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GEOLOGY AND MINERAL RESOURCES OF CHOCTAW COUNTY, OKLAHOMA

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Title Page Illustration

Ink drawing by Roy D. Davis from a photograph (see fig. 10, p. 17) of the Soper Limestone Member of the Bokchito Formation (Lower Cretaceous) at its type locality east of Soper, west-central Choctaw County, Oklahoma. This limestone bed, shown here overlying the Denton Clay Member of the Bokchito Formation, has been known informally as the "*Ostrea carinata*" bed.

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CONTENTS

	Page
Abstract	1
Introduction	2
Location and description of area	2
Purpose and methods of investigation	2
Previous investigations	2
Geography	3
Climate	3
Cities and towns	3
Roads and railroads	3
Industries	4
Topography and drainage	4
Dams and reservoirs	5
Hugo Dam and Lake	5
Boswell Dam and Reservoir	5
Pine Creek Dam and Reservoir	6
Lake Roebuck	6
Lake Raymond Gary	6
Historical background	6
Stratigraphy	7
Stratigraphic summary	7
Mississippian System	9
Meramecian(?) and Chesterian Series	9
Stanley Group	9
Tenmile Creek Formation	9
Moyers Formation	9
Pennsylvanian System	9
Morrowan Series	9
Jackfork Group	9
Chickasaw Creek Formation	9
Wildhorse Mountain Formation	9
Prairie Hollow Shale Member	10
Upper massive sandstone member	10
Cretaceous System	11
Comanchean Series	11
Trinity Group	11
Antlers Sandstone	11
Fredericksburg Group	13
Walnut Clay	13
Goodland Limestone	13
Kiamichi Formation	15
Washita Group	15
Caddo Formation	15
Bokchito Formation	16
Denton Clay Member	16
Soper Limestone Member (new)	16
Weno Clay Member	17
McNutt Limestone Member (new)	18
Pawpaw Sandstone Member	18
Bennington Limestone	19
Gulfian Series	19
Woodbine Formation	19
Quaternary System	21
Alluvium and terrace deposits	21
Alluvium	21
Terrace deposits	21
Cooke terrace	22
Ambrose terrace	22
Intermediate terrace	23
Hardeman terrace	24
Undifferentiated fluviatile terrace deposits	24

Page

Structural geology 24
Ouachita province 24
Coastal Plain province 25
Geologic history 26
Economic geology 26
Sand and gravel 26
Limestone 27
Sandstone 27
Shales for road metal 27
Water supplies 27
Clay products 27
Future possibilities 27
References cited 28
Appendix—measured stratigraphic sections 31
Index 37

ILLUSTRATIONS

Figures

1. Index map of Oklahoma showing location of Choctaw County 2
2. Generalized columnar section for Choctaw County 8
3. Red, green, and chocolate-brown shale of Prairie Hollow Shale Member of Wildhorse Mountain Formation 10
4. Upper massive sandstone member of Wildhorse Mountain Formation in Youngman quarry. 11
5. Typical exposure of Antlers Sandstone 12
6. Red cross-bedded Antlers Sandstone along east side of Red Rock Road 12
7. Goodland Limestone and overlying shale of Kiamichi Formation in Wray Wyable quarry north of Hugo 14
8. Close-up of uppermost Goodland Limestone and overlying beds of Kiamichi Formation in Wray Wyable quarry 14
9. Lower part of Denton Clay Member of Bokchito Formation, railroad cut east of Soper 17
10. Type locality of Soper Limestone Member of Bokchito Formation, railroad cut east of Soper 17
11. Weno Clay Member of Bokchito Formation, capped by remnant of McNutt Limestone Member 18
12. McNutt Limestone Member of Bokchito Formation along Horse Creek north of Grant 19
13. Basal pebble conglomerate of Woodbine Formation lying disconformably on Caddo Formation southeast of Swink 20
14. Tuffaceous concretionary beds in Woodbine Formation at intersection of Oklahoma Highway 109 and Crowder Springs Road 21
15. Alluvial or flood-plain level 30 feet above water level of Kiamichi River 21
16. Terrace gravels 23
17. Sand and gravel operations of Choctaw Materials Company north of Hugo 24
18. Terrace sands and gravels in abandoned pit northwest of Messer 25

Plate

1. Geologic map of Choctaw County .... pocket

TABLES

1. Average temperature and precipitation, by months, for Choctaw County 3
2. Population trends in Choctaw County, 1940-70 4
3. Industries in Hugo, Oklahoma 5
4. Historic sites in Choctaw County 7
5. Analysis of Denton Clay Member of Bokchito Formation 28

GEOLOGY AND MINERAL RESOURCES OF CHOCTAW COUNTY, OKLAHOMA

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Abstract.–Choctaw County comprises 784 square miles in southern Oklahoma. Boundaries include the Red River on the south, McCurtain County on the east, Pushmataha and Atoka Counties on the north, and Bryan County on the west.

Sedimentary rocks range in age from Late Mississippian (Meramecian? and Chesterian) to Late Cretaceous (Gulfian). These are overlain at places by extensive deposits of Quaternary terrace and alluvium. Late Mississippian and Early Pennsylvanian strata are exposed only in the northeastern part of Choctaw County as inliers projecting through the gently southward-dipping Cretaceous strata of the Gulf Coastal Plain province.

Mississippian strata include part of the Tenmile Creek Formation, which is assigned to the Stanley Group of Late Mississippian age. The Jackfork Group of Early Pennsylvanian age is represented by the Wildhorse Mountain Formation, including the Prairie Hollow Shale Member. The Moyers and Chickasaw Creek Formations, and the lower part of the Wildhorse Mountain Formation, are concealed by onlapping Cretaceous strata. The Lower Cretaceous beds rest unconformably on the folded and eroded Paleozoics and include, in ascending order: Antlers Sandstone (Trinity Group); Goodland Limestone and Kiamichi Formation (Fredericksburg Group); Caddo Formation, Bokchito Formation, and Bennington Limestone (Washita Group). The Woodbine Formation of Late Cretaceous age unconformably overlies the Lower Cretaceous units.

Choctaw County is thinly populated and is economically underdeveloped. Its principal resources are abundant land and water. The value of the land is controlled mainly by the soils, which are related directly to the underlying bedrock or to surficial deposits of terrace and alluvium.

In general, the Antlers Sandstone gives rise to an irregular, hilly topography and a thick sandy soil of low fertility. The Antlers terrane is best adapted for growing trees (including pines) and Bermuda pasture grass.

The limestone-shale sequence of the Goodland, Kiamichi, and Caddo forms a gently rolling topography, black topsoil, and upland prairie well adapted to pasture grass. The Bokchito Formation grades upward from clay to sand, giving rise to rolling hills and sandy topsoil with tree and grass cover. The Woodbine Formation forms an irregular, deeply dissected terrane best adapted to growing hardwoods, especially oak.

Broad expanses of flat-bottomed flood plains and terraces along the Red River and its tributaries offer the best cropland in the County. With adequate fertilization and summer irrigation, these areas can be made very productive. Today, cotton, alfalfa, and peanuts are being grown on bottom-land farms.

Choctaw County has an abundance of water. The average annual rainfall of 47 inches provides adequate moisture throughout most of the year and feeds the major south-flowing rivers, which are being dammed to form large reservoirs for recreation, flood control, and possibly irrigation. The Hugo Dam and Reservoir on the Kiamichi River are now complete (1975), and the Boswell Reservoir on Boggy Creek has been authorized. These new lakes should attract both tourists and industry and give Choctaw County a much-needed economic stimulus.

Mineral products include abundant sandstone and limestone for quarrying, sand and gravel for construction purposes, and ground water. Commercial production of oil and gas has not been established, and prospects for future development are not promising. However, the area has not been condemned by drilling, and both Arbuckle and Ouachita structures are believed to underlie the Cretaceous coastal-plain strata.

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INTRODUCTION

Location and Description of Area

Choctaw County, Oklahoma, comprises 784 square miles in the southern part of the State (fig. 1). It is bounded on the east by McCurtain County, on the north by Pushmataha and Atoka Counties, and on the west by Bryan County. The Red River forms all but a small part of the southern boundary, separating Choctaw County, Oklahoma, from Lamar and Red River Counties, Texas. Choctaw County is approximately rectangular in shape, measuring 45 miles from east to west and 18 miles from north to south.

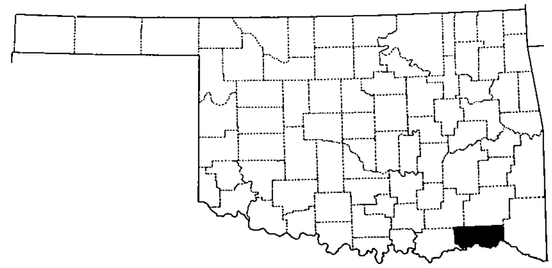

Figure 1. Index map of Oklahoma showing location of Choctaw County.

Purpose and Methods of Investigation

The primary purpose of this investigation was the detailed areal mapping of sedimentary strata cropping out in Choctaw County. Four graduate students from The University of Oklahoma, working under the direction of the senior author, mapped the area during the summers of 1965, 1966, and 1967. The western part was mapped by Jeffries (1965), the central by Dalton (1966), and the eastern by Alfonsi and Duarte-Vivas (1967). Field work was checked by the senior author, and several critical areas were remapped during August 1969 and August 1971.

Mapping was accomplished on township plats prepared from aerial photographs (scale, 3.1 inches per mile). Formation contacts and other data were traced on acetate overlays covering the photos; these were later placed on the township plats. Data from the township plats were transferred to a base map, which was photographically reduced to a scale of 1.5 inches per mile. Marion Clark, Oklahoma Geological Survey cartographer, prepared the final color geologic map at a scale of 1 inch to the mile (pl. 1, in pocket).

During the course of the field work, representative stratigraphic sections were measured and described. Samples were examined and analyzed at The University of Oklahoma. The project was financed by the Oklahoma Geological Survey.

Previous Investigations

Early geographic and geologic investigations along the Red River dating back to the early part of the 19th century have been summarized by Larkin (1909, p. 3-4, 13). These include mapping by Alexander von Humboldt from 1799 to 1804, William Kennedy in 1836, and G. A. Scherpf in 1841.

The first important geologic work on the Cretaceous of the Red River region was by Roemer, from 1845 to 1847 (Roemer, 1846, 1848, 1852). In 1852, an exploratory party under Captain R. B. Marcy traveled from Fort Smith, Arkansas, into what is now Oklahoma. Dr. G. G. Shumard (1854), a physician attached to the expedition, applied the name *Washita Limestone* to beds exposed near old Fort Washita in Bryan County, Oklahoma, and collected fossils that were later 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. In his report (1856), Marcou described Cretaceous strata in this region.

Hill (1887) prepared a stratigraphic section of Cretaceous strata for the Red River region. Hill's monograph (1901) still serves as a standard reference for the Cretaceous of northern Texas and southern Oklahoma. Taff (1902, 1903) mapped Cretaceous and older strata in southern Oklahoma in his description of the Tishomingo and Atoka quadrangles and proposed much of the Cretaceous nomenclature for this region. Stephenson (1918) mapped portions of southern Oklahoma and northeastern Texas.

Detailed mapping of Love and Marshall Counties was completed by Bullard (1925, 1926). Davis (1960) summarized the Cretaceous stratigraphy and prepared a geologic map of McCurtain County. Neville M. Curtis, Jr., mapped Bryan County (1956-61), but the results of his work were not published.

Prior to this investigation, no detailed geologic map of Choctaw County had been completed. Information for Choctaw County for the geologic map of Oklahoma (Miser, 1954) was based mainly on reconnaissance mapping by Miser and Taff, except for the northeastern part, which was mapped by Honess (1923).

Recent investigations concerning the Cretaceous of southern Oklahoma have been completed by graduate students from The University of Oklahoma. These include theses by Heilborn (1949), Skolnick (1949), Gibbs (1950), Prewit

(1961), Blau (1961), Hedlund (1966), Redman (1964), Olson (1965), Jeffries (1965), Dalton (1966), Alfonsi (1968), Currier (1968), Duarte-Vivas (1968), Ganser (1968), and Hart (1970). Frederickson, Redman, and Westheimer (1965) reported on the geology and petroleum resources of Love County, Oklahoma.

Stenzel (1971) has redefined genera and species of certain Cretaceous oysters that occur in Choctaw County. An attempt has been made to follow his nomenclature. Fay (1975) has clarified the historical record as to the original collecting localities of three type specimens from Choctaw County, *Mortoniceras vespertinum* (Morton), *Gryphaea corrugata* Say, and *Texigryphaea pitcheri* (Morton); he has suppressed the name *Gryphaea corrugata* as a *nomen nudum*.

Geography

Climate

Choctaw County has a warm, humid, continental to subtropical climate. The summers are hot and humid; winters are relatively mild. The average annual rainfall is 47.08 inches, with April, May, and June being the wettest months. Temperatures are known to range from a minimum of −3°F to a maximum of 110°F. August is the warmest month, with an average temperature of 82.8°F; January is the coldest month, with an average temperature of 43.5°F (table 1).

The average frost-free period extends from about March 20 to November 8, giving an annual growing season of 230 days (Morris, 1952, p. 37).

Cities and Towns

Hugo, the Choctaw County seat, was named by Mrs. W. H. Darrough (whose husband surveyed the original townsite) in honor of the famous author Victor Hugo (Ruth, 1957, p. 376). Hugo has an altitude of 549 feet and a population of 6,585 (1970 census). Choctaw County has a population of 15,141, according to the 1970 census, having declined from 28,358 in 1940 to 20,405 in 1950 and to 15,737 in 1960. Hugo is a popular resort center and serves as winter headquarters for several circuses.

Smaller towns in Choctaw County include Boswell (population 755), Fort Towson (population 430), Soper (population 322), Grant (population 273), Sawyer (population 100), and Swink (population 88). Small rural centers, consisting mainly of a general store, include Apple, Bluff, Duland, Fallon, Forney, Frogville, Gay, Good, Goodland, Hamden, Huskey, Kent, Mayhew, Messer, Nelson, Ord, Sandbluff, Shoals, Speer, Spencerville, Sunkist, and Virgil.

Population continues to decline in the rural areas and small towns in Choctaw County, with only Hugo showing an increase. For information concerning population trends in Choctaw County, see table 2.

Roads and Railroads

U.S. Highway 70 traverses Choctaw County from west to east, passing through Boswell, Soper, Hugo, Sawyer, and Fort Towson. U.S. Highway 271 and State Highway 2 bisect the area, running northward from the Texas line through Grant and

Table 1.—Average Temperature and Precipitation, by Months, for Choctaw County

Month	Temperature (25-year average)	Precipitation (30-year average)
January	43.5	3.54
February	47.3	3.31
March	54.5	3.83
April	63.7	5.15
May	70.9	5.94
June	79.0	4.43
July	82.5	3.65
August	82.8	3.54
September	76.2	3.59
October	65.6	3.44
November	53.9	3.50
December	45.8	3.25
Annual	63.8	47.08

Data from U.S. Weather Bureau station, Hugo, Oklahoma. Reproduced from Pullen and others (1963).

Table 2.—Population Trends in Choctaw County, 1940-70

Area or town	Year 1940[1]	1950[1]	1960[1]	1970	Percent change 1940-70
Choctaw County	28,358	20,405	15,637	15,141	–46.6
Hugo	5,904	5,984	6,287	6,585	+11.5
Boswell	962	875	753	755	–21.5
Fort Towson	501	713	474	430	–14.2
Soper	481	337	309	322	–33.0
Grant	309	351	286	273	–11.7
Swink	116	96	86	88	–24.9

[1]Data from Pullen and others (1963).

Hugo, westward from Hugo to the Forney Corner, and thence northward toward Antlers. State Highway 109 extends southward from Boswell for a distance of 6 miles, turns eastward across the southern part of the area to a point 2 miles northeast of Frogville, and thence northward to Fort Towson. State Highway 93 extends northward from the U.S. Highway 70 junction approximately 2 miles east of Hugo to Messer, thence northeastward across the Hugo Reservoir and northward into Pushmataha County. State Highway 147 runs northward from Sawyer. The Indian Nation Turnpike (completed in 1970) extends north-south through Choctaw County near Hugo. A system of county roads provides adequate access to nearly all parts of the County.

The area is served by two railroads. The St. Louis and San Francisco runs east-west across the area parallel to U.S. Highway 70, connecting Boswell, Soper, Hugo, and Fort Towson. A north-south line of the St. Louis and San Francisco extends from Texas northward through Grant, Hugo, and Speer to Antlers.

Industries

Choctaw County is an agricultural area dominated by grazing and crop growing. Large areas once under cultivation are being converted to pasture land. Principal farm crops include peanuts, cotton, alfalfa, wild hay, Johnson grass, hay, and sorghum.

Much of the County is covered by a heavy growth of timber. The northern part, underlain by the Antlers Sandstone, is yielding a substantial amount of pine, and today some of this is being cut for the lumber industry. South of the Antlers Sandstone outcrop is a broad belt of prairie soils and grasses developed on the shales and limestones of the Washita Group. The southern part of the County is a belt of rolling, forested land formed on sandstone of the Woodbine Formation and adjacent terrace deposits of the intermediate level. A broad belt of flat, somewhat sandy cropland occupies the alluvium and lower terrace levels along the Red River and its major tributaries.

The Goodland Limestone forms a narrow belt extending across the County from northwest to southeast. The Goodland is a source of limestone that is quarried in (1) sec. 25, T. 5 S., R. 13 E., and sec. 30, T. 5 S., R. 14 E.; and (2) north of Hugo in sec. 5, T. 6 S., R. 20 E. (see pl. 1, in pocket). Extensive deposits of sands and gravels are present in terrace materials, especially in the vicinity of Messer, where several pits are being worked.

Several industrial plants operate in Hugo. These include a creosote plant, a cotton compress, a peanut huller, a cotton gin, and a glove factory (table 3).

Topography and Drainage

Choctaw County is in the northern part of the Dissected Coastal Plain province, a subdivision of the Gulf Coastal Plain of the southern United States. The topography is maturely dissected and gently rolling. Southward homoclinal dip gives the area a gentle southward slope characterized by low cuestas and long, gentle dip slopes. Altitudes range from approximately 650 feet in northern parts to 380 feet along the Red River, giving a maximum relief of approximately 270 feet.

The northern part of the area is well dissected and has a hilly topography developed on the Antlers Sandstone. Inliers of sandstone of the Jackfork Group projecting through the Antlers form long, conspicuous ridges in the northeastern part. The central part of the County is characterized by a gently rolling topography with large areas of upland prairie developed on thin terrace cover and gentle dip slopes formed on limestones of the Washita Group. The southern part is irregular and deeply dissected by several south-flowing tributaries of the Red River. Broad

Table 3.—Industries in Hugo, Oklahoma

Firm name	Address	Number of employees
Cearley Machine Shop	204 W. Duke	7
Central Forests Products	W. of city	34
Choctaw Electric Corp.	308 N. Broadway	(51)
Choctaw Materials, Inc.	NE. of city	14
Cowley Manufacturing Co.	708 W. McAlester	9
Fry Forest Products (lumber)	409 S. 7th St.	23
Fry Forest Products (preservative)	W. of city	46
Hugo Dress Co.	501 N. Industrial St.	2
Hugo Ice Cream Co.	108 N. "A" St.	14
Hugo Mattress Factory	W. of city	(2)
Hugo Milling Co.	S. of city	20
Hugo Publishing Co.	114 N. Broadway	9
Idabel Stone Co.	N. of city	18
Lone Star Gas Co.	113 E. Jackson	(8)
Ohlfest and Son	707 N. 2d St.	2
Public Service Co.	117 E. Jackson	(24)
Quadrant Corp.	W. of city	100
Southwestern Bell Telephone Co.	215 E. Kirk	(55)
Walden Chemical Mixer	211 N. "A" St.	6
Wells-Lamont Corp.	E. Kirk Rd.	220

Data from Hugo Chamber of Commerce, 1967; *Oklahoma Directory of Manufacturing*, 1974; *Hugo Telephone Directory*, 1973; Center for Economic and Management Research, University of Oklahoma. Numbers shown in parentheses are for 1967.

expanses of flat-bottomed flood plains and low terraces characterize the extreme southern part.

The area is drained by the Red River and its two main tributaries, Muddy Boggy Creek and the Kiamichi River. Small tributaries of the Red River include Whitewater, Horse, Goodwater, Carney, and Doaksville Creeks. Tributaries of Muddy Boggy Creek are Lick, Pointer, Mayhew, Tanyard, Beaverdam, and Crowder Creeks. Tributaries of the Kiamichi River are North Fork, Salter, Bird, and Gates Creeks.

Dams and Reservoirs

Several large dams and reservoirs have been approved by Congress for the southeastern Oklahoma area. Two of these are in Choctaw County. They are (1) Hugo Lake (nearing completion) and (2) Boswell Reservoir (approved). Several small lakes are present in Choctaw County; the two most important of these are Lake Roebuck and Lake Raymond Gary.

HUGO DAM AND LAKE

The Hugo Dam and Lake, on the Kiamichi River 7 miles east of Hugo, near the village of Sawyer (pl. 1, in pocket), was authorized by the Flood Control Act of 1946. The dam is constructed of rolled material, and the dam, including the spillway, is 10,200 feet long and rises 101 feet above the river bed. The spillway has a concrete ogee weir 290 feet wide and is surmounted by six 40- by 50-foot gates with a maximum discharge of 369,999 cubic feet per second (cfs). The top of the dam has an elevation of 452.5 feet, the flood-control level is 437.5 feet, and the conservation-pool level is 404.5 feet. The flood-control pool covers 34,490 acres and has a reservoir capacity of 966,500 acre-feet; the conservation pool covers 13,250 acres and has a reservoir capacity of 157,300 acre-feet. The entire drainage area includes 1,709 square miles (data from U.S. Army Corps of Engineers).

BOSWELL DAM AND RESERVOIR

The Boswell Reservoir, which has a projected location on Boggy Creek below the confluence of Muddy Boggy and Clear Boggy Creeks 3 miles west of Soper (pl. 1, in pocket), was authorized by the Flood Control Act of 1946. The reservoir will be a multipurpose project to include water supply, recreation, and fish and wildlife preservation.

The dam is to be constructed of rolled earth-fill material. The dam and spillway together will be 12,450 feet long and will rise 95 feet above the stream bed. The top of the dam will have an elevation of 493 feet; the top of the conservation pool will be 435 feet, and the top of the flood-storage pool, 479 feet. The spillway will be a grated, concrete ogee-weir type. Eleven 50- by 25-foot spillway gates will release 307,000 cfs during maximum discharge. Low flow will be regulated by ten 7- by 14-foot sluices.

The drainage area embraces 2,273 square miles. The conservation pool will cover 5,540 acres and 35,800 acre-feet of water. The flood-control pool will inundate 48,700 acres, with a storage capacity of 1,094,200 acre-feet. Thus the total storage capacity will be 1,130,000 acre-feet (data from U.S. Army Corps of Engineers, April 1968).

PINE CREEK DAM AND RESERVOIR

The Pine Creek Dam and Reservoir have been completed recently on Little River below its junction with Pine Creek in McCurtain County, Oklahoma (sec. 23, T. 5 S., R. 21 E.), to the east of Choctaw County. The conservation-pool level of 443.5 feet will create a lake covering 5,000 square miles with 77,700 acre-feet of water. The flood-control level of 480.0 feet will create a reservoir covering 17,200 acres with a reservoir capacity of 465,800 acre-feet. During time of maximum flooding, the waters of the Pine Creek Reservoir will inundate a small area along Pine Creek in eastern Choctaw County (secs. 13, 14, 23, and 24, T. 5 S., R. 20 E.).

LAKE ROEBUCK

Lake Roebuck, Oklahoma's largest natural lake (Ruth, 1957, p. 390), occupies a large abandoned meander on the flood plain of the Red River southwest of Grant (pl. 1, in pocket). It covers 350 acres and is stocked with bass, channel catfish, and other game fish.

LAKE RAYMOND GARY

Lake Raymond Gary, near Fort Towson in eastern Choctaw County (pl. 1, in pocket), covers approximately 300 acres when filled. The lake is spring fed and is stocked with bream, crappie, catfish, and bass. It was designed for recreation and provides swimming, boating, skiing, and fishing. Ample tables, shelters, and other facilities make this an important recreational area.

Historical Background

Choctaw Indians from Georgia, Alabama, and Mississippi settled in what is now Choctaw County in 1833 following their relocation by the federal government (Pullen and others, 1963). Prior to their arrival, the area's population consisted of a few white settlers and the troops stationed at the army garrison established in May 1824 under the command of Col. Matthew Arbuckle.

Choctaw County, originally part of the lands of the Choctaw Indian Nation, played an important role in the historical development of Oklahoma. The Oklahoma Historical Society has placed roadside markers at or near the site of many famous landmarks in Oklahoma. A brief description of these is contained in a booklet published by the Oklahoma Historical Society and edited by Wright and Shirk (1958). A listing of significant historic sites in Choctaw County is included in table 4. Robert O. Fay, Oklahoma Geological Survey, has shown some of these on the geologic map accompanying this report (pl. 1, in pocket).

Early industry in Choctaw County was restricted to "patch-farming." Game was plentiful and easily obtainable, and subsistence-living was typical. A few large plantations were owned by wealthy Indians who had intermarried with whites. Negro slavery was a common practice, and many Indian plantation owners had their slaves. Corn, cotton, and livestock were produced on the plantations and the products shipped on the Red River.

Following the Civil War and the building of the railroads, immigration of whites from Texas and Arkansas increased markedly. Agricultural activities became more diversified as wheat, oats, vegetables, and other crops were introduced. Several sawmills were established, and the lumbering business prospered until 1910, when most of the timber was exhausted.

Presbyterian, Baptist, and Catholic missionaries had come to the area before the Indian migration of 1833, and several missions and mission schools were established. These include Spencer Academy, Goodwater Mission, and Goodland Mission.

Prior to 1900, legal ownership of land was unknown and "squatters-rights" prevailed. The Indian lands were surveyed in 1900, and legal rights were assigned to the squatters. Several townsites were officially established, including Tailholt, whose name was changed to Hugo in 1902.

Agriculture prospered as Choctaw County continued to develop during and after World War I. During this time, a cotton compress, a peanut sheller, and the Hugo Division of the Frisco Railroad were established. Economic chaos struck the area during the drought and depression of 1929-33. Farms were abandoned, people moved into small rural communities, and an extensive welfare program was initiated by the federal government.

During World War II, it became obvious that new industries must be brought into Choctaw County if its economy were to survive. Several

Table 4.—Historic Sites in Choctaw County

1. Goodland Mission (Presbyterian, U.S.), 1848 to present, in Choctaw Nation, 2 mi SW. Hugo.
2. Rose Hill, site 3 mi SE. Hugo, 1844, home of Robert M. Jones, noted Choctaw planter; old cemetery here.
3. Goodwater Mission, Choctaw Girls' School, 1842, site about 4 mi W. Frogville. Old mission cemetery and missionary graves (1848) near school.
4. Ft. Towson, established by Col. Matthew Arbuckle, 1824; site of U.S. Post Office about 1 mi NE. town of Ft. Towson.
5. Doaksville, 1830's, site W. edge Ft. Towson. Old cemetery contains grave of noted David Folsom, Choctaw chief, and other graves.
6. Choctaw Chief's House, Choctaw Nation, oldest building standing in Oklahoma, dating from 1832. Part of 2-story log house ½ mi N. and 1½ mi E. Swink.
7. Choctaw Ration Station, near Ft. Towson, 1831-34; site near "Witch Hole" 2 mi S. Swink and near old landing site for corn shipped up Red River by Army.
8. Old Spencer Academy established 1841, Choctaw Boys' School; cemetery of missionary graves, on ridge ½ mi W. of school site, 9 mi N. Sawyer, SW¼ sec. 6, T. 5 S., R. 19 E. (Here "Uncle Wallace" Willis and his wife, Negro slaves, first sang his song "Swing Low Sweet Chariot," in early 1850's.)
9. New Spencer Academy, 2d site, 1883; about 7 mi N. Soper.
10. Living Land Presbyterian Church, 1856; cemetery of Hotchkin family, on Red River about 2½ mi SE. Bluff, sec. 31, T. 7 S., R. 16 E.
11. Mayhew, old site on Mayhew Creek, SE¼ sec. 6, T. 6 S., R. 14 E. First post office established here Feb. 5, 1845, Charles F. Stewart, postmaster and owner of store; graves in cemetery date from 1850's. New site of Mayhew is in SE¼ sec. 1, T. 6 S., R. 13 E.; Mayhew court ground, Jackson County (1886), Choctaw Nation, was here, and last court house is standing.
12. Old water mill on Kiamichi River, site in vicinity of Sawyer, 1820's, north of present Kiamichi River bridge on U.S. Highway 70.
13. Providence Mission, Baptist, 1837, site at or near "Rose Hill," home of Col. Robert M. Jones, SE. of Hugo.
14. Horse Prairie, W. side Kiamichi River, E. "Rose Hill," location of Chief Nitakechi's house, Choctaw Nation, 1834.
15. Cole Nelson home; site near Nelson; prominent leader in Choctaw Nation before Civil War.
16. Spring Bluff, pre-Civil War, shown on early maps in Forks of the 2 Boggy Creeks, probably in NW. Choctaw County.
17. Folsom Salt Works; Folsom settled at site in 1836, 3½ mi E. and 2½ mi N. Boswell, NW¼ sec. 35, T. 5 S., R. 14 E.
18. Rock Chimney Ferry—E. side Kiamichi River near Sawyer; 2 old stone chimneys marked this ferry at old house built long before Civil War; site shown on old maps about 7 mi W. of Doaksville (sec. 25, T. 6 S., R. 18 E.), now just N. of bridge across Kiamichi River on U.S. Highway 70. This was river crossing on road from Doaksville to Boggy Depot. Old water mill (see 12 above) was near this ferry and house site.

Data taken from Oklahoma Historic Sites Committee (1958, p. 6-7).

plants have been established in Hugo (table 3), the largest being the Wells-Lamont Corporation, which employs nearly 300 people.

STRATIGRAPHY

Stratigraphic Summary

Rocks exposed at the surface in Choctaw County range in age from Late Mississippian (Meramecian? and Chesterian) to Late Cretaceous (Gulfian). These are overlain at places by extensive deposits of terraces and alluvium of Pleistocene and Holocene age (fig. 2; pl. 1, in pocket).

Mississippian rocks are limited to a few small exposures in the extreme northeastern corner of the County, where they are overlapped by the Antlers Sandstone of Early Cretaceous age. Mississippian strata present are part of the Tenmile Creek Formation (Stanley Group). The overlying Moyers Formation has not been recognized and is believed to be concealed beneath the overlapping Cretaceous rocks.

Outcropping Pennsylvanian rocks are confined to the Wildhorse Mountain Formation, including the Prairie Hollow Shale Member and an unnamed upper sandstone member, of the Jackfork Group (Morrowan). The underlying Chickasaw Creek Formation, the lowermost unit of the Jackfork Group as recently defined by the Oklahoma Geological Survey (see Briggs, 1973, p. 2, fig. 2, and pl. 1), has not been identified in Choctaw County; like the Moyers Formation, it is believed to be concealed beneath Cretaceous rocks.

SYSTEM	SERIES	GROUP, FORMATION, MEMBER	ROCK	THICKNESS (FEET)	DESCRIPTION OF UNITS
QUATERNARY	HOLOCENE	ALLUVIUM		20-30	Clay, sand, and silt of modern flood plains. Surface 20 feet above normal water level in Red River.
QUATERNARY	PLEISTOCENE	TERRACE DEPOSITS		90-120	Sand, silt, clay, and gravel making up four distinct levels: Qt_1, Qt_2, Qt_3, and Qt_4.
CRETACEOUS	GULFIAN	WOODBINE FORMATION		300-400	Includes a basal red-brown ferruginous pebble conglomerate; yellow to reddish-brown cross-bedded sandstone; varicolored shales (Rainbow Clay Member); volcanic tuff and sandstone exhibiting large green calcareous concretions in a matrix of friable tuff; some dark-colored shales.
CRETACEOUS	COMANCHEAN	WASHITA GROUP: BENNINGTON LIMESTONE		0-18	Gray to gray-brown sandy, fossiliferous limestone, which weathers to pitted and honeycombed surfaces; abundant *Ilymatogyra arietina* (Roemer).
CRETACEOUS	COMANCHEAN	WASHITA GROUP: BOKCHITO FORMATION: PAWPAW SANDSTONE		35	Yellow to reddish-brown sandstone interbedded with gray to brown sandy clays; abundant molds and casts of *Protocardia*.
CRETACEOUS	COMANCHEAN	WASHITA GROUP: BOKCHITO FORMATION: MCNUTT LIMESTONE		2-3	Gray-brown sandy limestone with abundant *Rastellum (Arctostrea) quadriplicatum* (Shumard).
CRETACEOUS	COMANCHEAN	WASHITA GROUP: BOKCHITO FORMATION: WENO CLAY		30-53	Brownish shales with interbeds of yellow to red ferruginous sandstone; abundant selenite crystals on weathered surfaces; *Turritella* and *Protocardia* common.
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 CLAY		45-65	Blue-gray shale, grading upward into marly limestones near top.
CRETACEOUS	COMANCHEAN	WASHITA GROUP: CADDO FORMATION		140-150	Upper part (Fort Worth equivalent) includes gray shales and interbedded gray to cream-colored limestones; lower part includes blue-gray shales and gray silty limestone containing large cephalopods (Duck Creek equivalent). *Texigryphaea pitcheri* (Morton) and *Texigryphaea washitaensis* (Hill) common in formation.
CRETACEOUS	COMANCHEAN	FREDERICKSBURG GROUP: KIAMICHI FORMATION		28-33	Dark-gray to black fissile clay shale interbedded in upper part with thin beds of yellow-gray fossiliferous limestones with *Texigryphaea navia* (Hall).
CRETACEOUS	COMANCHEAN	FREDERICKSBURG GROUP: GOODLAND LIMESTONE		26-55	White massive-bedded biomicritic limestone; lower part is nodular; upper part weathers into thin, curved plates.
CRETACEOUS	COMANCHEAN	TRINITY GROUP: ANTLERS SANDSTONE		200-600	White to reddish-yellow fine-grained quartzose sand; ferruginous, poorly cemented; some beds of coarse sands and gravels; lenticular beds of varicolored clay.
PENNSYLVANIAN	MORROWAN	JACKFORK GROUP: WILDHORSE MOUNTAIN FORMATION: UPPER MASSIVE SANDSTONE MEMBER		2,000+	Gray to white compact, heavy-bedded quartzitic sandstone.
PENNSYLVANIAN	MORROWAN	JACKFORK GROUP: WILDHORSE MOUNTAIN FORMATION: PRAIRIE HOLLOW SHALE MEMBER		200-300 EST.	Red to green to chocolate-brown platy shale with thin interbeds of fine-grained sandstone; exposed thickness about 35 feet.
PENNSYLVANIAN	MORROWAN	JACKFORK GROUP: CHICKASAW CREEK FORMATION		?	Concealed (?) by overlap of Antlers Sandstone.
? MISSISSIPPIAN	? MERAMECIAN (?) AND CHESTERIAN	STANLEY GROUP: MOYERS FORMATION		?	Concealed (?) by overlap of Antlers Sandstone.
MISSISSIPPIAN	MERAMECIAN (?) AND CHESTERIAN	STANLEY GROUP: TENMILE CREEK FORMATION		?	Gray-green compact fine-grained argillaceous sandstone, nonfossiliferous. Exposures limited to three small areas. Thickness unknown.

Figure 2. Generalized columnar section for Choctaw County.

Lower Cretaceous strata rest unconformably upon eroded Paleozoic rocks. The Lower Cretaceous is divided into the Trinity, Fredericksburg, and Washita Groups, in ascending order. The Trinity Group is represented by the Antlers Sandstone, the Fredericksburg Group by the Goodland Limestone and the Kiamichi Formation, and the Washita Group by the Caddo Formation, the Bokchito Formation (Denton-Weno-Pawpaw sequence), and the Bennington Limestone.

The lowermost unit of the Upper Cretaceous, the Woodbine Formation, lies disconformably upon Lower Cretaceous rocks; the Grayson Marlstone is absent by erosion, and the Bennington Limestone has been removed at places by erosion. In extreme southeastern Choctaw County, the Woodbine Formation and its basal conglomerate rest disconformably upon the Caddo Formation.

Cretaceous sediments dip gently southward at rates of 50 to 125 feet per mile, forming low, northward-facing escarpments and long, gentle, southward-sloping dip slopes. Mississippian and Pennsylvanian strata (Stanley and Jackfork Groups) are folded to form the Hugo syncline, a southwestern extension of the Ouachita Mountain province.

Several distinct terrace and alluvial levels parallel the Red River and its tributaries, Kiamichi River and Muddy Boggy Creek.

Mississippian System

Meramecian(?) and Chesterian Series

STANLEY GROUP

Tenmile Creek Formation

The term *Stanley* was proposed by Taff (1902, p. 4) for exposures near the town of Stanley, Pushmataha County, Oklahoma. Harlton (1938, p. 854) elevated the Stanley to group rank and applied the name *Tenmile Creek Formation* to the lowermost subdivision, the name being taken from exposures along Tenmile Creek, 3 miles west of Miller, Pushmataha County, Oklahoma. The Tenmile Creek was originally defined as including all beds between the Arkansas Novaculite and the siliceous shale member of the Moyers Formation.

The Tenmile Creek Formation is poorly exposed in the northern and eastern parts of sec. 1, T. 5 S., R. 20 E., where it forms three small outliers in the Antlers Sandstone of Early Cretaceous age. Thickness determinations could not be made on the limited exposures available. Here, the exposed Tenmile Creek Formation consists of gray-green argillaceous, nonfossiliferous, compact fine-grained sandstone that weathers dark green. No sedimentary analyses were made of the Choctaw County rocks, although Woodson (1964, p. 15) described the sandstones in southeastern Pushmataha County as consisting of 94 to 99 percent quartz with traces of feldspar, muscovite, tourmaline, chert, and limonite (as stain). Sedimentary structures, including flute casts, groove casts, ripple marks, cross-bedding, and convolute bedding, were observed by Woodson (p. 15) in southernmost Pushmataha County.

The Tenmile Creek Formation has long been referred to the Mississippian System. On the basis of radiolarians, sponge spicules, and conodonts, Hass, Cline, and others have assigned the Stanley Group to the Meramecian (Cline, 1960, p. 40-41). Current studies by members of the Oklahoma Geological Survey are expected to yield more precise dating than is now available; preliminary evidence indicates that most of the Stanley is Chesterian.

Moyers Formation

The Moyers Formation, the upper unit of the Stanley Group, has not been observed in Choctaw County, where it is apparently concealed beneath the onlapping Antlers Sandstone of Early Cretaceous age.

Pennsylvanian System

Morrowan Series

JACKFORK GROUP

Chickasaw Creek Formation

The Chickasaw Creek Formation, the basal unit of the Jackfork Group of Early Pennsylvanian age, as recently defined by the Oklahoma Geological Survey, had heretofore been considered the uppermost unit of the Stanley Group of Mississippian age (see Briggs, 1973, p. 2, fig. 2, and pl. 1). Like the underlying Moyers Formation, it is apparently concealed beneath Cretaceous rocks in Choctaw County. In southern Pushmataha County, the Moyers and the Chickasaw Creek have an aggregate thickness of 1,200 feet.

Wildhorse Mountain Formation

The Wildhorse Mountain Formation was named by Harlton (1938, p. 878). At the type locality in Pushmataha County, the Wildhorse Mountain consists of 3,550 feet of massive sandstones interbedded with shales and thin sandstones (Cline, 1960, p. 48). Shelburne (1960, p. 27) reported a thickness of 3,880 feet in the Boktukola syncline in northern McCurtain and southwestern Le Flore Counties. There, the formation is divisible into three members: (1) a lower, unnamed member, composed of 1,700 feet of gray shale, friable yellow-green sandstone, and quartzitic gray sandstone; (2) the Prairie Hollow Shale Member, composed of about 310 feet of subequal amounts of gray sandstone and maroon and chocolate shale; and (3) an upper, unnamed sandstone member, composed of soft yellow-weathering sandstone interbedded with gray shales, and gray fine-grained, thin-bedded quartzitic sandstones, having a thickness of 1,771 feet.

In northeastern Choctaw County, the exposed Wildhorse Mountain Formation includes the Prairie Hollow Shale Member and the overlying unnamed massive sandstone member.

Prairie Hollow Shale Member.—The Prairie Hollow Shale Member was named by Harlton (1938, p. 880) from Prairie Hollow, on the west side of Round Prairie syncline at the type locality of the Prairie Mountain Formation (Cline, 1960, p. 49). Harlton considered the Prairie Hollow Shale to be a member of the Prairie Mountain Formation. Cline (1960, p. 50) assigned the Prairie Hollow Shale to the Wildhorse Mountain Formation.

In Choctaw County, the Prairie Hollow Shale Member is exposed in secs. 5, 6, 8, and 17, T. 5 S., R. 20 E., near the base of Bull Mountain, where the shale is quarried for road metal (pl. 1, in pocket). The walls of the quarry reveal an exposed thickness of 25 to 35 feet. The member (fig. 3) consists of red, green, chocolate, and maroon shales and thin beds of gray-green fine- to medium-grained sandstones. The unit is soft and crumbly and weathers rapidly. Contacts with subjacent and with overlying strata were not observed because of limited exposure and overlap of the Antlers Sandstone of Early Cretaceous age.

Upper massive sandstone member.—The upper massive sandstone member of the Wildhorse Mountain Formation was described by Cline (1960, p. 49) and placed in the upper part of the formation, having been assigned previously to the Prairie Mountain Formation by Harlton. Woodson (1964, p. 30) mapped this member with the Prairie Mountain Formation.

The upper massive sandstone member is gray to white compact, iron-stained, thin- to medium-bedded quartzitic sandstone interbedded with thin layers of brown and green siltstone and red to gray shales. Analyses by Woodson (1964, p. 60-65) from the lower part of the sandstone sequence indicate a composition ranging from 92 to 95 percent quartz, 1 to 4 percent feldspar, 1 to 3 percent chert fragments, 1 to 3 percent muscovite, and traces of tourmaline cemented by quartz overgrowth in a matrix of clay.

This sandstone unit is exposed in a series of prominent ridge-forming inliers projecting through the Antlers Sandstone (basal Cretaceous). The largest exposure covers approximately 4 square miles in secs. 5, 6, 7, 8, 17, and 18, T. 5 S., R. 20 E., and secs. 1 and 2, T. 5 S., R. 19 E. (pl. 1, in pocket). The highest point on this ridge is Bull Mountain (Sobol Lookout Tower), at an elevation of 841 feet. The second largest exposure is Spencerville Mountain, an east-west-trending ridge in secs. 13 and 14, T. 5 S., R. 18 E., and secs. 17 and 18, T. 5 S., R. 19 E. Additional scattered exposures are present, and their distribution and structure outline a synclinal fold whose axis trends

Figure 3. Red, green, and chocolate-brown shale of Prairie Hollow Shale Member of Wildhorse Mountain Formation, SE¼ sec. 8, T. 5 S., R. 20 E.

northeast-southwest and plunges southwestward beneath the Cretaceous and alluvial cover. This structure was referred to as the Hugo syncline by Honess (1923, p. 248-249).

The total thickness of the upper massive sandstone member in Choctaw County is unknown because of discontinuous exposures. An estimated thickness of 2,000 feet, based on limited outcrop control and dip determinations, is in close agreement with thicknesses measured by Shelburne (1960, p. 28) in southern Le Flore and northern McCurtain Counties, where 1,771 feet of the upper Wildhorse Mountain is exposed on the north limb of the Boktukola syncline. Piatt (1962, p. 35) reported a thickness of 1,778 feet for the upper sandstone member on the north limb of the Bethel syncline in eastern Pushmataha County.

Only the more resistant sandstone beds are exposed in the ridges surrounding the Hugo syncline. Alfonsi (1968, p. 12) calculated the exposed thickness on Spencerville Mountain to be about 450 feet. Approximately 250 feet is poorly exposed along a road leading to the lookout tower on top of Bull Mountain. A thickness of 51 feet is well exposed in the Clement Brothers quarry, SE¼ sec. 17, T. 5 S., R. 19 E. (Alfonsi, 1968, p. 12), and 20 feet is well exposed in the walls of the Youngman quarry, sec. 1, T. 5 S., R. 19 E. (fig. 4).

No fossils were found in the Wildhorse Mountain Formation in Choctaw County. *Lepidodendron* and *Calamites* were reported by Shelburne (1960, p. 28) and Piatt (1962, p. 35) from exposures in adjacent counties. The formation, part of the Jackfork Group, had been classed as Late Mississippian by Cline (1960, p. 10, 43) but now is considered Early Pennsylvanian (Morrowan) by recent workers.

Cretaceous System

Comanchean Series

TRINITY GROUP

Antlers Sandstone

The Trinity Group, which is represented in Oklahoma by the Antlers Sandstone, was originally described by Hill (1887, p. 296-298) as the "Dinosaur Sands." Hill (1891, p. 510) applied the term *Paluxy* to exposures of white "pack-sand" near the town and creek of Paluxy, Somerville County, Texas, and assigned the unit to the Fredericksburg Group. Taff (1892, p. 272) placed the Paluxy in the Bosque Division (Trinity Group). Hill (1894, p. 317) reassigned the Paluxy to the Trinity Group, and in 1901 he (p. 131) applied the term *Antlers* to Trinity equivalents. The terms *Trinity*, *Paluxy*, and *Antlers* were used more or less interchangably until 1957, when Forgotson (1957, p. 2335) restricted the term *Paluxy* to a sandstone-shale facies, which he considered to be time-equivalent to the Walnut Clay, previously assigned to the Fredericksburg. Forgotson (p. 2352) concluded that the Antlers Sandstone of northern Texas and southern Oklahoma is a time-stratigraphic equivalent of the uppermost Trinity and lower Fredericksburg Groups.

Figure 4. Upper massive sandstone member of Wildhorse Mountain Formation in Youngman quarry, SW¼NW¼ sec. 1, T. 5 S., R. 19 E. Note 15° dip.

Following current usage in Oklahoma (Frederickson and others, 1965, p. 14-15), the term *Antlers* is herein applied to a lithogenetic unit composed mostly of sands lying between the Paleozoic unconformity surface and the base of the Goodland Limestone. The Holly Creek gravels and the De Queen Limestone, which are present in McCurtain County, Oklahoma, have not been recognized in Choctaw County.

The Antlers Sandstone is exposed in a belt ranging from 1 to 9 miles in width, extending diagonally across the northern part of the area (pl. 1, in pocket). The sands and sandy clays of the Antlers are easily eroded and produce a rolling topography characterized by a heavy growth of vegetation (figs. 5, 6). The sandy soil developed on the Antlers has a low fertility and is lacking in organic matter. It is best adapted to the growing of trees and Bermuda pasture grass.

The thickness of the Antlers Sandstone cannot be determined accurately by field investigations. In Love County, Oklahoma (Frederickson and others, 1965, p. 16), the thickness ranges from 200 feet in the northern part of the county to 600 feet near the Red River. Bullard (1926, p. 21) reported 400 to 600 feet in wells in Marshall County, Oklahoma; Davis (1960, p. 27) reported a maximum of 880 feet in southeastern McCurtain

Figure 5. Typical exposure of Antlers Sandstone at road junction, NW corner sec. 15, T. 5 S., R. 15 E.

Figure 6. Red cross-bedded Antlers Sandstone along east side of Red Rock Road, 2 miles north of Fort Towson, sec. 12, T. 6 S., R. 19 E.

County, with northward thinning. Prewit (1961, pl. 2) showed southward thickening from 320 feet to 900 feet in the subsurface south of the area of outcrop.

The lithology of the Antlers is variable. However, the formation is composed mostly of fine- to coarse-grained, moderately sorted, poorly indurated, irregularly cross-bedded ferruginous sand. Its color varies from white to light gray to red. Its composition is almost entirely quartz sand. Accessory minerals (Manley, 1965, p. 28) include zircon, rutile, tourmaline, pyrite, leucoxene, and magnetite. Interbedded clays vary in color from white to light green to red and purple. Irregular lenses of gravels ranging from a few inches to more than 3 feet are interbedded with the clays and sands. At places where the Antlers is in contact with sandstone of the Jackfork Group, a basal conglomerate composed of sandstone cobbles and boulders is present.

Manley (1965, p. 46) recognized four major clay-mineral zones in the basal Cretaceous sediments: (1) a lower, mixed illite-montmorillonite zone derived from the Ouachita Mountains; (2) a middle montmorillonite-illite-kaolinite zone derived from the Ouachita and Arbuckle Mountains and the McAlester (Arkoma) basin; (3) an upper-middle montmorillonite zone derived from the Anadarko basin; and (4) an uppermost kaolinite-rich zone possibly derived from the Appalachian and Wichita Mountains.

The Antlers Sandstone rests unconformably on older sedimentary rocks. In northeastern Choctaw County, the Antlers is in contact with various units of the Stanley and Jackfork Groups of late Paleozoic age. The contact is well exposed in the SE¼ sec. 17, T. 5 S., R. 19 E., in a quarry operated by Clement Brothers Company. There, abundant pebbles and cobbles of Jackfork sandstone have been incorporated in basal beds of the Antlers. Northwestward, near Tishomingo (Johnston County, Oklahoma), beds of the Trinity Group rest unconformably on Precambrian granite.

The contact with the overlying Goodland Limestone appears to be conformable, although the Goodland rests on different lithologies from place to place. The Walnut Clay, with its basal "*Exogyra*" shell agglomerate, which is developed in Love County and parts of Johnston County to the west, has not been recognized in Choctaw County; it has apparently graded laterally into the lower part of the Goodland Limestone. Local irregularities along the contact of the Goodland and the Antlers can be explained by variations within the upper Antlers and differential compaction of lime muds of the Goodland on mudstone layers in the Antlers.

No fossils were observed in the Antlers Sandstone in Choctaw County. Bullard (1926, p. 22) reported oyster beds containing *Ceratostreon texanum* and *Ostrea crenulimargo* in the upper Antlers near Gainesville, Texas. Vanderpool (1928, p. 1089) described similar occurrences near Marietta, Love County, Oklahoma. Petrified wood has been reported by several investigators, including Davis (1960, p. 29) and Redman (1964, p. 25), and was collected by the senior author in southern Marshall County.

The Antlers Sandstone is a Lower Cretaceous transgressive sheet sand that becomes progressively younger northward. It is believed to be equivalent to the upper part of the Trinity Group as recognized in Texas.

FREDERICKSBURG GROUP

Hill (1887, p. 296-299) proposed the term *Fredericksburg division* for Lower Cretaceous carbonates overlying the Dinosaur sand (Trinity Group) near the town of Fredericksburg, Texas. Hill (1891, p. 514) redefined the Fredericksburg Group to include the *Caprina* limestone (Edwards), the Comanche Peak Chalk, the Walnut Clay, and, tentatively, the Paluxy Sand; the latter was removed from the Fredericksburg by Taff (1892, p. 245), and the Kiamichi Formation, previously placed in the overlying Washita Group, was assigned to the Fredericksburg.

According to Hill (1894, p. 303), the Fredericksburg division of the Red River area comprises the Walnut Clay and the Goodland Limestone. Assignment of the Kiamichi has long been controversial; the U.S. Geological Survey (Imlay, 1944, chart 3) now considers it to be the uppermost unit of the Fredericksburg.

Walnut Clay

The term *Walnut* was proposed by Hill (1891, p. 504, 512) for yellow laminated clay marls containing abundant *Ceratostreon texanum*, overlying the Paluxy Sand and underlying the Comanche Peak Chalk in Texas.

The Walnut Clay is poorly developed north of the Red River in Oklahoma. Bullard (1926, p. 26), Frederickson and others (1965, p. 19), and Ganser (1968, p. 13) recognized the Walnut Clay facies in Love, Marshall, and Johnston Counties, but concluded that it was gradational upward into the Goodland Limestone with which it has been included.

The Walnut Clay facies has not been identified in the Choctaw County exposures, although locally the Goodland Limestone rests on pockets or lenses of varicolored clay shale herein interpreted as a local facies of the Antlers Sandstone.

Goodland Limestone

Hill (1891, p. 514) named the Goodland Limestone from exposures near the former site of Goodland (now Good), Choctaw County, Oklahoma. In 1894, Hill (p. 303-304) described the Goodland as "a hard, pure white crystalline limestone" capping the Walnut Clay. He considered it to be the 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 the equivalent of the Edwards and the Comanche Peak Limestones. This conclusion is supported by recent workers, including Lozo (1959, p. 4), Young (1959, p. 97-98), and Blau (1961). For a detailed account of the history of nomenclature, the reader is referred to Blau (1961, p. 3-11).

The Goodland Limestone forms a nearly continuous band trending southeastward across Choctaw County; it is interrupted at places by terrace and alluvial cover (pl. 1, in pocket). The outcrop belt varies from less than 0.25 mile to more than 3 miles. Several large outliers characterize the unit in the northwestern part of the County.

The thickness of the Goodland ranges from 26 feet in the western part of the County to more than 55 feet in the eastern. Because of its relatively uniform thickness, the unit is often referred to by local inhabitants as the "Thirty-foot lime." Southeastward thickening of the unit, beginning noticeably in the Fort Towson area, may be the result of addition of the Edwards reefoid facies in upper parts.

The Goodland is a white massively bedded, finely crystalline to microcrystalline high-calcium limestone that weathers gray to pale yellow. The lower part of the formation is white and nodular and weathers gray to buff. The upper part is a massive white limestone that tends to exfoliate into thin, curved sheets. The uppermost part typically weathers with a honeycomb appearance. Typical exposures are shown in figures 7 and 8.

Chemical analyses (Blau, 1961, p. 38, table 1) show the Goodland to be nearly pure limestone with an average carbonate content of 97.00

percent. In southern Oklahoma, the calcium carbonate content ranges from 91.24 to 98.45 percent, and the magnesium carbonate content from 0.86 to 1.21 percent. Three samples taken from quarries in Choctaw County contained 96.50, 98.36, and 98.45 percent calcium carbonate and 0.92, 0.88, and 0.86 percent magnesium carbonate (Blau, 1961, p. 41, table 1).

Blau (1961, p. 26) divided the Goodland into a lower molluscan facies, which he called Comanche Peak, and an upper rudistid facies, the Edwards; the contact between the two is everywhere gradational. The Goodland was not subdivided in this report.

The Goodland Limestone is resistant to erosion and commonly caps a prominent north-facing escarpment across the area, which can be traced readily on aerial photographs.

Stratigraphic relations of the Goodland and the underlying Antlers are controversial. Several writers, including Jeffries (1965), Dalton (1966), Duarte-Vivas (1968), and Alfonsi (1968), on the basis of the absence of the Walnut Clay and the slightly undulating surface of the basal Goodland, postulated a disconformity. Frederickson and others (1965) and Blau (1961) maintained that the contact is gradational and transitional where the Walnut Clay facies is developed and that no

Figure 7. Goodland Limestone and overlying shale of Kiamichi Formation in Wray Wyable quarry north of Hugo, NW¼SE¼ sec. 5, T. 6 S., R. 17 E.

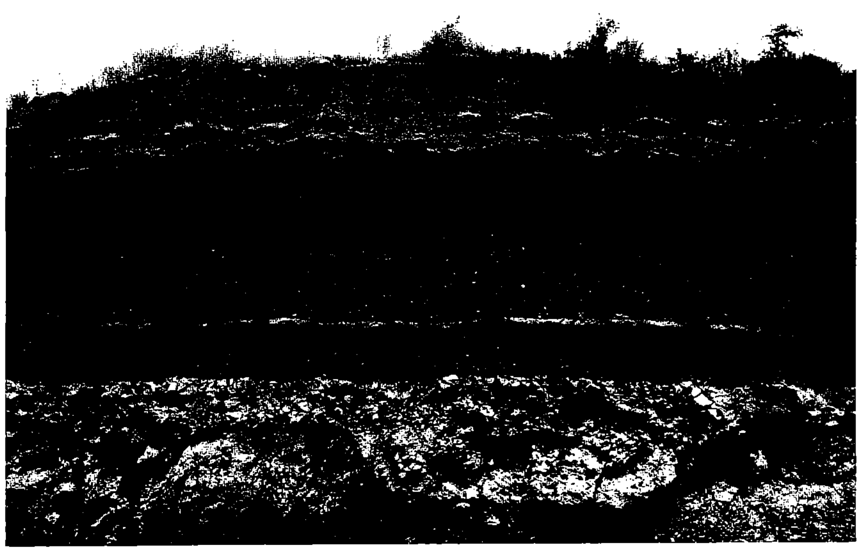

Figure 8. Close-up of uppermost Goodland Limestone and overlying beds of Kiamichi Formation in Wray Wyable quarry, NW¼SE¼ sec. 5, T. 6 S., R. 17 E. Note thin fossiliferous "shell beds" in upper part of Kiamichi, which contain abundant *Texigryphaea navia* (Hall).

unconformity exists where the Goodland rests directly on the Antlers. The senior writer shares the latter viewpoint, visualizing the Walnut Clay as a local facies in a continuous transgressive sea from Antlers through Goodland time. The upper boundary of the Goodland, although marked by an abrupt change of facies, appears conformable except in the area of Fort Towson, where both Gibbs (1950, p. 31) and Duarte-Vivas (1968, p. 26) have described worm burrows in and oxidation of Goodland limestone directly below the contact.

The Goodland is fossiliferous, and an assemblage consisting of *Salenia mexicana* (Roemer), *Ceratostreon texanum* (Roemer), *Lima wacoensis* (Roemer), *Enallaster texanus* (Roemer), *Turritella seriatim-granulosa* Roemer, *Tylostoma elevatum* (Shumard), *Oxytropidoceras acutocarinatum* (Shumard), *Aporrhais tarrantensis* Stanton, *Pecten (Neithea) subalpinus* (Boese), *Texigryphaea mucronata* (Gabb), *Trigonia* sp., *Turritella* sp., and *Protocardia* sp. was collected from Choctaw County exposures.

The Goodland is correlated with the Edwards and Comanche Peak Limestones of central Texas and may include strata equivalent in age to the Walnut Clay in its basal part.

Kiamichi Formation

The term *Kiamichi* (Kiamitia) was applied by Hill (1891, p. 515) to exposures on the plains of the Kiamichi River near Fort Towson, Choctaw County, Oklahoma. He assigned the formation to the base of the Washita Group; present usage places it at the top of the Fredericksburg.

The outcrop of the Kiamichi forms a long, nearly continuous southeast-trending band across Choctaw County paralleling the outcrop of the underlying Goodland (pl. 1, in pocket). The outcrop belt ranges in width from a few hundred yards to more than 2 miles.

The Kiamichi Formation maintains a relatively uniform thickness along the outcrop belt in Choctaw County. A thickness of 33 feet has been observed in the western part of the County, 36 feet in the central part, and 28 feet in the east-central part. According to Prewit (1961, p. 25), the unit thickens southward to 80 feet in the subsurface of southern McCurtain County.

The Kiamichi Formation consists mostly of dark-gray to black platy clay shales interbedded with thin yellow limestones. The lower part is usually black shale. A thin unfossiliferous, siliceous limestone occurs about 4 feet above the base in a quarry north of Hugo (sec. 5, T. 6 S., R. 17 E.). Overlying this bed is several feet of dark-gray shale, succeeded near the top by three or four thin beds of brown limestone. These beds are made up predominantly of shells of the pelecypod *Texigryphaea navia* (Hall) (fig. 8). The top of the uppermost "shell bed" marks the top of the Kiamichi.

Erosion of underlying shales causes the shell beds to break off and slump to form slabs of "edgerock," which lie in any position from horizontal to vertical.

Eastward, in the vicinity of Fort Towson, the lower shale beds are replaced by fossiliferous marlstones containing an abundance of oyster shells, especially *Texigryphaea navia* (Hall). *Oxytropidoceras belknapi* (Marcou) occurs at places in the upper part of the Kiamichi.

WASHITA GROUP

The Washita Group, uppermost division of the Comanchean Series of Early Cretaceous age, was named by Hill (1887, p. 297) from exposures near Fort Washita, in northwestern Bryan County, Oklahoma. It is represented in Choctaw County by (in ascending order) the Caddo Formation, the Bokchito Formation, and the Bennington Limestone. This group includes shales, limestones, and sandstones (in order of abundance) and attains a thickness of more than 400 feet.

The following subdivisions are recognized.

Texas		*This report*	
Grayson Formation		(Absent in Choctaw County)	
Main Street Limestone		Bennington Limestone	
Denison Formation	Pawpaw Sandstone	Bokchito Formation	Pawpaw Sandstone
			Mc Nutt Limestone
	Weno Clay		Weno Clay
			Soper Limestone
	Denton Clay		Denton Clay
Fort Worth Formation		Caddo Formation	
Duck Creek Formation			

Caddo Formation

Taff (1902, p. 6) applied the term *Caddo* to a 150-foot sequence of marls, shales, and limestones overlying the Kiamichi Formation in the vicinity of Caddo, Bryan County, Oklahoma. Hill (1891, p. 504, 516) had previously applied the names *Duck*

Creek and *Fort Worth* to units of comparable stratigraphic position in northern Texas. No attempt was made to map the Duck Creek and Fort Worth Formations separately in Choctaw County because no mappable boundary was observed between the units. In general, the lower part of the Caddo resembles the Duck Creek, and the upper part is similar to the Fort Worth.

In Choctaw County, the combined thickness of the Duck Creek and Fort Worth is approximately 150 feet. The lower part (Duck Creek equivalent) consists of finely laminated blue-gray shales and blue-gray silty and argillaceous limestones. The upper part (Fort Worth equivalent) consists of gray shales and interbedded white- to cream-colored limestones. The top of the Caddo is characteristically a heavy-bedded cream-colored fossiliferous limestone approximately 7 feet thick.

The Caddo Formation lies conformably on the Kiamichi Formation and is succeeded conformably by the Denton Clay Member of the Bokchito Formation.

Fossils collected from the lower Caddo (Duck Creek equivalent) include *Oxytropidoceras belknapi* (Marcou), *Kingena wacoensis* (Roemer), *Plicatula dentonensis* Cragin, *"Exogyra" plexa* Cragin, *Texigryphaea navia* (Hall), *Texigryphaea belviderensis* (Hill and Vaughan), *Texigryphaea washitaensis* (Hill), *Mortoniceras trinodosum* (Boese), *Desmoceras brazoense* (Shumard), *Inoceramus comancheanus* Cragin, and *Hamites fremonti* Marcou. Fossils from the upper Caddo (Fort Worth equivalent) are *Rastellum (Arctostrea) quadriplicatum* (Shumard), *Rastellum (Arctostrea) carinatum* (Lamarck), *Macraster elegans* Shumard, *Holaster simplex* Shumard, *Trigonia* sp., *Aetostreon walkeri* (White), *Cyprimeria texana* Roemer, *Drakeoceras maximum* (Lasswitz), *Pecten (Neithea) texanus* Roemer, *Leiocidaris hemigranosus* (Shumard), *Lima wacoensis* Roemer, and *Texigryphaea washitaensis* (Hill).

Bokchito Formation

The Bokchito Formation was named by Taff (1902, p. 6) for exposures along Bokchito Creek near the town of Bokchito in Bryan County, Oklahoma. The sequence of units, as described by Taff, consists of approximately 140 feet of clay shale, sandy clay, clay-ironstone concretions, friable sandstones, arenaceous limestone, and fossiliferous, ferruginous limestone. Previously, three members had been recognized. These are, in ascending order, Denton Clay, Weno Clay, and Pawpaw Sandstone. At the top of the Denton Clay Member is a persistent limestone marker bed commonly referred to as the *"Ostrea carinata"* bed. At the top of the Weno Clay Member, an arenaceous limestone, previously known as the "Quarry Limestone," serves as a marker bed separating the Weno from the overlying Pawpaw Sandstone Member. New names are herein proposed for the *"Ostrea carinata"* and the "Quarry Limestone" marker beds, the *Soper Limestone Member* and the *McNutt Limestone Member*, respectively.

Denton Clay Member.—The Denton Clay was named by Taff and Leverett (1893, p. 272) for exposures along Denton Creek, Denton County, Texas. The Denton was originally assigned to the upper part of the Fort Worth Formation, but it was reassigned by Hill (1901, p. 115), who considered it a separate stratigraphic unit lying between the Fort Worth and the Weno Clay. At the type locality, the Denton consists of approximately 40 feet of bluish shales and marls capped by a thin fossiliferous limestone (*"Ostrea carinata"* bed).

The Denton Clay Member is poorly exposed in Choctaw County. Its outcrop forms a narrow southeastward-trending belt extending from the County line west of Boswell through Soper and Hugo, disappearing beneath an extensive terrace cover south of Sawyer along the Kiamichi River (pl. 1, in pocket).

The thickness along the outcrop belt ranges from 45 to 65 feet, and 50 feet has been reported in the subsurface (Prewit, 1961, p. 32). The unit consists of blue-gray to brownish-gray clay shales that grade upward into gray shale and marly fossiliferous limestones capped by the resistant *"Ostrea carinata"* limestone marker bed (Soper Limestone Member of this report).

The clays and shales of the Denton Member are soft and nonresistant to weathering. They commonly form an undulating surface covered by grasses and prairie hay. Exposures are generally poor; the best exposure is along a railroad cut and ditch approximately half a mile southeast of Soper (figs. 9, 10).

Few fossils have been reported or found in the lower, shaly portion of the Denton. Soft gray marly shales and interbedded limestones near the top of the Denton have yielded abundant *Texigryphaea washitaensis* (Hill), *Pecten (Neithea) texanus* Roemer, *Rastellum (Arctostrea) quadriplicatum* (Shumard), *Trigonia clavigera* Cragin, and *Rastellum (Arctostrea) carinatum* (Lamarck).

Soper Limestone Member (new).—The term *Soper Limestone Member* is herein applied to a gray-brown to reddish hard, compact, fossiliferous limestone bed heretofore commonly referred to as the *"Ostrea carinata"* bed. Actually *"Ostrea carinata"*—now known as *Rastellum (Arctostrea) carinatum*—occurs only sparingly in this unit throughout much of southern Oklahoma and is more abundant in certain beds in the Fort Worth Formation (upper Caddo equivalent).

The Soper Limestone Member is named for an exposure in a railroad cut 0.5 mile southeast of Soper, Choctaw County, Oklahoma (NE¼SW¼ sec. 13, T. 6 S., R. 15 E.; fig. 10), where it is 1.5 feet thick. It is a hard, resistant unit that forms a prominent ledge capping the underlying Denton Clay Member. Because of its resistant nature, it forms a conspicuous bench where it crosses a highway or stream. Several south-flowing streams are floored with this resistant unit.

Figure 9. Lower part of Denton Clay Member of Bokchito Formation, south side of railroad cut east of Soper, NE¼SW¼ sec. 13, T. 6 S., R. 15 E.

The Soper Limestone Member serves as a good marker bed separating the Denton and Weno Clay Members. Its contact with the underlying Denton is gradational; its contact with the overlying Weno is sharp and non-transitional.

The Soper is fossiliferous, carrying an abundance of *Texigryphaea washitaensis* (Hill), numerous *Rastellum (Arctostrea) quadriplicatum* (Shumard), and scattered *Rastellum (Arctostrea) carinatum* (Lamarck).

Weno Clay Member.—The Weno Clay was named by Hill (1901, p. 121) for exposures near the village of Weno, northeast of Denison, Grayson County, Texas. The type Weno was described as comprising 92 feet of very ferruginous brownish-clay marls and marly clays. The "Quarry Limestone" (McNutt Limestone Member of this report), a blue massive arenaceous limestone that oxidizes yellow, was included in the Weno by Hill, although it was later placed in the lower Pawpaw Sandstone Member by Stephenson (1918, p. 142).

The Weno Clay Member forms a broad, southeast-trending outcrop extending from the Choctaw County line west of Boswell to the Kiamichi River south of Sawyer, where it passes beneath the

Figure 10. Type locality of Soper Limestone Member of Bokchito Formation, shown overlying upper part of Denton Clay Member, in railroad cut about 50 yards west of view shown in figure 9. This is *"Ostrea carinata"* bed of Hill.

terrace cover (pl. 1, in pocket). The thickness ranges from 30 to 53 feet in outcrop; 50 feet was reported by Prewit (1961, p. 33) in the Welch and Goldfeder 1 Moseley well, sec. 11, T. 7 S., R. 13 E. The Weno consists of brownish shales and thin beds of red ferruginous sandstone. The lower part is predominantly shale with scattered thin seams of gypsum. Selenite crystals occur on weathered surfaces. The upper part becomes increasingly sandy, and at places the upper beds consist of massive yellow fine-grained, poorly consolidated sandstone. The McNutt Limestone Member ("Quarry Limestone" of previous reports) forms a persistent cap above the Weno and serves as a marker bed to separate the Weno from the overlying Pawpaw Sandstone Member (fig. 11).

Ferruginous sandstones in the Weno Clay Member contain numerous molds and casts of *Protocardia* sp. and *Turritella* sp. The overlying McNutt Limestone Member ("Quarry Limestone") is the principal zone of *Rastellum (Arctostrea) quadriplicatum* (Shumard).

McNutt Limestone Member (new).—The term *McNutt Limestone Member* is proposed for a 2- to 3-foot bed of sandy, locally platy, fossiliferous limestone previously referred to as the "Quarry Limestone." The name is taken from the McNutt Ranch, 4 miles southeast of Soper, Choctaw County, Oklahoma, in NE¼SE¼ sec. 36, T. 6 S., R. 15 E., where the unit is well exposed and forms the caprock around the hills of this upland area (pl. 1, in pocket; fig. 11).

The McNutt Limestone Member varies from an arenaceous limestone to a highly calcareous sandstone, with the carbonate facies predominant. A sample taken from exposures east of U.S. Highway 271, north of Grant, on the south bank of Horse Creek, contained 77 percent carbonate and 23 percent insoluble material consisting of fine quartz sand and traces of magnetite (Alfonsi, 1968, p. 3).

The McNutt Limestone Member has been traced along a discontinuous outcrop from west of Boswell southeastward to Horse Creek near Grant. The best exposures are in and around the town of Boswell; in an area southeast of Soper in secs. 25 and 36, T. 6 S., R. 15 E., and sec. 30, T. 6 S., R. 16 E.; and on Horse Creek north of Grant, in sec. 9, T. 7 S., R. 17 E. (fig. 12).

Pawpaw Sandstone Member.—The Pawpaw Sandstone (or Sand) was named by Hill (1894, p. 330) for exposures along Pawpaw Creek near Denison, Grayson County, Texas, where the unit was described as light-drab, fossiliferous, thinly laminated clay lying between the Weno Clay and the Main Street Limestone. It was said to become increasingly sandy in northern Texas.

The Pawpaw Sandstone Member in Choctaw County consists of red and yellow sandstones interbedded with gray to reddish-purple sandy clay. The sandstones are friable, poorly indurated, and ferruginous. Weathered slopes are covered with clay-ironstone fragments and sandy rubble. The upper part is dominantly a fine-grained ferruginous sand cemented by yellow silty clay. Sieve analysis of a representative sample from the eastern part of the County (Duarte-Vivas, 1968, p. 37) indicates that the bulk of the grains are in the 3.0 ϕ to 4.0 ϕ range on the phi scale. The member is fairly uniform in thickness, averaging 35 feet.

The Pawpaw forms an outcrop belt ranging

Figure 11. Weno Clay Member of Bokchito Formation, capped by remnant of McNutt Limestone Member (upper left). Wall of small farm pond on McNutt Ranch, NE¼SE¼ sec. 36, T. 6 S., R. 15 E.

Figure 12. McNutt Limestone Member of Bokchito Formation exposed along Horse Creek north of Grant, east side of sec. 9, T. 7 S., R. 17 E.

from 1 to 3 miles in width, extending from the County line west of Boswell southeastward to the vicinity of Sawyer, where it passes beneath terrace cover along the Kiamichi River (pl. 1, in pocket).

The ferruginous sandstones of the Pawpaw contain an abundance of molds and casts of small bivalves, including numerous specimens of *Protocardia* sp. A small cephalopod, tentatively identified as *Engonoceras serpentinum* (Cragin), was collected in the southeast corner of sec. 36, T. 6 S., R. 15 E., on the McNutt Ranch.

Bennington Limestone

The Bennington Limestone was named by Taff (1902, p. 5) for exposures of dull-blue massive limestone exposed near Bennington in Bryan County, Oklahoma, where a thickness of 10 feet is present.

In Choctaw County, the Bennington consists of gray to gray-brown sandy, fossiliferous limestone that weathers to pitted and honeycombed surfaces. Insoluble-residue studies of samples from the southern part of the County indicate 83.6 to 87 percent calcium carbonate and 13 to 16.4 percent fine-grained quartz sand and clay. The thickness ranges from 0 to 18 feet, with an average thickness of about 6 feet.

The outcrop band is narrow and discontinuous, extending from south of Boswell to Grant (pl. 1, in pocket). The unit reappears in a tributary stream of the Kiamichi River in secs. 15, 16, 21, and 22, T. 7 S., R. 19 E. The best exposures are southeast of Soper, in a sinuous belt from sec. 34, T. 6 S., R. 16 E., to the vicinity of Grant in sec. 15, T. 7 S., R. 17 E.

Fossils are abundant in the Bennington Limestone. Characteristic forms include *Ilymatogyra arietina* (Roemer), *Kingena wacoensis* (Roemer), *Rastellum (Arctostrea) quadriplicatum* (Shumard), and *Pecten (Neithea) texanus* Roemer.

Gulfian Series

Woodbine Formation

The Woodbine Formation was named by Hill (1901, p. 293) for exposures near Woodbine, Cooke County, Texas. Hill described it as a sequence of ferruginous, argillaceous sands and laminated, locally bituminous sandy clays. Hill divided the Woodbine into three members (ascending): (1) Dexter, (2) Lewisville, and (3) upper sand and clays (later assigned to the Eagle Ford Formation). Bergquist (1949) divided the Woodbine into (1) the Dexter Member, (2) the Red Branch Member (new), (3) the Lewisville Member, and (4) the Templeton Member (new). Davis (1960, p. 41) recognized only two divisions in McCurtain County: (1) a lower tuffaceous member and (2) an upper sandy member.

The Woodbine crops out in a wide belt across southern Choctaw County (pl. 1, in pocket). Maximal width of the outcrop belt is 10 miles, in the area south of Boswell. It passes beneath terrace cover along Muddy Boggy Creek south of Soper and reappears only in a few scattered exposures from there eastward. The Woodbine is deeply weathered throughout the area, forming a thick red sandy and clayey soil, which at places is very difficult to differentiate from terrace materials. Exposures are exceptionally poor, and only a generalized sequence of lithic units can be established.

The thickness of the Woodbine in southern Choctaw County has not been determined with certainty. The Welch and Goldfeder 1 Moseley well, NE¼ sec. 11, T. 7 S., R. 13 E., about 2 miles from the updip margin, penetrated 100 feet of lower Woodbine sand and maroon and green shale (Prewit, 1961, p. 40). This is probably the Dexter Member. The estimated thickness for the southern part of the County is between 300 and 400 feet, a figure that is in agreement with thicknesses previously established in Texas.

The easternmost exposure of the Woodbine in Choctaw County is in secs. 12 and 13, T. 7 S., R. 20 E., adjacent to the McCurtain County line. There, the basal Woodbine is a pebble conglomerate (fig. 13) composed of well-rounded quartzite and chert pebbles in a matrix of coarse-grained ferruginous sand. Overlying the conglomerate are brick-red to brown slightly calcareous, fine- to very fine-grained, angular to subangular, iron-stained, friable sandstones. Sieve analysis of these sands reveals a grain size ranging from 2.0 ϕ to 3.5 ϕ on the phi scale (Duarte-Vivas, 1968, p. 41). The sandstones contain a small amount of feldspar and magnetite. The basal conglomerate rests unconformably on the Caddo Formation. The exposed thickness is about 25 feet.

The tuffaceous phase of the Woodbine is exposed along a small creek in secs. 16, 21, and 22, T. 7 S., R. 19 E., where it lies on the Bennington Limestone. Here, the unit consists of yellow-brown cross-bedded, poorly cemented, medium-grained tuffaceous sand. Locally, calcite cementation has formed large green concretionary masses or lenses ranging in size from a few inches to several feet. The concretionary lenses are surrounded by yellow-brown thin-bedded tuffaceous sand containing a large amount of magnetite. This exposure resembles the tuffaceous member of the McCurtain County section.

Figure 13. Basal pebble conglomerate of Woodbine Formation lying disconformably on Caddo Formation in small outlier southeast of Swink, secs. 12 and 13, T. 7 S., R. 20 E.

Closely related or similar tuffaceous beds have been observed in other scattered localities in southeastern Choctaw County. Small concretionary boulders are present along Oklahoma Highway 109 west of Shoals, secs. 27 and 34, T. 7 S., R. 18 E. Thin-bedded tuffaceous sands were observed along a farm road south of Shoals in secs. 2 and 3, T. 8 S., R. 18 E., and in a tributary stream in NW¼ sec. 17, T. 7 S., R. 19 E.

An excellent exposure of sandstone of the Woodbine Formation occurs along a country road passing through the center of sec. 12, T. 7 S., R. 18 E. Here, the basal Woodbine appears to overlap the Bokchito Formation. Terrace cover makes precise relations difficult to establish. The exposed Woodbine at this locality is a red to yellow poorly cemented, medium-grained, cross-bedded sand. In this general area, the basal sandstone is succeeded by mottled gray to reddish-brown sandy clay. Vertical clay "pipes" ranging in diameter from 3.0 to 10.0 inches are characteristic. This may be the "Rainbow Clay," which occurs at the top of the Dexter Member in Texas.

A 32.5-foot section of basal Woodbine north of Grant, on the south bank of Horse Creek, sec. 14, T. 7 S., R. 17 E., was measured and described by Gibbs (1950, p. 52). Inasmuch as that exposure is now largely concealed by vegetation, Gibbs' description is relied upon. In this area, the Woodbine Formation rests directly on the Bennington Limestone. The contact is still visible in the roadcut along U.S. Highway 271. The lower 10 feet consists of red to yellow fine-grained, cross-bedded quartz sand. Fifteen inches of red clay and sandy clay overlie. The succeeding 13 feet consists of light-brown medium-grained, cross-bedded sandstone. Succeeding beds consist of red sand and sandy clay characterized by numerous "clay pipes."

Tuffaceous concretionary beds are well exposed at the intersection of Oklahoma Highway 109 and the Crowder Springs Road at the junction of secs. 13, 14, 23, and 24, T. 7 S., R. 14 E. (fig. 14). They occur along a creek crossing the road between sec. 24, T. 7 S., R. 14 E., and sec. 19, T. 7 S., R. 15 E. At the crossroads, the green calcareous concretionary beds are overlain by gray to black shale. This section resembles an exposure on the south side of the Red River east of the

Figure 14. Tuffaceous concretionary beds in Woodbine Formation at intersection of Oklahoma Highway 109 and Crowder Springs Road, junction of secs. 13, 14, 23, and 24, T. 7 S., R. 14 E.

bridge leading to Arthur City, Texas, where both the concretionary and shaly facies are well exposed beneath the terrace. The general lithology and sequence suggest that these beds occur at the stratigraphic position of the Red Branch Member of the Texas section.

Other exposures of the Woodbine Formation are in road cuts running normal to the strike of some of the more resistant beds. The interrelationship of these isolated exposures has not yet been established.

Quaternary System

Alluvium and Terrace Deposits

Alluvium

Extensive deposits of Quaternary (Holocene) alluvium occur along all major drainage in Choctaw County (pl. 1, in pocket). Well-defined flood-plain complexes border the Red River and its major tributaries, Muddy Boggy Creek and the Kiamichi River. The flood-plain complex includes the deposits of the channel-bar type as well as broad alluvial flats, which border the major streams. The flood-plain or valley flat lies about 20 feet above channel level along the Red River and 30 feet above the Kiamichi (fig. 15).

Flood-plain deposits consist of sand, silt, and clay. The surface varies from essentially flat to gently rolling. Along the Red River, the alluvium is sandy and gives rise to well-drained medium to light-textured sandy loams of the Yahola, Verdigris, and Miller soils (Buckhannan and others, 1937, soil map). Flood-plain deposits along Muddy Boggy Creek and the Kiamichi River are poorly drained, forming heavy- to medium-textured clay and silty clay loam. Flood-plain soils along the Kiamichi River include the Atkins silt loam and the Pope sandy loam. The Kaufman clay soil characterizes the bottom land along Muddy Boggy Creek.

All of the flood plain of the Kiamichi River north of Sawyer has been inundated by the waters of Hugo Lake, and the flood plain of Muddy Boggy Creek will be inundated by waters of the Boswell Reservoir (authorized). The flood plain of the Red River forms a broad, relatively fertile stretch of farmland now in cultivation. Irrigation and proper fertilization could make this into one of the richest belts of farmland in Oklahoma.

Terrace Deposits

Several distinct terrace levels of Pleistocene age can be distinguished along the Red River and its tributaries. Stephenson (1918, p. 132) was one of the first geologists to recognize multiple levels. He observed (1) the present flood plain of the Red River, (2) a well-defined river terrace 45 to 75 feet above low-water level of the Red River, (3) a terrace plain 140 to 160 feet above water level, and (4) remnants of surficial deposits at higher altitudes.

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 molluscan forms as well as physiographic expression. The terrace levels and their elevations above the Red River in counties in northern Texas are as follows.

Figure 15. Alluvial or flood-plain level 30 feet above water level of Kiamichi River, SE¼ sec. 20, T. 5 S., R. 18 E. This locality was recently inundated by Hugo Lake.

Name	*Elevations above Red River*
Nebraskan terrace	150-160 feet
Hardeman terrace (Kansan)	90-110 feet
Intermediate terrace (Illinoian)	70 feet
Ambrose terrace (early Wisconsinan)	30-45 feet
Cooke terrace (late Wisconsinan)	18-20 feet

Five levels have been designated by the Texas Bureau of Economic Geology on the geologic map of the Texarkana 1:250,000-scale sheet (which includes southern Choctaw County) along the Red River: 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), a surface of residual gravels 160 ± 10 feet above modern flood plains.

Three well-developed terrace levels and possible remnants of a fourth have been recognized above flood-plain level in Choctaw County in the present investigation (pl. 1, in pocket).

Cooke terrace (Qt_1).—The Cooke terrace of late Wisconsinan age is a moderately well-defined surface preserved along the north side of the Red River. The surface exhibits well-preserved meander scars and other evidence of stream-channel activity. The Cooke terrace level along the Red River is very near the alluvium level of Muddy Boggy Creek and the Kiamichi River.

Three isolated patches of the Cooke terrace have been recognized and mapped (pl. 1, in pocket). The first of these occupies about 4 square miles in T. 7 S., R. 16 E., where the terrace level is 16.5 feet above the Red River flood plain. The surface is relatively flat and locally poorly drained. The principal soils are the Lonoke clay (Buckhannan and others, 1937, soil map). The soil is heavy textured and gives rise to fertile soil suitable for cultivation where properly drained.

The second area is about 3 miles southeast of Grant, where the areal extent is approximately 12 square miles. Here, the Cooke terrace level is 15 feet above the Red River flood plain. Principal soils are the Lonoke clay and Lonoke silty clay loam (Buckhannan and others, 1937, soil map). The soil is heavy textured, dark in color, and makes excellent farmland.

The third area is an elongate, northeast-trending belt about 1 to 2 miles in width, situated in the Frogville area. Here, the Cooke terrace lies about 10 feet above the alluvium level; however, erosion by bordering streams has modified the frontal edge. The terrace surface is relatively flat, and both pastureland and farmland have been developed. Again, the principal soils are the Lonoke clay and Lonoke silty clay loam (Buckhannan and others, 1937, soil map).

Ambrose terrace (Qt_2).—The Ambrose alluvial terrace of early Wisconsinan age is present along the north side of the Red River and is well developed along Muddy Boggy Creek and the Kiamichi River (pl. 1, in pocket). Along the Red River, this terrace level is approximately 10 to 15 feet above the Cooke terrace, or 27.5 feet above the flood plain. A 12- to 15-foot rise marked the boundary of the Ambrose terrace and the alluvium along the Kiamichi River, now Hugo Lake (secs. 28 and 29, T. 5 S., R. 18 E.). Near Gay, in T. 7 S., R. 16 E., the Ambrose level is 27.5 feet above the alluvium of Muddy Creek near its confluence with the Red River.

The Ambrose terrace is composed of gravel, sand, silt, and clay. Gravels tend to be fairly well sorted and cross-bedded, grading upward into and interbedded with sands and beds of silty clay. The surface is characterized by an abundance of small circular mounds known as "pimple mounds," whose origin has been the subject of numerous papers (e.g., Melton, 1954). The area occupied by the Ambrose terrace is generally in grassland. Soils formed on the Ambrose surface include the Lonoke clay, the Teller fine sandy loam, the Brewer silty clay loam, and the Myatt very fine sandy loam (Buckhannan and others, 1937, soil map).

The Ambrose terrace is well developed in the vicinity of Gay (T. 7 S., R. 16 E.), where it covers more than 10 square miles. Scattered exposures, mainly preserved on the insides of major bends in Muddy Boggy Creek, extend from 1 mile north of Duland (sec. 34, T. 6 S., R. 15 E.) northwestward to a point 4 miles northeast of Boswell, in sec. 33, T. 5 S., R. 14 E.

Along the Red River, the Ambrose terrace is best developed in the Bluff-Gay vicinity near the confluence of Muddy Boggy Creek and the Red River, as previously mentioned. A second major development is in the vicinity of Grant, where approximately 10 square miles of terrace cover is preserved. Eastward from there, a long, narrow band of questionable Qt_2 parallels the Red River in T. 8 S., Rs. 18 and 19 E., and extends northeastward to the vicinity of Frogville. Much of this terrace is masked by windblown material, and its presence and extent are based mainly on soils (Buckhannan and others, 1937, soil map).

The Ambrose terrace level has been recognized in the Huskey area (secs. 11, 12, 13, and 14, T. 7

S., R. 19 E.). There, it lies about 10 feet below the Qt_3 level and rests on the Caddo Formation near the river bridge.

From Huskey northwestward along the lower part of the Kiamichi River, the Ambrose terrace is represented by large expanses on the insides of the bends of the Kiamichi River. The terrace lies 20 to 25 feet above the flood-plain level of the Kiamichi River and 30 feet above the alluvium of the Red River. Five major terrace remnants have been recognized between Huskey and Sawyer.

The Ambrose terrace along Hugo Lake, northwest of Sawyer and the Hugo Dam, rose 10 to 15 feet above the flood-plain level of the Kiamichi River prior to inundation. Extensive deposits of gravel are present, and numerous abandoned pits. During construction of the Hugo Dam and the access roads, sands and gravels were obtained from sec. 29, T. 5 S., R. 18 E. (fig. 16). This deposit was approximately 12 feet thick and rested on alluvium of the Kiamichi River (fig. 15). The lower 5 feet consisted of coarse, well-sorted gravels; the upper 7 feet was fine-grained sand and clay.

Intermediate terrace (Illinoian) (Qt_3).—The Illinoian or intermediate terrace level is extensively developed in parts of Choctaw County (pl. 1, in pocket). The deposits consist mainly of gravel and sand with minor amounts of silt and clay. Extensive deposits of commercial-grade gravels occur within this terrace. At places the frontal edge is dissected and beveled. It commonly rests on the Qt_2 level on one side and bedrock on the other. At places it rests directly on the bedrock surface. The intermediate terrace level is 30 to 40 feet above the Qt_2 level and 50 to 65 feet above the flood-plain level. The maximum thickness observed is 30 feet.

Two small isolated exposures of Qt_3 occur in southwestern Choctaw County, in T. 8 S., R. 14 E. There, the upper surface of the terrace is 50 feet above the flood plain of Whitegrass Creek and 70 feet above the Red River channel.

The second area of exposure is east of Gay, where three small patches have been tentatively mapped on the basis of topography and soils. No actual terrace material was observed. Directly eastward, in the vicinity of Grant, extensive deposits of Qt_3 are preserved. These lie approximately 20 to 25 feet above the Qt_2 level, 65 feet above the Red River flood plain, and about 90 feet above the water level in the Red River channel. The terrace is deeply dissected at places by major south-flowing tributary streams. The Qt_3 deposit can be traced eastward to Carney Creek, west of Shoals; from there eastward to Frogville, the age of the uppermost terrace is conjectural. Following procedure established by the Texas Bureau of Economic Geology (Barnes, 1966), the senior author has mapped this as a deeply dissected remnant of the Hardeman terrace (Qt_4). Discussion will follow in a later paragraph.

The Qt_3 level has been identified in the area northeast of Frogville, where it covers about 3 square miles. An elongate patch is preserved north of the Kiamichi River along Oklahoma Highway 109.

A large, east-west-trending belt of upland terrace extends from Sawyer eastward through the Fort Towson area to the vicinity of Swink. Genetic affinities of this terrace level are not

Figure 16. Terrace gravels, SE¼NE¼ sec. 29, T. 5 S., R. 18 E. This locality was recently inundated by Hugo Lake.

known; they may have formed by the Red River at a much earlier time, or they may be related to the Kiamichi River. Near Sawyer, the surface of this terrace is 70 feet above the flood plain of the Kiamichi River and about 90 feet above the channel level. If this terrace is related to the Kiamichi River, then it is part of the Qt_3 level. Soils are Lufkin and Sawyer very fine sandy loam (Buckhannan and others, 1937, soil map).

Large deposits of Qt_3 cover approximately 6 square miles in the vicinity of Messer, in the eastern part of T. 5 S., R. 17 E. Extensive gravel deposits characterize this terrace level, and many pits have been worked in this area. The Choctaw Materials Company (fig. 17) operates several pits in sec. 36, T. 5 S., R. 17 E., and Hugo Sand and Gravel Company has been operating in sec. 24 (fig. 18). The upper surface of the terrace was 65 feet above the former Kiamichi River flood plain.

Isolated patches of upland terrace materials characterize the area east of the Kiamichi River. In general, these are 50 to 60 feet above the flood-plain level and are less than 30 feet thick. They usually lie on bedrock. "Pimple mounds" are characteristic.

Hardeman terrace (Qt_4).—The Hardeman terrace (Kansan) consists of approximately 30 feet of gravel, sand, and silt. This terrace is deeply dissected, and only at places is the section complete. Where fully developed, the top surface lies approximately 100 to 110 feet above the flood-plain level.

The senior author has followed the Texas Bureau of Economic Geology (Barnes, 1966) in assigning approximately 8 square miles between Shoals and Frogville, in T. 7 S., Rs. 18 and 19 E., to this level (pl. 1, in pocket). Contacts with adjacent deposits are difficult to establish because of the deep dissection, extensive sheet wash in the upper parts of gullies, and a veneer of windblown material. The thin western edge of this terrace was measured 75 feet above the flood-plain level, and a maximum thickness of 30 feet places the highest part of this terrace 100 feet above the flood-plain level and about 120 feet above the Red River channel. Additional work is needed to delineate more carefully the extent and relationships of the various terrace levels in this area. Qt_4, as herein mapped, rests almost everywhere on deeply dissected Woodbine rocks, and the Woodbine has been identified in nearly all of the gullies involved.

Undifferentiated fluviatile terrace deposits.—A few isolated patches of terrace material occur at places in Choctaw County (pl. 1, in pocket). At some places, it was impossible to assign these to any specific level. Many appear to correspond most closely to Qt_3, and some are so designated.

STRUCTURAL GEOLOGY

Choctaw County occupies parts of two major physiographic and tectonic provinces, the Ouachita foldbelt and the Coastal Plain province.

Ouachita Province

The northeast-trending folds and faults of the Ouachita system disappear southwestward beneath the overlying Cretaceous Coastal Plain sediments. Paleozoic rocks are exposed only in the northeastern part of the County, where the resistant

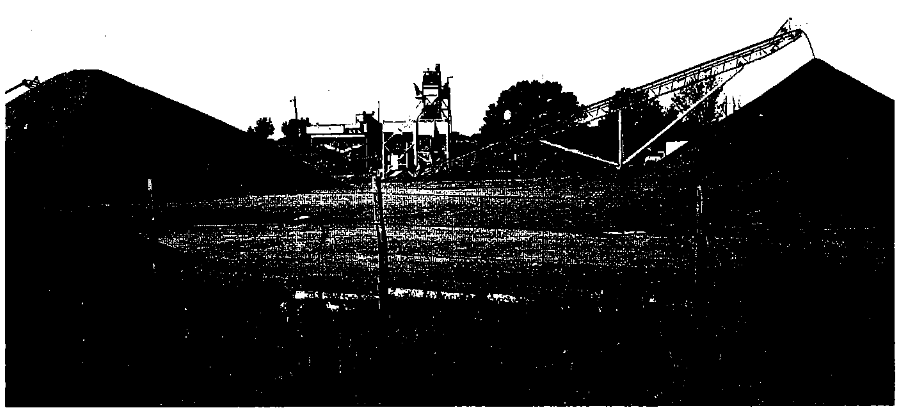

Figure 17. Sand and gravel operations of Choctaw Materials Company north of Hugo, west side of Oklahoma Highway 93, sec. 36, T. 5 S., R. 17 E.

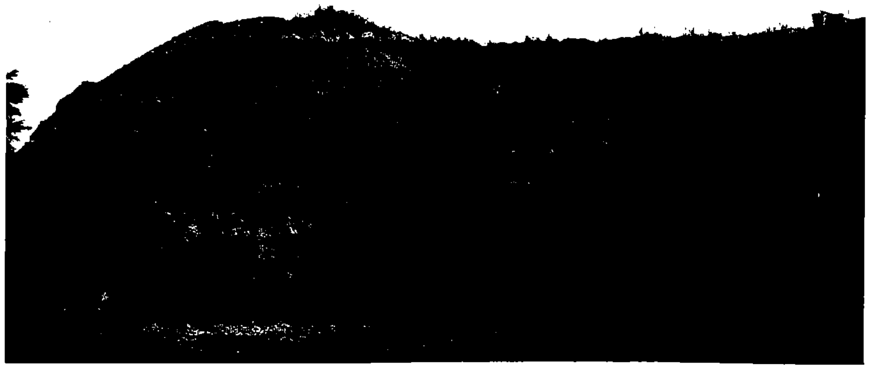

Figure 18. Terrace sands and gravels in abandoned pit northwest of Messer, NW¼ sec. 24, T. 5 S., R. 17 E.

strata of the Stanley and Jackfork Groups project above the present Cretaceous surface (pl. 1, in pocket).

The principal structural feature in northeastern Choctaw County is the Hugo syncline, whose axis extends approximately east-west, plunging westward and southwestward at approximately 10°. The Hugo syncline was recognized and mapped by Honess (1923, p. 248). The south limb of the syncline forms Spencerville Mountain, a long, linear ridge of sandstone of the Jackfork Group (Wildhorse Mountain Formation), which dips northward at 17°. Round Mountain, in secs. 14 and 15, T. 5 S., R. 19 E., is an eastern extension of this limb. Bull or Signal Mountain occupies the northeastern end of the Hugo syncline. There, the upper massive sandstone member and the underlying Prairie Hollow Shale Member of the Wildhorse Mountain Formation form an arcuate belt of exposures 6 miles long. At the southern end, the dip is 10° northwestward; at Sobol Lookout Tower on top of Bull Mountain, the dip is 10° westward; along the northern limb near the Choctaw-Pushmataha County line, dips ranging from 15° to 25° are toward the southwest and south. Scattered exposures to the west indicate closure of this structure.

Coastal Plain Province

Regional structure of the Cretaceous Coastal Plain province is homoclinal, with a general east-southeast strike and a gentle southward dip.

Various estimates have been made of the rate of dip of the Cretaceous strata. These estimates are in general accord. Honess (1930, p. 94) estimated the regional dip of Cretaceous sediments to range from 40 to 70 feet per mile. Gordon (1911, p. 33) had previously compared barometric readings on the base of the Goodland Limestone with the elevationof the base of the Goodland in a water well at Paris, Texas, and calculated a regional dip of 56 feet per mile for that unit over a distance of 30 miles. Prewit (1961, p. 46), using subsurface information, observed the dip to be about 50 feet per mile across Bryan and Choctaw Counties, increasing to 125 feet per mile in McCurtain County. Dalton (1966, p. 50) indicated dips of less than 1° in central Choctaw County, whereas Duarte-Vivas (1968, p. 44) reported a 2° dip in southeastern Choctaw County.

Two sets of vertical joints have been observed in the limestones of the upper part of the Caddo Formation and in the Soper Limestone Member of the Bokchito Formation. These joints strike N. 60°-65° E. and N. 30°-35° W., being approximately at right angles. The northeast-trending set is better developed.

The southeastward trend of Muddy Boggy Creek, diagonally across the Cretaceous outcrops (pl. 1, in pocket), suggests that this stream is structurally controlled, inasmuch as its northwestward projection coincides with the position of the Sulphur fault in the Arbuckle Mountains. It appears that small-scale faulting, not observable at the surface, has created a zone of weakness in surface or near-surface rocks along which the stream course formed. The relationship of the joint sets and the postulated fault has not been determined, although the joints may be related to lateral slippage along the fault. The northeast-trending set of joints reflects, in general, the trends of the Ouachita structures and may be related to vertical adjustment along these fractures.

Subsurface studies by Prewit (1961) indicate that Cretaceous sediments were deposited on a relatively even post-Paleozoic erosional surface except in the area of the Paleozoic outliers in northeastern Choctaw County. Southward tilting of this surface during Cretaceous and later time created a tilt of the pre-Cretaceous surface of 80 feet per mile.

GEOLOGIC HISTORY

In order to understand the sequence of events that constitutes the geologic history of Choctaw County, it is necessary to reconstruct the tectonic history of a much larger area.

Two distinct geosynclines characterized the Midcontinent region during Paleozoic time. One of these, the Ouachita, trended northeastward across southern Arkansas, southeastern Oklahoma, and central Texas. During early Paleozoic time, the Ouachita trough took on the aspects of a eugeosyncline, receiving large amounts of clastics and colloidal silica from the island arc Llanoria. In Late Mississippian and Early Pennsylvanian time, the outer part of the Ouachita trough was uplifted and the axis of maximal deposition shifted northward into the area of Stanley-Jackfork deposition. Renewed uplift in post-Morrowan time shifted the axis of maximal deposition northward into the Arkoma (McAlester) basin, where thick clastic Atokan sediments accumulated. Pre-Atokan sediments in the Ouachita Mountains are commonly referred to as the Ouachita facies.

The second Paleozoic geosyncline in the Midcontinent region was the northwest-trending Oklahoma trough (variously referred to as the Wichita trough, Arbuckle geosyncline, Harrisburg trough, and ancestral Anadarko basin). This intracratonic basin was bordered on the southwest by the Texas peninsula and on the northeast by the stable cratonic shelf. This northwest-trending Oklahoma trough connected the Ouachita trough, to the southeast, and the Cordilleran or Rocky Mountain geosyncline, to the northwest. It received approximately 17,000 feet of pre-Pennsylvanian sediments (Ham, 1969, p. 19) consisting of carbonates, sands, and shales of the Arbuckle facies.

Late Pennsylvanian orogenic movements created the southeast-trending Arbuckle Mountains. The Arbuckles were subsequently faulted and overthrust by the Ouachita Mountain segment (probably in latest Pennsylvanian time, Marathon orogeny). These movements created two sets of mountains, the southeast-trending Arbuckles and the northeast-trending Ouachitas, which apparently intersect beneath Cretaceous cover. The Ouachita thrust sheets either override the Arbuckle structure in the subsurface, or the Arbuckle salient is bounded by tear faults that bring the Ouachita facies and structures to their present position with respect to the Arbuckle uplift.

Following the late Paleozoic orogenic movements, the southern Midcontinent area underwent extensive erosion. Permian, Triassic, and Jurassic sediments are not known in southern Oklahoma.

In Early Cretaceous time, a shallow sea advanced into southern Oklahoma from the south, depositing the Antlers Sand (and older units in McCurtain County) across the pre-Cretaceous erosion surface. Subsequent deepening of the sea witnessed deposition of the carbonates and shales of the Goodland, Kiamichi, and Caddo. Renewed activity in the source area or slight regression of the sea saw introduction of the clastics of the Bokchito Formation. This was followed by marine inundation and deposition of the Bennington Limestone. Post-Bennington regression was followed by transgression of the Late Cretaceous Woodbine sea to complete the depositional history of Choctaw County.

Post-Woodbine, pre-Pleistocene deposits are not known to occur in Choctaw County, although younger Cretaceous deposits are extensively developed in Texas. Terrace building and downcutting during Pleistocene and Holocene time complete the geologic history of this County.

ECONOMIC GEOLOGY

Choctaw County is not richly endowed with natural resources of a geologic nature. No metallic mineral deposits have been reported, nor have commercial quantities of oil and gas been established. The principal economic products are sand, gravel, stone, and fresh water.

The actual cash value of raw materials from Choctaw County varies with demand. The total value of sand, gravel, and stone for 1959 was $149,860; for 1962, $614,558; for 1963, $280,333; for 1964, $189,725; for 1965, $185,109; for 1967, $897,000; for 1968, $272,000; and for 1969, $546,000 (data from U.S. Bureau of Mines Minerals Yearbooks). Values for intervening and subsequent years are not available. The amount of sand, gravel, and stone used increased during construction of the Hugo Dam and can be expected to increase during construction of the Boswell Dam.

Sand and Gravel

Sand and gravel are abundant in terrace and alluvial deposits, especially along the Kiamichi

River (now Hugo Lake) north of Hugo, where major operations are or have been in production (pl. 1, in pocket). The largest company currently producing is Choctaw Materials Company, whose output exceeds 1,000 tons per day from pits in NE¼ sec. 36, T. 5 S., R. 17 E. (fig. 17). Hugo Sand and Gravel Company operated from pits in NW¼ sec. 24, T. 5 S., R. 17 E. (fig. 18). Additional operations are in NW¼ sec. 18, T. 5 S., R. 18 E. Small abandoned pits are scattered throughout the County.

Materials range in size from fine sand to coarse gravel. Pea gravel (about 3/8 inch in diameter) is used mainly for road surfacing; concrete gravel (1.0 to 1.5 inches) is used in construction.

Limestone

Limestone for building purposes, road metal, and agricultural lime is abundant. The principal source is the Goodland Limestone of Early Cretaceous age. The only large quarry in operation during the time of mapping was the Wray Wyable quarry north of Hugo, where the Goodland reaches a thickness of nearly 30 feet (SE¼ sec. 5, T. 6 S., R. 17 E.; see pl. 1, in pocket).

Prior to 1954, Choctaw Lime Company operated a large quarry in the Goodland Limestone at the eastern edge of Fort Towson (sec. 19, T. 6 S., R. 20 E.). According to Cullen (1917), this quarry was first operated in 1824.

Sandstone

Sandstone of the Wildhorse Mountain Formation of the Jackfork Group (Lower Pennsylvanian) has been quarried for road surfacing and riprap in the northeastern part of the County (pl. 1, in pocket). A quarry operated by Clement Brothers Company in sec. 17, T. 5 S., R. 19 E., supplied material for construction of the Pat Mayse Dam near Arthur City, Texas; the upstream side of that dam is riprapped with blocks of Jackfork sandstone. In sec. 1, T. 5 S., R. 19 E., the Youngman Company of Baxter Springs, Kansas, has operated a quarry since November 1966. Most of the material quarried (sandstone of the Wildhorse Mountain Formation) was used in construction of the dam at Pine Creek Reservoir, McCurtain County, Oklahoma. The quarry produced 124,163 cubic yards of stone from November 1966 to June 15, 1967 (Duarte-Vivas, 1968, p. 46).

Shales for Road Metal

The green and maroon shales of the Prairie Hollow Shale Member of the Wildhorse Mountain Formation (Jackfork Group; Lower Pennsylvanian) are quarried near Bull Mountain in secs. 8 and 17, T. 5 S., R. 20 E. The material is utilized by County Commissioners for road metal.

Water Supplies

The principal water-bearing formation is the Antlers Sandstone of Early Cretaceous age, which crops out across northern Choctaw County and dips gently southward beneath younger Cretaceous rocks. In the area of outcrop, and downdip beneath younger rocks, the water in the Antlers is generally suitable for domestic, municipal, and industrial uses. At Hugo, a gravel-packed municipal well yielded 450 gallons per minute during a pumping test (Davis, 1960, p. 31). The water from the upper part of the Antlers is high in lime content, which is probably derived from the overlying Goodland Limestone.

The Goodland Limestone, the Kiamichi Formation, and the Caddo Formation yield relatively little water. Small amounts of water are available in the Pawpaw Sandstone Member of the Bokchito Formation and the Woodbine Formation. Their yields would probably be sufficient only for domestic supply, and the water is probably inferior in quality. Terrace and alluvial deposits offer small amounts of water for farm and livestock supply.

Abundant surface water for industrial uses and possibly for irrigation is available now that Hugo Lake has been completed. The completion of Boswell Reservoir will, of course, add greatly to these supplies.

Clay Products

Of the various formations observed during the investigation, the Denton Clay Member of the Bokchito Formation (Lower Cretaceous) appeared to offer the greatest potential for the making of brick and other clay products. Samples were obtained from the lower part of the Denton Clay Member from an exposure on the south side of the railroad tracks in sec. 13, T. 6 S., R. 15 E., near the town of Soper (fig. 9). These were submitted to the laboratories of the Oklahoma Geological Survey for analysis and firing. The results of the analysis by William H. Bellis of the Oklahoma Geological Survey staff are shown in table 5. However, according to the analysis, the presence of montmorillonite and the relatively high shrinkage factor of the fired material render this clay unfit for the making of high-quality brick.

Future Possibilities

Choctaw County is richly endowed with land, water, and timber and could well become a

Table 5.—Analysis of Denton Clay Member of Bokchito Formation

(Analysis by William H. Bellis, Oklahoma Geological Survey)

X-ray-diffraction analysis: predominantly kaolinite with lesser amounts of montmorillonite and illite.

Plasticity: 38%, becoming soupy at about 53%.

Drying-weight loss at 230°F overnight: 22.53% average for 13 bricks.

Fired bricks:

Temperature (°F)	Weight loss (%) dry basis	Linear shrinkage (%) dry basis
1800	8.88	5.0
1900	8.90	5.0
2000	8.92	5.0
2100	8.92	5.0
2200	8.88	0.0
2300	8.98	0.0

Colors of fired bricks were shades of red and brown.

Remarks: The montmorillonite content is a potential source of trouble if this material were to be used for structural-clay products. It may be possible, however, to dilute the adverse effect of the montmorillonite with the addition of another shale.

moderately rich area where thousands of people could be relocated and dozens of new industries established. The Hugo and Boswell reservoirs will provide ample water for industry and irrigation. The Indian Nation Turnpike, which passes through the western edge of Hugo, will connect Paris, Texas, with the Tulsa area, providing rapid and economical transportation facilities. Adequate rail transportation is currently available. Lumbering could once more become a leading industry in northern Choctaw County, large cattle ranches could be established in the black-prairie-soil region of central Choctaw County, and croplands along the Red River bottom could be made more productive with adequate fertilization and irrigation.

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APPENDIX

Measured Stratigraphic Sections

1. Bluff west of Muddy Boggy Creek, McLeod Prison farm, N½ sec. 21, T. 5 S., R. 14 E. (Jeffries, 1965, p. 48).

	Thickness (ft)
Goodland Limestone (top eroded):	
Limestone, massive, finely crystalline, nodular; white on fresh surface, pale yellow on weathered surface; fossiliferous throughout, especially near base; thin marl bed 3 inches thick 1 foot above base	16.3
Antlers Sandstone:	
White to yellow clayey sand; grades downward into yellow-brown to gray mottled sandy clay; white to gray clay nodules up to 6 inches thick	85.0
Base of exposed section (alluvium along Muddy Boggy Creek).	

2. Exposed face in quarry, NE¼ sec. 25, T. 5 S., R. 13 E. (Jeffries, 1965, p. 48).

	Thickness (ft)
Kiamichi Formation:	
Limestone, thin-bedded, brownish-yellow, fossiliferous; contains abundant specimens of *Texigryphaea navia* (Hall)	0.6
Shale, soft, brown to gray	12.0
Limestone, thin-bedded, brownish-yellow, fossiliferous; contains abundant *Texigryphaea navia* (Hall)	1.0
Shale, soft, brown to gray	1.0
Limestone, thin-bedded, brownish-yellow, abundantly fossiliferous; contains *Texigryphaea navia* (Hall)	0.5
Shale, soft, brown to gray	11.0
Limestone, thin-bedded, brownish-yellow	0.5
Shale, soft, dark-gray	5.8
Limestone, thin-bedded, white	0.3
Clay, yellow-orange, mottled	1.2
Goodland Formation:	
Limestone, massive, fossiliferous; weathers by exfoliation into curved plates; white on fresh surface, pale yellow on weathered surface	3.9
Shale, gray, platy	0.3
Limestone, massive, fossiliferous, nodular; weathers by exfoliation into curved plates; white on fresh surface, pale yellow on weathered surface; calcite crystals in voids	10.0
Base of exposed section.	

3. Section measured north-south along county road, west side of secs. 27 and 34, T. 5 S., R. 13 E. (Jeffries, 1965, p. 49).

	Thickness (ft)
Caddo Formation:	
Limestone, white, fossiliferous; contains fucoidal markings (Fort Worth equivalent)	4.0
Covered (probably shale and sandy clay)	84.0
Limestone, thin-bedded, white	0.5
Shale, soft, gray	40.0
Top of Kiamichi Formation.	

4. Slope west of stream, NE¼ sec. 14, T. 6 S., R. 14 E. (Jeffries, 1965, p. 50).

	Thickness (ft)
Bokchito Formation:	
McNutt Limestone Member:	
Limestone, sandy, platy, fossiliferous, with *Texigryphaea washitaensis* (Hill); yellow brown on fresh surface, dark brown on weathered surface. "Quarry Limestone" of previous reports	2.0
Covered	44.0
Caddo Limestone (not measured).	

5. Section along Oklahoma Highway 109 south of Boswell, west side, secs. 29 and 32, T. 6 S., R. 14 E. (Jeffries, 1965, p. 50).

	Thickness (ft)
Bennington Limestone (float only).	
Bokchito Formation:	
Pawpaw Sandstone Member:	
Red sandstone and red sandy shale, poorly exposed	33.0
Top of McNutt Limestone Member ("Quarry Limestone").	

6. Slope east of county road, SE¼ sec. 32, T. 6 S., R. 15 E. (Jeffries, 1965, p. 51).

	Thickness (ft)
Bennington Limestone (top eroded):	
Limestone, yellow-brown, fossiliferous, fucoidal, sandy, contains *Ilymatogyra arietina* (Roemer)	2.0
Bokchito Formation:	
Pawpaw Sandstone Member:	
Poorly exposed yellow-red sandstone, thin-bedded, fossiliferous, with molds of *Protocardia* sp.	14.0
Base of exposed section.	

7. South stream bank, 0.1 mile west of railroad trestle, NE¼SW¼NE¼ sec. 5, T. 6 S., R. 17 E. (Dalton, 1966, p. 62).

	Thickness (ft)
Goodland Limestone:	
Limestone, white, chalky, fossiliferous; thin shattered plates; solution cavities; caps hill	10.5
Shale, gray, platy	0.2
Limestone, white to light-gray, pale-yellow on weathered surface, nodular, fossiliferous; contact gradational with underlying clayey sand	5.3
Antlers Sandstone:	
Sand, brown-yellow, iron-stained, unconsolidated, interbedded with gray and purple clay; clay content increases in upper part	17.0
Clay, gray, platy	0.7
Pack sand, white, massive-bedded, fine-grained, well-rounded, well-sorted	5.5
Sandstone, hard, white on fresh surface, yellow-brown on weathered surface, interbedded with thin gray shale laminae; forms ledge	1.3
Pack sand, massive, white, fine-grained, well-rounded, well-sorted	5.3
Sand, light-yellow-brown, consolidated, clayey	0.5
Clay, purple, sandy	0.6
Sandstone, hard, white; weathers yellow brown; forms ledge	0.9
Clay, soft, purple, with streaks of yellow	4.3
Clay, light-gray, sandy; limonitic nodules cover slope to stream bed	3.0

Base of exposed section.

8. Exposed face in Wray Wyable limestone quarry, NW¼SE¼ sec. 5, T. 6 S., R. 17 E. (Dalton, 1966, p. 63).

	Thickness (ft)
Kiamichi Formation:	
Limestone, yellow-brown, thin-bedded, fossiliferous; contains many *Texigryphaea navia* (Hall)	0.5
Shale, dark-gray to black, soft, platy	12.5
Limestone, yellow-brown, fossiliferous; contains many *Texigryphaea navia* (Hall)	0.5
Shale, yellow to light-brown, soft	3.0
Limestone, yellow-brown, extremely fossiliferous; contains many specimens of *Texigryphaea navia* (Hall)	0.5
Shale, yellow to light-brown, soft	1.2
Limestone, yellow-brown, fossiliferous; forms ledge; contains *Texigryphaea navia* (Hall)	0.7
Shale, dark-gray, brittle; becomes lighter gray near top	12.9
Limestone, white to light-gray, sandy; forms ledge	0.6
Shale, dark-gray, platy	3.9
Goodland Limestone:	
Limestone, white on fresh surface, pale yellow on weathered surface; fossiliferous; weathers by exfoliation into small curved plates	5.4
Shale, gray, thinly laminated, platy	0.2
Limestone, white on fresh surface; weathers pale yellow; massive, chalky, fossiliferous; contains many *Turritella* sp. replaced by calcite; sparry calcite crystals up to 4 mm in diameter fill voids	9.2
Shale, gray, thinly laminated, platy	0.2
Limestone, white to pale-gray on fresh surface; weathers light yellow; nodular, fossiliferous, slightly argillaceous; darker gray near bottom	14.5

Base of exposed section; quarry floor.

9. Escarpment 0.1 mile east of section-line road, W½ sec. 36, T. 5 S., R. 16 E., and W½ sec. 1, T. 6 S., R. 16 E. (Dalton, 1966, p. 64).

	Thickness (ft)
Caddo Formation:	
Limestone, white on fresh surface; weathers pale yellow; abundantly fossiliferous; contains *Texigryphaea washitaensis* (Hill) and scattered ammonites. Caps escarpment	7.0
Clay, gray, shaly; interbedded with white limestones up to 1 foot in thickness; 60% clay	26.7
Limestone, white on fresh surface; weathers pale yellow; fossiliferous	2.0
Clay, black, shaly	3.8
Shale, gray-black, clayey; interbedded with hard white fossiliferous limestone beds 9 to 22 inches in thickness; shale forms 75 percent of rock	34.0
Limestone, white, hard, fossiliferous; contains *Texigryphaea washitaensis* (Hill) and *Kingena wacoensis* (Roemer)	1.5
Shale, gray-green, clayey; interbedded with thin white argillaceous, extremely fossiliferous limestones 5 to 7 inches in thickness; shale forms 80 percent of rock	67.0

Top of Kiamichi Formation.

10. Railroad cut in NE¼SW¼ sec. 13, T. 6 S., R. 15 E. (Dalton, 1966, p. 64).

	Thickness (ft)
Bokchito Formation:	
Soper Limestone Member:	
Limestone, light-brown, with purple streaks on fresh surface, gray-brown on weathered surface, hard; extremely fossiliferous, with *Texigryphaea washitaensis* (Hill), *Rastellum (Arctostrea) quadriplicatum* (Shumard), echinoid spines. Dips less than 1° to south. ("*Ostrea carinata*" limestone of previous reports.)	1.7
Denton Clay Member:	
Shale, gray, platy, sandy	2.2
Limestone, light-brown on fresh surface, gray-brown on weathered surface, hard; forms ledge; fossiliferous; contains *Texigryphaea washitaensis* (Hill)	0.5
Clay, yellow, soft	0.4

Shale, gray, sandy, fossiliferous, interbedded with layers of clay 1.8

Limestone, gray on fresh surface, light-brown on weathered surface; contains *Pecten (Neithea) texanus* Roemer and *Texigryphaea washitaensis* (Hill) 1.0

Shale, gray, sandy, fissile, soft 0.8

Sandstone, gray, hard, calcareous, medium-grained 0.6

Shale, gray, soft, clayey 0.5

Base of exposed section.

11. Slope on west side of section-line road, SE¼ sec. 23, T. 6 S., R. 16 E. (Dalton, 1966, p. 65).

Thickness (ft)

Bokchito Formation:

McNutt Limestone Member:

Limestone, gray on fresh surface; weathers gray-yellow; sandy, fossiliferous; contains abundant *Rastellum (Arctostrea) quadriplicatum* (Shumard); "Quarry Limestone" of previous reports 1.7

Weno Clay Member:

Sand, reddish-brown, fine-grained, poorly consolidated, clayey; interbedded with thin gray clay laminae 4.6

Shale, reddish-brown, sandy; interbedded with thin poorly consolidated sandstones up to 6 inches in thickness; black ferruginous fragments cover slope . . 5.2

Clay, gray, soft 1.8

Clay shale, red-brown, sandy; becomes increasingly sandy in upper part, where sandy red clay predominates; interbedded with thin, discontinuous gray and purple clay laminae; ferruginous fragments cover slope 16.0

Clay, gray; ferruginous stain on weathered surface 5.4

Clay, reddish-brown, sandy; interbedded with well-indurated sandstones up to 4 inches in thickness 2.9

Clay, gray on fresh surface; pale-yellow surficial coating; ferruginous fragments cover slope 6.0

Clay, gray to red, mottled, soft 2.9

Top of Soper Limestone Member ("*Ostrea carinata*" bed).

12. Road cut, U.S. Highway 271, 1.0 mile north of Grant, SW¼SW¼ sec. 10, T. 7 S., R. 17 E. (Dalton, 1966, p. 66).

Thickness (ft)

Bennington Limestone:

Limestone, light-gray-brown on fresh surface, pale yellow on weathered surface, sandy, fossiliferous; contains *Ilymatogyra arietina* (Roemer); not measured.

Bokchito Formation:

Pawpaw Sandstone Member:

Sandstone, reddish-brown, fine-grained, fossiliferous; contains molds and casts of *Protocardia* sp.; interbedded with thin gray clay 16.0

Sandstone, light-brown, well-indurated . . 2.5

Sandstone, reddish-yellow, poorly consolidated 1.0

Sandstone, light-brown; weathers dark brown; well indurated, fine grained 1.7

Sandstone, yellow-brown, moderately consolidated, fine- to medium-grained . . . 2.4

Sandstone, light-brown; weathers dark brown; moderately consolidated, fine grained; contains ferruginous nodules . . . 1.4

Clay, gray, interbedded with thin, dark-red ferruginous sandstones; ferruginous fragments cover slope 8.6

McNutt Limestone Member; not measured.

13. South bank of Horse Creek, NE¼NE¼ sec. 15, T. 7 S., R. 17 E. (Dalton, 1966, p. 67).

Thickness (ft)

Woodbine Formation:

Sandstone, brick-red, clayey, loosely consolidated; caps hill. Approximate exposed thickness 24.0

Bennington Limestone:

Limestone, light-yellow-brown on fresh surface, dark-gray-brown on weathered; upper part honeycombed with solution cavities; extremely fossiliferous; includes *Ilymatogyra arietina* (Roemer). Lower part is nodular, fossiliferous; includes *Kingena wacoensis* (Roemer) and *Texigryphaea* sp. 18.0

14. Road cut in section-line road, 0.1 mile north of intersection with Oklahoma Highway 109, SW¼SW¼ sec. 8, T. 7 S., R. 17 E. (Dalton, 1966, p. 67).

Thickness (ft)

Woodbine Formation:

Clay, brick-red, sandy; contains dark ferruginous nodules up to 2.0 inches in diameter 2.4

Sandstone, dark-reddish-yellow, fine-grained, cross-bedded; contains small circular inclusions of gray and red clay 2.9

Clay, gray and red, mottled 1.5

Sandstone, light-yellow-brown, moderately consolidated, fine-grained, quartzose; contains streaks of organic matter . . 4.3

Base of exposed section.

15. Hugo Sand and Gravel Company pit, NW¼NW¼ sec. 24, T. 5 S., R. 17 E. (Dalton, 1966, p. 67).

Thickness (ft)

Terrace deposit:

Clay, variegated gray and brown; weathers light reddish brown 4.0

Gravel lens, 15 to 20 feet in length, composed of rounded quartzite and chert pebbles and cobbles; contact with both underlying sand and overlying clay pinches and swells 2.5

Sand, dark-red, fine- to medium-grained, compact, cross-bedded	1.5
Gravel: rounded chert and quartzite pebbles in a red sandy matrix	3.6
Clay, variegated gray and white, sandy	1.0
Sand, yellowish-red, coarse-grained	1.5
Gravel: rounded to subangular chert pebbles and cobbles, 1 to 6 inches in diameter; contains red sandy matrix	9.0

Base of measured section.

16. Exposed face in Clement Brothers quarry, NW¼SW¼ sec. 17, T. 5 S., R. 19 E. (Alfonsi, 1968, p. 55).

	Thickness (ft)
Jackfork Group:	
Wildhorse Mountain Formation:	
Sandstone, light-brown to light-purple; weathers brown to white; quartzitic; stratified in beds up to 1 foot thick	30.0
Sandstone, light-green, massive; weathers purple and greenish purple; hard, quartzitic; vertically jointed with ferruginous fillings	21.0

Base of exposed section.

17. Escarpment, south bank of Horse Creek, 50 yards north of town cemetery of Grant, sec. 14, T. 7 S., R. 17 E. (Alfonsi, 1968, p. 56).

	Thickness (ft)
Woodbine Formation:	
Sandstone, brick-red, loosely consolidated, fine- to medium-grained; angular to subangular quartz grains	5.0
Sandstone, brown, loosely consolidated, fine- to medium-grained; subangular to subrounded quartz grains	6.0
Sandstone, red, loosely consolidated, fine- to medium-grained; subrounded to subangular quartz grains	8.0

Base of exposure.

18. Exposed face in gravel pit, east bank of Kiamichi River (now Hugo Lake), 0.6 mile northwest of Sawyer, NW¼SW¼ sec. 24, T. 6 S., R. 18 E. (Alfonsi, 1968, p. 56).

	Thickness (ft)
Terrace deposit:	
Sand, reddish-yellow, fine- to medium-grained	1.5
Gravel: quartzite pebbles and cobbles up to 11 inches in diameter, loosely cemented in sandy matrix	2.7
Gravel: chert and quartzite pebbles up to 2 inches in diameter, loosely cemented with purple-yellow sand	1.8
Gravel: chert and quartzite pebbles up to 4 inches in diameter; matrix is yellow-brown sand	2.2
Clay, purple; weathers yellow and brown	0.6

19. Exposed face in Youngman quarry, SW¼NW¼ sec. 1, T. 5 S., R. 19 E. (Duarte-Vivas, 1968, p. 60).

	Thickness (ft)
Wildhorse Mountain Formation:	
Upper massive sandstone member:	
Sandstone, hard, compact, quartzitic, nonfossiliferous, gray to dull red; well-developed vertical jointing 6 to 10 inches apart	4.4
Sandstone, medium-hard, gray, nonfossiliferous	0.6
Shale, gray, thin-bedded, iron-stained	0.5
Sandstone, gray, quartzitic, nonfossiliferous	0.4
Shale, gray, thin-bedded, iron-stained	0.2
Sandstone, gray to light-blue, quartzitic, nonfossiliferous; purple coloration on weathered surfaces; bottom markings conspicuous	13.5
Shale, gray to red, sandy, iron-stained	13.5
Sandstone, gray to blue-gray, quartzitic, nonfossiliferous; vertically jointed with joints 6 to 8 inches apart	6.2

20. Exposed face, Fort Towson quarry, SW¼NW¼ sec. 19, T. 6 S., R. 20 E. (Duarte-Vivas, 1968, p. 61).

	Thickness (ft)
Goodland Limestone:	
Limestone, massive, fossiliferous, white to yellow, iron-stained near top; worm borings in upper 18 inches	9.3
Shale, thin-bedded, gray, fossiliferous	0.2
Limestone, massive, fossiliferous, white to yellow	6.4
Limestone, massive, fossiliferous, nodular, white on fresh surface, gray on weathered surface	9.0
Shale, gray, thinly laminated, fossiliferous	0.2
Limestone, massive, fossiliferous, nodular, white on fresh surface, yellow-gray on weathered surface; slightly argillaceous	13.0

Base of exposed section at quarry floor.

21. Slope north side of U.S. Highway 70, 0.25 mile east of Fort Towson, NW¼SW¼ sec. 19, T. 6 S., R. 20 E. (Duarte-Vivas, 1968, p. 61).

	Thickness (ft)
Kiamichi Formation:	
Marlstone, gray to blue, very fossiliferous; contains abundant *Texigryphaea navia* (Hall)	6.2
Goodland Limestone:	
Limestone, massive, fossiliferous, white on fresh surface, gray on weathered surface; limonite stain and worm burrows in upper 5 inches; abundant fossils, including *Texigryphaea* sp. and *Pecten* sp.	5.3

Base of exposed formation.

22. Ridge west of Doaksville Creek, NW¼NW¼ sec. 10, T. 7 S., R. 20 E. (Duarte-Vivas, 1968, p. 62).

	Thickness (ft)
Caddo Formation:	
Limestone, massive, fossiliferous; yellow on fresh surface, gray-brown where weathered	2.0
Marlstone, yellow-gray, fossiliferous	0.1
Limestone, yellow, medium-hard, fossiliferous	0.8
Shale, sandy, gray, fossiliferous; contains abundant *Texigryphaea* sp.	6.7
Limestone, thin-bedded, compact, fossiliferous; reddish stain on weathered surface	0.5
Covered (probably shale and sandy clay)	10.5
Limestone, fossiliferous, gray on fresh surface, yellow-brown on weathered surface; abundant *Texigryphaea* sp. and *Pecten* sp.	2.7
Covered (probably shale)	5.2
Limestone, compact, fossiliferous, gray-yellow	0.3
Covered (probably shale)	10.0
Limestone, compact, fossiliferous, gray to yellow; reddish stain where deeply weathered	2.0
Covered (probably shale)	4.0
Limestone, compact, yellow-white, fossiliferous; contains *Pecten (Neithea) texanus* Roemer and *Texigryphaea washitaensis* (Hill)	2.2
Covered (probably shale)	4.0
Limestone, compact, gray to yellow, fossiliferous; abundant *Texigryphaea* sp.	1.2
Covered (probably shale)	2.0
Limestone, compact, gray to yellow, fossiliferous; abundant *Texigryphaea* sp.	3.0
Marlstone, yellow-gray, fossiliferous; grades into overlying limestone	3.2
Limestone, compact, yellow-gray, fossiliferous; abundant *Pecten* sp.	2.0
Covered (probably shale)	7.0
Base of exposure.	

23. Kiamichi River bend, SW¼NW¼ sec. 14, T. 7 S., R. 19 E. (Duarte-Vivas, 1968, p. 62-63).

	Thickness (ft)
Bokchito Formation:	
Weno Clay Member:	
Shale, gray, very soft, nonfossiliferous; clay-ironstone concretions exposed on weathered surfaces	5.2
Soper Limestone Member:	
Limestone, brown to reddish-gray, fossiliferous; contains *Rastellum (Arctostrea) quadriplicatum* (Shumard), *Texigryphaea washitaensis* (Hill), and *Trigonia emoryi* Conrad; bed cut by vertical joints striking N. 65° E.	1.2
Base of exposed section at river level.	

Index

(Boldface numbers indicate main references; brackets indicate table numbers; parentheses indicate figure numbers)

Aetostreon walkeri 16
agriculture 1, 4, 6, 28
Alfonsi, P. P., cited 2, 3, 11, 14, 34
alluvial deposits 1, 4, 7, 11, 13, **21**, 22, 27, (2, 15)
altitudes 4
Ambrose terrace level **22-23**, (2)
Anadarko basin 12, 26
Antlers 4
Antlers Sandstone 1, 4, 7, 9, 10, **11-13**, 14, 15, 26, 27, 31, 32, (2, 5, 6)
Aporrhais tarrantensis 15
Appalachian Mountains 12
Apple 3
Arbuckle, Col. Matthew 6
Arbuckle Mountains, Arbuckle geosyncline 1, 12, 25, 26
Arkansas Novaculite 9
Arkoma basin 12, 26
Atkins silt loam 21
Atoka County 1, 2
Atoka quadrangle 2
Barnes, V. E., cited 23, 24
Bellis, W. H. 27, [5]
Bennington 19
Bennington Limestone 1, 9, 15, **19**, 20, 26, 31, 33, (2)
Bergquist, H. R., cited 19
Bethel syncline 11
Blau, P. E., cited 3, 13, 14
Bluff 3, 22
Boggy Creek 1, 5
Bokchito 16
Bokchito Formation 1, 9, 15, **16-19**, 20, 25, 26, 27, 31, 32, 33, 35, (2, 9, 10, 12), [5]
Boktukola syncline 9, 11
Bosque Division 11
Boswell 3, 4, 16, 17, 18, 19, 22, 31
Boswell Reservoir **5-6**, 21, 26, 27, 28
Brewer silty clay loam 22
Briggs, Garrett, cited 7, 9
Bryan County 1, 2, 15, 16, 19, 25
Buckhannan, W. H., cited 21, 22, 24
Bullard, F. M., cited 2, 11, 13
Bull (Signal) Mountain 10, 11, 25, 27
Caddo 15
Caddo Formation 1, 9, **15-16**, 17, 20, 23, 25, 26, 27, 31, 32, 35, (2, 13)
Calamites 11
Caprina limestone (Edwards) 13
Carney Creek 23
Ceratostreon texanum 13, 15
Chesterian Series 1, 7, 9, (2)
Chickasaw Creek Formation 1, 7, 9
Choctaw Indians, Choctaw Indian Nation 6
Choctaw Lime Company quarry 27
Choctaw Materials Company sand and gravel pits 24, 27, (17)
cities and towns **3**
Clark, Marion 2
clay products **27**, [5]
Clear Boggy Creek 5
Clement Brothers quarry 11, 12, 27, 34
climate **3**, [1]
Cline, L. M., cited 9, 10, 11
Coastal Plain province 1, 4, 24, **25-26**
Comanchean Series **11-19**, (2)
Comanche Peak Chalk, Comanche Peak Limestone 13, 14, 15
Cooke County, Texas 19
Cooke terrace level **22**, (2)
Cordilleran geosyncline 26
Cretaceous 1, 2, 7, 9, 10, **11-21**, 24, 25, 26, 27, (2)
Cretaceous oysters 3
Cullen, John, cited 27
Currier, J. D., Jr., cited 3
Curtis, N. M., Jr. 2
Cyprimeria texana 16
Dalton, R. C., cited 2, 3, 14, 31, 32, 33
dams and lakes **5-6**
Darrough, Mrs. W. H. 3
Davis, L. V., cited 2, 13, 19, 27
Denison Formation 15
Denison, Texas 17, 18
Denton Clay Member of Bokchito Formation 15, **16**, 17, 27, 32, (2, 9, 10), [5]
Denton County, Texas 16
Denton Creek 16
Denton-Weno-Pawpaw sequence 9
De Queen Limestone 11
Desmoceras brazoense 16
Dexter Member of Woodbine Formation 19, 20
"Dinosaur Sands" 11, 13
Dissected Coastal Plain province 4
Doaksville Creek 5, 34
Drakeoceras maximum 16
Duarte-Vivas, Andrew, cited 2, 3, 14, 15, 18, 20, 25, 27, 34, 35
Duck Creek Formation 15, 16
Duland 3, 22
Eagle Ford Formation 19
economic geology **26**
"edgerock" 15
Edwards Limestone 13, 14, 15
Enallaster texanus 15
Engonoceras serpentinum 19
"Exogyra" plexa 16
"Exogyra" shell agglomerate 12
Fallon 3
Fay, R. O. 6
cited 3
Flood Control Act of 1946 5
Forgotson, J. M., Jr., cited 11
Forney 3, 4
Fort Towson 3, 4, 6, 13, 15, 23, 27, 34, (6)
Fort Towson quarry 34
Fort Washita 2, 15
Fort Worth Formation 15, 16, 17, 31
Fredericksburg division 13
Fredericksburg Group 1, 9, 11, **13-15**, (2)
Fredericksburg, Texas 13
Frederickson, E. A., cited 3, 11, 13, 14
Frogville 3, 4, 22, 23, 24
Frye, J. C., cited 21
Ganser, R. W., cited 3, 13
Gay 3, 22, 23
geography 1, **3-7**
geologic history **26**
Gibbs, H. D., cited 2, 15, 20
Good 3, 13
Goodland 3, 13
Goodland Limestone 1, 4, 9, 11, 12, **13-15**, 25, 26, 27, 31, 32, 34, (2, 7, 8)
Goodwater Creek 5
Gordon, C. H., cited 25
Grant 3, 4, 6, 18, 19, 20, 22, 23, 33, 34, (12)
Grayson County, Texas 17, 18
Grayson Formation, Grayson Marlstone 9, 15
Gryphaea corrugata 3
Gulfian Series 1, 7, **19-21**, (2)
Ham, W. E., cited 26
Hamden 3
Hamites fremonti 16
Hardeman terrace level 22, 23, **24**, (2)
Harlton, B. H., cited 9, 10
Harrisburg trough 26
Hart, T. A., cited 3
Hedlund, R. W., cited 3
Heilborn, George, cited 2
Hill, R. T., cited 2, 11, 13, 15, 16, 17, 18, 19
history **6-7**, [4]
Holaster simplex 16
Holly Creek gravels 11
Holocene 7, 21, 26, (2)
Honess, C. W., cited 2, 11, 25
Horse Creek 18, 20, 33, 34, (12)
Hugo 3, 4, 6, 7, 15, 16, 27, 28, (7, 17)
Hugo Dam, Hugo Lake, Hugo Reservoir 1, 4, **5**, 21, 22, 23, 26, 27, 28, 34, (15, 16)
Hugo Sand and Gravel Company sand pit 24, 27, 33
Hugo syncline 9, 11, **25**
Hugo, Victor 3
Humboldt, Alexander von 2
Huskey 3, 22, 23
Illinoian terrace level 22, **23-24**
Ilymatogyra arietina 19, 31, 33

Imlay, R. W., cited 13
Indian Nation Turnpike 4, 28
industries 1, 4, 6, 7, [3]
Inoceramus comancheanus 16
Jackfork Group 1, 4, 7, **9-11**, 12, 25, 26, 27, 34, (2)
Jeffries, E. L., cited 2, 3, 14, 31
Johnston County 12, 13
Kansan terrace level 22, 24
Kaufman clay soil 21
Kennedy, William 2
Kent 3
Kiamichi Formation 1, 9, 13, **15**, 16, 26, 27, 31, 32, 34, (2, 7, 8)
Kiamichi River 1, 5, 9, 15, 16, 17, 19, 21, 22, 23, 24, 26, 34, 35, (15)
Kiamichi River flood-plain complex 21
Kiamichi River tributaries 5, (2)
Kingena wacoensis 16, 19, 32, 33
Lake Raymond Gary 5, **6**
Lake Roebuck 5, **6**
Lamar County, Texas 2
Larkin, Pierce, cited 2
Le Flore County 9, 11
Leiocidaris hemigranosus 16
Leonard, A. B., cited 21
Lepidodendron 11
Leverett, S., cited 16
Lewisville Member of Woodbine Formation 19
Lima wacoensis 15, 16
limestone, commercial 1, 4, **27**
Little River 6
Llanoria 26
Lonoke clay 22
Lonoke silty clay loam 22
Love County 2, 3, 11, 12, 13
Lozo, F. E., cited 13
Lufkin very fine sandy loam 24
lumber industry 6, [3]
McAlester (Arkoma) basin 12, 26
McCurtain County 1, 2, 6, 9, 11, 15, 19, 20, 25, 26, 27
McNutt Limestone Member of Bokchito Formation 15, 16, 17, **18**, 31, 33, (2, 12)
McNutt Ranch 18, 19
Macraster elegans 16
Main Street Limestone 15, 18
Manley, F. H., Jr., cited 12
Marathon orogeny 26
Marcou, Jules 2
  cited 2
Marcy, Capt. R. B. 2
Marietta 13
Marshall County 2, 11, 13
Mayhew 3
Melton, F. A., cited 22
Meramecian(?) Series 1, 7, 9, (2)
Messer 3, 4, 24, (18)
Miller 9
Miller soil 21
mineral products 1, **26-28**, [5]
Miser, H. D., cited 2
missions 6, [4]
Mississippian System 1, 7, 9, 11, 26, (2)
Morris, J. W., cited 3
Morrowan Series 7, **9-11**, 26, (2)
Mortoniceras
  trinodosum 16
  vespertinum 3
Moyers Formation 1, 7, 9
Muddy Boggy Creek 5, 9, 19, 21, 22, 25, 31
Myatt very fine sandy loam 22
Nebraskan terrace level 21, 22
Nelson 3
Oklahoma Geological Survey 2, 7, 9, 27, [5]
Oklahoma Historical Society 6
Oklahoma Historic Sites Committee, cited [4]
Oklahoma trough 26
Olson, L. J., cited 3
Ord 3
"*Ostrea carinata*" bed 16, 17, 32, 33, (10)
Ostrea crenulimargo 13
Ouachita foldbelt, Ouachita geosyncline, Ouachita Mountains, Ouachita province, Ouachita trough 9, 11, **24-25**, 26
Oxytropidoceras
  acutocarinatum 15
  belknapi 15, 16
Paleozoic 9, 12, 24, 26
Paluxy Sand 11, 13
Paluxy, Texas 11
Pawpaw Sandstone Member of Bokchito Formation 15, 16, 17, **18-19**, 27, 31, 33, (2)
Pecten
  (Neithea) subalpinus 15
  (Neithea) texanus 16, 19, 33, 35
  sp. 34, 35
Pennsylvanian System 1, 7, **9-11**, 26, 27, (2)
petrified wood 13
Piatt, Larry, cited 11
"pimple mounds" 22, 24
Pine Creek 6
Pine Creek Dam and Reservoir **6**, 27
Pleistocene 7, 21, 26, (2)
Plicatula dentonensis 16
Pope sandy loam 21
population 1, 3, (4)
Prairie Hollow 10
Prairie Hollow Shale Member of Wildhorse Mountain Formation 1, 7, **10**, 25, 27, (2, 3)
Prairie Mountain Formation 10
Precambrian granite 12
Prewit, B. N., cited 2, 15, 16, 18, 19, 25, 26
Protocardia sp. 15, 18, 19, 31, 33
Pullen, Jake, cited 6, [1, 2]
Pushmataha County 1, 2, 4, 9, 11, 25
"Quarry Limestone" 16, 17, 18, 31, 33
Quaternary **21-24**, (2)
Rainbow Clay Member of Woodbine Formation 20, (2)
rainfall 3, [1]
Rastellum (Arctostrea)
  carinatum 16, 17
  quadriplicatum 16, 17, 18, 19, 32, 33, 35
Red Branch Member of Woodbine Formation 19, 21
Redman, R. H., cited 3, 13
Red River 1, 2, 4, 5, 9, 11, 13, 20, 21, 22, 23, 24, 28
  tributaries 5
Red River County, Texas 2
roads and railroads **3-4**, 6
Rocky Mountain geosyncline 26
Roemer, F. V., cited 2
Round Mountain 25
Round Prairie syncline 10
Ruth, Kent, cited 3, 6
Salenia mexicana 15
Sandbluff 3
sands and gravels 1, 4, **26-27**, (17)
sandstone, commercial 1, **27**
Sawyer 3, 4, 5, 16, 17, 19, 21, 23, 34, [1]
Sawyer very fine sandy loam 24
Scherpf, G. A. 2
shales, commercial **27**
Shelburne, O. B., Jr., cited 9, 11
Shirk, G. H., cited 6
Shoals 3, 20, 23, 24
Shumard, B. F. 2
Shumard, G. G., cited 2
Skolnick, Herbert, cited 2
Sobol Lookout Tower 10, 25
soils 1, 4, 21, 22
Soper 3, 4, 5, 16, 17, 18, 19 , 27, (9)
Soper Limestone Member of Bokchito Formation 15, **16-17**, 25, 32, 33, 35, (2, 10)
Speer 3, 4
Spencerville 3
Spencerville Mountain 10, 11, 25
Stanley 9
Stanley Group 1, 7, **9**, 12, 25, 26, (2)
Stenzel, H. B., cited 3
Stephenson, L. W., cited 2, 17, 21
stratigraphic sections **31-35**, (2)
stratigraphy **7-24**, (2)
structural geology **24-26**
Sulphur fault 25
Sunkist 3
Swink 3, 23, (13)
Taff, J. A., cited 2, 9, 11, 13, 15, 16, 19
Teller fine sandy loam 22
temperatures 3, [1]
Templeton Member of Woodbine Formation 19
Tenmile Creek 9
Tenmile Creek Formation 1, 7, **9**, (2)
terrace deposits 1, 4, 7, 13, 18, **21-24**, 27, 33-34, (2, 16, 18)
Texarkana sheet 22
Texas Bureau of Economic Geology 22, 23, 24
Texigryphaea
  belviderensis 16
  mucronata 15
  navia 15, 16, 31, 32, 34, (8)
  pitcheri 3
  sp. 33, 34, 35
  washitaensis 16, 17, 31, 32, 33, 35

"Thirty-foot lime" 13
timber 4, 27, 28
Tishomingo 12
Tishomingo quadrangle 2
topography 1, 4, 11
Trigonia
clavigera 16
emoryi 35
sp. 15, 16
Trinity Group 1, 9, **11-13**, (2)
Turritella
seriatum-granulosa 15
sp. 15, 18
Tylostoma elevatum 15
U.S. Army Corps of Engineers 5, 6
U.S. Bureau of Mines Minerals Yearbooks, cited 26
U.S. Geological Survey 13
University of Oklahoma, The 2
Vanderpool, H. C., cited 13
Verdigris soil 21
Virgil 3
Walnut Clay 11, 12, **13**, 14, 15
Washita Group 1, 4, 9, 13, **15-19**, (2)
Washita Limestone 2
water resources 1, **27**
Weno Clay Member of Bokchito Formation 15, 16, **17-18**, 33, 35, (2)
Weno, Texas 17
Westheimer, J. M., cited 3
Whitegrass Creek 23
Whitewater Creek 5
Wichita Mountains 12
Wichita trough 26
Wildhorse Mountain Formation 1, 7, **9-11**, 25, 27, 34, (2, 3, 4)
Wisconsinan terrace level 21, 22
Woodbine Formation 1, 4, 9, **19-21**, 24, 26, 27, 33, 34, (2, 13, 14)
Woodbine, Texas 19
Woodson, J. P., cited 9, 10
Wray Wyable quarry 27, 32, (7, 8)
Wright, M. H., cited 6
Yahola soil 21
Young, Keith, cited 13
Youngman quarry 11, 34, (4)