zones, thickest 0.1 to 0.2 foot thick	5.4
Clay, fossiliferous, very dark gray; massive; 30 to 59 percent of material is sand-sized pelecypod fragments. Lower surface is weathered light brown and orange; pelecypod fragments gravel sized here	0.2
GOODLAND LIMESTONE	
Limestone, moderately light gray, weathering light brown and orange; fine grained, crystalline; in three beds; pyritic mineralization, selenite gypsum. Some gravel-sized pelecypod fragments. Appears gradational with overlying unit	0.3
Limestone, as below. In one to three beds	5.2
Limestone, white to lightest gray; very fine and dense; hard, except occasional chalky samples; single bed, except top 1 foot in places is distinct. Generally a few percent sand-sized pelecypods and other fossil fragments; whole fossils rare	10.9
Shale, medium-gray, forms base of exposure.	

Note: In the shales of the Kiamichi are numerous casts of *Pholadomya sancti-sabae*, with *Tapes whitei, Adkinsites bravoensis, Manuaniceras elaboratum.*

22. Creek exposure, about 0.2 mile south-southeast of turn in public road, NW¼SE¼NE¼NW¼ sec. 3, T. 5 S., R. 8 E. (Hart, 1970, p. 214–215).

GOODLAND LIMESTONE	Thickness (ft)
Limestone float, similar to underlying unit	2.1
Limestone, white, weathering light gray with spotty yellowish cast; very fine grained and dense, some samples somewhat chalky; generally massive; section 3 to 6 feet above base contains wavy zones, each about 0.1 foot thick, of flaky marl. Scattered pelecypods, gastropods, echinoids in various orientations; many samples contain few percent sand-sized fossil fragments	13.0
Clay, marly, white; irregularly crumbly. Numerous pelecypods and echinoids. Occasional nodular limestone masses, white; very fine grained and dense, hard	1.0
ANTLERS SANDSTONE	
Sandstone, light- to very light gray, weathering medium orange; fine to medium grained, well sorted, subrounded to rounded, soft and friable; mostly massive, except in lower 1 foot, platy parting; minor sulphur staining, ferruginous cementation in top 0.2 foot; smooth top, rarely even 0.1 foot undulation. Rare bits of carbonized wood	6.0
Clay, moderately dark to medium gray; traces of silt; fracturing irregularly; sulphur staining and odor, limonite staining	1.7
Sandstone, purplish-medium-gray; fine to medium grained, rounded to subrounded soft and friable; massive, heavy sulphur staining; base undulatory	0.5
Clay, shiny black, weathering moderately dark purplish gray; fractures irregularly; limonitic staining	0.4
Sandstone, light-gray to moderately light gray, upper part weathering medium orange; very fine grained, minor content up to medium grained, moderately to well sorted, soft and friable; massive; abundant selenite gypsum crystals associated with orange weathering	7.1

23. West bank of stream 0.4 mile west of north-south road, NW¼NW¼SW¼ sec. 6, T. 5 S., R. 12 E. (Olson, 1965, p. 49).

GOODLAND LIMESTONE	Thickness (ft)
Limestone, dense, white; scales off in thin plates with solution cavities, caps escarpment	1.3
Limestone, irregularly bedded, nodular, white, fossiliferous	3.0
Limestone, soft, marly, irregularly bedded, very light bluish gray, fossiliferous, grades into clay below	3.3

ANTLERS SANDSTONE

	Thickness (ft)
Clay, thin-bedded, moderately fissile, medium-grayish-blue, unfossiliferous, limonitic laminae throughout	7.3
Sandstone, moderately indurated, white, weathers light brown to purple, crossbedded, very well sorted, well rounded, medium-grained quartz, iron-cemented, forms bench	3.3
Pack sand, unconsolidated, white, well-sorted, well-rounded, with subordinate lenses up to 4 feet thick of variegated clay and sandy clay, purple, grayish-white to yellowish-white	7.8

24. Roadcut 0.3 mile north of Matoy, SW¼NW¼ sec. 9, T. 5 S., R. 12 E. (Olson, 1965, p. 49–50).

	Thickness (ft)
GOODLAND LIMESTONE	
Limestone, dense, white, caps escarpment. Soil and debris cover lower contact not measured.	
ANTLERS SANDSTONE	
Clay, sandy, light-gray	1.5
Sand, unconsolidated, brownish-yellow, iron-stained, medium-grained, with high clay content	0.8
Sand, unconsolidated, light-gray, very fine grained, clayey	2.8
Tripoli, porous, lightweight, friable, white overall color; becomes more dense near middle of bed, with varicolored, milk white, gray, pink and light blue, irregularly shaped particles of opaline material; bed thickness pinches and swells from 3 to 6 inches	0.5
Clay, sandy, light-gray	1.8
Sandstone, moderately indurated, white fresh, weathers brown, medium-grained, well-rounded, well-sorted; forms ledge	3.8
Pack sand, massive, white	13.8
Clay, sandy, yellowish-brown and light-gray interbedded	2.8
Pack sand, massive, white	6.0

25. Escarpment 0.1 mile east of Stuart Ranch headquarters, SE¼NW¼ sec. 4, T. 5 S., R. 11 E. (Olson, 1965, p. 50).

	Thickness (ft)
KIAMICHI FORMATION, caps hilltop, covered, not measured	
GOODLAND LIMESTONE	
Limestone, hard, massive, white on fresh surface, very light gray on weathered surface, thin plates with solution cavities scale-off, fossiliferous	12.3
Limestone, chalky, white	3.6
Limestone, nodular, white; becomes marly toward bottom	3.8
ANTLERS SANDSTONE	
Pack sand, white, covered, not measured.	

26. West bank of Creek 0.2 mile south of bridge on section road, SW¼NE¼NE¼ sec. 21, T. 5 S., R. 11 E. (Olson, 1965, p. 50).

	Thickness (ft)
CADDO FORMATION	
Duck Creek Member	
Clay, medium-gray to buff, with thin interbeds of gray marl near top; becomes lighter colored near bottom	18.0
Limestone, soft, white	0.5
Clay, fissile, black, finely laminated	10.3
Marl, bluish-gray, discontinuous	0.3
Clay, fissile, black, finely laminated	2.0

27. East bank of creek 0.3 mile west of section road, SW¼NE¼ sec. 30, T. 5 S., R. 13 E. (Olson, 1965, p. 51–52).

	Thickness (ft)
Terrace deposits, caps bank	
Sand and gravel, gradational from fine red sand in upper part to subangular pebbles of Fort Worth Limestone, and abraded Fort Worth fossil material at base, poorly sorted overall, with much silt and subangular to subrounded pebbles and cobbles of hard ferruginous, purple sandstone scattered through the terrace deposit. Lower contact very irregular, channelling pronounced, maximum exposed thickness	10.0
CADDO FORMATION	
Duck Creek Member	
Clay, shaly, bluish-black, thin-bedded, weathers to brownish gray, maximum thickness	11.0
Marl, bluish-gray, fossiliferous; includes, *Pecten* sp., *Texigryphaea* sp., *Kingena* sp., *Exogyra* sp., gastropods, *Hamites* sp., *Mortoniceras* sp., *Desmoceras* sp., noted in stream bed immediately below exposure	0.6
Clay, shaly, bluish-black	1.2

28. Broad expanse of shallow, inactive quarries near center of sec. 30, T. 5 S., R. 12 E. (Olson, 1965, p. 51).

	Thickness (ft)
CADDO FORMATION	
Fort Worth Member	
Limestone, hard, yellowish-white fresh, weathers to brownish-yellow, irregularly bedded, fossiliferous; includes *Texigryphaea*, echinoids, ammonites and fucoids. Caps hill. Maximum exposed thickness	5.0
Covered, probably interbedded brownish clay and thin-bedded limestone, fossiliferous; excellent collecting area on slopes above and below stock tank located NE¼NW¼NE¼.	

29. Sugarloaf Mountain, NE¼ sec. 22, T. 5 S., R. 12 E. (Olson, 1965, p. 51–52).

	Thickness (ft)
BOKCHITO FORMATION	
Weno Member	

Clay, gray with ferruginous laminae grading upward into red sandy clay and fossiliferous ferruginous sandy clay containing numerous casts of *Turritella* sp. and *Protocardia* sp. Caps hill, approximate thickness 40.0

Soper Member

Limestone, impure, hard, purple, highly fossiliferous, containing numerous *Texigryphaea washitaensis* 0.9

Denton Member

Clay, sandy, gray 1.2

Limestone, impure, shelly, purple 0.4

Clay, sandy, ferruginous-stained, shelly 0.2

Clay, sandy, gray, covered to bottom contact with soil 52.5

CADDO FORMATION (Fort Worth equivalent).

30. Creek bed 0.05 miles west of State Highway 22, SE¼NE¼SE¼ sec. 4, T. 6 S., R. 11 E. (Olson, 1965, p. 52).

Thickness (ft)

BOKCHITO FORMATION

Soper Member

Limestone, very hard, coarsely crystalline, yellowish-brown, fossiliferous; *Texigryphaea washitaensis* predominating, with numerous *Rastellum carinatum*, echinoid plates and spines 1.0

Denton Member

Clay, brownish-yellow, well-laminated, fossiliferous 2.8

Marl, shelly, light-gray, with thin nodular, discontinuous, shelly limestone bed near top 1.4

Clay, blackish-gray, waxy, unfossiliferous, bottom contact covered 2.0

31. Roadcut on State Highway 22, SE¼NE¼SE¼ sec. 9, T. 6 S., R. 11 E. (Olson, 1965, p. 52).

Thickness (ft)

BOKCHITO FORMATION

McNutt Member

Limestone, massive, sandy, hard, brownish-yellow on fresh surface, orange-brown on weathered surface, glauconitic, fossiliferous; includes *Rastellum quadriplicatum* 2.9

Limestone, brownish-yellow, and sandy clay, yellow, alternating in thin wavy beds 1.4

Sand, yellow, crossbedded with marcasite concretions 2.2

Limestone, hard, sandy, purplish-gray fresh surface, orange-brown weathered surface, fossiliferous 3.1

Weno Member

Clay, sandy, yellowish-brown, well-laminated; bottom contact covered.

32. Railroad cut 0.2 mile east of Bokchito Creek, NW¼NE¼ sec. 26, T. 6 S., R. 12 E. (Olson, 1965, p. 53).

Thickness (ft)

BENNINGTON LIMESTONE

Limestone, dense, brownish-yellow, fossiliferous; includes *Ilymatogyra arietina*, caps cut 1.8

Limestone, nodular, brownish-yellow, with solution cavities 5.1

BOKCHITO FORMATION

Pawpaw Member

Sandstone, moderately indurated, yellowish-brown, fine-grained 1.8

Sand, brownish-yellow 1.0

33. Roadcut, State Highway 70 E., 1.5 miles north of Smith-Lee, SW corner, sec. 26, T. 7 S., R. 12 E. (Olson, 1965, p. 53).

Thickness (ft)

WOODBINE FORMATION

Clay, slightly fissile, calcareous, light-gray and sandy clay, yellow interbedded; clay predominates over thinner beds of sandy clay, which range in thickness to 3 inch maximum; sand fraction fine- to medium-grained quartz, subangular to rounded, moderately poorly sorted, becomes more sandy upward 6.8

Sandstone, massive, moderately well indurated, yellowish-brown, medium-grained, well-rounded, well-sorted 6.0

34. West bank of Red Branch Creek, 0.3 mile north of Red Branch Creek, 0.3 mile north of section road, NW¼SE¼ sec. 24, T. 7 S., R. 12 E. (Olson, 1965, p. 53).

Thickness (ft)

WOODBINE FORMATION

Red Branch Member

Shale, black carbonaceous 1.5

Lignite, black interbedded with carbonaceous shale 1.4

Shale, black, carbonaceous 10.3

Lignite, black 0.8

Shale, dark-gray with plant impressions 1.1

Clay, dark-brown carbonaceous 0.9

Lignite, black 0.4

35. Roadcut 0.3 mile south of Long Creek, SE¼ sec. 16, T. 8 S., R. 10 E. (Olson, 1965, p. 54).

Thickness (ft)

WOODBINE FORMATION

Templeton Member

Marl, moderately hard, tan 0.8

Clay, slightly fissile, buff 1.8

Shale, fissile, bluish-black, well-laminated, with calcareous septarian nodules: selenite crystals disseminated through shale bed 11.0

36. East bank of Sandy Creek, SW¼SW¼SE¼ sec. 25, T. 8 S., R. 7 E. (Currier, 1968, p. 60).

Thickness (ft)

Terrace deposit (not measured)
CADDO FORMATION
Limestone, light-gray, weathering yellowish-gray; well indurated; fossiliferous, containing *Texigryphaea washitaensis* and *Plicatula dentonensis* 0.9
Shale, olive-gray, weathering light-olive-gray; light-gray, nodular, thin-bedded limestone common in basal portion of unit; slightly fissile; silty; calcareous; sparsely fossiliferous; problematical fucoids present on base of limestone beds; contact with overlying unit sharp 18.4
Limestone light-gray, weathering yellowish-gray; well indurated; calcite veinlets in upper 0.5 foot of unit; local ferruginous stains; fossiliferous; contact with overlying unit sharp 1.9
Marlstone, medium-gray, weathering light olive gray; weakly cohesive; sparsely fossiliferous; contact with overlying unit gradational 2.1
Limestone, light-olive-gray, superficially stained light brown; nodular; irregular partings of marl; contact with overlying unit sharp 2.3
Base of exposure, creek alluvium.

37. South bank of creek, east side of section line road, NW¼SW¼ sec. 30, T. 8 S., R. 8 E. (Currier, 1968, p. 61).

Thickness (ft)

Terrace deposit (not measured)
BOKCHITO FORMATION
Denton Member
Clay, olive-gray, weathering yellowish gray; calcareous; silt content increases toward top of unit; calcareous cemented siltstone stringers weather out, littering surface with platy material; sparsely fossiliferous in lower portion 8.8
Limestone, light-gray, weathering yellowish gray; moderately indurated; nodular; interbedded light-olive-gray, calcareous shale; gradational irregular contacts between interbedded material; fossiliferous, many *Texigryphaea washitaensis*; contact with overlying clay unit gradational 8.1

38. Bluff on east side of Lake Texoma, 0.9 mile north of U.S. Highway 70, 0.2 mile west of east section line, NE¼NE¼ sec. 28, T. 6 S., R. 7 E. (Currier, 1968, p. 61–62).

Thickness (ft)

BOKCHITO FORMATION
Soper Member
Limestone, pale-yellowish-brown, weathering moderate-yellow-brown; well indurated; fine- to coarse-grained calcarenite; ferruginous stains on weathered surface; bioclastic; abundant *Rastellum (Arctostrea) quadriplicatum*, a few *Pecten*, and echinoid spines and plates 0.9
Marlstone, yellowish-gray, weathering dark yellowish orange; slightly indurated; fossiliferous with abundant *R. quadriplicatum;* contact with overlying limestone gradational 1.1
Limestone, light-olive-gray, weathering moderate yellowish brown; well indurated; medium- to coarse-grained calcarenite; silty, fossiliferous with many *R. quadriplicatum;* contact with overlying unit gradational 1.1
Limestone, yellowish-gray, weathering grayish orange; moderately indurated; silty, coquinoidal with predominantly *Texigryphaea washitaensis*, contact with overlying unit sharp 0.4
Denton Member (restricted)
Marlstone, light-olive-gray, weathering yellowish gray; weakly cohesive; abundant fossils in lower portion, becoming sparsely fossiliferous in upper portion, predominantly *Texigryphaea washitaensis* along with *Rastellum quadriplicatum* and a few *R. carinatum;* contact with overlying unit sharp 4.4
Clay, light-olive-gray, weathering yellowish-gray; weakly cohesive; calcareous; limonitic; abundant fossils in lower portion, becoming sparsely fossiliferous in upper portion, including *Texigryphaea washitaensis* and *Rastellum quadriplicatum;* contact with overlying unit gradational 1.6
Shale, light-gray, weathering olive gray; fissile, becoming platy to blocky in upper portion; ferruginous concretions occur locally; several thin-bedded clay-ironstone layers; contact with the overlying unit gradational 5.9
Base of exposure at water level.

39. South bank of westward-flowing creek, 0.2 mile north of U.S. Highway 70, NW¼SE¼SW¼ sec. 27, T. 6 S., R. 7 E. (Currier, 1968, p. 63–64. This section was independently measured and described by Ganser; see measured section 51, this report.)

Thickness (ft)

BOKCHITO FORMATION
Weno Member
Sandstone, dark-yellowish-brown; deeply weathered; moderately indurated; composed of subangular to subrounded, fine quartz grains with limonitic cement; fossiliferous, including numerous poorly preserved ferruginous molds and casts of *Protocardia texana* 0.4

Shale, medium-dark-gray; slightly fissile; silty; very poorly exposed 7.8
Sandstone, grayish-orange, weathering dark-yellow-orange; deeply weathered; medium to thick bedded; friable; composed of subangular fine quartz grains with iron-oxide stain; micaceous; interference ripple-marks present on several thick beds; subordinate thin-bedded, olive-gray shale increases toward basal contact with the underlying unit 11.3
Shale, olive-gray, weathering light-olive-gray; platy to blocky on weathered surface, giving shaly appearance; silt content increases in upper portion; clay ironstone concretions and stringers weather out, littering surface with platy material; selenite gypsum crystals on weathered surface 41.5
Shale, olive-gray, weathering light-olive-gray; subordinate (30 percent) interbedded grayish-orange; calcareous-cemented, carbonaceous, micaceous siltstones and very fine grained sandstones with average thickness of 0.3 foot; platy to blocky on weathered surface, giving shaly appearance; slightly silty; containing discontinuous layers of clay ironstone; contact between siltstones and shale beds gradational 9.7
Shale, olive-gray, weathering light-olive-gray: platy to blocky on weathered surface; waxy; calcareous 7.2
Base of exposure.

40. Cut near oil storage tank, 0.3 mile north of U.S. Highway 70, west side of section line road, SE¼SE¼ sec. 27, T. 6 S., R. 7 E. (Currier, 1968, p. 64–65).

Thickness (ft)

BOKCHITO FORMATION
McNutt Member
Limestone, moderate yellowish-brown, weathering medium brown; well indurated; fine- to coarse-grained calcarenite; sandy, glauconitic, fossiliferous, numerous *Rastellum quadriplicatum* 1.4
Weno Member
Sandstone, medium-light-gray, weathering light brown; well indurated; calcareous cement; contact with overlying limestone unit sharp 0.3
Sandstone, yellowish-gray, weathering moderate brown; deeply weathered; massive bedded; friable; composed of poorly sorted, subangular to subrounded, fine to medium quartz grains with a silt matrix; ferruginous stained; irregular, medium-gray, silty clay partings increase toward top of unit; abundant well-preserved fossils in basal 0.5 foot, becoming sparsely fossiliferous in upper portion; fossils decompose rapidly upon exposure 5.6
Shale, light-olive-gray, weathered surface superficially stained dark yellowish orange; slightly fissile; secondary calcite cement; contact with overlying sandstone unit gradational 0.4
Sandstone, yellowish-gray, weathering dark yellowish orange; friable; composed of subangular, fine quartz grains; micaceous; contact with overlying unit gradational 0.9
Shale, medium-dark-gray, weathering light gray; contains discontinuous siltstone stringers and lenses; poorly fissile; silty, iron-oxide concentrations occur above many of the sandstone stringers 6.8
Base of cut.

41. North bank of Red River, 0.1 mile northwest of mouth of Webb Creek, SW¼NW¼SE¼ sec. 13, T. 9 S., R. 8 E. (Currier, 1968, p. 65–66).

Thickness (ft)

Terrace deposit (not measured)
BOKCHITO FORMATION
Pawpaw Member
Shale, light-olive-gray, weathering yellowish gray; slightly fissile; silty 5.0
Sandstone, light-brown, weathering dark-yellowish-orange; moderately indurated; fine grained; calcareous and limonitic cement; sparsely fossiliferous; contact with overlying unit sharp 0.5
McNutt Member
Limestone, yellowish-gray, weathering light olive gray; well indurated; fine- to coarse-grained calcarenite; sandy; glauconitic; fossiliferous, with *Rastellum quadriplicatum;* contact with overlying unit sharp 3.3
Siltstone, medium-dark-gray, weathering light olive gray; poorly indurated; blocky; clayey; calcareous; contact with overlying unit sharp 3.4
Limestone, light-olive-gray, weathering dark yellowish brown; well indurated; less resistant toward center; fine- to medium-grained calcarenite; sandy; local ferruginous stains; bioclastic; contact with overlying unit gradational 2.5
Marlstone, light-gray, weathering yellowish gray; moderately indurated; fine-to coarse-grained calcarenite; glauconitic; sparsely fossiliferous; contact with overlying unit gradational 1.3
Limestone, light-olive-gray, weathering moderate yellowish brown; well indurated; fine- to coarse-grained calcarenite; sandy glauconitic; fossiliferous; contact with marlstone gradational 2.3
Weno Member
Sandstone, grayish-orange, weathering moderate yellowish brown; very

friable; composed of moderately well sorted, subangular, fine quartz grains; micaceous; fossiliferous, abundant *Rastellum quadriplicatum* concentrated in a 1.5 foot band near center of unit; contact with overlying unit sharp 5.0
Base of exposure, water level.

42. West bank of Webb Creek, SE¼SE¼NE¼ sec. 13, T. 9 S., R. 8 E. (Currier, 1968, p. 66–67).

Thickness (ft)

Terrace deposit (not measured)
BOKCHITO FORMATION
Pawpaw Member
Shale, dusky-yellowish-brown, weathering light gray; poorly fissile, waxy; contact with underlying unit gradational 10.2
Shale, olive-gray, weathering medium olive gray; subordinate interbedded, yellowish-gray siltstones and very fine grained sandstones 0.1 to 0.3 foot thick; slightly fissile; silty; flattish, discontinuous layer of clay ironstone near base; thin veneer of well-preserved fossils occur in basal portion of many of the silts and sandstones 15.5
Base of exposure, creek alluvium.

43. South bank of Chukwa Creek, 30 yards east of U.S. Highway 75, SW¼NW¼NW¼ sec. 28, T. 6 S., R. 9 E. (Currier, 1968, p. 67–68).

Thickness (ft)

BENNINGTON LIMESTONE
(caps bank)
Limestone, grayish-orange, weathered surface superficially stained dark yellowish brown; well indurated; medium- to coarse-grained calcarenite; glauconitic; clay and siltstone blebs toward basal portion; very pitted on weathered surface due to removal of clay blebs; fossiliferous; irregular basal contact 1.0
BOKCHITO FORMATION
Pawpaw Member
Sandstone, yellowish-gray, weathering light brown; friable; massive bedded; composed of moderately sorted, subangular to subrounded, fine quartz grains; micaceous; well-indurated, calcareous-cemented sand protrudes from the weathered surface just below the overlying limestone unit 6.9
Sandstone, yellowish-gray, weathering grayish orange; very friable; composed of subrounded, fine quartz grains; micaceous; irregular shaped ferruginous concretions around clay masses in a discontinuous layer in upper portion, becoming sparsely scattered throughout rest of unit 8.9
Base of exposure, creek alluvium.

44. East bank of creek, 0.3 mile due west of the east section line SW¼NE¼ sec. 19, T. 6 S., R. 9 E. (Currier, 1968, p. 68–69).

Thickness (ft)

BENNINGTON LIMESTONE
(top eroded)
Limestone, yellowish-gray, weathering brownish gray; well indurated; honeycombed with solution cavities; very fossiliferous, including abundant *Ilymatogrya arietina* 1.3
Limestone, grayish-yellow, weathering grayish orange, poorly indurated; silty; sparsely fossiliferous; contact with overlying unit gradational 0.8
Limestone, yellowish-gray, weathering pale yellowish brown; well indurated; hackly on weathered surface; fossiliferous, with *Ilymatogyra arietina* predominating, accompanied by a few *Turritella* sp. and *Pecten* sp.; contact with overlying unit gradational 2.8
Limestone, very pale orange, weathering yellowish gray; moderately indurated; silty; sparsely fossiliferous; contact with overlying unit gradational 0.6
Limestone, very light gray, weathering light gray; moderately indurated; fossiliferous, with *Ilymatogyra arietina* and *Rastellum quadriplicatum*, contact with overlying unit gradational 1.2
Limestone, yellowish-gray, weathering dark yellowish brown; well indurated; fossiliferous, abundant *R. quadriplicatum*, abundant *Ilymatogyra arietina*, few *Kingena wacoensis*, and *Pecten* sp.; contact with overlying unit sharp 3.0
Note: Hand lens examination revealed all units to be very fine- to coarse-grained calcarenites, with fine- to medium-grained modes.
BOKCHITO FORMATION (not measured nor described).

45. About 2½ miles northwest of Colbert. South bank of Little Sand Creek, 0.1 mile east of abandoned Bennington Limestone quarry, SE¼NE¼NE¼ sec. 11, T. 8 S., R. 7 E. (Currier, 1968, p. 69–70).

Thickness (ft)

Terrace deposit (caps stream bank—not described 8.7
WOODBINE FORMATION
Dexter Member (Dexter Sandstone unit)
Claystone, olive-gray, weathering pale yellowish brown; poorly indurated; blocky; silty 2.1
Siltstone, pale-yellowish-brown, weathering yellowish orange; deeply weathered; poorly indurated; containing alternating gradational silty clay layers; limonitic; contact with overlying claystone gradational 2.2
Sandstone, yellowish-gray, weathering grayish orange; friable; com-

posed of well-sorted, subrounded fine quartz grains; contact with overlying unit sharp 5.6
Dexter Member (Basal Shale unit)
Shale, brownish-black, weathering brownish gray; fissile; waxy; local ferruginous concretions and partings; contact with overlying unit sharp 4.5
GRAYSON MARLSTONE
Shale, olive-gray, weathering light olive gray; blocky; becoming slightly fissile in upper portion; silty; calcareous; fossiliferous, *Texigryphaea roemeri* common; contact with overlying shale gradational 3.7
Marlstone, olive-gray; weathering light olive gray; weakly cohesive; regular interbedded light-gray, nodular limestone; thickness of nodular layers decreases upward; fossiliferous, predominantly *Texigryphaea roemeri*, accompanied by *Turrilites brazoensis, Pecten texanus, Protocardia texana, Cyprimeria* sp., *Homoya washita* 11.3
Marlstone, olive-gray, weathering light olive gray; platy to blocky; sparsely fossiliferous 4.4
Limestone, light-gray, weathering yellowish gray; moderately indurated; silty; nodular; olive-gray marl interbedded at regular intervals; fossiliferous, predominantly *Ilymatogyra arietina*, some *Texigryphaea roemeri*, accompanied by *Turrilites brazoensis, Pecten texanus, Protocardia texana, Cyprimeria* sp., *Engonoceras* sp., *Cymatoceras? texanum, Turritella* sp., *Holectypus limitis, Enallaster texanus, Pseudonanchys completa, Hemiaster calvini* 7.9
BENNINGTON LIMESTONE (not measured).

46. Roadcut approximately 0.1 mile south of Chukwa Creek, west side of road, SE¼SE¼ sec. 19, T. 6 S., R. 9 E. (Currier, 1968, p. 71–72. This section was independently measured and described by Hart. See measured section 2, this report. The lower 20 feet of this section is no longer exposed.)

Thickness (ft)

WOODBINE FORMATION
Dexter Member
Sandstone, dark-yellowish-orange, weathering moderate reddish brown; contains discontinuous silty shale stringers; slightly indurated, forming protective cap on ridge; crossbedded; moderately to poorly sorted, subangular, fine quartz grains with a silt matrix; iron oxide stained; carbonaceous material present between cross laminations 3.1
Shale, light-olive-gray, weathering grayish orange; slightly fissile; silty; minor partings of indurated siltstone and clay ironstone weathers out, littering surface with platy material 6.1
Sandstone, grayish-orange, weathering banded grayish-orange and dark yellowish orange; friable; crossbedded; composed of well-sorted, subangular, fine quartz grains; clay blebs in upper 0.5 foot; lenticular 6.9
Sandstone, grayish-orange, weathering moderate yellowish brown; contains interfingered light-olive-gray, silty, carbonaceous shale; friable; consists of fine quartz grains; local ferruginous concretions; typically, the contact between the sandstone and shale bedding is separated by a clay ironstone layer approximately 0.1 inch thick 13.2
Sandstone, light-brown, weathering moderate yellowish brown; massive-bedded with several interfingering, thin-bedded, light-olive-gray shales; composed of well-sorted, subrounded to rounded, medium quartz grains with iron oxide stain 16.8
Sandstone, brownish-gray, weathering pale yellowish brown; poorly indurated; slightly silty in basal portion, becoming waxy in upper portion; blocky; clay ironstone bed 0.5 foot thick in lower portion of unit; contact with overlying sandstone sharp 17.5
Sandstone, mottled-light-gray and moderate-reddish-orange, ferruginous stain tends to mask mottled appearance on highly weathered surface, yielding moderate-reddish-brown; massive friable; composed of poorly sorted, subangular, fine to medium quartz grains with a silt and clay matrix; moderately indurated ferruginous concretions typically form around cylindrical and elliptical masses of light-gray silty clay; contact with overlying claystone gradational 19.0
Covered, probably shale.

47. North bank of creek, 0.1 mile north of U.S. Highway 75, NE¼NE¼SW¼ sec. 27, T. 7 S., R. 8 E. (Currier, 1968, p. 72–73).

Thickness (ft)

Colluvium 6.0
WOODBINE FORMATION
Red Branch Member 6.0
Shale, dusky-yellowish-brown, weathering pale yellowish brown; fissile; waxy; superficial limonite stains 0.8
Coal, black, platy, crumbly 0.2
Claystone, very light gray, weathering yellowish gray; poorly indurated; platy to blocky; waxy 0.3
Coal, black, blocky; sulfur-stained surface; lenticular 1.1
Claystone, dark-gray, weathering light gray; poorly indurated; waxy; carbonaceous 0.8

Coal, black; blocky; sulfur-stained surface; lenticular 1.3
Shale, medium-gray, weathering light gray; poorly fissile; silty with limonite and hematite stains 3.7
Base of exposure.

48. Quality Sand and Gravel Pit, SE¼SE¼SE¼ sec. 17, T. 8 S., R. 8 E. (Currier, 1968, p. 73).

Thickness (ft)

Terrace deposit
Sand, mottled, very pale orange and moderate-reddish-brown; poorly sorted, subangular, fine to very coarse quartz grains 3.7
Gravel, light-brown; crossbedded; very poorly sorted, from clay size to 10 cm in diameter, coarse material consisting of quartz, quartzite, chert, clay balls 5.6
Sand, dark-yellowish-orange; crossbedded; subrounded, medium quartz grains; scattering of rounded pebbles reaching 15 mm in diameter 4.9

49. Roadcut in hill on U.S. Highway 70 the C E½ of south section line, sec. 27, T. 6 S., R. 7 E. (Ganser, 1968, p. 54–55).

Thickness (ft)

WOODBINE FORMATION
Dexter Member
Sandstone, coarse, brick-red; slope littered with clay ironstone and sandy ironstone slabs 2.8
Conglomerate, chert, quartzite, quartz pebbles; coarse sand, ferruginous cement; dark reddish brown; top and bottom well consolidated; middle is poorly cemented and yellow brown 1.0
Sandstone, crossbedded, light-gray to brick-red; moderately indurated 0.8
Sandstone, dark-red-brown; poorly consolidated; thin bedded; limonite concretions on surface 2.5
Sandstone, dark-red, weathers to thick, well-indurated bed at base; beds thin upward; limonite concretions at top 2.8
Sandstone, red-brown, yellow near top; poorly consolidated 2.7
BENNINGTON LIMESTONE
Limestone, light-yellow-brown, weathers to dark brownish gray; sandy; fossiliferous 1.5
Limestone, light-gray, weathers slightly yellow gray; locally highly fossiliferous; abundant *Ilymatogyra arietina* 1.7
Limestone, largely grass covered 2.5
Limestone, gray, weathers darker gray; silty to sandy; fossiliferous 4.8
BOKCHITO FORMATION
Pawpaw Member
Sandstone, brown, largely grass covered (not measured).

50. Roadcut one mile north of U.S. Highway 70 on east-west section-line road, NE¼ sec. 27, T. 6 S., R. 7 E. (Ganser, 1968, p. 55).

Thickness (ft)

BENNINGTON LIMESTONE
Limestone, gray to yellow-brown, weathers brown or dark gray; beds 8 inches thick at base, thin upward to 2 inches. Marly limestone between beds of limestone; light gray; thickens upward 7.0
Limestone, chalky, gray, fossiliferous 7.3
BOKCHITO FORMATION
Pawpaw Member
Sandstone, reddish-brown, fossil fragments, 25 percent carbonate content decreasing rapidly downward 2.0

51. South bank of creek, the C NW¼SE¼SW¼ sec. 27, T. 6 S., R. 7 E. (Ganser, 1968, p. 55–56. This section was independently measured and described by Ganser. It appears to have been taken in the same area as Currier's section, measured section 39, this report.)

Thickness (ft)

BOKCHITO FORMATION
Weno Member
Sandstone, red; ferruginous; *Turritella* sp.; lower contact gradational 5.0
Sandstone, yellow, fine-grained to very fine grained; frequent thin layers of blue-gray sandy clay; sand beds 6 inches thick to thin laminae 20.0
Shale, blue-gray; yellow sand content increases upward 53.0
Sandstone, 75 percent; very fine grained; light to dark-yellow beds to 6 inches thick. Sandy clay, 25 percent; yellow-brown. One, 3-inch bed of red-purple siltstone 5.0
Clay, blue-gray, basal 2 feet, shaly; brownish gray above; increasingly sandy upward; sand is white to yellow, very fine to fine-grained. 13.0
Soper Member floors the creek.

52. Along shore of Lake Texoma, NE¼SE¼SE¼ sec. 28, T. 6 S., R. 7 E. (Ganser, 1968, p. 56).

Thickness (ft)

BOKCHITO FORMATION
Soper Member
Limestone ("*Ostrea carinata* bed") coquinoidal; *Texigryphaea washitaensis, Rastellum quadriplicatum;* reddish purple, some yellow iron stains 0.5
Denton Member
Clay, yellow; increasingly calcareous downward; base is fairly well indurated; sandy; *Texigryphaea washitaensis* 2.5
Clay, sandy; light-blue-gray, weathers to brownish gray; yellow sand in layers; 4-inch bed of sandy limestone 3 feet from top of unit, several zones of very abundant, *Texigryphaea washitaensis* near the top; clay becomes shaly toward base; little sand; some ironstone concretions 24.0
Water level.

53. Shore of Lake Texoma, NW¼NE¼SE¼ sec. 1, T. 6 S., R. 7 E. (Ganser, 1968, p. 57–58).

	Thickness (ft)
BOKCHITO FORMATION	
Denton Member	
Clay, blue-gray, weathering to yellow brown	3.0
Clay, sandy, blue, weathering to sand yellow; platy to fissile, hard; litters slope	0.3
Clay, blue, weathering to yellow brown; selenite, weathering product	6.5
CADDO FORMATION	
Limestone and clay; 10 inches of clay in two beds; blue gray, weathering gray; limestone in two beds; chalky, nodular, gray white with some yellow surface stains; fossiliferous	1.5
Limestone, gray, weathering to yellow white with some reddish stains on surface; 2-3 inches calcareous clay about every foot in upper part; less clay in lower part; very nodular; fossiliferous	5.0
Limestone, gray-white, weathering to chalky white, with *Texigryphaea washitaensis* and *Pecten* sp	2.0
Clay, gray; fossiliferous	0.7
Limestone and clay, mainly covered with debris	5.0
Water level.	

54. Northeast bank, Cumberland Cut, the C W½ sec. 26, T. 5 S., R. 7 E. (Ganser, 1968, p. 58–59).

	Thickness (ft)
Terrace deposit (not measured)	
CADDO FORMATION	
Clay shale 50 percent, gray, weathering to gray blue; shaly; ¼-inch layer of fine, yellow sand; large fucoids; calcareous. Limestone, 50 percent, gray-white; chalky; lower beds 3–4 inches thick; upper beds are 5–7 inches thick	10.0
Clay, brownish-gray, weathering to gray; occasional ¼-inch ball of yellow sand; selenite, weathering product; two chalky, gray limestone layers 2–3 inches thick	4.5
Limestone, yellow-gray, weathers to more yellowish gray; irregular bedding	1.2
Clay, brownish-gray, weathers gray	2.8
Limestone, gray, weathers gray white; irregular bedding	0.7
Shale, blue-gray; calcareous	1.1
Limestone, gray-white; some clay partings	2.0
Limestone, dark-gray; irregular bedding; about 1/3 clay	2.5
Clay, blue-gray; shaly; small pelecypods	3.0
Water level.	

APPENDIX B.—WELL LOG OF THE PURE OIL COMPANY 2 LITTLE-210, SW¼SE¼NW¼ sec. 34, T. 5 S., R. 7 E., BRYAN COUNTY

(Depths in feet)

FORMATION	TOP	BOTTOM
Sand & shells	0	99
Sand	99	135
GOODLAND TOP	135	
Lime	135	155
ANTLERS TOP	155	
Sand	155	420
Sand & red clay	420	430
Clay, sandy, red	430	450
Sand	450	480
Clay, sandy, red	480	490
Sand	490	508
Clay, red to green	508	530
Marl	530	540
Sand	450	550
Clay	550	560
Shale & lime	560	570
Sand	570	597
Conglomerate & sand	597	605
SPRINGER TOP	605	
Shale	605	2280
Shale & sand	2280	2300
Shale	2300	2315
Shale & sand	2315	2320
Shale	2320	2905
CANEY TOP	2905	
Shale, black	2905	2940
Shale & lime	2940	2950
Shale, black	2950	2985
Shale & lime	2985	3000
Shale	3000	3020
Shale & lime	3020	3030
Shale, black	3030	3100
Shale & lime	3100	3130
Shale, black	3130	3235
SYCAMORE TOP	3235	
Siltstone	3235	3449
Lime	3449	3467
Siltstone	3467	3473
Siltstone & shale	3473	3482
WOODFORD TOP	3482	
Shale & chert	3482	3629
Shale	3629	3654
Shale & chert	3654	3679
Shale	3679	3718
HUNTON TOP	3718	
Lime & chert	3718	3731
Lime	3731	3769
Lime & chert	3769	3839
Lime, granular	3839	3959
Lime, red	3959	3969
Lime, granular	3969	4004
Lime, dense	4004	4019
Lime, crinoidal	4019	4024
Lime, glauconitic	4024	4028
Lime, oolitic	4028	4033
SYLVAN TOP	4033	
Shale, green	4033	4199
Shale, brown	4199	4279
Shale, dolomitic	4279	4286
VIOLA TOP	4286	
Lime	4286	4319
Lime, cherty	4319	4439
Lime	4439	4454
Lime, cherty	4454	4519
Lime	4519	4579
Lime, cherty	4579	4594
Lime	4594	4629
Lime, cherty	4629	4710
Lime	4710	4725
Lime & chert	4725	4730
BROMIDE TOP	4730	
Lime	4730	4740
Lime & green shale	4740	4761
Lime	4761	4785
Sand, fine, calc.	4785	4795
Lime, sandy	4795	4806
Lime	4806	4815
Lime & green shale	4815	4845
Lime, sandy	4845	4860
Lime & green shale	4860	4878
Shale, green	4878	4882
Lime & green shale	4882	4892
Sand, calcareous	4892	4898
Sand & shale	4898	4916
Sand, spotted	4916	4934
Siltstone & lime	4934	4956
Sand & green shale	4956	4984
Lime, sandy	4984	4988
Sand, asphaltic	4988	5001
Sand, tight, spotted	5001	5010
Sand, asphaltic	5010	5017
Sand & green shale	5017	5025
Sand, asphaltic	5025	5028
Sand, spotted stain	5028	5037
Sand, argillaceous	5037	5043
Sand, asphaltic	5043	5052
Sand, asphaltic	5052	5056
Sand, porous	5056	5062
Sand, calcareous	5062	5071
Sand & shale	5071	5074
Sand, tight	5074	5090
Sand & green shale	5090	5101
Sand, calcareous	5101	5113
Lime	5113	5120
Sand, calcareous	5120	5122
Sand & lime, sandy	5122	5125
Sand, asphaltic	5125	5132
Sand, asphaltic	5132	5136
Sand, calcareous	5136	5156
Lime, sandy, stained	5156	5166
Sand, asphaltic	5166	5175
Sand, calcareous	5175	5178
Shale, green	5178	5182
Sand, calcareous	5182	5196
Sand, spotted stain	5196	5200
Sand, calcareous	5200	5216
McLISH TOP	5216	
Lime	5216	5235
Sand, calcareous	5235	5245
Sand & green shale	5245	5257
Sand, calcareous	5257	5263
Sand & green shale	5263	5270
Shale, green	5270	5275
Lime, sandy	5275	5280
Shale, green	5280	5285
Lime & green, sandy sh.	5285	5320

FORMATION	TOP	BOTTOM
Lime & green shale	5320	5350
Shale, green	5350	5370
Lime, sandy green sh.	5370	5420
Shale, green	5420	5425
Sand, calcareous	5425	5460
Shale, green	5460	5475
Lime	5475	5485
Sand, calcareous	5485	5490
Lime	5490	5495
Sand, calcareous	5495	5505
Lime	5505	5520
Shale, green	5520	5525
Lime & green shale	5525	5550
Lime	5550	5585
Lime & green shale	5585	5599
Sand, calcareous	5599	5602
Sand & lime	5602	5632
Sand, oil stained	5632	5642
Sand, argillaceous	5642	5652
Sand, oil stained	5652	5660
Sand & shale	5660	5668
Sand, oil stained	5668	5683
Sand, calcareous	5683	5690
Sand, tight, stained	5690	5713
OIL CREEK TOP	5713	
Shale & sand	5713	5725
Lime & sand	5725	5730
Lime & green shale	5730	5735
Lime	5735	5750
Lime, sandy	5750	5770
Lime	5770	5793
Shale, green	5793	5800
Lime	5800	5803
Lime, sandy	5803	5810
Lime	5810	5815
Lime & green shale	5815	5834
Lime	5834	5839
Lime & sandy, green sh.	5839	5857
Lime	5857	5868
Lime & green shale	5868	5880
Shale, green, limy	5880	5890
Lime	5890	5900
Shale, green, sandy	5900	5910
Lime & green shale	5910	5915
Shale, green	5915	5918
Lime	5918	5923
Shale, green & limy	5923	5930
Sand, calcareous	5930	5935
Shale, green & lime	5935	5940
Lime	5940	5944
Shale, green & sand	5944	5955
Lime	5955	5962
Sand, calcareous	5962	5970
Shale, green & sand	5970	5975
Lime, sandy	5975	5990
Shale, green	5990	5995
Lime, sandy	5995	6000
Shale, green	6000	6015
Lime & shale, green	6015	6020
Shale, green	6020	6030
Lime & shale, green	6030	6045
Shale, green	6045	6050
Lime	6050	6055
Shale, green	6055	6065
Lime & shale, green	6065	6090
Lime	6090	6095
Shale, green & sand	6095	6100

FORMATION	TOP	BOTTOM
Lime & green shale	6100	6125
Shale, green	6125	6130
Lime, sandy	6130	6134
Sand, calcareous	6134	6138
Lime & green shale	6138	6160
Shale, green	6160	6165
Lime, sandy	6165	6179
Sand, asphaltic	6179	6185
Sand	6185	6189
Sand, asphaltic	6189	6192
Sand, oil stained	6192	6219
Sand, calcareous	6219	6227
Sand, oil stained	6227	6245
Sand, calcareous	6245	6255
Sand, oil stained	6255	6260
Sand, calcareous	6260	6270
Lime	6270	6278
Sand, tight	6278	6290
Lime	6290	6305
Shale, green	6305	6314
Sand, tight	6314	6326
Sand, oil stained	6326	6332
Sand, calcareous	6332	6348
Sand & green shale	6348	6358
Lime & green shale	6358	6365
Lime, sandy	6365	6378
Shale, green	6378	6385
Lime, sandy	6385	6400
Lime & green shale	6400	6414
Sand, oil stained	6414	6420
Sand, calcareous	6420	6423
Shale, green	6423	6430
Sand, oil stained	6430	6440
Lime & green shale	6440	6450
Sand, oil stained	6450	6456
Sand, tight	6456	6460
Sand, oil stained	6460	6465
Lime	6465	6475
Sand, tight	6475	6483
Sand, oil stained	6483	6486
Lime, sandy & green shale	6486	6495
Sand, oil stained	6495	6508
Lime	6508	6513
Sand	6513	6533
Lime	6533	6536
Sand	6536	6558
Lime	6558	6565
Sand, tight	6565	6578
Lime	6578	6581
Sand, tight	6581	6603
JOINS TOP	6603	
Dolomite	6603	6615
Lime	6615	6700
Lime, sandy	6700	6708
Lime	6708	6718
Sand, tight	6718	6724
Lime, sandy	6724	6736
Lime	6736	6740
Sand, calcareous	6740	6746
Dolomite	6746	6750
Lime	6750	6760
Lime, sandy	6760	6765
Lime & dolomite	6765	6770
Lime	6770	6781
Lime & dolomite	6781	6792
Dolomite	6792	6800
Sand	6800	6814

FORMATION	TOP	BOTTOM
ARBUCKLE TOP	6814	
Dolomite	6814	6825
Dolomite, sandy	6825	6835
Dolomite	6835	6850
Dolomite, sandy	6850	6858
Sand, asphaltic	6858	6868
Dolomite	6868	6898
Dolomite, sandy	6898	6900
Sand	6900	6905
Dolomite	6905	6910
Sand, dolomitic	6910	6923
Lime	6923	6942
Sand, calcareous	6942	6947
Dolomite, sandy	6947	6960
Lime	6960	6968
Dolomite	6968	6993
Dolomite, hard	6993	6995

FORMATION	TOP	BOTTOM
Dolomite	6995	7010
Lime	7010	7025
Dolomite	7025	7058
Dolomite, sandy	7058	7064
Dolomite	7064	7100
Dolomite, sandy	7100	7135
Sand	7135	7140
Dolomite, reddish	7140	7175
Dolomite & chert	7175	7180
Dolomite, reddish	7180	7225
Dolomite & lime	7225	7250
Dolomite & chert	7250	7255
Dolomite, red, sandy	7255	7373
Lime, oolitic	7373	7380
Dolomite, reddish	7380	7498
Lime, oolitic	7498	7500
T.D.		7500

INDEX

(**Boldface** numbers indicate main references; parentheses indicate page numbers of figures; brackets indicate page numbers of tables)