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GEOLOGY AND GROUND-WATER RESOURCES OF SOUTHERN McCURTAIN COUNTY, OKLAHOMA

BY

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Prepared in cooperation between the Oklahoma Geological Survey and the U. S. Geological Survey

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FOREWORD

Oklahoma Geological Survey Bulletin 86 makes available to the citizens of Oklahoma important information on ground-water supply. The report was completed by L. V. Davis in 1955 and was delivered to the State survey in 1958. The map and figures were redrafted by draftsmen of the State survey and the report was edited here.

Use of the name Antlers sand is not approved by the Federal survey. The name is used on the map by authority of the State, but the unit is consistently called Paluxy sand in the text. The map was not critically examined by the Federal survey after redrafting.

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GEOLOGY AND GROUND-WATER RESOURCES OF SOUTHERN McCURTAIN COUNTY, OKLAHOMA

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ABSTRACT

McCurtain County, in the southeastern corner of Oklahoma, is roughly rectangular, has an area of about 1,900 square miles, and had a population of about 31,388 (1950). The southern part of the county, considered in this report, is in the Dissected Coastal Plain and is relatively flat, having a surface relief of about 200 feet. The county is drained by the Red and Little Rivers.

Mineral resources consist of gravel, sand, clay, limestone, and oil and asphaltic sand. These mineral resources, other than sand and gravel for road ballast, are little used.

Sand, shale, and limestone, of Cretaceous age, underlie the surface of southern McCurtain County. The formations exposed, in ascending order, are the Holly Creek formation, De Queen limestone, Paluxy sand, Goodland limestone, Kiamichi formation, and lower part (Early Cretaceous) of the Washita group of the Comanche series, and the Woodbine formation, Tokio formation, and Brownstown and Ozan formations, undifferentiated, of the Gulf series (Late Cretaceous age). The regional dip is southward about 100 feet per mile, locally interrupted by gentle folding. These formations are overlain along the larger streams by alluvium and at other places by terrace deposits.

The Paluxy sand and the alluvium of the Red River are the most productive ground-water reservoirs in southern McCurtain County. The Paluxy is the source of public water supply for Valliant, Millerton, and Garvin. Municipal wells tapping water in this formation are generally less than 360 feet deep and their maximum yields are not more than 261 gallons per minute, which is considerably less than the Paluxy is capable of yielding to properly constructed wells that penetrate the entire water-bearing zone. The water is hard but has a relatively low mineral content.

A pumping test on the municipal water wells at Valliant was analyzed according to the Theis nonequilibrium formula and yielded about 14,000 gpd/ft for the coefficient of transmissibility. From the same test a value of 4.2×10^{-5} was obtained for the coefficient of storage.

The sands of the Paluxy function as one large reservoir. Ground-water withdrawals from this reservoir have not appreciably affected the water levels except in the vicinity of Valliant, where a long-term drawdown has occurred since 1908.

The alluvium along the Red River has a maximum thickness of about 110 feet. The water contained in it is hard but suitable for most uses. However, it is reported to be saline in some places. The alluvium yields water from dug and driven wells for domestic and stock use. Yield of several hundred gallons per minute may be expected from properly constructed wells.

INTRODUCTION

Purpose and Scope of the Investigation

This report makes available to the public such information on the ground-water resources of southern McCurtain County as may be useful for guidance in locating ground water for industries, for municipalities, or for irrigation.

The investigation described in this report was designed to determine, so far as practical, (1) the areas capable of supplying large quantities of water for industrial, municipal, or irrigation use, (2) the areas where the readily available supplies of ground water are not being utilized fully, and (3) the trend of water levels in the different aquifers in order to ascertain whether the ground-water reservoirs are being depleted.

Location of the Area

McCurtain County lies in the extreme southeastern corner of Oklahoma (fig. 1). It is bordered on the east by Arkansas, on the south by Texas, where the south bank of Red River forms the boundary, on the west by Choctaw and Pushmataha Counties, and on the north by Pushmataha and LeFlore Counties. The southern half of the county is covered in this report; it includes all parts of Tps. 5 to 10 S., Rs. 21 to 27 E., and comprises about 1,100 square miles. The largest town and county seat is Idabel, which had a population of 4,621 in 1950. Other towns are Broken Bow, Valliant, Wright City, Garvin, and Millerton.

McCurtain County is traversed by U. S. Highway 70; Oklahoma State Highways 3, 7, 21, 21A, 57, 87, and 98; the St. Louis-San Francisco Railway; and the Texas, Oklahoma Eastern Railroad. A privately owned railroad, the Dierks Lumber Co. Railroad, extends northward from Wright City to Clebit.

Previous Investigations

Geologic reports on southern McCurtain County have been concerned chiefly with the geology and nomenclature of the rocks rather than with the ground-water possibilities. However, the geologic reports by Hill (1901) and Veatch (1906) include material relevant to the ground-water conditions in McCurtain County.

In 1936 and 1937 the State Mineral Survey, which was a project of the Works Progress Administration, sponsored and directed by the Oklahoma Geological Survey, made a survey of the mineral resources of the State, including an inventory of water wells used for domestic and public supply. The data obtained have been tabulated by the Oklahoma Geological Survey, and typewritten reports may be examined at the Survey office in Norman.

McCurtain County is included on the maps accompanying a report entitled "Geology of Oklahoma ground-water supplies," by Dott (*in* Smith, 1942, p. 49, 52). The geology of a portion of McCurtain County is described in Oklahoma Geological Survey Mineral Report 23 entitled "Oil possibilities near Idabel, McCurtain County, Oklahoma," by Davis (1953).

Present Investigation

Field work for the present investigation was begun in the fall of 1949 by Charles L. Fair, who spent about 7 months in McCurtain County making an inventory of the water wells and doing areal geologic mapping of the Goodland limestone and younger rocks. His work is incorporated in the geologic map accompanying this report. William H. Bush spent several months in 1950 and 1951 making an inventory of the water wells. The author spent part of 1953 and 1954 completing the geologic mapping and the field work.

In addition to geologic mapping the investigation included the examination and interpretation of electric and drillers' logs; the study of well cuttings; the preparation of geologic cross sections and maps showing geologic structure, formation thickness, and water-table and piezometric surfaces.

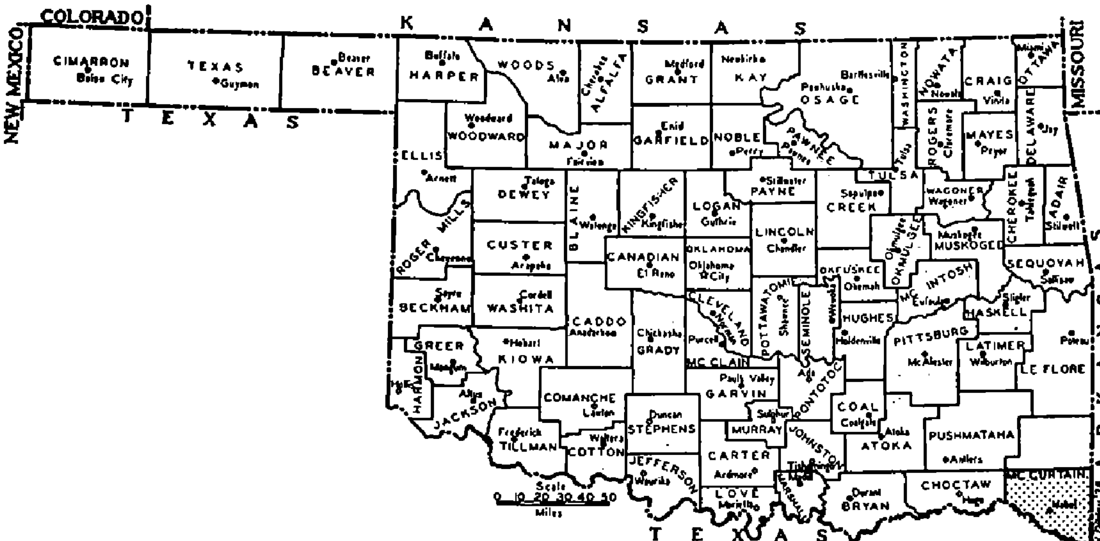

Fig. 1. Index map of Oklahoma showing location of southern McCurtain County.

Selected observation wells in the various aquifers were measured at weekly or monthly intervals, and one well was equipped with an automatic water-stage recorder, which gave a continuous record of the fluctuations of the piezometric surface of ground water in the Paluxy sand. The ability of the Paluxy sand to store and transmit water was determined for one area by a pumping test.

Samples of water collected during this investigation were analyzed by standard methods. Most of the analyses were made in laboratories of the Quality of Water Branch, U. S. Geological Survey. Chloride tests were run in the field to determine the areas of salt-water contamination.

Well-Numbering System

The well-numbering system used in this report is based on the township system of land subdivision of the General Land Office. The first part of the well number is the township number, the second is the range number, and the third is the section. Thus 8S24E-10 designates a well in sec. 10, T. 8 S., R. 24 E. Where several wells are recorded in the same section, serial numbers are added to distinguish one from another. For example, well 8S24E-10-2 is the second well recorded in sec. 10.

In table 7 the wells are grouped by townships, under a side heading. The well numbers are given in the first, or lefthand, column. The part of the well number designating the township and range is given once, at the left in boldface type, and only the section and serial elements of the number are shown on the line describing the well, thus: 8S24E

-10-1

-10-2

Locations within the sections are given in the second column of the well tables, following the usual pattern of land descriptions: NW¼NE¼SE¼. In this example, the smallest fractional unit is given first; the location is the northwesternmost 10 acres of the section, and is read the NW¼ of the NE¼ of the SE¼. This part of the location is not repeated in other tables, and in most cases it is not mentioned in the text.

ACKNOWLEDGMENTS

State and federal agencies cooperated in the investigations for this report. City officials of the various towns in the area furnished data regarding their municipal water systems, water requirements, and financial conditions. Well drillers supplied information concerning the geologic materials penetrated while drilling water wells, and the quality of water in completed wells. Individual well owners and tenants were free with data pertaining to farm wells. Oil prospectors in McCurtain County furnished drillers' logs and electric logs of oil test holes.

GEOGRAPHY

Topography

Southern McCurtain County is in the Dissected Gulf Coastal Plain. The north boundary of the province is the north edge of the outcrop of the Trinity group of rocks. The northern part of southern McCurtain County is characterized by a rolling topography developed by differential erosion of the sands and clays of the Trinity and the overlying terrace gravels. In the southern part of the area, from about the latitude of Little River south to the alluvium and terrace deposits of Red River, the general dip of the rocks is southward, locally interrupted by gentle folding. The alternation of resistant and weak strata produces a stairstep topography, the limestones and other resistant beds forming northward-facing escarpments and gentle slopes to the south. Local relief in most places does not exceed 100 feet and generally is much less.

Little River crosses about midway of southern McCurtain County, flowing eastward, and Glover Creek and Mountain Fork River flow into it from the north. Red River, flowing southeast, forms the south boundary of the county. Alluvial plains on these streams range in width from less than a quarter of a mile to about five miles. A high-terrace deposit, ranging in width from half a mile to about four miles, and about 20 miles long, borders the north edge of the Red River alluvium in the southeastern part of the area.

TABLE 1.—MONTHLY AND ANNUAL PRECIPITATION IN INCHES, AT IDABEL, McCURTAIN COUNTY, OKLA.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Departure from average[1]
1907	....	....	2.30	5.90	11.39	2.47	3.64	1.22	1.04	4.76	5.22	3.21	....	
1908	3.53	3.32	2.11	7.60	9.32	10.64	6.37	1.33	3.45	.46	2.89	.52	51.54	+ 5.01
1909	.50	3.35	2.30	3.16	5.04	2.68	....	....	....	....	....	....	....	
1910	....	4.59	1.49	3.58	3.17	....	....	....	....	....	....	....	....	
1911	....	....	....	5.50	.70	2.05	4.21	3.70	2.40	1.14	2.10	....	....	
1912	1.07	....	....	....	2.69	4.03	2.80	4.50	....	....	....	....	....	
1913	....	....	....	....	....	....	....	....	....	3.01	....	6.80	....	
1914	....	3.21	7.64	6.62	6.90	2.00	.20	4.03	.10	.48	1.42	7.54	....	
1915	4.01	6.40	10.60	8.28	4.71	....	2.80	7.05	2.20	....	2.60	....	....	
1926	....	....	....	....	3.16	3.06	10.05	4.17	1.97	5.27	1.68	6.86	....	
1927	3.22	5.18	3.67	11.48	5.41	2.10	4.82	1.96	2.73	5.14	2.02	3.83	51.56	+ 5.03
1928	1.64	2.08	2.13	5.89	3.19	9.38	2.47	3.68	.30	2.09	4.79	6.48	44.12	— 2.41
1929	632	3.45	2.52	3.47	8.24	2.36	2.49	.00	5.73	4.53	2.34	3.82	45.27	— 1.26
1930	4.04	4.77	1.99	2.01	9.56	.34	.03	2.67	3.17	4.15	3.38	1.23	37.34	— 9.19
1931	.62	4.74	3.99	1.95	1.53	3.12	4.63	1.44	.36	2.49	4.13	6.04	35.04	—11.49
1932	9.91	4.42	4.64	3.69	2.01	5.66	4.68	1.90	.77	2.52	.63	7.67	48.50	+ 1.97
1933	4.66	3.15	4.10	3.09	4.69	.21	3.14	7.64	2.81	3.65	.76	3.38	41.28	— 5.25
1934	2.37	2.04	4.88	4.07	1.19	2.57	1.06	.16	1.33	.14	8.66	3.41	34.88	—11.65
1935	6.40	2.12	3.58	6.46	11.03	9.66	2.39	1.85	3.86	3.61	5.08	2.80	58.84	+12.31
1936	.70	1.06	.68	.97	5.17	.03	3.65	.34	5.38	4.66	1.59	4.49	28.72	—17.18
1937	6.32	1.22	3.38	3.20	5.57	4.35	2.13	3.05	1.19	2.60	4.23	5.15	42.39	— 4.14
1938	11.49	5.54	5.31	4.71	3.99	3.22	4.91	2.35	1.37	.21	3.80	1.60	48.50	+ 1.97
1939	3.80	7.10	4.78	6.38	5.23	2.62	1.79	2.30	.30	2.16	4.66	1.23	42.35	— 4.18
1940	1.94	2.14	3.13	6.81	9.34	5.14	6.20	.88	1.10	2.81	8.64	4.98	53.11	+ 6.58
1941	1.87	2.27	2.32	7.17	.78	8.60	5.95	1.82	2.66	4.22	2.18	3.28	43.12	— 3.41
1942	1.59	1.56	3.30	10.85	8.20	2.27	.25	3.29	1.69	2.87	2.27	4.34	42.50	— 4.03
1943	.43	.92	2.48	4.94	9.07	2.11	.74	.02	8.84	5.24	2.48	5.00	42.23	— 4.30
1944	2.63	7.26	4.94	4.87	12.79	1.97	1.07	3.95	1.41	.66	4.53	7.53	53.61	+ 7.08
1945	1.78	7.84	13.14	3.96	4.23	7.14	4.11	4.18	7.36	5.24	1.72	1.33	62.03	+15.50
1946	5.74	6.55	6.63	3.58	8.61	1.16	1.06	4.04	1.25	1.92	11.13	3.97	55.64	+ 9.11
1947	2.19	1.07	4.38	4.27	12.27	1.58	1.56	2.56	2.31	2.68	4.27	5.15	44.29	— 2.24

TABLE 1.—Continued

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Departure from average[1]
1948	6.66	4.24	5.32	2.19	9.33	1.39	3.46	1.44	.33	6.35	3.06	3.16	46.93	+ .40
1949	10.15	4.56	4.12	3.66	4.51	11.82	4.07	2.40	4.10	3.18	.59	4.11	57.90	+11.37
1950	8.50	7.62	2.62	5.69	8.38	1.72	11.50	2.78	7.25	1.90	1.10	.10	59.16	+12.63
1951	4.70	6.22	.55	4.07	2.57	7.03	3.44	.16	9.53	3.33	3.85	2.78	48.23	+ 1.70
1952	4.19	3.79	4.66	11.46	4.69	.33	2.44	2.02	.94	.36	9.58	3.74	48.19	+ 1.66
1953	2.18	1.98	4.93	9.12	8.46	.47	6.07	.65	1.39	1.82	2.11	4.21	43.39	— 3.14
1954	4.97	2.13	.99	4.24	9.86	.44	1.18	.38	2.23	9.02	1.34	2.74	39.51	— 7.02
1955	1.53	2.54	4.63	5.11	6.73	.96	3.32	6.62	7.45	1.61	.83	1.54	42.87	— 3.66
1956	1.63	6.71	2.08	3.35	2.62	1.37	1.36	2.22	.29	1.67	4.56	2.67	30.53	—16.00
1957	4.91	4.68	8.32	14.34	12.41	4.77	.66	1.82	7.11	3.93	7 99	2.45	73.39	+26.86
Average[1]	4.29	3.76	4.14	5.06	6.41	3.42	3.39	2.33	3.21	3.04	3.73	3.75	46.53	

[1] Average as computed by U. S. Weather Bureau, Oklahoma City, Okla.

.... No record.

Drainage

The area lies within the Red River drainage basin. The Red is a perennial stream with a wide, relatively shallow channel having a low gradient and a large sediment load. The low gradient and large sediment load have resulted in intricate stream meanders over a wide alluvial plain. Oxbow lakes and marshy areas are numerous and a rise in the river may flood thousands of acres.

Little River is the major tributary of the Red River in McCurtain County. It enters southern McCurtain County near its northwest corner and flows southeastward and eastward, leaving the county east of Goodwater. It flows into the Red River in Hempstead County, Arkansas. Little River is a perennial stream with steep mud banks, a sand and gravel stream bed, and heavy timber on the bottom lands. Other perennial streams are the Mountain Fork River, Glover, Yashau, and Lukfata Creeks, which flow into Little River from the north, and Norwood, McKinney, Waterhole, and Clear Creeks, which flow into the Red River.

Climate

McCurtain County has a humid climate (Thornthwaite, 1941, p. 3, pl. 3). In winter the temperatures generally are mild, there being only occasional short periods of severe cold and almost no snow. In summer some days are uncomfortably hot, and there are many warm nights.

Precipitation generally exceeds the losses by evaporation and plant use, resulting in a moist subsoil and additions to ground water, but several years of average or above-average rainfall may be followed by several dry years during which soil moisture is deficient. Intense thunderstorms, accompanied by local heavy precipitation, are common, as well as storms of regional extent.

TABLE 2.—AVERAGE MONTHLY PRECIPITATION, IN INCHES, AT IDABEL, OKLA.[1]

December	3.76	March	4.14	June	3.42	September	3.21
January	4.29	April	5.06	July	3.39	October	3.04
February	3.75	May	6.41	August	2.33	November	3.73
Seasonal total	11.80		15.61		9.14		9.98

[1] Average as computed by U. S. Weather Bureau, Oklahoma City, Okla.

Records of precipitation have been kept by the U. S. Weather Bureau at Idabel from 1907 to date (table 1). The annual precipitation has ranged from 28.72 to 73.39 inches (table 1). About 60 percent of the total annual precipitation occurs in the months of December through May (table 2).

The temperature at Idabel has ranged from —11° F on February 2, 1951, to 114° F on August 10, 1936. January has the lowest average temperature and July and August have the highest (table 3). The average annual temperature at Idabel is about 64.4° F, which is about 3.8° F above the average for the State.

TABLE 3.—AVERAGE MONTHLY TEMPERATURES, IN DEGREES F, AT IDABEL, McCURTAIN COUNTY, OKLAHOMA

	Highest monthly average temperature		Lowest monthly average temperature		Long term average temperature 1916-1957 inclusive
	Degrees	**Year**	**Degrees**	**Year**	
Jan.	51.6	1952	32.1	1940	44.4
Feb.	53.3	1957	40.2	1936	47.6
Mar.	62.2	1938	48.2	1947	54.6
Apr.	67.7	1954	59.7	1953	63.3
May	74.1	1956	65.2	1954	70.1
June	84.8	1953	75.1	1955	78.6
July	87.4	1954	76.7	1950	82.3
Aug.	87.4	1934	79.0	1940, 1949, 1955	82.4
Sept.	81.6	1939	70.9	1950	75.7
Oct.	70.1	1931	59.6	1952	65.4
Nov.	59.6	1942	48.4	1947	52.7
Dec.	50.8	1946	40.8	1945	45.3

The average number of days between the last killing frost in the spring and the first killing frost in the fall, for the period of record, is about 229 days. The last killing frost generally occurs late in March, but has ranged from March 7 to April 19. The first frost in the fall usually occurs in the latter part of November, but has ranged from October 8 to November 23.

Population

Idabel, located near the middle of the south half of McCurtain County, is the largest city in the county. The population of the incorporated towns for the years 1920, 1930, 1940, and 1950, as reported by the United States Census Bureau, is given in table 4. These figures show that the smaller towns have consistently lost population and that the area as a whole has been losing population since 1920. The losses in rural population reflect the mechanization of farm operations and greater opportunities for employment in industrial areas elsewhere.

TABLE 4.—POPULATION OF SOUTHERN McCURTAIN COUNTY

Incorporated city or town	1950	1940	1930	1920
Idabel	4,671	3,689	2,581	3,067
Broken Bow	1,838	2,367	2,291	1,983
Valliant	(a)	551	608	809
Haworth	(a)	232	276	400
Garvin	(a)	170	263	292
County total	31,588	41,318	34,759	37,905

(a) Not listed separately in census table.

Economic Development

Only a few generations ago southern McCurtain County was heavily timbered and only a few patches of prairie were scattered here and there. Wild turkeys, deer, bear, and many other kinds of game abounded. The area was unsettled and used only by the plains Indians as a hunting ground.

Crop production in southern McCurtain County, as indicated by census data, apparently reached a peak near the close of World War I, and has declined steadily since that time. The major portion of this reduction and the abandonment of tracts of land are the result of low productive capacity and soil erosion. A smaller part of the reduction is due to retirement of bottom lands because of frequent flooding and drainage difficulties. At present, most of the crop production in the area is concentrated in the alluvium along the Red River. In other parts of the area, current agricultural programs are directed principally toward grazing for beef and dairy cattle and other livestock. The chief crops are corn and sorghums, for both grain and forage, and cotton.

The cutting and processing of lumber, together with the production of creosoted fence posts are the important industries in southern McCurtain County. The two largest mills, owned by Dierks Forests, Inc., are at Broken Bow and Wright City and process hardwood and pine, respectively. Numerous small mills are in operation at Valliant, Millerton, Garvin, Idabel, Broken Bow, and elsewhere in the county.

Mineral Resources

No metallic mineral deposits of commercial significance are known in southern McCurtain County. Nonmetallic minerals, in order of their importance, are gravel, sand, clay, limestone, petroleum, and asphaltic sand.

Gravel and sand in large quantities are available from terrace deposits and from the gravels in the Woodbine formation. Although many quarries have been opened, they have been operated only intermittently to meet local needs for road construction. The clays of the Washita group and older rocks of the Cretaceous are suitable only for common brick (Sheerar and Redfield, 1932, p. 167-169). Clays in formations younger than the Washita group have not been tested but are believed to be of better quality than the older clays. The Goodland limestone is quarried in the NW$\frac{1}{4}$ sec. 23, T. 7 S., R. 23 E., by the McCurtain Lime Co. The crushed rock has been used principally for agricultural lime and chicken grit. An analysis of the Goodland limestone made in the laboratories of the Oklahoma Geological Survey shows that it is suitable for many other uses. The analysis in percentage shows insoluble material to be 2.40; R_2O_3, 1.30; CaO, 54.28; MgO, none; CO_2, 42.59; total 100.57.

Prior to 1952 there were no producing oil wells in McCurtain County. At least 17 wells were drilled in search of oil in southern McCurtain County during the period 1916 to 1952; none yielded oil in commercial quantities, although traces of oil or gas were reported in 12 of them.

Oil was found on December 27, 1952, in a 330-foot well drilled for water by J. H. Wilson on the farm of W. O. Harmon, in the SE¼ SE¼ NE¼ sec. 5, T. 8 S., R. 23 E. (Davis, 1953). The oil was encountered in the top of the Paluxy sand at a depth of about 325 feet below the surface. Oil was bailed from the hole at irregular intervals for several days, the total being estimated as 35 or 40 barrels. A test was then made in which the hole was bailed dry, and after a 50-minute interval it yielded 40 gallons of 28.6-gravity black oil. A pump was installed but the yield quickly dropped to only a few barrels per day, owing to encroachment of fine Paluxy sand.

The unexpected discovery led at once to the drilling of the W. D. Seay Oil Co. No. 1 M. T. Smith test well in the NW¼SW¼NW¼ sec. 4, T. 8 S., R. 23 E., which on January 10, 1953, also encountered oil in the upper part of the Paluxy sand. This well, only about 600 feet from the Harmon well, was not completed because of litigation concerning the lease.

The Seay Oil Co. then drilled a twin well to the No. 1 Harmon to a total depth of 1,364 feet. A core from 1,354 to 1,364 feet recovered brown oil-saturated Cretaceous sand and hard "slate" of Paleozoic age. An electric log was made of the well, and welded-joint casing four inches in diameter was run to the bottom and cemented. However, nearly every joint leaked because of faulty welding and the hole could not be bailed dry. Nevertheless, the casing was perforated from 1,340 to 1,350 feet to recover several gallons of light-green oil through almost 1,300 feet of water in the well. The casing was perforated also from 1,228 feet to 1,240 feet and from 1,055 feet to 1,068 feet, but the results were indecisive. The well was finally abandoned.

Since 1952 there has been further development of the immediate area around the Harmon farm, most of the wells encountering oil in the fine sand at the top of the Paluxy, but because of difficulties in completing the wells nearly all of them have been abandoned.

In the SE¼ sec. 22, T. 6 S., R. 21 E., about half a mile north of Valliant, an asphaltic sand in the upper part of the Paluxy is exposed over an area of several acres. Spasmodic attempts to develop the deposit have been made since 1922, but none proved to be commercially successful.

Table 5.—Generalized section of rocks exposed in southern McCurtain County, Okla.

System	Series	Group	Formation	Thickness (feet)	Lithology and water-bearing properties
QUATERNARY	Pleistocene and Recent		Alluvium	0 - 80	Gravel, sand, silt, and clay on the present and old flood plains of the Red and Little Rivers and their tributaries. Yields hard water to domestic and stock wells; probably capable of yielding several hundred gallons of water per minute in some localities.
QUATERNARY	Pleistocene and Recent		Terrace deposits	0 - 40	Unconsolidated gravel, sand, silt, and clay occurring in large and small deposits over southern McCurtain County; probably remnants of formerly more extensive deposits; found mostly on higher ground. Generally too highly dissected and drained of ground water to yield more than enough for domestic or stock use.
			UNCONFORMITY		
CRETACEOUS	Gulf		Ozan and Brownstown formations, undifferentiated	- - -	Soft chalky marls and limestones with interbedded calcareous clays. Yield only enough ground water for domestic use.
			UNCONFORMITY		
CRETACEOUS	Gulf		Tokio formation	0 - 595	Gray cross-bedded sand, interbedded with gray and dark-gray shale. Transmissibility generally low, owing to clay and silt in formation. Probably yields less than 20 gpm.
			UNCONFORMITY		
CRETACEOUS	Gulf		Woodbine formation	0 - 355	Upper member mostly gray to brown cross-bedded quartz sand and sandy gravel. Lower member principally cross-bedded dark tuffaceous sand, red clay, and gravel lentils. The formation is not a productive aquifer; most wells yield only sufficient water for domestic or stock use. Quality is poor.
			UNCONFORMITY		

Table 5.—Continued

System	Series	Group	Formation	Thickness (feet)	Lithology and water-bearing properties
CRETACEOUS	Comanche	Washita	(Includes Kiamichi formation of Fredericksburg group)	0 - 235	Gray fossiliferous limestones and calcareous dark-blue shale: thins eastward. Contains relatively small amounts of water of poor quality in solution openings and cracks in the limestones.
		Fredericksburg	Goodland limestone	25 - 130	Thin-bedded dense limestone at the top; soft chalky and massive limestone in lower part. Entire formation fossiliferous. Does not yield much water to wells. Water is of poor quality.
			UNCONFORMITY		
CRETACEOUS	Comanche	Trinity	Paluxy sand	0 - 900	Mostly quartz sand with some interbedded clay and a few shaly limestone lentils. Contains large amounts of ground water. Maximum reported yield about 260 gpm from a municipal well at Valliant. Probably could supply sufficient water for irrigation in some areas. Water is saline southwest of Idabel and east of Idabel south of Little River.
			De Queen limestone	0 - 190	Clayey limestone, blue-gray and gray; thins westward. Contains a small amount of water along bedding planes; wells in it have small yields, which are quickly exhausted.
			Holly Creek formation	0 - 1,070	Gravel, mostly interbedded with silt and clay; thins westward. Yields little ground water to wells, generally only enough for home and stock use.
			UNCONFORMITY		

GENERAL GEOLOGY

Summary of Stratigraphy

The bedrock exposed in southern McCurtain County consists of sedimentary rocks of the Comanche and Gulf series of the Cretaceous system (pl. I). The oldest formation is the Holly Creek, which is overlain by the De Queen limestone and Paluxy sand, all of the Trinity group. These crop out in the northern part of southern McCurtain County. Above them, from oldest to youngest, are the Fredericksburg and Washita groups, which crop out as east-west bands south of the latitude of Little River. The Trinity, Fredericksburg, and Washita groups constitute the Comanche series of rocks in this county.

The Gulf series, overlying the Comanche, consists of the Woodbine formation at the base followed by the Tokio formation, and the Ozan and Brownstown formations, undifferentiated. The Woodbine and Tokio crop out as east-west bands in the southern part of the area. The Ozan and Brownstown, undifferentiated, crop out in a small area in the southeastern part of the county.

Alluvial deposits overlie the bedrock in the valleys, and terrace deposits are scattered in small and large deposits over the entire area.

Table 5 shows the sequence and character of the bedrock formations at the surface in southern McCurtain County.

Summary of Structure

The regional structure of the Cretaceous rocks in McCurtain County is a southward-dipping homocline, the maximum dip of which is about 100 feet per mile. The regional stratigraphic and structural relationships of the rocks of the Comanche series are described by Miser (1927, p. 443), who says, "They are separated from the underlying rocks by a profound unconformity whose plane truncates folded and faulted rocks of many ages. . . . . also, they are separated from the superjacent Upper Cretaceous (Gulf) rocks by an angular unconformity whose plane truncates all the several formations of Lower Cretaceous (Comanche) age, the youngest in Oklahoma and the oldest in Arkansas. Furthermore, the basal unit—the Trinity formation—contains beds in Arkansas that do not extend westward far into Oklahoma, owing to a westward overlap of the upper part of the Trinity over the lower part of the formation."

In McCurtain County the upper part of the Comanche series is represented by the Washita group. The erosion that caused the eastward thinning of the Washita marks the end of the Comanche epoch, and the contact between the Washita and the overlying Woodbine formation marks a plane of unconformity. The local differences in thickness of the Washita group doubtless are partly due to unevenness of the eroded surface, even though that surface may have approximated a peneplain. The differences may be due partly to the influence of minor folding during the period of erosion.

Originally the rocks of the Comanche series must have extended far north of their present occurrence, at least as far north as the latitude of Smithville, so that they covered and shielded from erosion the quartz veins of the Ouachita Mountains (oral communication, H. D. Miser). These quartz veins apparently were covered as late as Woodbine time (Late Cretaceous), because the gravel of the Woodbine, which, in northern McCurtain County, is composed of pebbles derived from the Ouachita Mountains is lacking in quartz pebbles. Erosion has worn down and removed the sediments to create the present topography. During this period of erosion the quartz veins were uncovered, and they supplied much quartz to make up the matrix of the terrace gravels which are widespread throughout southern McCurtain County.

The overlap and unconformable relations described by Miser (1927) and the folds now known to be present in southern McCurtain County have resulted in structural and stratigraphic traps in the sands of the Trinity group where petroleum, if present in nearby rocks, could accumulate. At least some of these traps are known to contain petroleum.

Measurements of dip in exposures of the Woodbine and younger formations are not reliable guides to the structure of the rocks of the Comanche series because of cross-bedding and because of the unconformity separating the Comanche from the Gulf series. However, some indication of the structure may be disclosed by the areal distribution of these formations. Indications of structure are found in the Washita group of rocks where they crop out at the surface. Three such areas are described in the following paragraphs.

An inlier of rocks of the Washita group is exposed along Bokchito Creek in the SW¼ sec. 33, T. 7 S., R. 23 E., and the NW¼ sec. 4, T. 8 S., R. 23 E., and has been described by Davis (1953, p. 11-12, fig. 2). Drilling has shown that the structure in the subsurface is an anticline whose axis roughly parallels the surface flexure (fig. 2). It is from this structure that the first petroleum was produced in McCurtain County. Possibly, lensing of sand beds in the upper part of the Paluxy also has helped to trap the oil. A sand about five feet thick was found just under the Goodland limestone in the discovery well in sec. 5, T. 8 S., R. 23 E., but it was not found in test holes in secs. 30 and 34, T. 7 S., R. 23 E. This anticline is probably only one of a group of anticlines in southern McCurtain County.

An inlier of rocks of the Washita group along Garvin Creek reveals folding that involves both the Washita group and the Woodbine formation. The inlier is in the SW¼ sec. 19 and the NW¼ sec. 30, T. 7 S., R. 23 E., and has been described by Davis (1953, p. 12, fig. 3).

The Washita group crops out much farther south along Perry Creek than the topography would require if the structure of the rocks were a simple southward-dipping homocline (pl. I). Some flexure of the rocks on the homocline is therefore indicated in secs. 34 and 35, T. 7 S., R. 23 E., and in secs. 2, 3, 10, and 11, T. 8 S., R. 23 E.

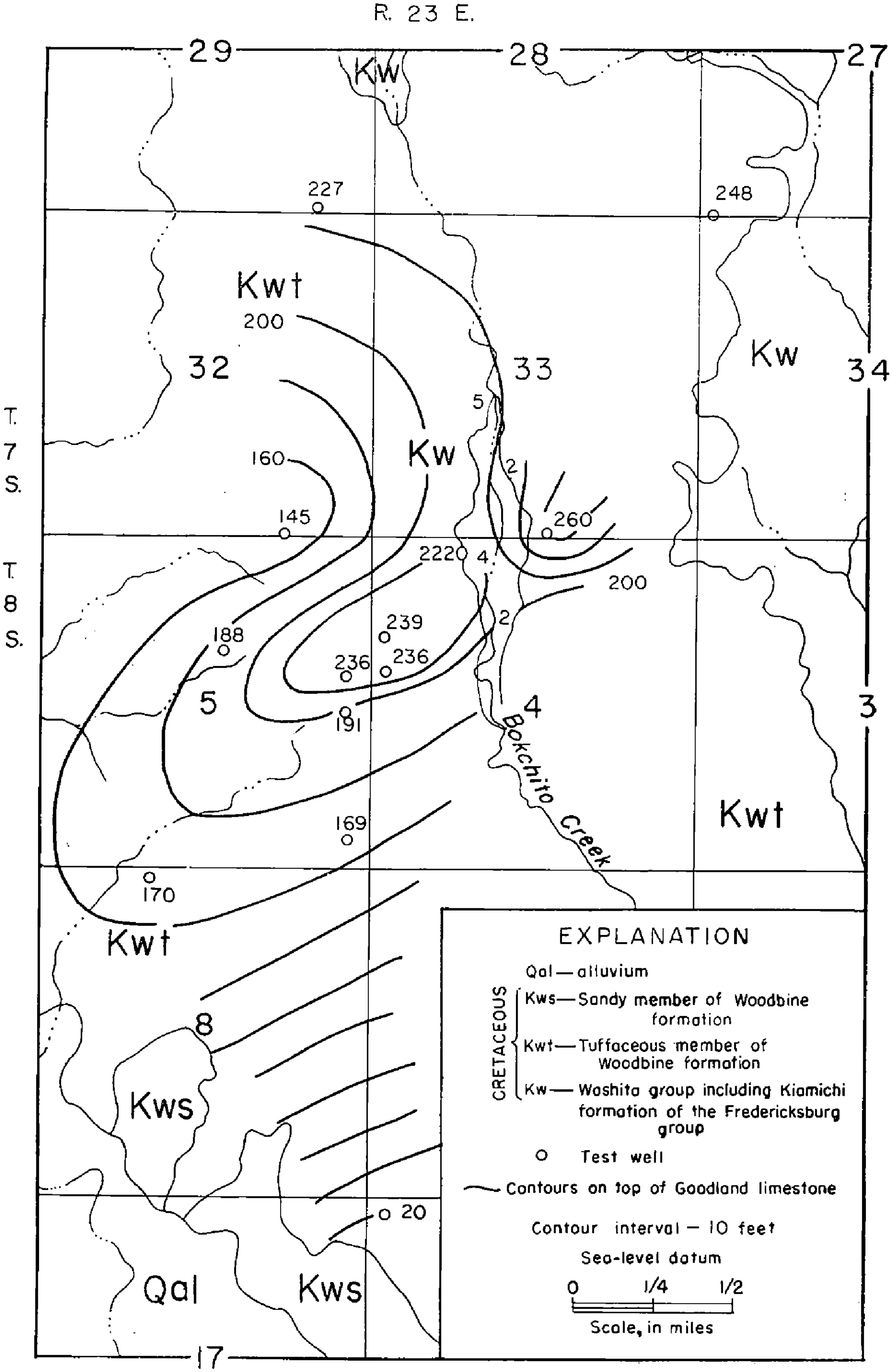

Fig. 2 Geologic structure on the top of the Goodland limestone. Contour interval 20 feet.

SURFACE STRATIGRAPHY

CRETACEOUS SYSTEM

Comanche Series

Trinity Group

The Trinity group is the basal division of the Cretaceous rocks in McCurtain County, Oklahoma. The group is divided into three formations which, in ascending order, are the Holly Creek formation, the De Queen limestone, and the Paluxy sand. The Holly Creek is composed of a series of red clays, thin sand beds, and gravel lenses. It yields potable water to farm wells in east central McCurtain County. The De Queen limestone consists of varicolored calcareous clays and pinkish-gray, yellowish-gray, or bluish-gray limetones and marls in beds generally less than a foot thick. Downdip beneath younger rocks it contains gypsum and anhydrite beds. The De Queen yields little ground water to wells in McCurtain County. The Paluxy sand is composed of white and yellow sands, some iron-cemented sandstones, conglomerates, and red, yellow, purple, or blue clays, and a few limestone lenses. The Paluxy is the most important aquifer in McCurtain County. It is the source of municipal supply at Valliant, Millerton, and Garvin, and supplies water to farmsteads throughout its outcrop area. The Trinity group ranges in thickness from a featheredge up to about 2,200 feet (fig. 3).

Holly Creek Formation

History of the name.—The name "Holly Creek," taken from Little Holly and Holly Creeks, southeast of Dierks in Howard County, Arkansas, was first used by Vanderpool (1928, p. 1079-1080), who applied it to the series of red clays, thin sand beds, and gravel lenses lying between the Dierks and De Queen limestones in Arkansas. In McCurtain County the Dierks limestone is absent and the name "Holly Creek" applies to the Cretaceous stratum below the De Queen limestone.

Distribution.—The Holly Creek formation crops out in an irregular band, about a quarter of a mile to two miles in width, extending eastward from sec. 36, T. 5 S., R. 23 E., to the Arkansas State line.

Thickness.—According to Honess (1923, p. 207), the Holly Creek formation in its outcrop area ranges from 30 to 100 feet in thickness. Well logs show it to be as much as 1,070 feet thick in the southern part of McCurtain County.

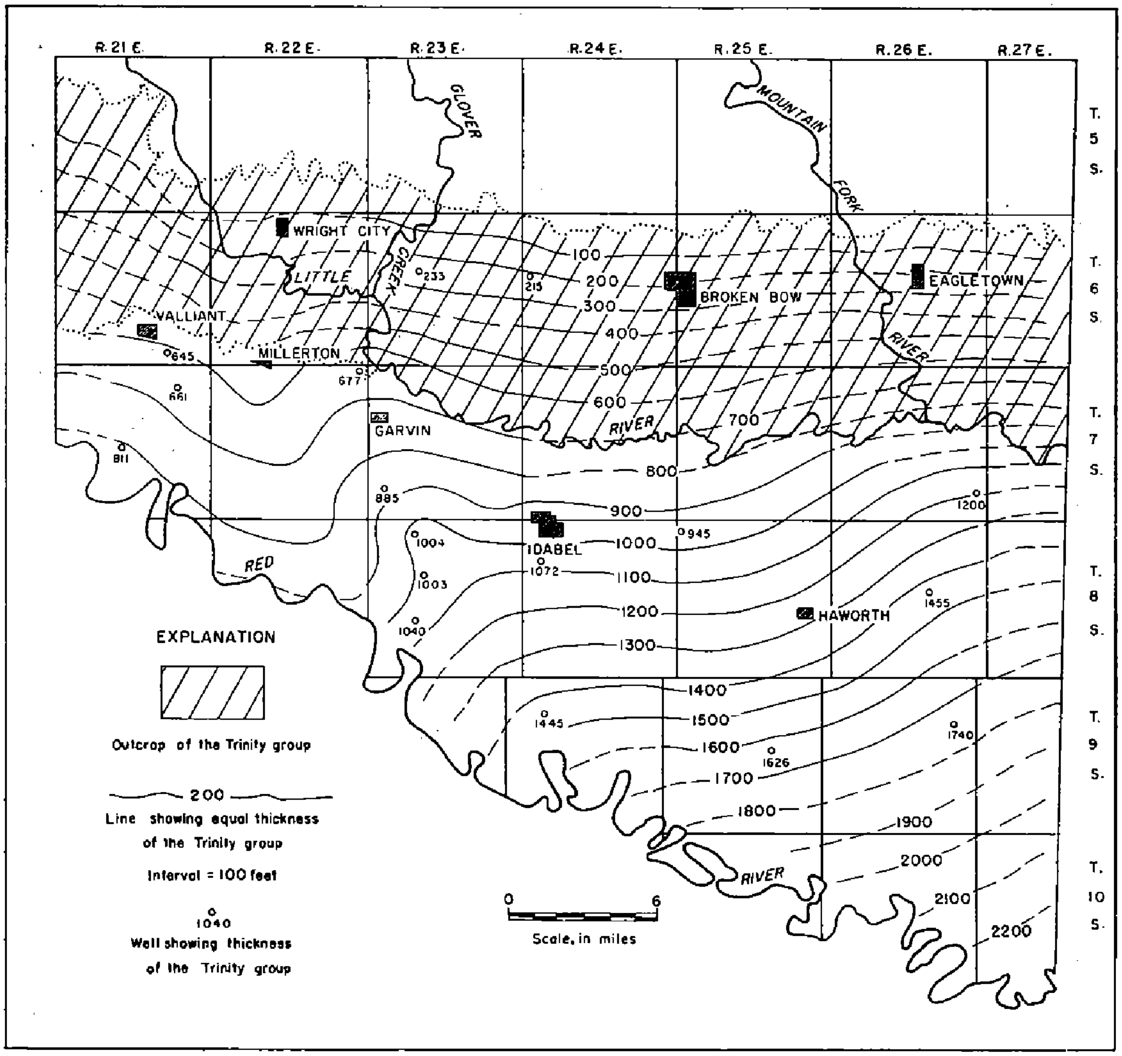

Fig. 3. Isopachous map of the Trinity group in southern McCurtain County, Oklahoma.

Character.—The Holly Creek formation is composed of lenticular beds of gravel, clay, and sandy clay. About half the pebbles in the gravel are quartz and the remainder are novaculite. They are clean at few places; generally they are interbedded with silt and clay.

Stratigraphic relations.—In McCurtain County, there is a major unconformity between the Trinity group and the underlying rocks where the almost horizontal beds of the Trinity rest upon steeply dipping, highly folded, peneplained rocks of Paleozoic age.

In the eastern half of the area the Holly Creek is the basal formation unit of Trinity age resting unconformably upon Paleozoic rocks. In the vicinity of sec. 1, T. 6 S., R. 23 E., the Holly Creek is overlapped westward by the De Queen limestone, which in turn is overlapped by the Paluxy sand. Thus the Paluxy is the basal formation of Trinity age resting unconformably on rocks of Paleozoic age in the western half of the county. This westward overlap of younger over older formations of the Trinity group is well illustrated in the areal distribution of the formations shown on plate I.

The Holly Creek formation is apparently conformable to the overlying De Queen limestone (May, 1950, p. 7).

Age and fossils.—The Holly Creek formation is of Early Cretaceous age. It is the oldest formation of the Trinity group of the Comanche series exposed in McCurtain County, Oklahoma. Fossils have not been collected from it.

Correlation.—The Holly Creek formation of McCurtain County is equivalent to the Holly Creek of Arkansas, which is equivalent to a part of the Rodessa formation of Arkansas, Louisiana, and east Texas, and to the basal sand of the Trinity group at the outcrops in north-central Texas (Imlay, 1945, p. 1418).

Water supply.—The sediments comprising the Holly Creek have a low transmissibility in most places in McCurtain County because of the high percentage of silt and clay in the formation. Consequently the formation yields little water to wells, the supply generally being sufficient only for home and stock use. Locally, however, the percentage of silt and clay decreases, and wells in these areas may yield as much as 50 to 75 gallons per minute.

De Queen Limestone

History of the name.—The De Queen limestone was named after the town of De Queen, Sevier County, Arkansas, by Miser and Purdue (1918, p. 19-22), who described the formation as consisting of limestone with an equal or greater amount of tough green clay and some gypsum and celestite. The name has always been used in its original sense.

Distribution.—The De Queen limestone crops out in McCurtain County just south of the Holly Creek formation in a narrow band ranging in width from several feet to more than half a mile. The outcrop extends from sec. 1, T. 6 S., R. 23 E., eastward to the Arkansas State line.

Thickness.—The De Queen limestone in McCurtain County ranges in thickness from 38 feet in the eastern part of its outcrop (May, 1950, p. 21) to less than a foot at the western extremity of its outcrop, where it lenses out. Downdip it attains a maximum thickness of 190 feet at the southeastern edge of the county.

Character.—The original description of the De Queen limestone by Miser and Purdue (1918, p. 22) applies mostly to Arkansas, where it consists of gray, hard, compact limestone in layers 10 inches thick, or less, and of yellowish-gray earthy, platy limestone containing small lenses of clay, along with an equal or greater amount of tough green clay with some gypsum and celestite. Included are many fossils, most of them pelecypods.

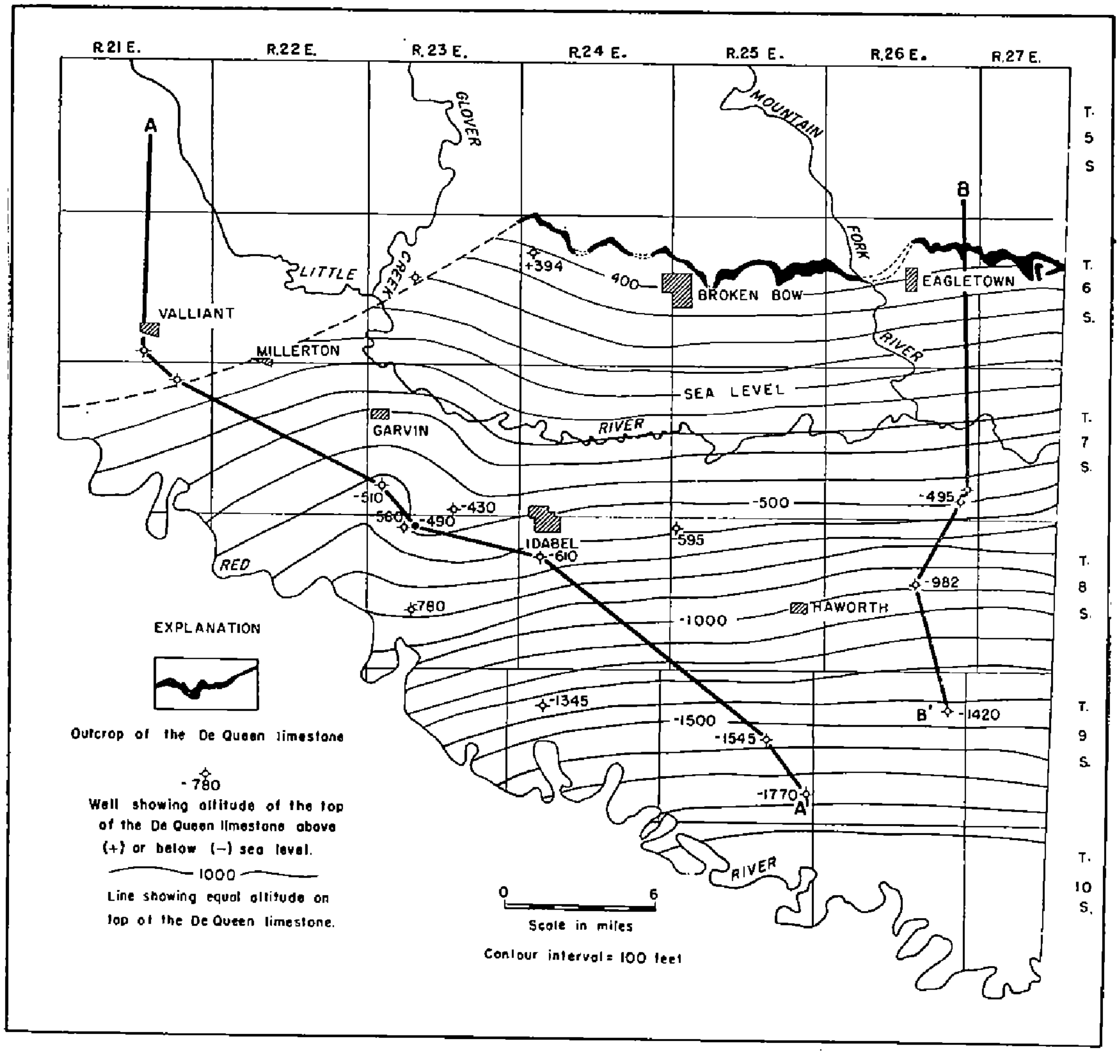

Fig. 4. Geologic structure on the top of the De Queen limestone, and location of cross sections A-A' and B-B' in McCurtain County, Oklahoma.

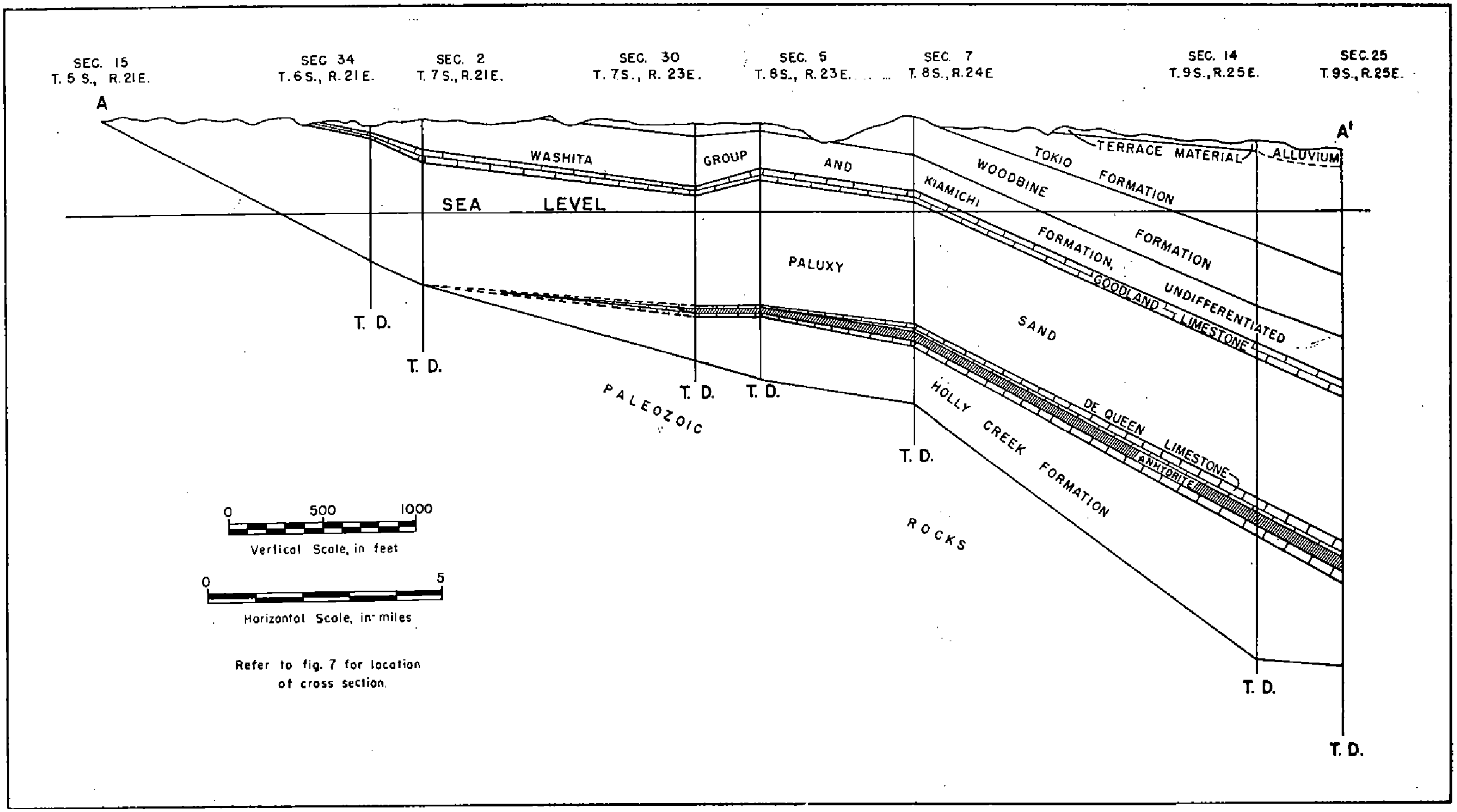

Fig. 5. Northwest-southeast cross section showing the thickening and facies changes of the De Queen limestone in McCurtain County, Oklahoma.

In Oklahoma the De Queen limestone exhibits much of the character of its outcrop in Arkansas. It consists of interbedded blue-gray, pinkish-gray, and yellowish-gray fossiliferous limestone and marl in layers generally less than a foot thick interbedded with varicolored calcareous clays. According to Honess (p. 207-209), the limestones are locally siliceous and at places there is a basal conglomerate that is composed of limestone-cemented gravel.

In the subsurface, south of an east-west line approximately at the latitude of Little River, thin beds of gypsum appear in the middle part of the De Queen limestone. Traced southward and southeastward, these rapidly thicken and grade into anhydrite. The evaporites of the De Queen attain a thickness of 80 feet in southern McCurtain County, where they are underlain and overlain by chalky fossiliferous limestones and clay shales. These limestones and shales are the lower and upper parts of the De Queen limestone (figs. 4, 5, and 6).

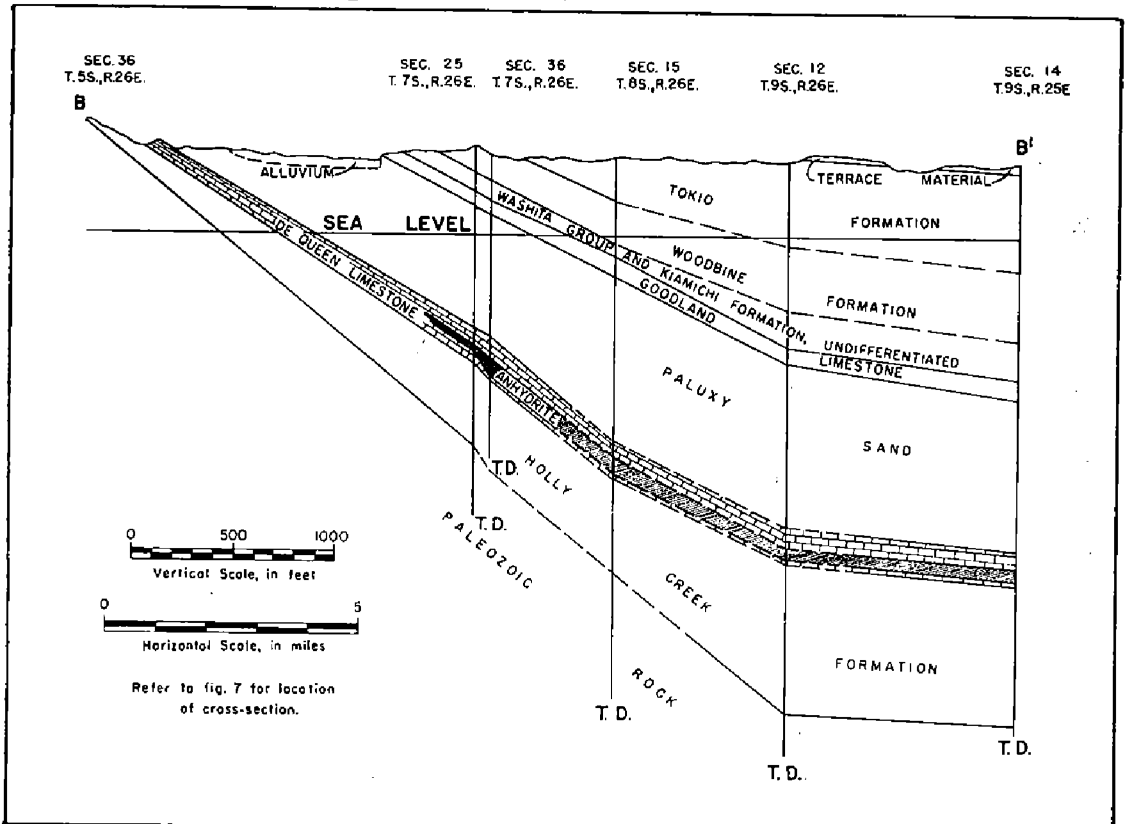

Fig. 6. North-south cross section showing the thickening and facies changes of the De Queen limestone in McCurtain County, Oklahoma.

Stratigraphic relations.—The De Queen limestone is conformable to the overlying Paluxy sand and to the underlying Holly Creek formation (Honess, 1923, p. 208; May, 1950, p. 7). It is unconformable to the underlying Paleozoic rocks where the Holly Creek is absent, as explained in the description of the stratigraphic relations of the Holly Creek formation.

Age and fossils.—The De Queen limestone is of Early Cretaceous age and is the middle formation of the Trinity group of the Comanche series in McCurtain County. The limestone is fossiliferous, but no collections were made for the purpose of this report. The most common Early Cretaceous fossils, according to May (p. 39), are *Cassiope branneri* and *Ostrea franklini.*

Correlation.—The De Queen is in the middle part of the Trinity group and is generally regarded as equivalent to a part of the Glen Rose formation of Texas (Vanderpool, 1928, p. 1079; Stanton, 1928, p. 276; Imlay, 1945, p. 1418).

Water Supply.—The De Queen, in McCurtain County, is relatively impervious. The formation contains only a small amount of ground water along bedding planes, and wells in it have small yields which are easily exhausted.

Paluxy Sand

History of the name.—The name Paluxy was first used by Hill in 1891 (p. 504) when he applied the term Paluxy sands to a fine white packsand, which oxidized to a red at the surface, and which closely resembled the underlying Trinity sands. The "Paluxy sands" were named after a town and creek called Paluxy in Somerville County, Texas (Hill, 1891, p. 510-511), and the formation was first assigned to the Fredericksburg division. In 1892 Taff (p. 272-273) placed the Paluxy in the Bosque division (Trinity group), and later Hill (1894, p. 317) also placed the Paluxy sand in the Trinity group, where it has remained.[1]

Distribution.—The outcrop of the Paluxy sand is the most widespread of that of any formation of Cretaceous age in McCurtain County (pl. I). It is exposed as an east-trending belt about 8 to 10 miles wide, which covers most of T. 6 S., Rs. 21 to 27 E. The entire outcrop is in the drainage basin of Little River, most of it being on the north side of the stream. Locally and along the streams the outcrop of the Paluxy is obscured by alluvium and terrace deposits.

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[1] Forgotson (Amer. Assoc. Petroleum Geologists Bull., vol. 41, p. 2328-2363) has shown that the type Paluxy is Fredericksburg. The so-called Paluxy of McCurtain County is either the upper part of the Antlers sand or may be assignable to the Rusk sand.—Editor.

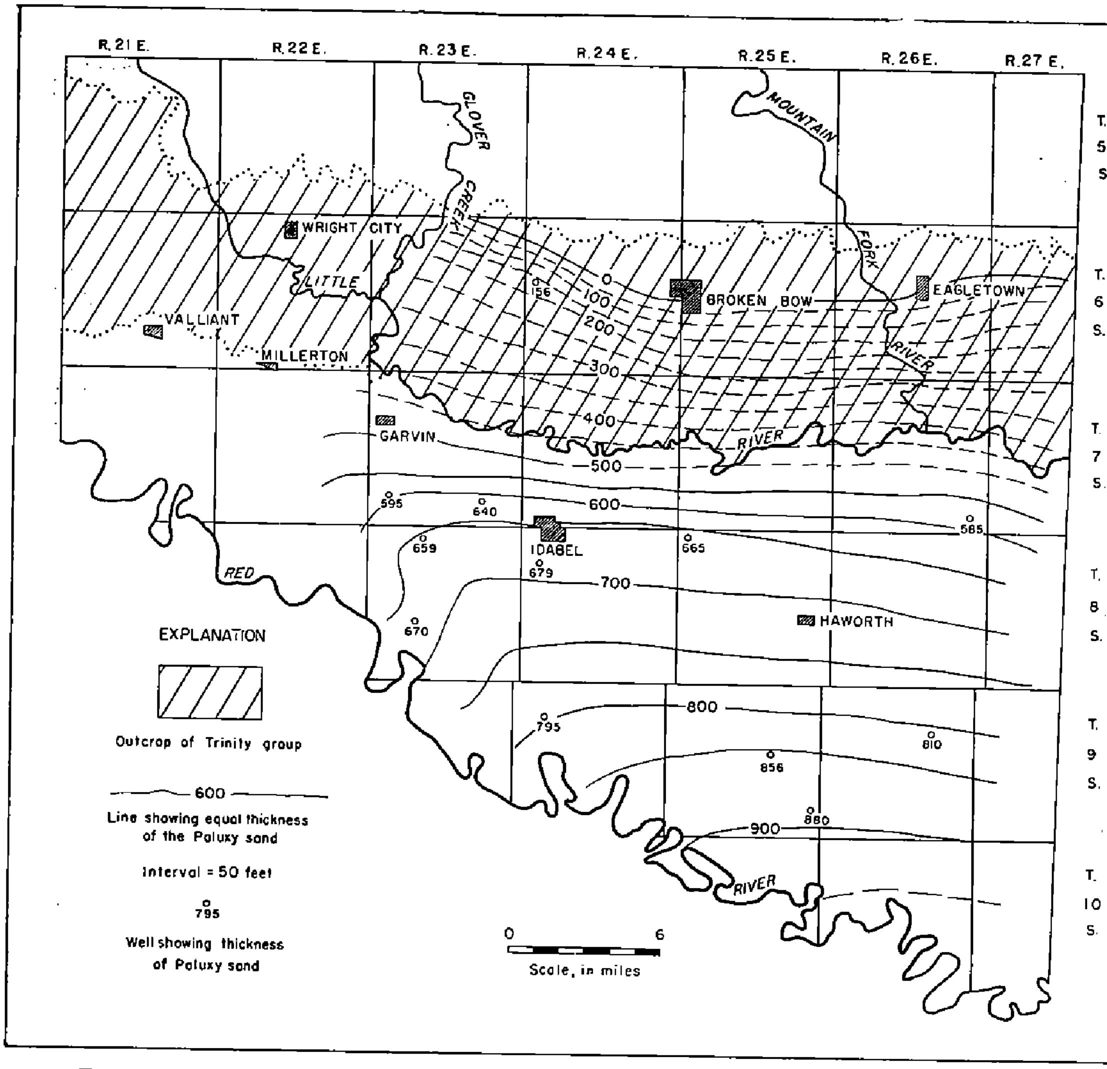


Fig. 7. Isopachous map of the Paluxy sand in McCurtain County, Oklahoma.

Thickness.—The Paluxy sand ranges in thickness from a featheredge at the north side of its outcrop to more than 880 feet in the southeastern part of McCurtain County (fig. 7). Well logs indicate that the formation thickens southward at the rate of approximately 75 feet per mile in its outcrop area, but at about 25 feet per mile downdip where it is buried under younger sediments (fig. 7).

Character.—On the outcrop, the Paluxy sand consists principally of well-rounded, well-sorted cross-bedded sand, which in most exposures is unconsolidated and friable. The sand is generally dark reddish brown to light gray, but some lenses are almost white. The color is determined mainly by the degree of oxidation of iron, which is present principally as cement, and also

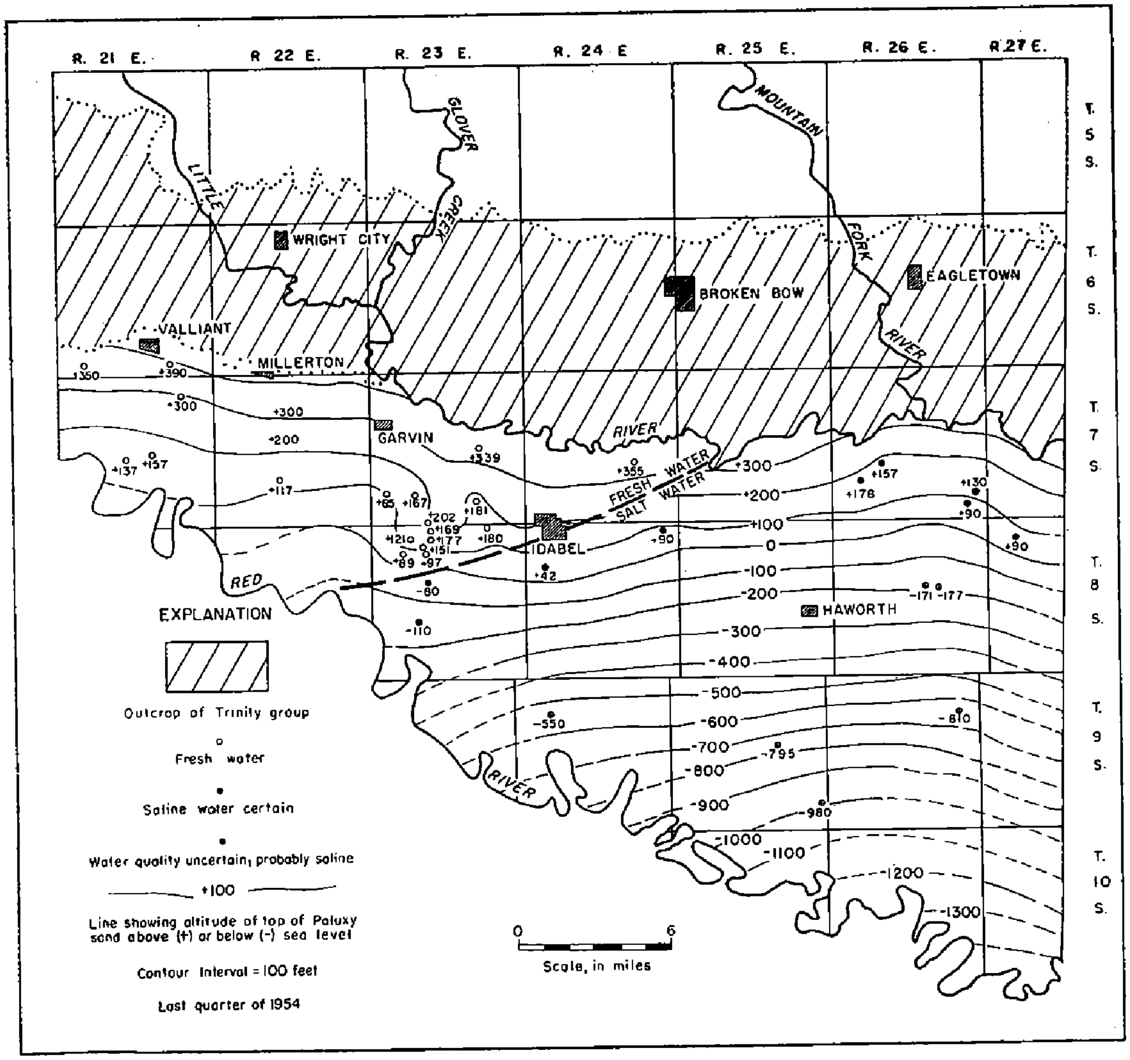


Fig. 8. Geologic structure on the top of the Paluxy sand in McCurtain County, Oklahoma.

as nodules of pyrite, marcasite, and limonite. Interbedded with the sand are minor amounts of clay, which generally are lenticular beds. A clay stratum five to 20 feet thick is present at the top of the Paluxy across most of McCurtain County in approximately the stratigraphic position of the Walnut clay of the Fredericksburg group. In the absence of fossils, however, the age of this clay remains in doubt and in this report the clay is included with the Paluxy. However, in several exposures a sand bed lies immediately underneath the Goodland limestone. One such exposure is in the SW¼ SE¼ sec. 22, T. 6 S., R. 21 E., where the Goodland is in direct contact with an asphaltic sand of the Paluxy.

The Paluxy crops out as low ridges trending northward. The maximum local relief is 100 feet, but good exposures of bedrock are few, largely because the formation is a loosely consolidated sand having little resistance to erosion. The largest and best section exposed in McCurtain County is a 45-foot bluff along U. S. Highway 70 where it crosses Little River between Idabel and Broken Bow in sec. 14, T. 7 S., R. 24 E. Well logs show that downdip beneath younger rocks the Paluxy consists of about 55 percent sand with a few gravel lenses, 30 percent sandy shale, 10 percent shale, and 5 percent limestone. The sands range in color from white to yellow; the shales are red, yellow, purple, or blue and occur more consistently in the lower part of the formation. The limestones are unconsolidated and are generally a dirty white.

Stratigraphic relations.—The Paluxy sand lies conformably on the underlying De Queen limestone (May, 1950, p. 7). Where the De Queen and younger rocks of Cretaceous age are absent the Paluxy lies unconformably on underlying rocks of Paleozoic age, as explained in the description of the stratigraphic relations of the Holly Creek formation. In McCurtain County the Paluxy sand is unconformable to the overlying Goodland limestone (Thompson and Hill, 1935, p. 1534-1536). This hiatus is well illustrated in the abandoned asphaltic sand quarry in the SE¼ sec. 22, T. 6 S., R. 21 E., about half a mile north of the town of Valliant.

Age and fossils.—The Paluxy sand is Early Cretaceous in age. It is the uppermost formation of the Trinity group of the Comanche series (Imlay, 1940, p. 37). Carbonized, silicified, and pyritized wood is relatively abundant locally.

Correlation.—The Paluxy sand of Oklahoma and Arkansas is generally regarded as equivalent to the Mooringsport formation of northern Louisiana and Texas (Imlay, 1940, p. 37) and to that portion of the Trinity group lying above the Glen Rose of northern Texas (Vanderpool, 1928, p. 1086).

Water supply.—In the area of its outcrop and downdip under younger rocks north and west of Idabel (fig. 8), the ground water in the Paluxy sand is generally suitable for industrial, municipal, and irrigation uses. Elsewhere in McCurtain County the Paluxy is a salt-water aquifer. The formation is the major source of ground water in the county; it furnishes water for domestic and stock supplies, and is being used for public water supply by Valliant, Millerton, and Garvin.

The depth to water ranges from a few feet to more than 80 feet below land surface, depending upon the topography and altitude of the water table or piezometric surface.

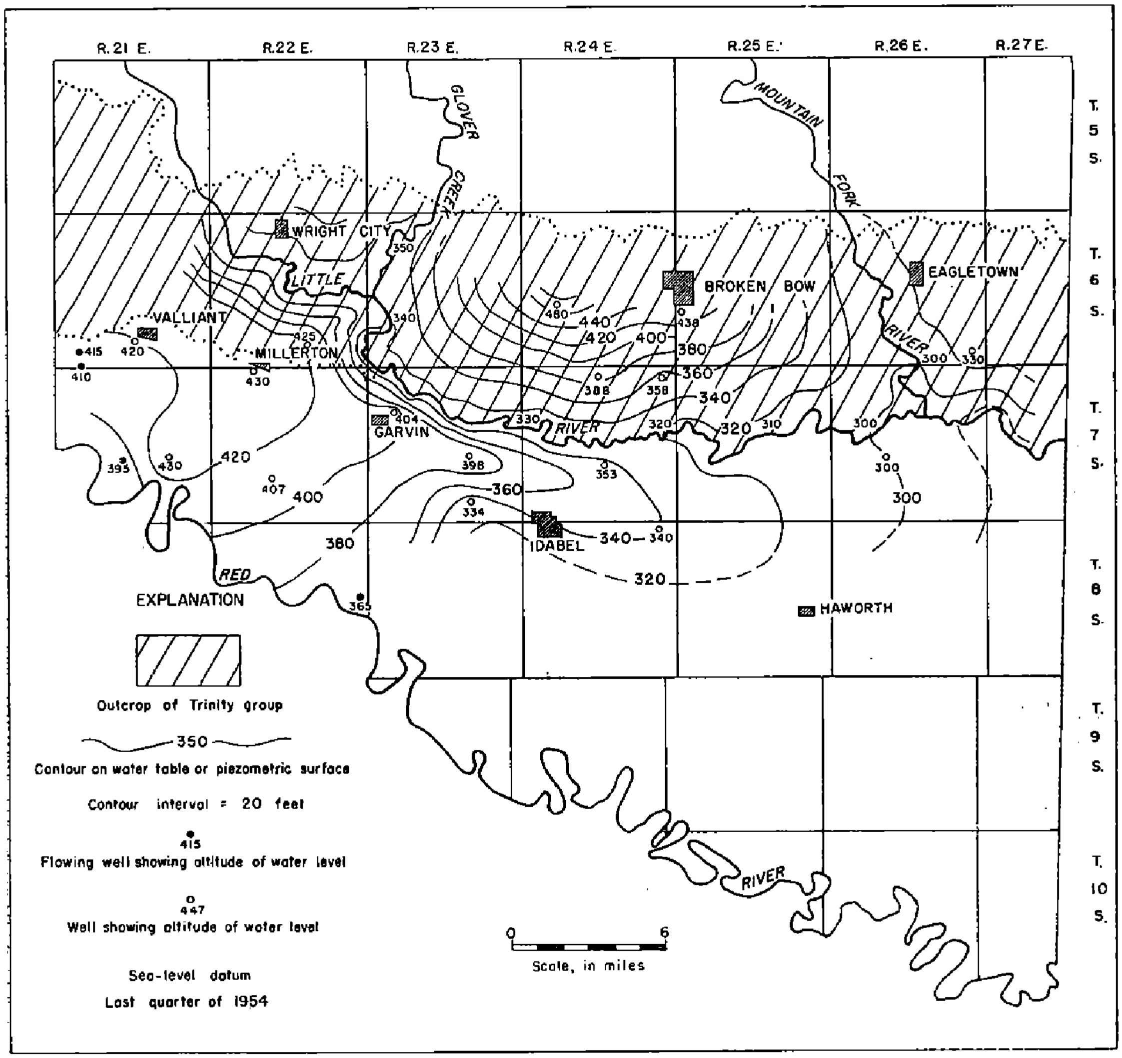


Fig. 9. Contour map of the water table and piezometric surface of ground water in the Paluxy sand in McCurtain County, Oklahoma.

The general slope of the water table in the outcrop area of the Paluxy sand is toward Little River (fig. 9), which has cut its channel below the water table and drains ground water from the formation. Downdip under younger rocks the water is under artesian pressure, and the piezometric water surface (altitude to which the water rises in an artesian well) generally slopes to the southeast except where it slopes southwest from the town of Valliant. This change in direction of slope is probably due to the lowering of the piezometric surface in this area caused by municipal pumping at Valliant and by water flowing to waste from artesian wells. At least three of the wells have been flowing since 1908.

The maximum yield of a water well in the Paluxy is largely dependent upon the type of well constructed in it. The municipal well at Valliant has casing perforated opposite the water sands. This well yielded 261 gallons per minute during a pumping test. At Hugo, about 24 miles to the west in Choctaw County, a gravel-packed municipal well yielded about 450 gallons per minute during a pumping test.

FREDERICKSBURG GROUP

The Fredericksburg group of other parts of Oklahoma and Texas is composed of the Walnut clay, the Goodland limestone, and the Kiamichi formation. To date, only the Goodland limestone and the Kiamichi formation have been identified in McCurtain County. The Walnut clay, discussed in this report with the Paluxy sand, may be present but has not been recognized because diagnostic fossils have not been found. The Kiamichi formation is similar in character to the overlying Washita group of rocks and there is no mappable stratigraphic boundary between them. Therefore, the Kiamichi is included with the Washita on the geologic map accompanying this report, and it is discussed with that group. On the geologic map of Oklahoma also (Miser, 1954) the Kiamichi formation was mapped with the Washita group.

Goodland Limestone

History of the name.—In 1891 Hill (p. 514) applied the name "Goodland" to a persistent limestone cropping out near the town of the same name in southern Indian Territory (now Choctaw County, Oklahoma). He wrote that the Goodland limestone is a single persistent layer which resembles the Caprina limestone in hardness but which has the Comanche Peak fauna. In his original description and again in 1894, Hill (p. 302-304) restricted the Goodland to the limestone above the Walnut clay and below the Kiamitia clay. However, Taff (1902, p. 6; 1903, p. 6) included the Walnut clay in the Goodland, and this usage was adopted by the U. S. Geological Survey.

Stephenson (1918, p. 135) found the basal three to six feet of the Goodland limestone in southern Marshall and Bryan Counties, Oklahoma, to consist of layers of persistent compact thin-bedded coquina-like limestone with interbedded thin layers of dark marly shale. To these beds he applied the name Walnut shaly member, stating that these beds were not recognized by Hill in the type section at Goodland, in Choctaw County. Stephenson also said that he believed future investigations would demonstrate the appropriateness of restricting the name Goodland to the massive limestone above his Walnut shaly member, in accordance with Hill's original usage.

The writer has not identified the Walnut clay as such in southern McCurtain County, and the Goodland limestone of this report is a sequence of massive limestone beds above the Trinity group and below the Kiamichi formation.

Distribution.—The outcrop of the Goodland limestone crosses the McCurtain County line from Arkansas just north of Cerrogordo in sec. 21, T. 7 S., R. 27 E., and extends westward across McCurtain County in a narrow strip one-eighth to one-half mile wide. Along most of its length the outcrop is immediately south of Little River, and the sinuous outcrop pattern follows the river and its tributaries. The outcrop crosses into Choctaw County in sec. 30 T. 6 S., R. 21 E.

Thickness.—The Goodland limestone ranges widely in thickness along its outcrop. It is thickest in central McCurtain County near Idabel, where it is about 50 feet thick. Near the eastern boundary, in secs. 20 and 21, T. 7. S., R. 27 E., the measured thickness is about 25 feet, and at the western boundary, in secs. 30 and 31, T. 6 S., R. 21 E., the measured thickness is about 30 feet.

As identified in well logs, the Goodland limestone ranges in thickness from about 28 feet to about 95 feet (fig. 10). Probably this wide range is at least partly due to difficulty in identifying exactly the upper contact of the Goodland limestone. In some logs limestone beds in the lower part of the overlying Kiamichi formation and Washita group may have been included with the Goodland.

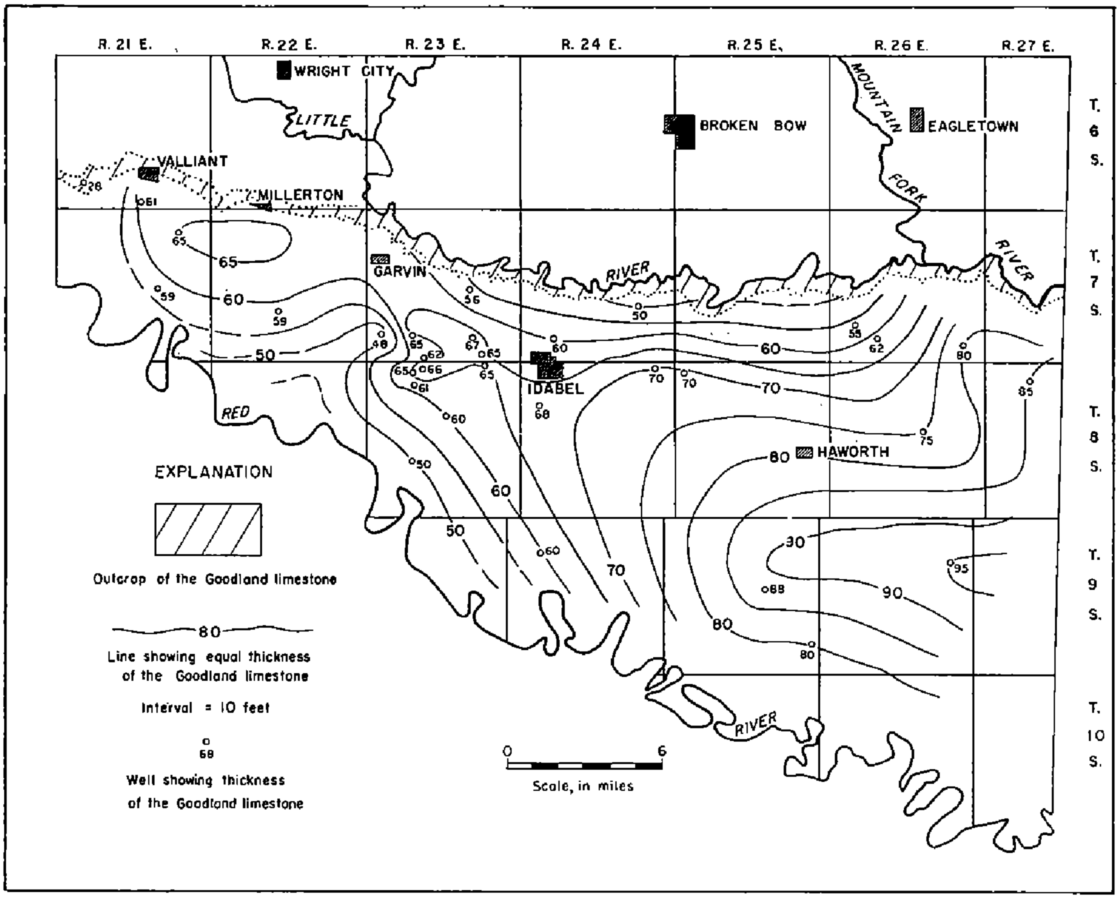


Fig. 10. Isopachous map of the Goodland limestone in McCurtain County, Oklahoma. Contour interval is 5 feet.

Character.—The Goodland limestone is one of the more easily recognized formations in the Cretaceous of southeastern Oklahoma. Over much of its outcrop it is well exposed, and among the best exposures are those along Little River and its tributaries in southern McCurtain County. In general, the formation consists of a thick irregularly bedded chalky, fine-grained crystalline limestone overlain by one to three relatively thin beds of dense coarse-grained crystalline limestone. The lower limestone is white on fresh surfaces, and gray, pale orange, or pale blue on weathered surfaces. The dense upper limestone is oolitic in places. It is grayish white to pale orange where unweathered and sooty gray on weathered surfaces. The formation is abundantly fossiliferous, containing pelecypods, gastropods, echinoids, and ammonites.

Stratigraphic relations.—The Goodland limestone in southern McCurtain County is underlain unconformably by the Paluxy sand, and is overlain conformably by the Kiamichi formation. In other parts of Oklahoma and Texas the Goodland limestone is underlain by the Walnut clay, but this formation has not yet been identified in southern McCurtain County. According to Thompson and Hill (1935, p. 1534-1536) the Fredericksburg group unconformably overlaps the Paluxy from south to north, and sediments composing the group thin northwestward. Thus, the absence of the Walnut clay beneath the Goodland limestone in southern McCurtain County may be attributed to nondeposition.

Age and fossils.—The Goodland limestone is of Early Cretaceous age. It is included in the Fredericksburg group of the Comanche series. Characteristic fossils of the lower part of the Goodland limestone in Oklahoma, according to Bullard (1926, p. 84), are *Enallaster texanus* Roemer, *Exogyra texana* Roemer, *Cyprimeria texana* Roemer, and *Gryphea marcoui* Hill and Vaughn. The upper part of the Goodland is characterized by *Oxytropidoceras acutocarinatum* (Shumard).

Correlation.—The Goodland limestone is considered to be correlative with the Comanche Peak limestone in Texas (Thompson and Hill, 1935, p. 1536-1537; Stephenson and others, 1942, p. 448).

Water Supply.—The presence of many solution pits, openings, and enlarged fractures in the outcrop of the Goodland limestone shows that the formation is susceptible to solution by water. However, water-well records show that few wells tap ground water in the Goodland limestone and these few yield water of poor quality. Downdip the limestone does not contain cracks and solution openings so characteristic of its surface exposures. Instead of being an aquifer from which a significant supply of ground water can be obtained, the Goodland limestone is nearly impervious; hydrologically it functions as a confining bed to contain the water in the Paluxy sand under artesian pressure.

Kiamichi Formation

The Kiamichi formation was named for the plains of the Kiamichi River near Fort Towson, Oklahoma (Hill, 1891, p. 504, 515), the type locality. It is apparently conformable to the Goodland limestone below and to the Washita group above. The contact of the Kiamichi formation with the underlying Goodland limestone is sharp and distinct at most places and the attitude of both formations is the same. The upper boundary of the Kiamichi has not been delineated in southern McCurtain County and the formation is included with the rocks mapped as "Washita." The Kiamichi is also included in the description of the distribution, thickness, character, and water-supply possibilities of the Washita group.

Washita Group, Undifferentiated

(Includes description of Kiamichi formation of Fredericksburg group)

The Washita group in McCurtain County includes beds of clay and limestone between the top of the Kiamichi formation and the base of the Woodbine formation. This restriction of the group is in accord with usage of the U. S. Geological Survey and the Oklahoma Geological Survey (Miser, 1954). The outcrop of the Washita group as shown on the geologic map accompanying this report includes the underlying Kiamichi formation of the Fredericksburg group because Washita and Kiamichi rocks are of similar lithology and there is no good mappable stratigraphic boundary between them. The Kiamichi is included in the description of the distribution, thickness, character, and water-supply possibilities of the Washita group. The Washita group has not been divided into formations in southern McCurtain County, but elsewhere in southern Oklahoma the following formations are recognized:

Grayson shale
Main Street limestone
Pawpaw formation
Weno clay
Denton clay
Fort Worth limestone
Duck Creek formation

The Washita group, including the Kiamichi formation, thins eastward because of erosion prior to the deposition of the next younger rocks (Miser, 1927, p. 443-453) and only the lowermost part of the group is thought to be represented in McCurtain County. It is a poor aquifer and yields little water to wells.

History of the name.—The first reference to the term "Washita" was by Hill in 1887 (p. 298) when he used the term "Upper or Washita division" and applied it to the sandstones, marls, and limestones unconformably underlying the Timber Creek group (Woodbine formation) and conformably overlying the Fredericksburg division. However, Bullard (1926, p. 29) wrote that

Hill proposed the name Washita in 1889, presumably basing his statement on the fact that Hill (1889, p. 21) in that year had published a paper on the strata concerned, writing that the name "Washita division" was given to the rocks above the Caprina limestone. He took the name from the region where early explorers had first seen the rocks.

Distribution.—The Washita group, including the Kiamichi formation, in southern McCurtain County crops out as an east-west belt that is almost entirely confined to the latitude of T. 7 S. The outcrop is only about half a mile wide at the Arkansas State line in secs. 21 and 28, T. 7 S., R. 27 E. It widens irregularly westward, reaching its maximum width of about four miles in T. 7 S., R. 21 E.

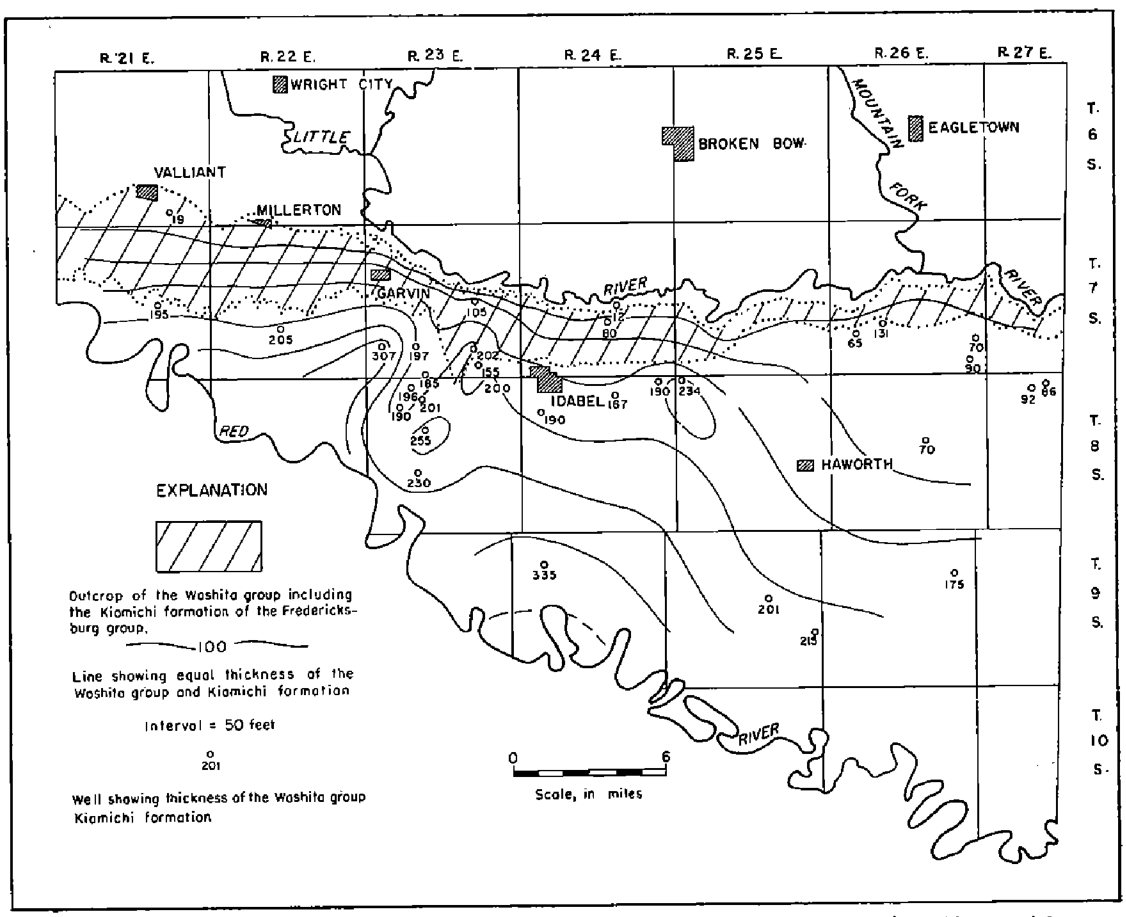


Fig. 11. Isopachous map of the Washita group, including the Kiamichi formation, in McCurtain County, Oklahoma.

Thickness.—The Washita group, including the Kiamichi formation, thins northeastward in southern McCurtain County (fig. 11), although evidence at the surface would suggest that the thinning is eastward. The eastward component of thinning is indicated by the narrowing of the outcrop pattern from west to east across McCurtain County. Logs of wells near the outcrop also show that the formation thins from about 200 feet on the western side of the county to less than 70 feet on the eastern side. Only the Kiamichi formation, 20 feet thick, of this sequence of rocks is present on the south side of Little River at the Arkansas State line (Dane, 1926). The northern component of thinning is indicated by well logs in the extreme southern part of the county, which show that the Washita group, including the Kiamichi formation, thins to the northeast instead of directly east as shown at the outcrop. According to Miser (1927, p. 443-453) this thinning is due to erosion prior to the deposition of the next younger rocks. The attitude of the Washita and Kiamichi is illustrated in figure 12.

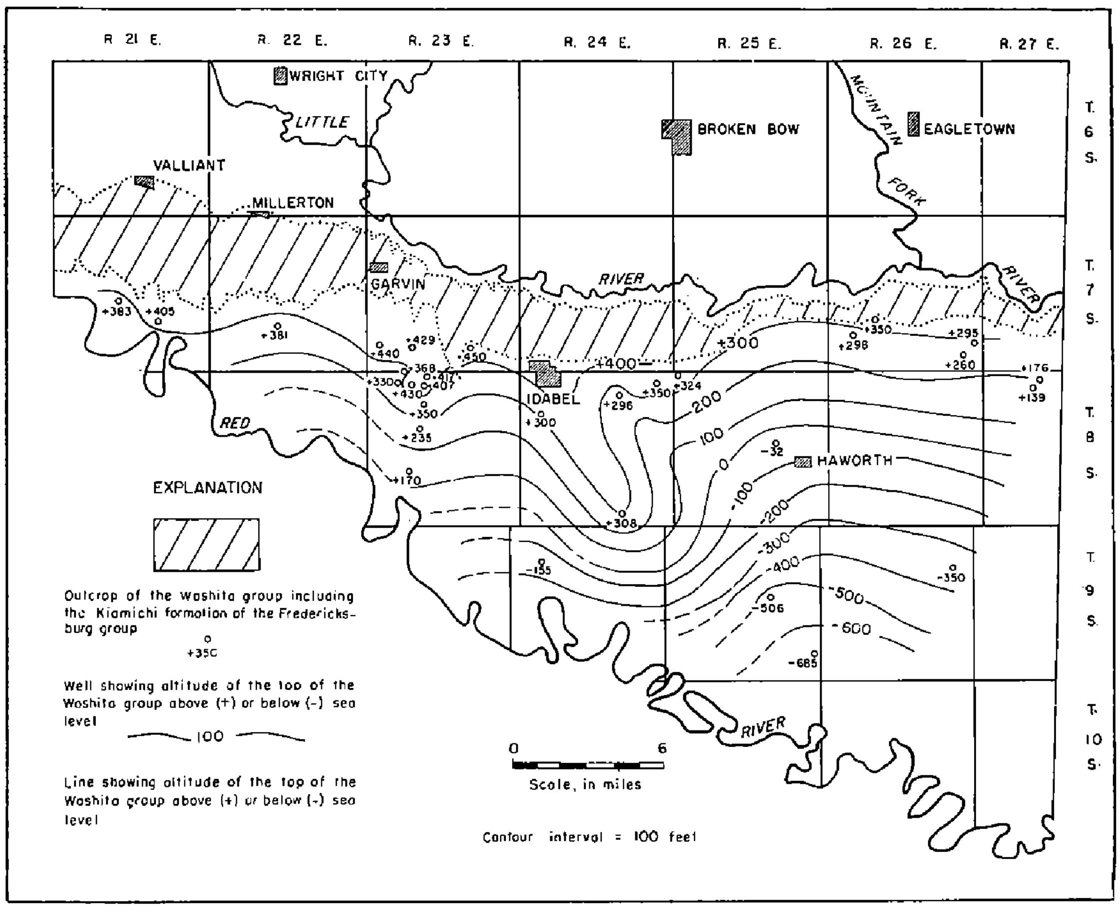


Fig. 12. Geologic structure on the top of the Washita group in McCurtain County, Oklahoma.

Character.—In southern McCurtain County the Washita group including the Kiamichi formation consists of relatively thin beds of highly fossiliferous gray limestone alternating with thick beds of unconsolidated clay. In the lower part the limestone beds are compact, bluish gray to white, and highly fossiliferous. In the upper part, the limestones are softer, thicker bedded, gray or yellowish tan, and almost as fossiliferous as in the lower part. As a rule, the fossils are better preserved and break out of the rock more easily than below. Thin beds of clay separate some of the limestone beds and thicker beds of clay shale separate others. These beds of clay shale are mostly dark blue or black, weathering to light gray, yellow, and various colors. The clays and clay shales are calcareous and commonly sandy.

Good local exposures of the Washita and Kiamichi are numerous, but in no single locality is the entire sequence of beds exposed. The better exposures are along the larger streams, most of which flow south almost at right angles to the strike of the beds of the Washita and Kiamichi.

Low eastward-trending hills and ridges are the typical topographic expression of the Washita and Kiamichi. These hills and ridges are formed of limestone, or clay capped by limestone. The soil is thin over the outcrop, and of little agricultural use, except for pasturage.

Stratigraphic relations.—The Washita group is underlain conformably by the Fredericksburg group and overlain unconformably by the Woodbine formation (Hill, 1887, p. 298). Details pertaining to the upper unconformable contact will be discussed under "Woodbine formation."

Age and fossils.—The Washita is the uppermost group of the Comanche series of the Cretaceous. In southern McCurtain County the group has been identified by (a) stratigraphic position and (b) general lithologic character, without corroborating paleontologic evidence. Gibbs' (1950, p. 42) report of *Leiocidaris hemigranosus* (Shumard) in eastern Choctaw County less than 1.5 miles west of the most southwesterly exposure of the Washita group in McCurtain County strongly suggests that beds at least as young as the Denton clay are present in McCurtain County. For a list of the index fossils of the Washita group, see Bullard (1926, p. 84-85).

Post-Washita erosion has probably removed all of the Washita group at the eastern edge of McCurtain County. The mapping unit is represented in that area by the Kiamichi formation of the Fredericksburg group (pl. I).

Correlation.—The term "Washita" is the accepted name for the rocks between the Fredericksburg group below and the Woodbine formation above. Only the lower part (Early Cretaceous) of the group is represented in southern McCurtain County because of the erosion that caused the eastward thinning of the Washita group.

Water supply.—The clays and limestones of the Washita group and the Kiamichi formation in McCurtain County are a poor aquifer. Shallow wells on the outcrop are not numerous, and only one well in the county, in sec. 4, T. 8 S., R. 24 E., is known to obtain water from those rocks downdip from the outcrop. The water is believed to occur in solution openings in the limestone and its quality is poor.

GULF SERIES

Woodbine Formation

The Woodbine is the oldest formation of the Gulf series in McCurtain County (Ross, Miser, and Stephenson, 1928, p. 175). The formation crops out across the middle of the southern half of the county and is divided into a lower tuffaceous member and an upper sand member. It ranges in thickness from a featheredge at the outcrop to more than 355 feet in the subsurface in the southeastern part of the county. The formation is not a productive aquifer.

History of the name.—The Woodbine formation was named by Hill in 1901 (p. 293-295) after the town of Woodbine in the northeastern part of Cooke County, Texas, to replace his name Timber Creek group, also known as the Lower Cross Timbers formation. He wrote that the rocks are largely ferruginous, argillaceous sands, characterized at places by intense brownish discoloration accompanying bituminous laminated clays. In 1928, Ross, Miser, and Stephenson (p. 175) presented evidence that the Woodbine is the basal formation of the Gulf series in southwestern Arkansas, southeastern Oklahoma, and northeastern Texas, and that in Arkansas and in McCurtain County, Oklahoma, it is the lower part of the "Bingen sand" of Veatch, as the Bingen was shown on the Geologic Map of Oklahoma (Miser, 1926). They dropped the name "Bingen sand." The new Geologic Map of Oklahoma (Miser, 1954) uses the term "Woodbine formation," and the name accordingly has been adopted for the present report.

Distribution.—The Woodbine formation crops out in Tps. 7 and 8 S. as an irregular belt across southern McCurtain County. The outcrop ranges in width from a quarter of a mile to as much as 4 miles; it is about 2 miles wide at the Arkansas State line in secs. 28 and 33, T. 7 S., R. 27 E., and only about 0.25 mile wide at the Choctaw County line on the west. From about the longitude of Idabel eastward the Woodbine is between outcrops of the Washita group and Kiamichi formation on the north and the Tokio formation on the south. There the surface drainage is northward into Little River. West of Idabel the Woodbine is between the outcrop of the Washita group on the north and the alluvium of the Red River on the south. There the surface drainage is southward into the Red River. Good exposures of the formation are along Perry Creek in the S½ sec. 4, and the SE¼ sec. 15, T. 8 S., R. 23 E., and along a branch of Waterhole Creek in sec. 30, T. 7 S., R. 23 E.

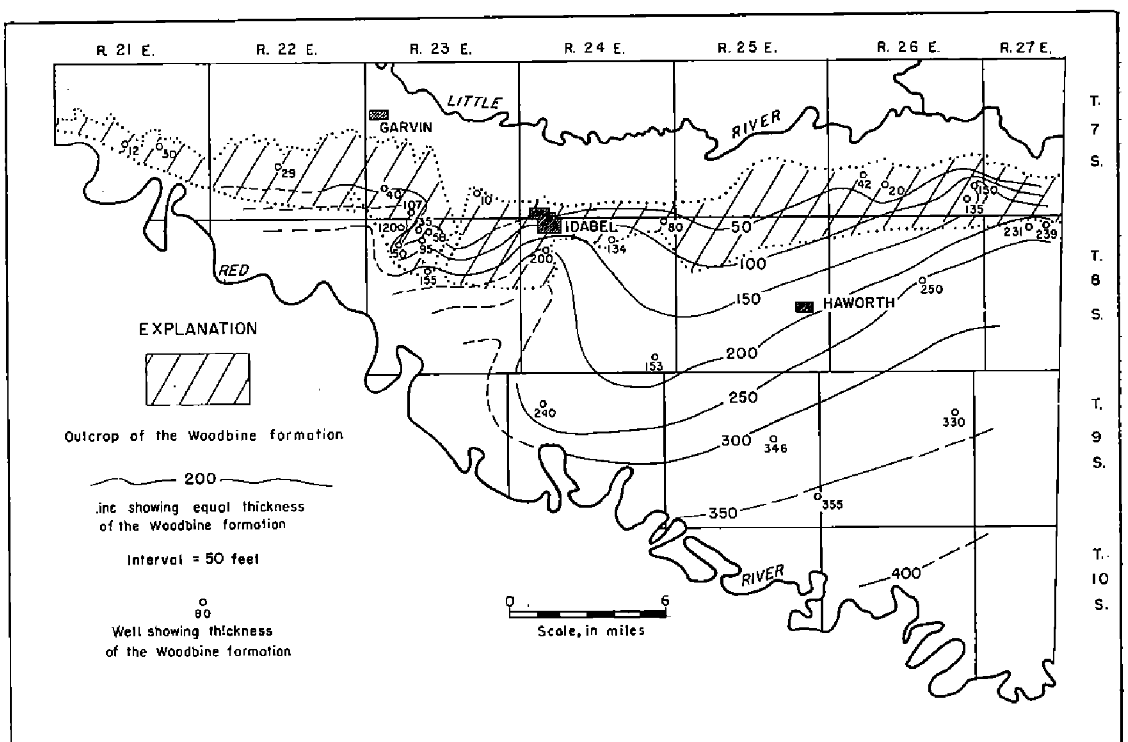


Fig. 13. Isopachous map of the Woodbine formation in McCurtain County, Oklahoma.

Thickness.—The thickness of the tuffaceous member of the Woodbine in McCurtain County, as estimated from well logs, ranges from about 155 feet, approximately 6 miles south of Garvin in the western part, to more than 355 feet, about 8 miles south of Haworth in the southeastern part (fig. 13). The thickness of the sandy member is not revealed by well logs, but from topographic maps it is estimated to be 100 feet or less.

Character.—The surface exposures of the Woodbine formation form low rolling hills that are covered with a thick mantle of red sand loam. Originally the outcrop was heavily timbered, but because the soil is highly productive most of the land has been cleared for farming.

The lower, tuffaceous, member of the Woodbine consists principally of highly cross-bedded coarse poorly consolidated dark-green tuffaceous sand that weathers yellowish green to yellowish red and locally is cemented by calcite into balls or lenses. Interbedded with the sand is brownish-red clay. At the base, in a few places, is a white sand that is almost identical in character with sand in the Paluxy. Also included are a few gravel lentils, some of them rather extensive. The clays are lenticular and occur throughout the member, but are more abundant in the upper part. Typically the clays are brownish red, but at places they are red. The clays are almost entirely noncalcareous. The lack of calcium carbonate and the reddish color of some of the clays of the Woodbine differentiate them from clays in the underlying Washita group. The upper member of the Woodbine formation is composed principally of gray to brown cross-bedded sand and sandy gravel with some brown or reddish-brown clay lenses.

At places it is difficult to distinguish gravels in the Woodbine from terrace gravels. A clear-cut differentiation can be made, however, on the basis of the quartz content of the gravels; gravels in the Woodbine contain little or no quartz, whereas terrace gravels contain large amounts of quartz (oral communication, H. D. Miser).

Stratigraphic relations.—The Woodbine formation is underlain unconformably by the Washita group (Hill, 1887, p. 298; Stephenson, 1927, p. 2-3, 15-16; Miser, 1927, p. 451; Miser and Purdue, 1929, p. 90), and is overlain unconformably by the Tokio formation (Stephenson, 1927, p. 6 and 16). According to Miser and Purdue, the Woodbine in southern Oklahoma and southwestern Arkansas rests upon the truncated edges of all the formations of the Comanche series—the youngest subjacent to the west, and the oldest to the east. The Woodbine rests upon beds tentatively assigned to the Denton clay of the Washita group at the western side of McCurtain County and upon the Kiamichi formation of the Fredericksburg group at the eastern side. Details pertaining to the upper, unconformable contact will be discussed under the Tokio formation.

Age and fossils.—The formation is sparingly fossiliferous, and only plant remains have been recovered. Fossil leaves have been found in a dark-gray clay lying stratigraphically near the middle of the Woodbine, in a stream cut about 0.25 mile north of the SW cor. sec. 30, T. 7 S., R. 23 E. These leaves were identified as *Viburnum robustum* Lesquereux, *Palaeocassia laurinae* Lesquereux, *Benzoin venostin,* and *Rhus redditiformis,* which are Late Cretaceous in age (Heilborn, 1949, p. 42-43).

Water supply.—The Woodbine in McCurtain County is not a highly productive aquifer. The permeability of the formation is generally low except in a few lenses of pure sand, or of sand and gravel. Many wells have been dug in the outcrop areas, but their yields are mostly sufficient only for farm homes or stock supply. The water is generally of inferior quality because of the mineral matter it dissolves from the tuffaceous material as it passes through the formation.

Tokio Formation

The Tokio formation in McCurtain County includes strata formerly assigned to the upper part of the Bingen formation, and was originally described as the Tokio sand member of that formation (Miser and Purdue, 1918, p. 23). The Tokio as defined has a gravel at the base and is separated from the underlying Woodbine formation by an unconformity. The formation is not a prolific aquifer.

History of the name.—The first reference to the name "Tokio" was by Miser and Purdue in 1918 (p. 19-24) when they segregated the upper 100 to 150 feet of sand, gravel, and clay of the Bingen formation of Veatch (1906, p. 23-24) and called it the Tokio sand member, after the village of Tokio, Hempstead County, Arkansas. Later, Dane (1926; Stephenson, 1927, p. 4-5; Dane, 1929, p. 29-30) raised the Tokio to formation rank, redefining its limits to include a gravel bed previously included in the upper part of the "Lower Bingen." Thus, the Tokio formation is the Tokio sand member of Miser and Purdue plus the underlying gravel bed, beneath which is a clearly defined contact with the underlying Woodbine formation (Dane, 1929, p. 29-30). The name Bingen was dropped because it included two units of different lithology and age.

Distribution.—The outcrop of the Tokio formation in McCurtain County covers about 80 square miles in an irregular wedge, the point of which is in sec. 22, T. 8 S., R. 23 E., about five miles southwest of Idabel. From sec. 22 the outcrop gradually widens eastward and at the Arkansas State line, in Tps. 8 and 9 S., it is about eight miles wide. The outcrop is bounded on the north by the tuffaceous member of the Woodbine formation and on the south by alluvium and terrace sediments along Red River, and by a small exposure of the Ozan and Brownstown formations undifferentiated. A good exposure of the Tokio is found on a hill along the quarter-line road in the NW¼ sec. 7, T. 8 S., R. 26 E.

Thickness.—The Tokio formation in McCurtain County thickens southeastward from a featheredge at the outcrop to more than 595 feet in the subsurface in the southern part of the county. In sec. 32, T. 8 S., R. 24 E., which is near the western end of the outcrop and near the contact with the overlying formation, a well penetrated 88 feet of the Tokio; and in sec. 12, T. 9 S., R. 26 E., which is about five miles from the Arkansas State line and also is near the contact with the overlying formation, a well penetrated 380 feet of Tokio. Farther south, in sec. 25, T. 9 S., R. 25 E., a well went through about 595 feet of Tokio (fig. 14). This last is comparable to a thickness of 588 feet found in a well at about the same latitude and four miles east of the Arkansas line.

Character.—The Tokio in McCurtain County crops out as low sandy rollng hills. Streams flowing over its surface have broad sandy bottoms. Good exposures of bedrock are few. The formation is composed of light-gray quartz sand and clay shale. The sands are cross-bedded and poorly sorted, at many places are argillaceous, and weather to brown, red, or a mottled color. In some exposures small hard plates cemented with iron weather out of the sand; in other exposures the sand is massively bedded and weathers to a soft, sandy soil. The clay shales are generally gray and at many places have dark-brown or black streaks caused by iron and maganese staining.

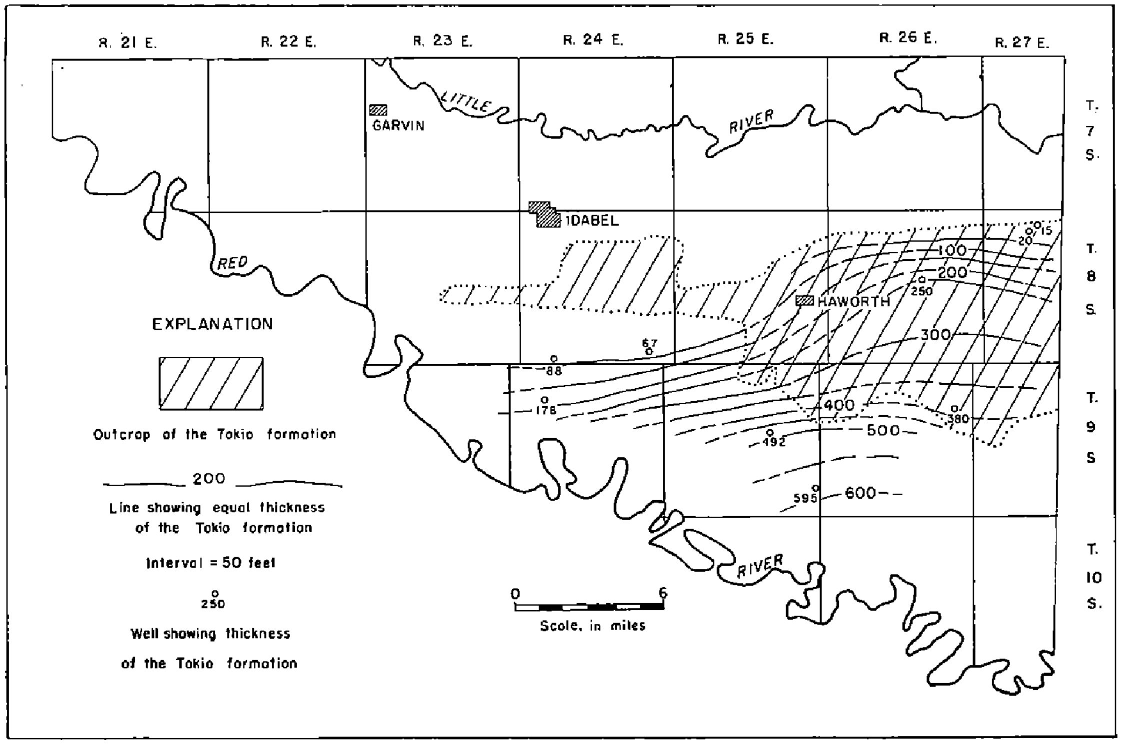


Fig. 14. Isopachous map of the Tokio formation in McCurtain County, Oklahoma.

The cross-bedding, together with petrified wood, poor sorting and local, intraformational unconformities, indicates that the Tokio is a product of shallow, near-shore environment.

A peculiar feature of the Tokio formation is the presence in it of cylindrical pipes or conical structures. These are erratically distributed, bunched at some places and widely scattered at other places, being most abundant about three miles south of the town of Haworth (in and near sec. 1, T. 9 S., R. 25 E.). They reach a maximum length of more than six feet and are perpendicular to the bedding planes. Most of them are circular in cross section, but many are ellipsoidal. They range in diameter from 0.1 foot to more than 0.7 foot, and although most are uniform in diameter throughout their length some are conical, the apex down. Some even have pipes within pipes. Their mineral composition is identical with that of the surrounding beds, but the pipe filling lacks stratification and is lighter in color. A hard, ironstone-like shell causes them to weather out as small knolls or humps.

Cylindrical structures somewhat similar to those in the Tokio have been interpreted by Gabelman (1953) as fossil springs or quicksand pipes originating in semicompacted surface mud. The bedding within the pipes was destroyed by particle flotation in meteoric water rising under local hydrostatic pressure from a channel or aquifer below the mud.

Stratigraphic relations.—The Tokio formation in Oklahoma and western Arkansas is underlain unconformably by the Woodbine formation (Stephenson, 1927, p. 6, 16). Traced eastward in Arkansas, the Tokio rests upon successively older rocks, according to Ross, Miser, and Stephenson (p. 179). The Tokio is overlain unconformably by the Brownstown formation (Dane, 1929, p. 46-48).

Correlation.—The Tokio of southeastern Oklahoma and southwestern Arkansas occupies the stratigraphic position of the Bonham clay (now called the Bonham marl) and Blossom sand of northeastern Texas (Dane, 1929, p. 42) and is equivalent to the Austin chalk as it is developed in the vicinity of Austin, Texas (Stephenson, 1927, p. 8).

Age and fossils.—The Tokio is late Cretaceous in age. It probably is not older than the Austin chalk according to Stephenson (Dane, 1929, p. 40-43), because of the presence in it of *Inoceramus* aff. *I. barabini*. Fossils recovered from the Tokio in Oklahoma are poorly preserved and are difficult to identify, although both plant and animal remains are found at many places. Pelecypod impressions weather out of indurated sandstone boulders in the SE¼ sec. 2, T. 8 S., R. 26 E. Imprints of pelecypods and other invertebrates of uncertain affinities are in an incoherent coarse sand cropping out on the eastern side of the section-line road in the NW¼ sec. 36, T. 8 S., R. 25 E. Petrified wood weathers out of a clay bed in a cut on the northern side of the quarter-section-line in the NW¼ sec. 7, T. 8 S., R. 26 E. Pelecypods and other invertebrates are in a sandy clay exposed in a cut on the southern side of the section-line road in the NE¼ sec. 32, T. 8 S., R. 26 E.

Water supply.—The sandy nature of the Tokio formation suggests that it might be a good aquifer, but much clay and silt are interspersed through the sands of the formation and these appreciably lower the permeability and transmissibility. No pumping tests have been made of the Tokio, but yields from it are expected to be no more than enough to supply farmsteads and stock. The quality of ground water from wells in the outcrop area is poor.

Ozan and Brownstown Formations, Undifferentiated

The outcrop of the Ozan and Brownstown formations, undifferentiated, extends from Arkansas into the southeastern part of McCurtain County, where it covers an area of about five square miles. The Ozan and Brownstown, which are the youngest rocks of Cretaceous age exposed in McCurtain County, unconformably overlie the Tokio formation and are the equivalents of parts of the Taylor marl in Texas. In the area covered by this report these formations are thin and have not been differentiated; both contain calcareous shales and some sands. Neither is important as a source of ground water in McCurtain County.

History of the name.—The name "Brownstown" was first applied by Hill (1888, p. 86-87) to marl beds near Brownstown, Sevier County, Arkansas, which he believed to overlie the chalk at White Cliffs (Annona chalk). Later, Hill (1894, p. 302) included in the Brownstown the strata above the Annona chalk and below the Washington beds (now included in the Nacatoch sand). In 1901 Hill (p. 340) applied the name "Brownstown" to marls that Veatch (1906, p. 25) regarded as both above and below the Annona. Veatch therefore defined the Brownstown as the marls below the Annona and overlying the Bingen formation. The Brownstown was redefined and restricted by Dane in 1929 (p. 46-67) to include only the lower part of the Brownstown of Veatch. Thus restricted, it includes the dark-gray calcareous clay or marl and subordinate sandy marl and fine-grained sand that rest unconformably on the Tokio formation and are overlain by the Ozan formation. The latter name was proposed by Dane for the upper part of the Brownstown marl of Veatch. He described the Ozan as consisting mostly of sandy, micaceous marl and as containing in its lower part glauconitic marl and sand which rests unconformably on the Brownstown marl.

Distribution.—The outcrop of the Ozan and Brownstown formations, undifferentiated, covers about five square miles adjacent to the Arkansas State line in the southern part of T. 9 S., and the northern part of T. 10 S., R. 27 E. Good exposures are along the eastern side of McKinney Creek in secs. 20 and 29, T. 9 S., R. 27 E.

Thickness.—It has not been possible to estimate the thickness of the Ozan and Brownstown formations, undifferentiated, in McCurtain County. An incomplete driller's log of a well in sec. 28, T. 9 S., R. 27 E., suggests that the unit may be as much as 195 feet thick.

Character.—In McCurtain County the undifferentiated Ozan and Brownstown formations consist of soft, chalky marls and limestones with interbedded calcareous clays. These strata form an escarpment that rises as much as 30 feet above the Tokio formation to the north and as much as 60 feet above the alluvial deposits to the west and south.

The limestones and marls are light gray to white on both fresh and weathered surfaces. Small black particles, about the size of very fine sand, along with a few small pebbles, are sparsely scattered through the limestone. The limestone weathers into angular or nodular boulders and cobbles because of vertical and horizontal jointing. The joints are weathered brown at most outcrops. The clays are light gray to brownish gray and contain a few brown iron stains. Mica and sand in the clay cause it to be flaky.

Stratigraphic relations.—Dane (1929, p. 47) reports that in Arkansas the Brownstown formation rests unconformably upon the Tokio formation. This unconformity has not been recognized in McCurtain County, Oklahoma, because the contact is concealed.

Age and fossils.—The Ozan and Brownstown, undifferentiated, have long been known to be of Late Cretaceous age. Fossils are abundant—pelecypods and ammonites are the most numerous macroinvertebrates, and microfossils are plentiful.

Correlation.—The Ozan is equivalent to the lower part of the Annona chalk of Red River County, northeastern Texas, and to the lower part of the Taylor marl, also in Texas. The Brownstown of southeastern Oklahoma and northeastern Texas is equivalent to a portion of the upper part of the Austin chalk in Texas (Stephenson, 1937, p. 133 and 135).

Water supply.—The Ozan and Brownstown, indifferentiated, are not important as a source of ground water in McCurtain County. The formations are composed of relatively impervious rocks in which ground water occurs mainly in cracks and crevices, and their areal extent is small.

QUATERNARY SYSTEM

Alluvium and Terrace Deposits

Alluvium and terrace deposits are here considered together because their mode of deposition is the same and, in general, they have the same hydrologic properties. These deposits are widely distributed and have considerable thickness over rather large areas along the Red and Little Rivers and Glover Creek. Such deposits along the smaller streams are generally thin and of small areal extent.

For the purposes of this report only the alluvium along the Red, Little, and Mountain Fork Rivers and Glover Creek has been mapped, and also only one terrace deposit (See pl. I). However, many small deposits are scattered throughout the area—notably over the outcrop of the Trinity group.

Alluvium is the material deposited by streams in recent geologic time. It is likely, but not certain, to be thickest near the middle of a valley, and it is thicker along major streams than along small creeks. These deposits are stream-laid unconsolidated sand, gravel, and clay in intergrading and intertonguing beds, and they are not well exposed except in the banks of streams. The terrace deposits lie at somewhat higher levels than the alluvium and are thought to have been deposited before the streams cut their valleys to the present levels. Hence, the terrace deposits probably are somewhat older than the alluvium and, in particular, are older than the deposits of the lowest bottom lands. The terrace deposits and alluvium mask the structure of the underlying bedrock, from which they are separated by a major unconformity.

The contact between the overlying Quaternary sediments and the underlying older deposits is irregular. The alluvial sediments are irregular, both in areal extent and thickness, at some places lying upon the level surface of the beds beneath them, and elsewhere filling up eroded depressions in the same beds. Buried stream channels are undoubtedly present beneath the alluvium and terrace sediments but data are not sufficient to delineate them.

The thickness of the alluvium ranges from a maximum of about 50 feet along Little River and its tributaries to about 110 feet along the Red River. The terrace deposits are generally less than 30 feet in thickness.

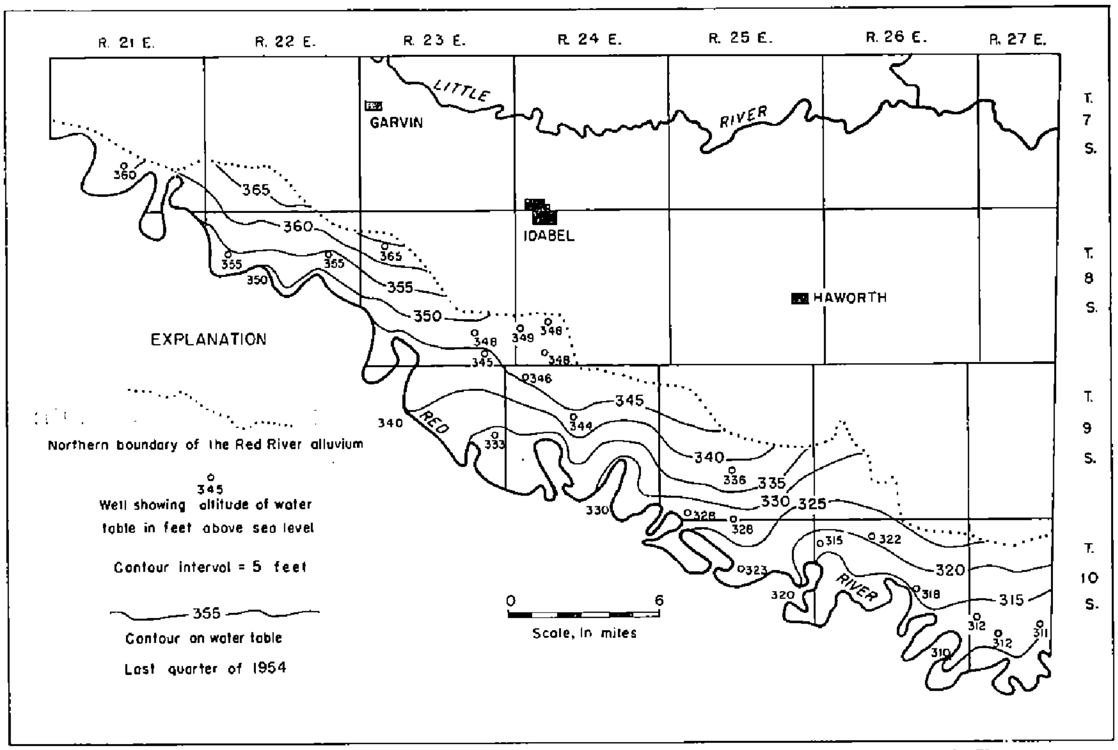


Fig. 15 Contour map of the water table in the alluvium along Red River in McCurtain County, Oklahoma.

The ground-water potentialities of the alluvium and terrace deposits in southern McCurtain County are largely untested. The dug or driven wells in the bottom lands yield small quantities of water, chiefly for domestic and stock use on farms. The alluvium along Little River and its tributaries is probably too silty and clayey to yield large quantities of water to wells. However, where the alluvium contains coarse sand and gravel, as along the Red River, it should be capable of yielding water freely. The terrace deposits along the Red River, shown on plate I and figure 15, contain a high percentage of silt and clay and are relatively impermeable, and wells tapping ground water in them have small yields. Generally, other terrace deposits in the county are relatively impermeable.

The quality of water from these alluvial sediments is suitable for most uses. However, it is reported that in places the alluvium of the Red River yields water that is too saline for irrigation or stock use.

OCCURRENCE AND BEHAVIOR OF GROUND WATER

The upper surface of the zone of saturation in ordinary permeable soil or rock is called the "water table." Where the upper surface is formed by impermeable rock and artesian conditions are said to exist the water table is absent. If a well is sunk, it remains empty until it enters a saturated permeable bed—that is, until it enters the zone of saturation; then water flows into the well. If the rock through which the well passes is all permeable, the first water that is struck will stand in the well at about the level of the top of the zone of saturation—that is, at about the level of the water table. If the rock overlying the bed in which the first water is struck is impermeable the water, called confined or artesian water, is under pressure that will raise it in the well to some point above the level at which it was struck. In such a place there is no water table.

The water table is not a level surface but has irregularities comparable with and related to those of the land surface, although it is less rugged. It does not remain in a stationary position but fluctuates up and down. The irregularities are due chiefly to local differences in average rates of gain and loss of water, and the fluctuations are due to changes in gain or loss from time to time.

Under natural conditions, recharge generally can occur only in the areas of outcrop, where water-table conditions prevail. The lag between the time of precipitation and a corresponding rise of water level in wells is generally greater under artesian than under water-table conditions, and increases with distance from the outcrop. Where this distance is great, the fluctuations due to precipitation are small or nonexistent, and only those due to pumping or variations in atmospheric pressure are readily evident. Changes in atmospheric pressure are readily evident. Changes in atmospheric pressure may cause changes in water level of a foot or more in artesian wells, the level rising when the pressure is low and declining when it is high.

The water table is not to be regarded as a single continuous surface, but rather as a great many small and interconnected surfaces. Each impermeable mineral grain that happens to be at the level of the water surface breaks the continuity of the water table. In sandstone the water surfaces are small and close together. Where the ground water is in fissures, fractures, or joints in rocks that otherwise are solid and impermeable, the water table consists of small irregular, rather widely separated water surfaces. This is probably the nature of the water table in the shale and limestone formations in McCurtain County, in which the openings constitute only a small fraction of the entire volume of the rocks—that is, the porosity is low.

ARTESIAN (CONFINED) WATER

Artesian or confined conditions are said to exist where a water-bearing bed is overlain by an impermeable or relatively impermeable bed that dips from its outcrop to the discharge area. Water enters the water-bearing bed at the outcrop and percolates slowly downward to the water table and then down the dip in the water-bearing bed beneath the overlying confining bed, where the water exerts considerable pressure against the confining bed. A well drilled through the confining bed into the water-bearing bed releases the pressure and the water rises in the well. Because of loss in head resulting from friction as the water percolates down the dip, the water level will not rise to an elevation as high as that of the water table in the outcrop area. Where the land surface is low enough the artesian pressure may be sufficient to raise the water above the surface, and flowing wells may be obtained.

In McCurtain County the Goodland limestone forms an impermeable confining bed above the Paluxy sand. These beds are at altitudes lower than their outcrop areas in southern McCurtain County, thus providing the conditions for artesian wells. In places in the southern part of the county the altitude of the land surface also is lower than that of the outcrop, or intake, area, and the wells flow at the surface.

DISCHARGE

In McCurtain County a portion of the ground water is lost by direct evaporation from the shallow-water areas; a larger amount is lost by transpiration from vegetation; and a part is lost through springs and effluent seepage along Glover Creek and the Mountain Fork, Little, Red Rivers and their tributaries where their channels are cut below the level of the water table. Ground water from the Paluxy sand, estimated at more than half a million gallons per day, is going to waste from five flowing wells in the southwestern part of McCurtain County. The public supplies at Valliant, Millerton, and Garvin are obtained from wells, and the unincorporated communities and rural residents obtain their domestic and livestock supplies from wells.

RECHARGE

Recharge is the addition of water to the underground reservoir. The primary source of such water in southern McCurtain County is precipitation in the form of rain, snow, or hail that falls on the outcrop or in nearby areas of northern McCurtain County and is discharged into the Trinity group by influent seepage from streams during periods of high water. When water falls on the ground, a part runs off and is carried away by rivers and streams, a part evaporates, a part returns to the atmosphere through transpiration by plants, and a part sinks into the ground, and becomes ground water. The amount of water that sinks into the ground depends upon the character of the surface—its slope, the porosity of the soil, the degree of saturation of the soil and the amount and type of vegetation—as porous dry soil will absorb more water from a relatively heavy rain than will a tight heavy soil. In hot weather the water may all evaporate before it has time to sink into the ground, and if any does enter the ground, it may soon be lost through transpiration or through evaporation from the soil. Ground-water recharge represents the residual after all three higher priority demands are met. Soil cracks formed during dry weather probably serve to speed up recharge when precipitation occurs after a long dry period.

Under natural conditions, the recharge to an underground reservoir is approximately balanced by the discharge from it. Hence a measure of the natural discharge is a rough measure of the recharge. Pumping or artesian flow from wells upsets this balance and causes a decline of water levels; eventually it diverts toward the wells a part of the natural discharge of springs and streams or increases the recharge. This diverted discharge is said to be salvaged. The lowering of the water table or piezometric surface by pumping or artesian flow makes room in the normally saturated part of the aquifer for water that otherwise might go as surface runoff. Thus, where precipitation is more than adequate, withdrawal of water may increase recharge by increasing the receptiveness of the aquifer.

Recharge from local precipitation. The annual average precipitation in the area of this report is more than 44 inches, but only a small fraction of this amount becomes ground water. In the area underlain by the Trinity group and by the terrace deposits along Red River, the bedrock is relatively permeable and recharge is much greater than in the areas underlain by the Goodland limestone and the Washita group where the rocks are much less permeable.

Recharge from subsurface inflow.—The movement of water under water-table conditions is primarily in the direction of the general slope of the surface, which in the area of this report is south and east. Therefore, water entering the Cretaceous rocks in areas immediately to the west in Choctaw County may eventually move into McCurtain County and contribute to the available supply of ground water.

The outcrop of the Cretaceous rocks in McCurtain County lies east and west. Water percolating into them flows downdip under the influence of gravity. South of the outcrop area is artesian water, which has few outlets, natural or artificial. Because the outlets are few, the quantity of water transmitted in a given period is small. Hence, subsurface flow is relatively unimportant.

Recharge from stream and ponds.—The alluvium receives water mainly from precipitation, but at times of high water the streams may make substantial though relatively temporary contributions to the ground water by way of bank storage. When the streams overtop their banks and spread across the flood plains, the percolation of water into the alluvium may be so general that a relatively large increase in stored ground water results. Considerable time may elapse before this increment of water can drain into the channel or otherwise be dissipated.

PUMPING TESTS

The amount of water a well will yield depends primarily on the hydraulic properties of the aquifer. These properties include the permeability, the transmissibility, the coefficient of storage, and the extent of the aquifer. Permeability is defined as the volume of flow per unit time per unit hydraulic gradient per unit area. As a field coefficient it usually is expressed as the number of gallons of water per day that can percolate through each mile of the water-bearing bed (measured at right angles to the direction of flow) for each foot of thickness of the bed and for each foot per mile of gradient, at the prevailing temperature of the ground water. The product of the permeability and the thickness of the water-bearing bed is termed transmissibility.

The coefficient of storage of an aquifer is the volume of water released from or taken into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface. Under water-table conditions the coefficient of storage is essentially equal, but not exactly equivalent, to the specific yield, which may be expressed as the ratio of (1) the volume of water which the material, after being saturated, will yield by gravity to (2) its own volume.

The coefficients of permeability, transmissibility, and storage can be determined by means of controlled pumping tests. Once computed these coefficients theoretically can be used to determine the quantity of water that can be pumped from a given well or wells with specific drawdowns in the pumped well or in other wells for any pumping period (Wenzel, 1942).

One pumping test was made in the Paluxy sand, using the municipal water wells at Valliant, Oklahoma. This test, described in the paragraphs that follow, was analyzed by methods in general use by the U. S. Geological Survey.

Test of the Paluxy sand.—Valliant water well 1, used in this test, was completed in 1936. It was drilled to a total depth of 363 feet and a 12-inch casing was set to a depth of 280 feet into a sandy lime. This left a total of 95 feet of water-saturated sand shut off behind the 12-inch casing. Torch-slotted 10-inch liner 100 feet long was set to 363. Therefore 17 feet of liner extended up into the 12-inch casing. The water is under artesian pressure and the piezometric surface is about 77 feet below land surface.

The pump assembly in well 1 consisted of a 25-horsepower electric motor, 140 feet of 5-inch column pipe, a 13-stage 8-inch bowl assembly, and 10 feet of 5-inch suction pipe with a 5-inch strainer.

Valliant water well 2, 105 feet north of well 1, was used as an observation well. The interval from 280 to 325 feet is open hole.

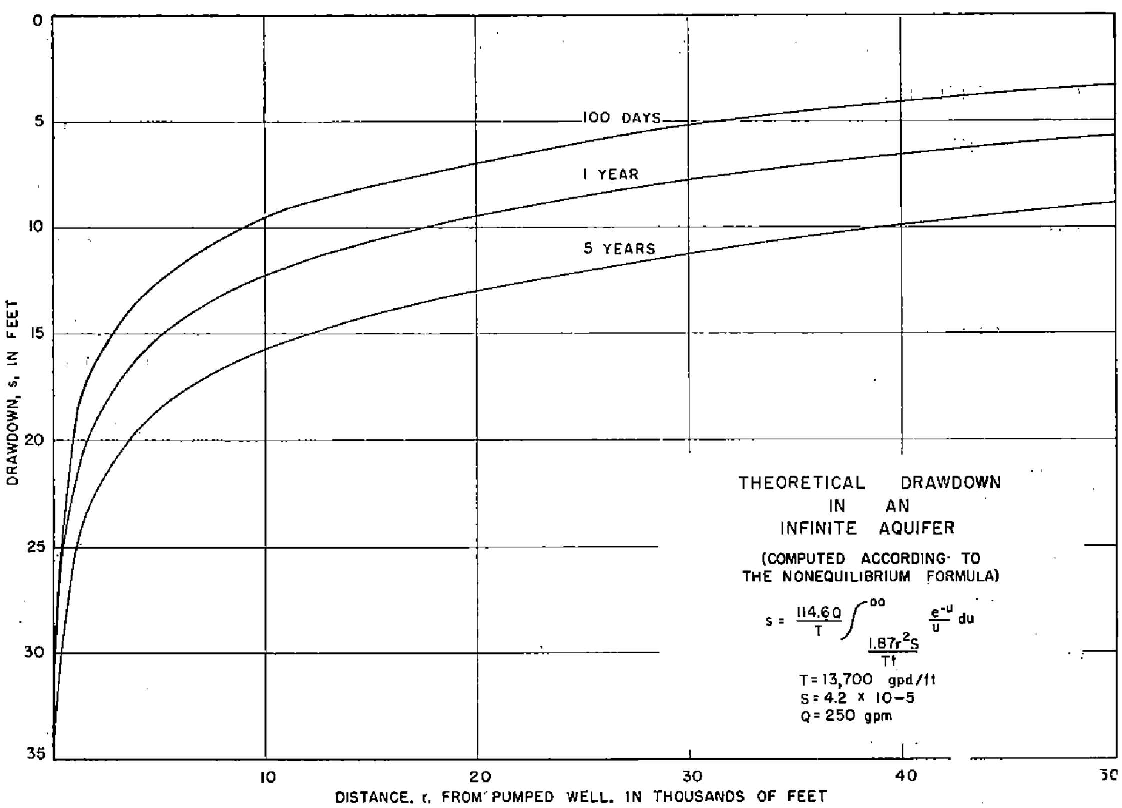
The pump in well 1 was on at 11:15 a.m., May 12, 1954, when first visited. Measurements of the depth to water were made in wells 1 and 2 from 12:25 p.m. until 3:18½ p.m., when the pump was shut down. The average pumping rate during the 2 hours and 54½ minutes of pumping was 261 gpm. The water level in the pumped well at the end of the pumping period was 103.29 feet below the measuring point, and in the observation well (well 2) it was 96.0 feet below the measuring point.

The alinement of the observed data is good. The deviations from the theoretical alinement are small and can be accounted for by fluctuations of water level induced by barometric fluctuations, or by slight inaccuracies in measurements.

The recovery of the water level in well 1 was analyzed praphically using the Theis recovery formula (Wenzel, p. 95), and the plotted points fall approximately on a straight line, indicating that the formula is applicable. From this analysis it appears that the coefficient of transmissibility is about 14,000 gpd/ft. The coefficient of storage could not be determined from the recovery data on well 1 because the Theis formula is not adapted to its determination where only the recovery of the water level in the pumped well is known.

Both the drawdown curve and the recovery curve in well 2 were analyzed by the Theis nonequilibrium formula. The results showed that the coefficient of transmissibility was about 13,000 gpd/ft and the coefficient of storage was about 4×10^{-5}.

If the coefficients of transmissibility and storage of the aquifer are known, the Theis formula can be used for estimating the drawdown at any place in the aquifer at any time and for any rate of continuous pumping. Curves representing the theoretical drawdown of water level at distances ranging from 1 to 50,000 feet from a well being pumped at a rate of 250 gpm for periods ranging up to 5 years have been prepared for an aquifer of infinite extent having a coefficient of transmissibility of 14,000 gpd/ft and a coefficient of storage of 4×10^{-5} (fig. 16). These coefficients are approximately those of the Paluxy sand at Valliant in McCurtain County.



$$s = \frac{114.6Q}{T}\int_{\frac{1.87r^2S}{Tt}}^{\infty} \frac{e^{-u}}{u}\,du$$

Fig. 16. Curves showing the theoretical drawdown in an aquifer of infinite lateral extent having hydraulic properties approximating those of the Paluxy sand at Valliant in McCurtain County, Oklahoma, for periods of 100 days to 5 years and at distances up to 50,000 feet from the pumped well.

Because the drawdown is theoretically proportional to the rate of pumping, drawdown at rates other than 250 gpm can be determined from the curves by multiplying the indicated drawdown by the appropriate ratio. For example, a well pumping 125 gpm will cause half the drawdown shown on the curve and a well pumping 500 gpm will cause twice the drawdown. The total drawdown at a given point caused by pumping several wells is equal to the sum of the drawdowns produced individually by the wells. For example, if two wells were to pump 250 gpm each for a period of 100 days, the drawdown at a point 5,000 feet from one well and 10,000 feet from the other would be about 12.5 feet plus 9 feet, or about 21.5 feet at the end of the period.

Although the pumping test indicates that the Paluxy sand is incapable of yielding extremely large quantities of water continuously without creating excessive drawdowns, wells yielding 200 to 300 gpm under intermittent pumping could be expected to have many years of useful life. Many wells, widely spaced and pumped intermittently, in the aggregate could draw a considerable volume of water from the Paluxy sand.

FLUCTUATIONS OF GROUND-WATER LEVEL

Measurements of depth to water have been made regularly in 17 wells in the area since 1949, and other wells have been measured for shorter periods. The average of the water levels in the 17 wells is shown graphically on figure 17, which gives also the precipitation and average monthly temperature at Idabel.

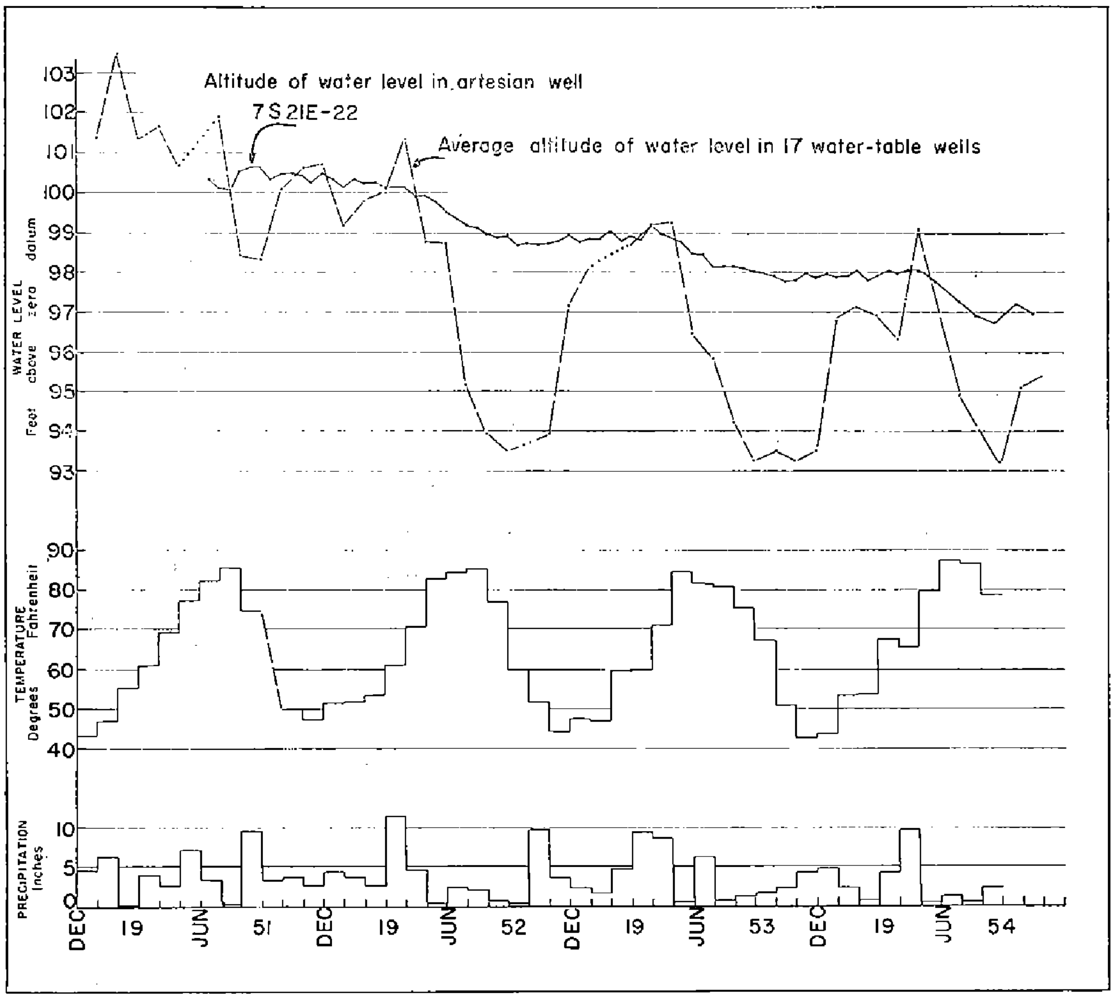


Fig. 17. Graph of water-level fluctuations in observation wells, McCurtain County, Oklahoma.

Annual fluctuations.—Measurements of water levels in wells during the 6-year period 1949 to 1954, inclusive, show the ground-water levels in southern McCurtain County to have been generally high during June and July (fig. 17). The high peaks occur in response to average yearly periods of maximum precipitation. The peak ground-water levels lag behind the period of heaviest precipitation because of the depth of the water table below the ground and the time consumed in the percolation of the water down to the water table. Where the water table is close to the land surface its response to precipitation is rapid and large, and where the water table is comparatively far beneath the surface its response to precipitation is slower and smaller.

In the area of this report, the ground-water levels generally begin to rise shortly after the first of the year in response to heavier precipitation, and in March and April the rate of rise increases sharply. The spring rains are typically slow and steady and thus favor infiltration of water into the ground. The spring rise continues until about July, when the yearly decline begins. This decline follows a decrease in recharge, which in turn is due to less precipitation coupled with accelerated evaporation and transpiration. Generally little or none of the summer and fall rain reaches the water table.

The late fall and winter rains do not have as much effect on the water levels as the spring rains because by fall there is a general deficiency in soil moisture. The soil and bedrock above the water table hold a considerable amount of water by molecular attraction on the individual particles and in very small voids. This water does not percolate downward to the water table. By autumn much of it has been transpired or evaporated and must be replaced before any water can penetrate to the water table. The process of replacement consumes most of the winter rains that sinks into the ground. Thus, although the winter rains do not always cause the water table to rise, they do pave the way for the yearly spring rise of the water table.

Daily fluctuations.—A continuous record of water level is available from only one well in the area of this report. This well (7S21E-22) penetrates the Paluxy sand and the hydrograph shows a marked daily fluctuation of water level, corresponding to diurnal pressure changes, which can be explained by the fact that artesian conditions prevail.

TABLE 6. CHEMICAL ANALYSES OF WATER FROM WELLS IN SOUTHERN MC CURTAIN COUNTY, OKLAHOMA
(Analytical results in parts per million except as indicated)

Aquifer: Qal, alluvium; Ktk, Tokio formation; Kwb, Woodbine formation; Kwk, Washita group, including Kiamichi formation of Fredericksburg group; Kfg, Goodland limestone; Ktp, Paluxy sand.

Location and Well No.	Depth (ft.)	Aquifer	Date of collection	Ca	Mg	Na & K	HCO_3	SO_4	Cl	F	NO_3	Total dissolved solids	Hardness Total	Hardness Non-carbonate	% Na	Sodium adsorption ratio	Specific conductance (micromhos at 25° C)
T. 6 S., R. 21 E.																	
27-2	363	Ktp	3-27-48	40	7.2	1.1	125	5.3	16.	0.0	0.0	136	130	27	1.0	0.0	293
		Ktp	8-16-51	45	7.5	6.6	180	5.2	3.5	0.1	0.0	161	143	0	8.0	0.2	290
T. 6 S., R. 22 E.																	
34-1	125	Ktp	12- 7-49	42	4.6	15	140	17	16	...	1.0	202	124	9	21	0.6	283
2	130	Ktp	12- 7-49	65	5.2	11	228	6.7	9.5	...	.5	223	184	0	12	0.4	381
T. 6 S., R. 25 E.																	
19	21	Ktp	3-26-48	13	2.1	20	49	3.0	22	...	14	84	41	1	52	1.4	136
T. 7 S., R. 21 E.																	
22	322	Ktp	5-18-51	58	7.4	43	280	20	12	...	1.1	296	175	0	35	1.4	494
T. 7 S., R. 22 E.																	
7	138	Ktp	12-21-44	46	6.0	29	216	11	10	...	.2	174	139	0	30	1.1	...
28	356	Ktp	5-10-51	30	11	202	278	88	170	...	.8	682	120	0	79	8.0	1180
T. 7 S., R. 23 E.																	
7	265	Ktp	8-16-51	11	3.1	102	235	42	16	.9	1.8	308	40	0	83	6.9	511
23-1	122	Kfg	9-14-49	13	2.8	586	592	778	14	...	4.5	1740	44	0	97	38	2510
T. 7 S., R. 24 E.																	
1-1	32	Ktp	12-20-44	21	3.0	8.7	68	2	7	...	20	139	65	0	36	0.5	...
23-1	105	Ktp	3-27-48	39	7.4	113	169	51	127	.1	2.0	430	128	0	66	4.3	859
2	183	Ktp	12- 3-49	146	35	289	493	459	181	...	.2	1410	508	104	55	5.6	2060
2	142	Ktp	12-12-49	82	14	93	325	53	101	...	0.0	523	262	0	44	2.5	923
27	267	Ktp	11-25-49	12	3.1	656	562	471	365	...	4.5	1810	43	0	97	44	2850

TABLE 6 (Continued)

Location and Well No.	Depth (ft.)	Aquifer	Date of collection	Ca	Mg	Na & K	HCO_3	SO_4	Cl	F	NO_3	Total dissolved solids	Hardness Total	Hardness Non-carbonate	% Na	Sodium adsorption ratio	Specific conductance (micromhos at 25° C)
T. 7 S., R. 26 E.																	
20-1	173	Ktp	5-22-51	305	70	3430	212	335	5690	...	5.6	10800	1050	876	88	46	17200
1	262	Ktp	5-22-51	243	48	4000	338	406	6240	...	6.7	11100	804	527	92	61	14000
T. 8 S., R. 23 E.																	
2-1	274	Ktp	3-27-48	94	10	123	96	17	300	.1	30	694	276	197	49	3.2	1190
T. 8 S., R. 24 E.																	
1	416	Ktp	9-13-49	29	13	1140	612	222	1320	3.0	4.0	3000	126	0	95	44	5090
4	301	Kwk	1- 8-50	5.4	2.7	745	675	49	670	...	2.4	1900	25	0	99	65	3250
7	27	Kwb	9-14-49	109	50	367	96	2.9	845	...	2.5	1710	478	399	63	7.3	2850
T. 9 S., R. 25 E.																	
21	16	Qal	11-22-50	1.8	2.1	12	20	8.2	5.2	...	7.3	47	13	0	66	1.4	59
33-1	18	Qal	12- 3-50	33	22	16	212	16	7	...	8.2	202	173	0	16	0.5	347
T. 10 S., R. 25 E.																	
10	15	Qal	11-30-50	160	52	20	690	60	18	...	3.9	649	613	48	7	0.4	1070
T. 10 S., R. 26 E.																	
6-2	165	Ktk	1- 9-51	141	69	118	684	52	196	...	2.3	934	636	75	29	2.0	1590

CHEMICAL CHARACTER OF GROUND WATER

Natural waters contain variable amounts and kinds of dissolved constituents as a result of the solvent action of water on minerals and rocks. Within reasonable limits the presence of mineral constituents in water adds to its value for irrigation use and human consumption. These minerals provide certain nutrients for the soil and plants, and they add to the potability of water for without them the water would have the flat taste of rain water.

Chemical analyses of 25 samples of water from 22 wells in McCurtain County are given in table 6. Of the samples analyzed, 18 were from 15 wells in the Paluxy sand, three samples were from wells in the alluvium, and one each from the Goodland limestone, Tokio formation, Woodbine formation, and Washita group.

SUITABILITY FOR DRINKING

Standards by which to judge the suitability of water for drinking purposes have been established by the U. S. Public Health Service (1946, p. 371). They indicate the maximum concentrations of certain constituents, in parts per million, that are acceptable for water used in conjunction with interstate commerce. Six constituents are considered significant and maximum limits for them are given as follows:

Constituent	Parts per million	Constituent	Parts per million
Iron and maganese together	0.3	Sulfate	250
Fluoride	1.5	Dissolved solids	500 (1,000 accepted)
Magnesium	125	Nitrate/[1]	44
Chloride	250		

[1] Standard recommended by Oklahoma State Department of Health.

The iron content was determined for only two samples from the Paluxy sand; both contained less than the maximum acceptable limit. Water from well 6S21E-27-2 contained 0.08 ppm iron and that from well 7S23E-7 contained 0.02 ppm.

The fluoride content was determined in only nine water samples and was below the acceptable limit in all except the samples from well 8S24E-1 from the Paluxy sand.

The nitrate content of all samples was below the maximum acceptable amount. Water from well 8S23E-2-1 contained 30 ppm, that from well 6S25E-19 contained 14 ppm, and all other samples contained less than 10 ppm.

Water from wells (7S24E-27, 7S26E-20-1, 8S23E-2-1, 8S24E-1) contain such concentrations of chloride and dissolved solids as to be unsuitable for drinking. Water from wells 7S23E-1 and 7S24E-23-2 (depth 183 feet), contained sulfates and dissolved solids in excess of the Federal standards. Twelve of the 25 samples analyzed contained more than the recommended 500 ppm of dissolved solids and 8 samples, including those from the Goodland limestone, Washita group, and Woodbine formation, contained more than 1,000 ppm. Two samples of water from the alluvium were suitable in all respects for drinking, the third contained 649 ppm dissolved solids and could probably be used with no ill effects. About a third of the water samples from the Paluxy sand, particularly those from T. 7 S., R. 24 E., and T. 8 S., R. 24 E., contained amounts of one or more constituents in excess of the recommended concentration limits.

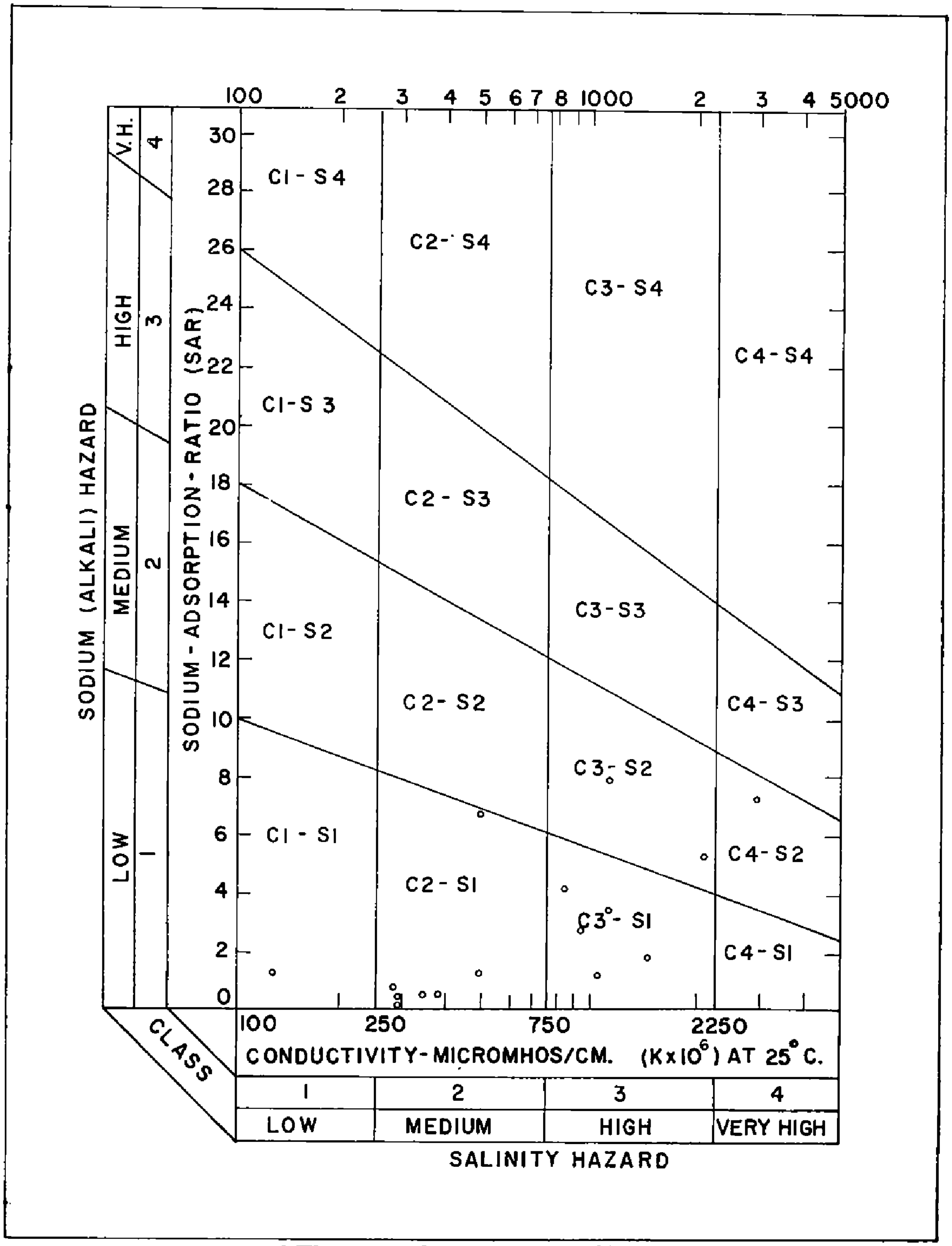
SUITABILITY FOR IRRIGATION

The total amount of dissolved minerals that can be tolerated in an irrigation water varies considerably with the type of soil being irrigated, the crops grown, the drainage of the land, and the amount of rainfall. As the mineral content increases, there is a greater tendency for the minerals to accumulate in the soil, making it necessary to increase the amount of water used because it has to serve the double purpose of supporting the crop and of leaching the accumulated salts from the soil. Of the various minerals normally present in natural waters, the concentration of sodium and its relative ratio to calcium and magnesium and its effect on the physical conditions of the soil is the most critical because of the tendency of adsorbed sodium to impair the soil's permeability. The sodium-adsorption-ratio (SAR) of a soil solution is defined by the equation:

$$SAR = Na \sqrt{\ (Ca + Mg\ /2}$$

where the Na, Ca, and Mg ions are expressed in equivalents per million. To convert the concentrations of Na, Ca, Mg ions from ppm to epm multiply by 0.04359, 0.04990, and 0.08224, respectively. Sodium adsorption ratio values for waters analyzed are given in table 6.

Figure 18 is a diagram for the classification of irrigation water based on the specific conductance and the sodium-adsorption-ratio. The specific conductance, which is an approximate measure of the total mineral content of a water, indicates the salinity hazard of the water, and sodium adsorption ratio indicates the sodium or



° Water sample reported in table 9.
Fig. 18. Diagram for the classification of irrigation waters.

alkali hazard of the water. To use the diagram, locate the point corresponding to the values for conductivity and SAR as shown in table 6. The position of this point determines the quality classification of the water. Points have been plotted on figure 18, except for analyses which fall outside the range of values on the figure, for water samples analyzed from McCurtain County. None of the water would present a high sodium hazard except the samples from wells 7S23E-23-1, 7S24E-27, 7S26E-20-1, 8S24E-1, and 8S24E-4 which have such high SAR values that they will not plot on the diagram. Those waters were rather high in salinity and would not be suitable for irrigation anyway. The water sample from the Tokio formation, one of the samples from the alluvium, and four samples from the Paluxy sand would present high salinity hazard. They would be suitable for irrigation only on well-drained soils or if salt-tolerant crops were being grown.

PRESENT DEVELOPMENT OF GROUND-WATER SUPPLIES

Ground water is the source of most domestic and stock water supplies in southern McCurtain County although streams and farm ponds also furnish large amounts of stock water. Four municipalities and one institution rely on ground water. In the present ground-water investigation, records of 126 water wells were obtained. Of these, 45 are domestic wells, 14 are domestic and stock wells, 10 are wells used only for stock, five are wells used for public supplies, two are industrial wells, one is an institutional well, seven are test holes that have been plugged, and 42 appear to be unused. Tables 7 and 8 record data on the wells.

WELLS USED FOR PUBLIC SUPPLY

Three towns in southern McCurtain County are supplied with water from wells through waterworks consisting of power-driven pumps, elevated storage tanks, and water mains. Deep-well turbine pumps or jack-lift pumps are used to lift the water directly from the well into elevated storage tanks. The water is given no special treatment, being kept in a closed-water system from aquifer to user. Some of the smaller towns have no public water systems, but depend on private wells. The following paragraphs summarize significant data regarding the public supplies in each town. Data on the surface-water supplies at Idabel, Broken Bow, and Wright City are included for completeness.

TABLE 7. RECORDS OF WATER WELLS AND TEST HOLES IN SOUTHERN MC CURTAIN COUNTY, OKLAHOMA

Probable aquifer: Qal, alluvium; Ktk, Tokio formation; Kwb, Woodbine formation; Kwk, Washita group (including Kiamichi formation of Fredericksburg group); Kfg, Goodland limestone; Ktp, Paluxy sand; Khc, Holly Creek.

Well No.	Location in section	Owner or tenant	Depth (feet)	Diameter (inches)	Probable aquifer	Water level Depth below land surface (feet)	Date of measurement	Altitude of land surface (feet)
T. 6 S., R. 21 E.								
27-1	SE NW	Town of Valiant	360	8	Ktp	40	3-10-51	
2	NW SE	do	363	12	Ktp	90	3-27-48	
T. 6 S., R. 22 E.								
32	SE SE	Miller	138	6	Ktp	70	12-21-44	
33	SE SW	Story Lmbr. Co.	160	6	Ktp	100	3-10-51	
34-1	NE SW NE	Wheelock Ind. Acad.	125	6	Ktp		12- 7-49	
2	NE SW NE	do	130	6	Ktp		12- 7-49	
T. 6 S., R. 23 E.								
28	SE SE	Westly Luiser	25	30	Ktp	14.95	1-28-50	384.6
T. 6 S., R. 24 E.								
14	NE SE	Okla. Forestry Div	134	6	Khc	0	4- 6-57	......
20	SW SW		28	24	Ktp	20	1-19-51	
T. 6 S., R. 25 E.								
19	SW SW SW	Jack Lane	21	30	Ktp	6.2	3-26-48	......
27	SE SE	Brantly	26	30	Ktp	2.78	12-15-49	443.3
T. 6 S., R. 26 E.								
36	SE SW	B. M. Littleton Store	14	36	Qal	5.55	3-30-48	337
T. 7 S., R. 21 E.								
22	NE NE	U. S. G. S.	308	6	Ktp	5.0	5-25-51	
T. 7 S., R. 22 E.								
25	SE SW	Odel J .Parish	40	21	Kwb	3.5	2-25-50	457.8
27	SE SE	D. G. Graham	21	24	Kwb	3.4	2-25-50	454.7
28	NW cor. NE	U. S. G. S.	356	6	Ktp	3.3	5-12-51	410
T. 7 S., R. 23 E.								
1	NW NW	___ McCain	26	50	Ktp	4.7	12-20-50	392.4
7	SW SE	City of Garvin	157	8	Ktp	8.9	12-21-44	......
17	NW NW	do	170	8	Ktp	...	3-10-51	...
23-1	SW NE	W. E. Carder	122	6	Kfg	...	9-13-49	...
2	NW NW NW	McCurtain Lime Co	201	6	Ktp	100	5- ?-49	...
28	SW SE	Lone Star Groc. Co.	19	20	Kwb	0.18	2- 8-50	481.01
29	SE NE NE	Margaret H. Hubanks	15	23	Kwk	1.6	2-10-50	472.4
30	SE SE	Elmer Holman	40	26	Kwb	6.77	2-25-50	423.8
32	NW NE NW	Maud Jackson	19	32	Kwb	1.87	2-10-51	450.52
34	NW cor. NW	U. S. G. S.	347	6	Ktp	128	5-30-51	...

TABLE 7 (Continued)

Well No.	Location in section	Owner or tenant	Depth (feet)	Diameter (inches)	Probable aquifer	Water level Depth below land surface (feet)	Date of measurement	Altitude of land surface (feet)
T. 7 S., R. 24 E.								
1-1	SE NW	Jack Johnson	32	24	Ktp	29.5	12-20-44	...
2	NW NW	Mrs. Murdock	19	24	Ktp	6.65	2- 6-50	372.21
2	SE NE	___ Long	12	30	Ktp	6.33	2- 6-50	366.85
4-1	NE NW	___ Stewart	15	32	Ktp	2.06	1-28-50	419.5
2	NE SE	J. W. Fisher	40	34	Ktp	24.60	1-28-50	411.8
5	SW SE	W. C. Westbrook	19	38	Ktp	4.14	1-28-50	377.56
7	SW SE SW	B. F. Pollard	23	24	Qal	18.48	9-12-49	478.8
18	NE NE	. . .	15	6	Qal	13	. . .	...
23-1	NE NE	J. C. Jackson	105	4	Ktp	...	3-27-48	...
2	SE SW	Clarence Davis	183	6	Ktp	...	4-25-50	443.33
3	SW NE	W. M. George	142	8	Ktp	98.57	12-12-49	...
4	SE SW	Wilbur Byrne	150	5	Ktp	63.05	12-12-49	...
27	SW SE	Neal Stanley	267	6	Ktp	...	11-25-49	...
T. 7 S., R. 25 E.								
24	SE SW SE	_ Lynch	16	32	Kwb	13.24	9-10-49	414.2
35	NE NE	W. B. Martin	44	6	Kwb	2.6	4-26-48	...
36	NW NW	Charles Bogart	50	55	Kwb	3.25	2-20-50	373.9
T. 7 S., R. 26 E.								
20	SE SE	U. S. G. S.	262	. .	Ktp	147	5-23-51	...
26	SW SW	H. C. Doan	28	48	Kwb	3.65	2-24-50	387.9
31	SE SW	Edna Robinson	20	42	Kwb	2.49	2-24-50	353.6
34	NE NE	J. W. Callahan	24	27	Kwb	4.78	2-24-50	388.7
T. 7 S., R. 27 E.								
6	NW SW	. . .	20	24	Qal	11.64	3-30-51	333.2
29	SW NW	U. S. G. S.	180	6	Ktp	...		
T. 8 S., R. 22 E.								
7	SE SE	. . .	25	1.25	Qal	20	1-16-51	...
10	SE SE	. . .	30	36	Qal	15	1-16-51	...
T. 8 S., R. 23 E.								
1	NW NW	Hugh Bearden	21	6	Kwb	1.98	2-18-50	480.3
2-1	NW NW NW	O. L. Hurn	274	5	Ktp	9.5	3-27-48	451.3
2	NW NW	do	23	29	Kwk	1.58	3-25-50	450.6
3	NW	J. Ford Schrock	49	5	Kwk	2.81	2-18-50	414.45
4-1	SW SW	Sam Allen	313	3	Ktp	...	2-18-50	...

TABLE 7 (Continued)

Well No.	Location in section	Owner or tenant	Depth (feet)	Diameter (inches)	Probable aquifer	Water level Depth below land surface (feet)	Date of measurement	Altitude of land surface (feet)
2	NW SW NW	W. D. Seay Oil Co. No. 1 M. T. Smith	303	8	Ktp	...	1-27-52	...
6	NE NE	Edgar Mitchell	69	5	Kwb	2.84	2-18-50	428.05
7-1	SE SE	Neal Wilson	55	5	Kwb	10.45	2-23-50	375.8
2	SE NE	. . . . .	15	24	Qal	7.5	3-29-51	375.0
10	NW NW	John McCombs	38	36	Kwb	7.97	2-23-50	412.7
12	SE SE SW	Oren C. Hicks	28	6	Kwb	.54	2-19-50	450.9
14	NE	John Derryberry, Jr.	41	30	Kwb	2.89	2-19-50	429.9
26	NW SW	. . . . .	14	18	Qal	7.5	3-29-51	358.0
34-1	NW NE	. . . . .	20	1.25	Qal	20	1-16-51	...
2	SE NW	. . . . .	18	1.25	Qal	...	3-29-51	358.±
T. 8 S., R. 24 E.								
1-1	N½ NW¼	Kiamichi sta.	416	8	Ktp	...	9- 6-49	...
2	NE NW NW	Oklahoma A. & M.	80	8	Kwb	7.53	8-29-51	...
4	SE SE	Idabel Country Club	301	6	Kwk	124.86	12-19-49	461.1
7	NE SE	Tommy Pyron	27	24	Kwb	17.31	9-13-49	...
9	NW	Ernest Brown	40	5	Kwb	3.13	2-24-50	461.3
11	SW SW	Carl Barrett	19	3	Kwb	3.0	2-24-50	430.0
13	NE NE	Pendleton Ranch	36	5	Kwb	2.1	2-27-50	381.1
17	NW NW	J. D. Billingsley	6	70	Kwb	3.31	2- 7-50	467.1
T. 8 S., R. 24 E.								
22	NW NW	W. A. Parker	21	5	Ktk	4.38	2-27-50	438.4
23	SE	. . .	25	24	Ktk	20.19	3-2- 50	427.75
29-1	NW NW	H. R. Latimer	19	30	Qal	1.88	2- 6-50	351.5
29-2	SW NW	. . .	32	48	Qal	3.35	2-12-51	354.0
31	SW SW	. . .	20	2	Qal	20	1-16-51	...
32-1	NW SW	Abandoned	34	2	Qal	4.85	2-12-51	...
32-2	SW SW	C. R. Frazier	135	...	Qal		5-12-51	...
34-1	. . .	H. D. Godwin	11	35	Qt	5.0	3-24-50	...
34-2	NE SE	U. S. G. S.	260	6	...	...	5-14-51	...
T. 8 S., R. 25 E.								
5	NW	O'Rear, Brown	18	1.25	Kwb	3.14	2-24-50	373.42
9	SE SE	T. Havens, H. Snider	17	27	Kwb	4.43	2-24-50	393.57
12	SW	J. M. Rogers	23	27	Kwb	4.62	2-24-50	416.28
22	SE SE	City of Haworth	...		Qtk	...	1-10-51	420
23	SW NE	P. Baxter	23	5	Qtk	3.41	3-24-50	404
28	NE	. . .	23	21	Qt	2.96	2-27-50	427.44
30	NE NE	H. N. Fuller	25	45	Qt	10.30	2-27-50	426.70

TABLE 7 (Continued)

Well No.	Location in section	Owner or tenant	Depth (feet)	Diameter (inches)	Probable aquifer	Water level Depth below land surface (feet)	Date of measurement	Altitude of land surface (feet)
T. 8 S., R. 26 E.								
30	NW	C. Ronald	17	3	Ktk	8.72	3- 2-50	415.78
34	NW	. . .	15	39	Ktk	7.09	3- 2-50	429.51
35-1	NE	S. W. Spencer	24	6	Ktk	2.26	3- 2-50	. . .
35-2	SE NE	H. L. Spenser	18	24	Ktk	4.3	3-24-50	344.18
T. 8 S., R. 27 E.								
5	NW	C. H. Vrinage	31	48	Kwb	17.8	2-24-50	464.8
7	NW	. . .	29	5	Ktk	5.06	2-24-50	405.7
T. 9 S., R. 23 E.								
14	NE NE SE	Church	33	1.25	Qal	10.05	3-29-51	350.0
T. 9 S., R. 24 E.								
6	NW NE NE	. . .	35	1.25	Qal	1.22	3-29-51	351
9	SW SE	. . .	24	1.25	Qal	3.4	2-11-51	350
10	SE SW	. . .	40	1.25	Qal	20	1-16-51	. . .
T. 9 S., R. 25 E.								
5	SW NE	. . .	40	18	Qt	29.87	2- 7-50	425.57
11	SE	John Cox	30	24	Qt	16.06	3- 2-50	398.13
13	SW NE NE	Abandoned	42	1.25	Qal	12.55	2- 1-51	350.0
14	NW	Charles Harris	20	21	Qal	11.96	3- 2-50	375.0
21	SE SE	U.S.G.S.	16	1.25	Qal	8.84	12-18-50	
22	SW SW	. . .	25	1.25	Qal	20	1-15-51	. . .
29	NW NW	. . .	30	1.25	Qal	20	1-15-51	. . .
32	NW SW	. . .	19	1.25	Qal	12.9	2-11-51	. . .
33-1	SE SE SE	U.S.G.S.	18	1.25	Qal	10.38	12-18-50	338.64
33-2	NE NE	U.S.G.S.	22	1.25	Qal	19.09	12-18-50	338.34
36	NE SE	. . .	25	1.25	Qal	19.3	2-11-51	332.0
T. 9 S., R. 26 E.								
22	NE	Carl Park	28	24	. . .	21.65	3-24-50	392.5
34	SW	Hall Denny	36	24	. . .	21.85	3-23-50	386.4
36	SW	Earl Clowers	33	10	. . .	18.16	3-23-50	390.0

TABLE 7 (Continued)

Well No.	Location in section	Owner or tenant	Depth (feet)	Diameter (inches)	Probable aquifer	Water level Depth below land surface (feet)	Date of measurement	Altitude of land surface (feet)
T. 9 S., R. 27 E.								
28	SW SW	U.S.G.S.	200	6	...	...	5-15-51	...
T. 10 S., R. 25 E.								
4	SE NE NE	U.S.G.S.	45	6	Qal	...	5-11-51	...
10	SW SW	U.S.G.S	15	1.25	Qal	8.64	12-18-50	331.98
T. 10 S., R. 26 E.								
2	NW	J. E. Stewart	24	24	Qt	12.35	3-23-50	367.15
4	SW NW	. . .	24	1.25	Qal	10.79	2- 9-51	...
5	NE SE	. . .	25	1.25	Qal	12	1-15-51	...
6-1	SW SW	. . .	25	1.25	Qal	20	1-15-51	...
C-2	SE SW	Preston Calvin	165	8	Ktk	15.7	1-15-51	...
10-1	SE NE	. . .	24	1.25	Qal	10	1-14-51	...
10-2	SE SE	Elmer Davis	22	1.25	Qal	20	1-14-51	...
15	SE NE	. . .	39	1.25	Qal	11.05	2- 9-51	333
T. 10 S., R. 27 E.								
19	NW SW	J. Haywood	32	1.25	Qal	18-20	1-14-51	...
21-1	SE SE	. . .	25	1.25	Qal	8 ±	1-14-51	...
21-2	SE SE	. . .	30	24	Qal	5.03	2- 9-51	...
29	NW NW	Abandoned	...	1.25	Qal	8.5	2- 9-51	325

Bokhoma.—This community, in the southeastern part of McCurtain County, is on the St. Louis-San Francisco Railway. It was settled about 1905 and for some time was the site of a rather large sawmill. When the timber was exhausted the mill ceased operations and the community declined in population, until now only a few people are left. Private wells tapping the Tokio formation always have been the only source of water supply.

Garvin.—Present-day Garvin is the remnant of a once-flourishing town which was founded in 1902 during construction of the A. and G. Branch of the St. Louis-San Francisco Railway. It was formerly called New Garvin—Old Garvin being the name of an agricultural settlement near the Indian Village about 2½ miles to the southeast. New Garvin originated as a "sawmill town," and in a short time there was in its vicinity the Steeger Lumber Co.; McDonald Dry Barrel & Hook Co.; Kilgore Stave Co.; and Choctaw Lumber & Veneer Co., the latter having the first rotary veneer plant in the State.

Prior to 1907, residents of Garvin obtained their water from the Durant Springs, about one mile south and half a mile west of town. Because water was needed for industrial uses a bond issue in the amount of $40,000 was authorized for the construction of a dam on Little River and a wooden aqueduct from the river to Garvin. Later, about 1917, another bond issue was authorized in the amount of $20,000 to repair, maintain, and expand this waterworks.

During this period of prosperity Garvin had the first bank, the first sidewalks and graded streets, and the first and most efficient waterworks in McCurtain County. During the second decade of this century the maximum population is estimated to have been about 15,000. By the early 1920's, however, most of the industry had moved away and Idabel had superseded Garvin as the business center of the county. The population of Garvin in 1950 was only 155.

Only vestiges of the former water-supply system remain—portions of the dam and foundation of the pumphouse, the settling basins, and the trench where the wooden aqueduct was laid. The present municipal water supply comes from one of two wells that were drilled between 1938 and 1942, which tapped water in the Paluxy sand. The water is of good quality at the well, but because of iron and rust from the old distribution system it is frequently "rusty" at the customer's tap.

Golden.—The village of Golden is about six miles east of Wright City on the Texas, Oklahoma, & Eastern Railroad. Its inhabitants depend upon shallow wells tapping the alluvium and Paluxy sand for their water supply.

Goodwater.—The little community of Goodwater in eastern McCurtain County was one of the first settlements in this area, and was the site of the U. S. Commissioners' Court, which was later moved to Garvin. This settlement has always depended upon shallow private wells tapping the Tokio and Woodbine formations for its water supply.

Haworth.—Haworth is located about 11 miles southeast of Idabel on the St. Louis-San Francisco Railway. The town was founded about 1902 and the present population is about 250. The system consists of a distribution system and an elevated storage tank of 37,000 gallons' capacity. Water is supplied to the system by a 5-hp. jet pump which draws water from a spring issuing from the Tokio formation about three-quarters of a mile southwest of town.

Millerton.—Millerton was first known as Parson's Post Office, being named after W. S. Parsons who first settled there in the 1890's. The name was changed to Millerton in 1906 when the Miller Lumber Co. established a mill at this locality. The company drilled two wells, one about 150 feet deep and the other about 200 feet deep, tapping water in the Paluxy sand. These wells yielded ample water for the mill and the town, the maximum population (1910-20) being about 450. One of the wells was abandoned about 1945, but the other is still in use.

Valliant.—Valliant was established in 1903 when it was platted by the Choctaw Townsite Commission, the lots being sold at public auction. The community grew rapidly and was incorporated as the town of Valliant in 1905. From its founding until about 1908 or 1909, residents of Valliant and vicinity obtained domestic water supplies from privately owned wells and by hauling water from Sand Springs, two miles southeast.

In 1908 to 1909 a dam was constructed on Clear Creek, about three miles southwest of town. The water was pumped to Valliant

TABLE 8. RECORDS OF WELLS AND TEST HOLES IN MC CURTAIN COUNTY, OKLAHOMA, SHOWING DISTANCE FROM LAND SURFACE TO TOP OF PRINCIPAL GEOLOGIC UNITS

ction	Location in section	Operator	Farm Name	Com-pleted	Eleva-tion	Total Depth	Cretaceous System								Older Rocks
											Trinity Group				
							Ktk	Kwb	Kw	Kf	Ktp		Kdq	Khc	
							Top	Top	Top	Top	Top	Thickness	Top	Top	Top
6 S., R. 21 E.															
34	SW NE SW	E. V. Abernathy	Scrivener #1	5- 1-35	470	965				19	80				725
29	SW SW		Deary #1	2- 7-50		70				10	38	32			
33	NW NE NE	C. F. Carter	Merrick #1	?- ?-44	500	460						460(?)			
27-1	SE NW	Town of Valliant	#1		510	363						360			
2	NW SE	do	#2		510	325						363			
6 S., R. 22 E.															
32	SE SE		Miller #1		500	138						138			
33	SE SW		Story Lumber Co. #1		500	160						160			
34-1	NE SW NE		Wheelock Ind. Acad. #1		445	125						125			
2	NE SW NE		do		445	130						130			
6 S., R. 23 E.															
17	NE SE NE	Otto Prassel	Swift #1	9-24-31	380±	950					22	233			255
28	SE SE		Luiser #1			25						25			
6 S., R. 24 E.															
7	C SE NW	Ranchman's Oil Co.	Patterson #1	5-19-32	550	1411					0	156	156	175	215
14	NE SE	Okla. State Forestry Div.		4- 6-57		134					13	50	63	111	120
20	SW SW	Ranchman's Oil Co.				28						28			
6 S., R. 25 E.															
19	SW SW SW		Jack Lane #1			30						30			
27	SE SE		Brantly #1			30						30			
6 S., R. 26 E.															
36	SE SW		B. M. Littleton #1			14									
7 S., R. 21 E.															
2	SW SE SE	A. R. Jordan	Hartline #1	11-17-51	530	6404				165	230				891 (?)
21	NW NW NE	Harry Appell	Pendergast #1	?- ?-44	395	1500			12		258				1069(?)
2	SE SW NE	McLaughlin	Hartline #1	5- ?-47	540	4347									
22	NE NE NE	U. S. G. S.	Test hole #1		435	322			30	225	284	38			

TABLE 8 (Continued)

ection	Location in section	Operator	Farm Name	Com- pleted	Eleva- tion	Total Depth	Cretaceous System: Ktk Top	Kwb Top	Kw Top	Kf Top	Trinity Group: Ktp Top	Ktp Thickness	Kdq Top	Khe Top	Older Rocks Top
7 S., R 22 E.															
1	NE	?	?	1916		1151									677
28	NW NE	U. S. G. S.	Test hole #2		410	356			29	234	293	63			
7 S., R. 23 E.															
30	SW SW SE	H. F. Wilcox	Newman #1	7-27-37	480	1380			40	347	395	595	990	1045	1280
23	NW NW NW	McCurtain Limestone Co.	Carder #1	6-17-49	500	201				105	161	40			
21	C NW NE	D. N. Springle	McReynolds-Mooreland #1	?- ?-53	480	305						305			
29	CSL SE SE	Tom Gray	D. Britt #1	1-31-53	475	344			46	243	308				
32	SW cor SE	Busby	Epperson #1		475	330			107						
34	SE NE SW	Davis	Whitter #1		437	1297				155	220	305	860		1100
34	NW NW NW	U. S. G. S.	Test hole #3	5-19-51	460	347			10	212	279				
33	SE SW SW	Lane-Storey	Crawford #1	3-30-53	445	291				185	247				
7	SW SE	City of Garvin			493	157						157			
17	NW NW	do			490	170						170			
7 S., R. 24 E.															
23	SW NE		W. M. George #1	12- 2-49	420	149				12	65	84			
23	SE SW		Clarence Davis #1	12- 7-49	445	190				80	130	60			
32	NW NW		Johnson #1	6- 5-53	410±	790				95	155				
7 S., R. 26 E															
25	SE SW SE	W. B. McLendon	Perry #1		445	1750			150	220	315	595	910	1115	1515
36	NW SE NW	do	Pride #1		395	1500			135	225	305	585	890	1120	
20	SE SE SE	U. S. G. S.	Test hole #5		370	262			20	151	213	49			
29	SW NW	do	Test hole #6		340	180			42	107	162	18			
8 S., R. 23 E.															
34	NE Cor.		Bill Loftin #1	11-25-49	365	525	110								
4	SW SW NW	W. D. Seay	M.T. Smith #1		465	342			58	215	288	34			
5	SE SE NE	W. D. Seay	Harmon #2	2- -53	465	1371			35	231	269	659	955	1010	1300
20	C SE	Robin H. Brians	Loyd Griffin #1	-53	360	1638			190	420	470	670	1140	1220	1510
5	SE SE NW	W. D. Seay	Edna Smith #1	4- -23	450	1360			120	262	331	679	1010	1110	

TABLE 8 (Continued)

Section	Location in section	Operator	Farm Name	Com-pleted	Eleva-tion	Total Depth	Cretaceous System Ktk Top	Kwb Top	Kw Top	Kf Top	Trinity Group Ktp Top	Ktp Thickness	Kdq Top	Khc Top	Top Older Rocks
5	SE NE SE	Glasscock	May #1	-53	470	321			62	264	316	5			
8	NW cor NW	V. L. Shirley	Tittle #1	-53	400	538			50	240	311				
4	NW NE NW	Richardson	Cornelius #1	-53	425	319			8	203	273	46			
5	NE SE SE	W. D. Seay	Harmon #1	-53	465	335					330	5			
4	SW SW SW		M. A. Allen #1	-53	460	315						315			
5	NE SE SE	Busby	Epperson #1	-53	475	334			43	243	304	30			
4	SW SW NW	Glasscock	Edwards #1	-53	450	396			33	224	290	106			
16	NW NW NW	Eureka	Dameron #1	-53	390	1596			155	410	470				1473
2	NW NW NE	Boucher	Henry Cook #1	-53	445	268				200	265	3			
5	SE SE SE	Houston Reno	Hill #1	4-11-53	463	370			95	296	366	4			
8 S., R. 24 E.															
1	C NW	Kiamichi Field Station	Water well #1		430	418			80	270	340	78			
7	NW NE SE	Sam H. Cassidy	Freda Stone #1	5-14-53	500	1755			200	390	458	679	1137	1215	1530
3	SW SE	Idabel Country Club	Water well #1	1- ?-50	430	301			134						
32	SW SW	U. S. G. S.	Test hole #8		354	135	47								
34	NE SE	U. S. G. S.	do #4		410	260	35	102	255						
8 S., R. 25 E.															
6	NW SW NW	Eureka	Sanders #1	1953	430	1472			106	340	410	665	1005	1011	1355
8 S., R. 26 E.															
15	NW NW SE	Red River Petroleum Co.	Spencer #1	1920	391	610		250	415	485	560				
15	NE NE SE	do	W. J. Whitman #1		383	26[illegible]0		250	415	485	560				2015
8 S., R. 27 E.															
4	SW SW NW	Henry J. Schafer	W. A. Dees #1	1932	430	812		15	254	340	416				
5	NE SE SE	Otto Prassel	Waggoner #1	8- 8-32	390	1008		20	251	343	428				
9 S., R. 24 E.															
8	C SE NW	Frank Walters	Coyle #1	4-16-53	335	2412	72	250	490	825	885	795	1680	1746	2330
9 S., R. 25 E.															
14	SW NW SW	Stumpff-McFaull	Robert Harris #1	1931	370	2841	38	530	876	1077	1165	856	2021		2791
25	SE SE SE	H. W. Snowden	Morgan #1	8-20-46	340	2874	75	670	1025	1240	1320	880	2200		
9 S., R. 26 E.															
12	C NW SW	Louis Sikes	Alto #1	8-20-36	360	2926		380	710	885	970	810	1780	1975	2710
10 S., R. 25 E.															
4	SE NE NE	U. S. G. S.	Test hole #9		380	45	23								

through an 8-inch iron pipe using a hydraulic turbine for power. In 1912 and 1913 a $20,000 bond issue was used to construct a water plant. The only treatment given water passing through this plant was filtration.

The present waterworks consists of two drilled wells at the southwestern edge of town. The first well was drilled in 1938 to a depth of 363 feet, tapping water in the Paluxy sand. The yield of this well was tested at 261 gpm in 1954. In 1940 the second well was drilled about 105 feet away from the first. It is 325 feet deep and also taps water in the Paluxy sand. This well is used only as an emergency supply because the hole is crooked and pumps operated in it quickly wear out.

SURFACE WATER USED FOR PUBLIC SUPPLY

Broken Bow.—The town of Broken Bow was platted in 1910 by the Choctaw Lumber Co., the lots being sold at public auction. In 1912 the company constructed a mill, water for which was obtained from a deep hole in Yashau Creek and piped through a 6-inch line to the mill, where it was stored in a pond measuring 100 feet by 30 feet and about 10 feet deep. During dry weather water was hauled by rail tank car from the vicinity of Wright City to supplement the supply from Yashau Creek. In 1920 the Choctaw Lumber Co. built a dam at a cost of $150,000 on Yashau Creek near the site of the formerly used "water hole." An 8-inch gravity-flow line extends from the lake to a pumping station near the outskirts of town. From there the water is sent to the mill under pressure, and enroute some of the water is diverted to the Broken Bow municipal system. Industrial use of water at the mill has ranged from about 160,000 gpd in 1912 to about 200,000 gpd in 1955.

Prior to 1920 residents of Broken Bow depended upon wells or hauled water for domestic supplies. In 1920 the town authorized a bond issue of $175,000 for the construction of a waterworks and a sewage-disposal plant. The water system, begun in 1921 and completed in 1922, consists of settling basins, two filters, and chlorination equipment. The water is distributed from an underground storage tank and from an elevated storage tank, each of 50,000 gallons' capacity. Plant capacity is about 360,000 gpd and usage (1954) is about 250,000 gpd.

Idabel.—Idabel, county seat of McCurtain County, is situated on the divide between Little River and the Red River. Settlement began about 1903, but it was not until 1906 that Idabel was incorporated as a town in Indian Territory, with a population of about 500. The original governmental survey included 40 acres, which was called Mitchel and later changed to Idabel. The following year (1907) it was incorporated as a town in the State of Oklahoma.

From 1903 until 1910 Idabel depended upon private wells and water distribution in barrels for its water supply. In 1910, city ordinance no. 44 passed as a bond issue in which $44,000 was set up to build a water system owned exclusively by Idabel for "protection of property, health, and peace and safety." Water was to be piped from Little River about 2.5 miles north of town. The bond issue was to be paid from taxes levied on city property, with payments semiannually from March 1910 to March 1935. The contract let under this bond issue was for wooden mains, which did not prove entirely satisfactory. Therefore, in March 1912, an emergency bond issue was passed, in the amount of $35,000, which authorized improvements to the water system. In May 1916, another bond issue in the amount of $7,000 authorized extensions in the water system in the form of a reservoir and electrically powered pumps. The public sanitary-sewer system was constructed in 1919 with money from a bond issue in the amount of $70,000.

In 1920 the town of Idabel was changed to the city of Idabel. In 1925 a filter plant was installed. Two pumps powered by 40- and 60-hp. diesel engines, located at Little River, pumped water into the filter plant, where another pump powered by a 120-hp. Fairbanks-Morse diesel pumped the water into the city system. By 1950 the average pumpage of water had reached about 250,000 gpd. In 1950 the water system was brought up to date. The 40-hp. diesel engine was replaced by a 60-hp. diesel engine. This new engine is run constantly, which permits the old 60-hp. engine to remain idle for standby use. The 120-hp. diesel engine was replaced by an electric motor. The sewage-disposal system was also enlarged in 1950. From 1950 to 1954 the average use of water by Idabel has been about 400,000 gpd.

Wright City.—Wright City was founded in 1910 by the Choctaw Lumber Co. as a "company town" upon completion of the Texas, Oklahoma, & Eastern Railway. The town was first named Bismark, but during World War I the Teutonic name Bismark invoked resentment and the name was changed to Wright City in memory of a Mr. Wright who drowned in the torpedoing of the liner Tuscania.

The mill utilizes raw water from a deep hole in Little River, and the Choctaw Lumber Co. provides filtered water to the company-owned houses in Wright City. The population, about 400, has remained constant, and the municipal system has remained unchanged since 1910, the filter plant providing about 200 gpm. However, industrial use of water by the mill has increased from 160,000 gpd in 1910 to 300,000 gpd in 1955.

GROUND-WATER RESOURCES BY AREAS

Ground water in small amounts is available to wells in most parts of southern McCurtain County. The wells are widely distributed but many wells are likely to supply only enough water for rather restricted domestic use.

Well data collected in 1936 by the Works Progress Administration project known as the State Mineral Survey show that 1,627 wells had an average depth of about 30 feet and an average depth to water of about 25 feet. A large percentage of the wells are reported to decline in yield or to fail entirely during drought. The average well depth and depth to water indicate that the wells generally are dug only a few feet into a zone of saturation, and a decline of only a few feet in the water level is enough to cause them to go dry. More by accident than intent, wells completed in times of drought may go below the lowest level of the water table and so may not fail completely. Those completed in wet years, on the other hand, may not extend below the lowest level. Fortunately they generally can be deepened successfully.

The southern part of the county can be divided roughly into four areas based on the types of aquifers and the amount and dependability of wells tapping water in them (fig. 19). The broad band of alluvium along the north bank of Red River (Area A, fig. 19) is one such area. The alluvium ranges in thickness up to more than one hundred feet and it contains water under water-table conditions. The water table fluctuates from near the surface during wet weather to about 20 feet below the surface during dry periods. This aquifer has been developed for domestic uses but it also has possibilities for development as a source of irrigation water. Yields of several hundred gallons per minute with a maximum lift of less than 75 feet can be expected from wells constructed in the coarser sections of the alluvium. The quality of water in the alluvium is generally good but in some places it is contaminated with saline water that probably migrates upward from underlying bedrock.

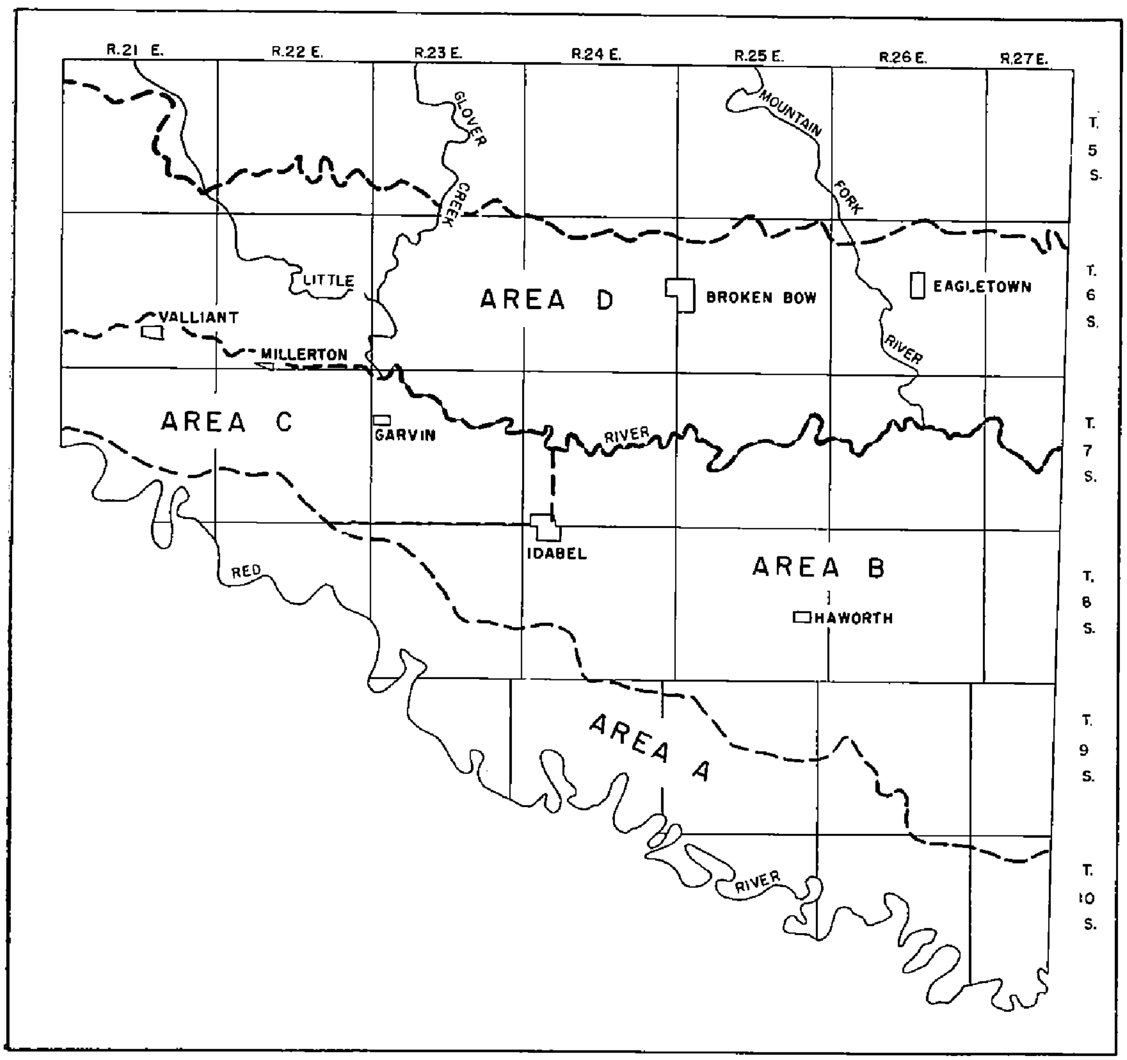


Fig. 19. Map showing ground-water areas of southern McCurtain County, Oklahoma.

Area B (fig. 19), the area north of the alluvium of the Red River and south of the outcrop of the Trinity group from Idabel, Oklahoma, east to the county line, and south of the latitude of

Idabel west of the town, is generally not very productive of ground water. Shallow wells in this area derive water in small quantities from poorly sorted terrace deposits, from thin sands, and from cracks and solution openings in limestone. The water table is close to the surface during wet periods but rapidly declines during dry periods. The quality of the water is suitable for domestic uses. The ground water is saline at depth.

That part of southern McCurtain County lying roughly north of the latitude of Idabel and extending west to the county line and south of the outcrop of the Trinity group (Area C, fig. 19) is similar in some respects to the area east of Idabel. Water-table wells have small yields and their water levels decline rapidly in dry weather. In this area the Trinity group is overlain by younger rocks and contains fresh water under artesian conditions. At low altitudes, wells drilled into the Trinity may flow at the surface. The artesian water is relatively undeveloped and is utilized only by municipalities and several small saw mills. The maximum yield of wells in the Trinity in this area is about 260 gpm but larger yields could be expected from better constructed wells. The aquifer is capable of yielding several millions of gallons of water per day and the quality is suitable for irrigation and most industrial uses.

In the area between the outcrop of the Goodland limestone and the northern extremity of the outcrop of the Trinity group (Area D, fig. 19) wells tap water under water-table conditions in the Trinity group and in the alluvium of Little River and its tributaries. The wells generally are less than 50 feet deep and yield only enough water for domestic use. Wells of larger yield could be constructed by drilling deeper into the Trinity group. The quality of water is fairly good in the alluvium and in the Trinity except in the southeastern portion of its outcrop where the Trinity contains highly saline water.

POTENTIAL DEVELOPMENT OF GROUND WATER

Ground-water resources in southern McCurtain County appear adequate for the needs of the various small municipalities and for rural, domestic, and farmstead requirements in the foreseeable future.

The quality of water pumped varies considerably throughout the area. In general, however, water having the best quality for municipal and industrial use is produced from the upper portion of the Paluxy sand in the fresh-water areas. This aquifer is undeveloped, except by municipal wells at Valliant, Garvin and Millerton, and the wells at Wheelock Indian Academy. Large areas adjacent to paved highways and railroads remain undeveloped. Water is obtainable at moderate depths, and yields in excess of 250 gpm may be expected.

The alluvium along the Red River is capable of yielding relatively large amounts of ground water. The water is suitable for irrigation, but it is hard and is reported to be highly mineralized locally. The physical conditions under which these sediments were deposited were such that great variation in the type and texture of the materials, both horizontally and vertically, is typical. Therefore, wells in the alluvium will differ widely in yield. However, where wells are completed in gravel layers in the alluvium, yields of several hundred gallons per minute should be obtainable.

Ground water in quantities sufficient for domestic and stock use is available at moderate depths throughout most of the area covered by this report.

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Appendix A

Logs of Wells and Test Holes in Southern McCurtain County

The following logs of wells in McCurtain County are from records of local water-well drillers, and from samples of drill cuttings from wells drilled for oil or water and test holes drilled during the program of investigation of the ground water in the county. When possible, the logs were interpreted by the author and formation names added in the appropriate places.

6S21E-29

Domestic water well, SW¼SW¼ sec. 29. Driller's log.

	Thickness (feet)	Depth (feet)
Clay, soft	8	8
Goodland limestone, white	30	38
Paluxy sand:		
Sand, yellow, soft	7	45
Clay, gray, soft	4	49
Gravel	1	50
Clay, yellow, soft	5	55
Clay, sandy	5	60
Sand, water-bearing	10	70

6S24E-14

Oklahoma State Forestry Service water well 1, NE¼ SE¼ sec. 14. Driller's log 0 to 34 feet. Sample log 34 to 134 feet.

	Thickness (feet)	Depth (feet)
Terrace sediment:		
Top soil	3	3
Gravel	10	13
Paluxy sand		
Shale, blue	17	30
Rock, hard	2	32
Shale, gray	2	34
Silt, light color, with some very fine, fine and medium quartz sand. Few fine gravels	4	38
Silt, light color, with very fine, fine, medium, coarse and very coarse sands. Some dark blue clay	2	40
Clay, blue with silt, very fine, fine, coarse and very coarse sand	6	46
Clay, blue, with fine and medium gravels	2	48
Fine gravels and gray clay mixed with some medium gravels and coarse sand in small amounts	2	50
Clay, varicolored (purple, yellow, blue) mixed with fine gravel, very coarse and coarse sands	5	55
Silt, gray and pink with some blue clay, fine and medium gravels and coarse sand	5	60
Silt, gray, with fine gravels, very coarse sand, and white calcareous clay	3	63
De Queen limestone:		
Calcite. milky white with some dark gray clay, fine gravel and very coarse sand	2	65
Silt and clay, dark and light gray with fine gravel, very coarse sand	9	74
Silt, light colored, calcareous with very coarse to coarse sands	8	82

Silt, red with gray clay, coarse sand	3	85
Silt and clay, mixed, green and red with little sand	5	90
Calcite, milky white with red and yellow silts and clays. Some coarse and very coarse sand	10	100
Mostly calcite, milky white with small amount coarse and very coarse sand	11	111
Holly Creek:		
Gravel, medium and fine with very coarse, coarse, and medium quartz sand, some calcite particles	7	118
Gravels, fine, with very coarse, coarse, and medium sands	2	120
Paleozoic (?):		
Sand, coarse, medium and fine	1	121
Sand, very coarse, with fine gravels, coarse, medium and fine sands and light-colored novaculite	6	127
Sand, very coarse, medium and fine with a little light green clay, and light-colored novaculite	7	134

7S21E-22

Test hole no. 1. NE¼NE¼NE¼ sec. 22. Sample log.

	Thickness (feet)	Depth (feet)
Woodbine formation:		
Soil	3	3
Clay, red, buff, gray	27	30
Washita group and Kiamichi formation, undifferentiated:		
Shale and limestone, gray, interbedded, 2 to 6 inches thick; limestone is very hard	5	35
Limestone, gray, hard, with thin clay breaks	25	60
Limestone, broken, with shale breaks	20	80
Limestone, hard	8	88
Shale	2	90
Shale and limestone, interbedded	5	95
Limestone, hard	3	98
Shale, soft	2	100
Shale, with thin lime streaks	5	105
Limestone, hard	3	108
Shale, hard	2	110
Shale, soft, black	5	115
Limestone, interbedded with shale and shells	5	120
Shale, blue, sticky	32	152
Limestone	3	155
Shale, limestone, shells, hard	10	165
Shale, soft	15	180
Shale, blue, soft, sticky	15	195
Shale, limestone, shells	15	210
Shale, blue	5	215
Limestone	10	225
Goodland limestone:		
Limestone, white	59	284
Paluxy sand:		
Clay, gray, some brownish streaks	12	296
Clay, reddish-brown and greenish-brown, maroon and gray	4	300
Clay, gray, some red-brown spots	3.5	303.5
Clay, dark-gray, with shell fragments	3.5	307
Sand, light-gray	11	318
Sand, light-gray, with some gray clay and brown clay chunks	4	322

A small amount of water was struck between 108 and 115 feet, in the Washita group, which after 24 hours rose to within 80 feet of land surface. The next water struck was between 313 and 322 feet in the Trinity group, which rose immediately to within 30 feet of land surface. On bailing test this well yielded 33 gpm with 23 feet of drawdown.

7S22E-28

Test hole no. 2, NW¼NE¼ sec. 28. Sample log.

	Thickness (feet	Depth (feet)
Woodbine formation:		
Clay, red, "waxey," with rounded novaculite pebbles and black manganese (?) streaks	8	8
Clay and sand, fine, yellowish-red-gray, interbedded sand and clay	8	16
Clay and sand, interbedded or mixed, yellow	4	20
Clay and sand as above, but gray	9	29
Washita group and Kiamichi formation, undifferentiated:		
Shale, blue-gray, clayey	11	40
Limestone, light-gray, fossiliferous, very hard	5	45
Limestone, dirty white (gray), crystalline, fossiliferous	6	51
Shells and shale, interbedded	1.5	52.5
Limestone, dirty white (gray), hard with small shale breaks	2.5	55
Limestone, dirty blue-white, hard, dense	1	56
Shale, blue-gray, with thin interbedded limestones	12	68
Shale, blue-gray, plastic, some dirty white limestones and shell fragments interbedded	6	74
Limestone, white, fossiliferous	2.5	76.5
Limestone and shale, light-gray limestone and blue-gray shale	3.5	80
Limestone and shale, white, fossiliferous limestone and blue-gray platy shale	5	85
Shale, blue-gray, with white crystals of calcite	5	90
Shale, blue-gray, black shale and some light-gray limestone with fossils and calcite crystals	4	94
Shale. dark-gray, micaceous, sandy clay with oyster shells	3	97
Shale, black, carbonaceous	3	100
Limestone, dirty white, soft, with some interbedded shale which contains numerous shell fragments	2.5	102.5
Shale, gray, with some light-gray limestone and numerous shell fragments	9.5	112
Shale, white and gray	3	115
Shale and limestone, black shale and dirty white fossiliferous limestone	3	118
Limestone, hard	1	119
Shale, dark	1	120
Shale, black carbonaceous, soft, with thin hard streaks; made just a smell of gas	7	127
Limestone, ranging from earthy to solid shell bed; hard drilling	2	129
Limestone, dirty-white, earthy, with interbedded shells	3	132
Limestone and shale, interbedded	3	135
Shale, black, carbonaceous	5	140
Shale, gray and black, interbedded with fossiliferous dirty white earthy limestone at base	21	161
Limestone, blue-gray, fossiliferous	2.5	163.5
Shale, black, carbonaceous	5.5	169
Limestone, gray, fossiliferous, interbedded with gray shale	3	172
Shale, black, carbonaceous	32	204
Shale, gray, and gray earthy interbedded lime	1	205

Shell bed	1.5	206.5
Shale, black	1	207.5
Limestone, with shells	4.5	212
Shale, dark	22	234
Goodland limestone:		
Limestone, white	6	240
Limestone, white, with fossil shells and black shale fragments	4	244
Limestone, white	4	248
Limestone, white, and some white calcareous clay marl	11	259
Limestone, white	3	262
Limestone, dirty white	31	293
Paluxy sand:		
Clay shale, green-to-red, very sticky	22	315
Shale, dark, sandy, interbedded with white, blue, and green clay	5.5	320.5
Sand, silty, with some clay streaks	4.5	325
No sample	5	330
Clay, silty, drilled to a light slush and would not settle	5	335
Shale. silty sand and clay, with a few hard streaks	16	351
Sand, buff, very silty	5	356

The only water encountered above the Trinity group was about ½ gpm, from the base of the Woodbine formation. The water in the Trinity formation was encountered at 335 feet and entered the bore hole with an audible noise; it rose to within 3.3 feet of the surface. The drawdown was 117 feet for 688 gallons (no bailing time given on log) and recovery was 25 feet in 30 minutes.

7S23E-23

Domestic water well. NW cor. sec. 23. Sample log.

	Thickness (feet)	Depth (feet)
Surface soil, black	4	4
Washita group including Kiamichi formation of Fredericksburg group:		
Limestone	1	5
Clay, yellow, with limestone shells	7	12
Clay, yellow, shell fragments	3	15
Clay, hard, blue, shell fragments	3	18
Clay, hard, blue	3	21
Clay, medium hard, blue	3	24
Limestone shell, yellow-to-blue	3	27
Limestone, gray, with clay lenses	3	30
Clay, soft, blue	3	33
Limestone, light- to dark-gray	3	36
Clay, soft, blue	3	39
Clay, hard, dark-gray	3	42
Clay, soft, gray	3	45
Clay, hard, dark-gray	3	48
Clay, gray	3	51
Clay, hard, gray	19	70
Limestone, medium-gray to tan, composed of shell fragments	10	80
Clay, medium-soft, blue	6	86
Clay, gray; abundant shell fragments	7	93
Clay, blue; some shell material	7	100
Limestone, gray-to-tan, composed of shell fragments	5	105

Fredericksburg group:		
Goodland limestone:		
Limestone, buff to white	6	111
Limestone, buff to white, oolitic	9	120
Limestone, buff to white, with shades of blue, oolitic	9	129
Limestone, blue-gray	3	132
Limestone, light to blue-gray	3	135
Limestone, gray to white	6	141
Limestone, light- to medium-gray	6	147
Limestone, light- to medium-gray, some pyrite	3	150
Limestone, light- to medium-gray	11	161
Trinity group:		
Clay, soft, dark-gray to black	1	164
Clay, soft, sandy, dark- to medium-gray	2	164
Sand, light- to medium-gray, very fine quartz grains, clear, fine, medium angular, well-sorted; pyrite particles	4	168
Clay, soft, brick-red with blue streaks	3	171
Clay, maroon and blue	6	177
Clay, sandy, red to brown; pyrite crystals	3	180
Clay, red, blue, brown	3	183
Shale, sandy, red, gray, black	2	185
Sand, incoherent quartz grains, fine, clear; water rose to 100-foot level	16	201

7S23E-30

H. F. Wilcox Oil & Gas Co. no. 1 Newman, SW¼SW¼SE¼ sec. 30. Sample log.

	Thickness (feet)	Depth (feet)
Samples start at		580
Trinity group:		
Paluxy sand:		
Sand, fine to medium, angular. white, loose (water sand)	30	610
No samples	30	640
Sand, shaly, brown	10	650
Shale, red	20	670
Sand, very fine to fine, white, loose (water sand)	30	700
Shale, red	30	730
Sand, medium, well-sorted, white, loose (water sand)	10	740
No samples	40	780
Sand, fine to medium, well-sorted, white, loose (water sand)	20	800
No samples	60	860
Sand, medium, well-sorted, white, loose; much carbonaceous matter (water sand)	20	880
No samples	10	890
Shale, gray; much fine pyrite and carbonaceous matter	20	910
Sand, medium, white, loose (water sand)	20	930
Shale, blue-gray	10	940
No samples	10	950
Sand, medium, well-sorted, white, loose (water sand)	25	975
Carbonaceous wood (peat?)	5	980
Carbonaceous wood (peat?), partly replaced by lime, some asphalt	10	990
No samples	10	1,000

De Queen limestone:		
Shale, gray, silty, gypsiferous	10	1,010
Sand, fine, silty, gypsiferous	35	1,045
Shale, gray, gypsiferous	15	1,060
Holly Creek formation:		
Shale, red, brown, gray	10	1,070
No samples	50	1,120
Sand, very fine to coarse, white (water sand)	5	1,125
Shale, gray; much pyrite	5	1,130
Shale, gray, gypsiferous, asphaltic	10	1,140
Gravel, yellow to brown, small to coarse	15	1,155
Sand, coarse, white, loose	5	1,160
Sand, medium, white, loose	10	1,170
Sand, fine to medium, white, loose, glauconitic	20	1,190
No samples	40	1,230
Sand, very fine, white, loose (water sand)	10	1,240
Sand, very fine to fine, slightly cemented with calcite	10	1,250
No samples	10	1,260
Silt, reddish-gray	10	1,270
No samples	5	1,275
Sand, coarse	5	1,280
Paleozoic strata:		
Sand, quartzitic, glauconitic, bluish-gray	30	1,310
No samples	40	1,350
Quartzite, much chert	19	1,369
Gravel, fine, red, stained with iron	6	1,375
Shale and sand, quartzitic, blue	5	1,380T.D.

7S23E-34

Test hole no. 3. 310 ft. east of NW cor. sec. 34.
Sample log.

	Thickness (feet)	Depth (feet)
Gulf series:		
Woodbine formation:		
Clay, yellow, silty and sandy	5	5
Clay, red, silty; tuff stringer at 7 ft.	5	10
Comanche series:		
Washita group including Kiamichi formation of Fredericksburg group:		
Limestone and shale, interbedded dirty white limestone and gray shale; some shell fragments	9	19
Limestone and shale, gray	2	21
Limestone, gray to white; gray clay stringer at 25 ft.; some shell fragments	5	26
Limestone, gray to brown, very fossiliferous; many echinoid spines	4	30
Limestone and shale, gray; interbedded shale is clayey	6	36
Limestone, hard, gray, with gray clay stringers	4	40
Limestone, gray, hard, fossiliferous	14	54
Limestone, gray, hard, fossiliferous; clay stringers	2	56
Limestone, soft, fossiliferous	2	58
Shale, blue-gray, soft	3	61
Limestone, hard, gray	2	63
Limestone and shale, hard, light-gray, fossiliferous limestone and shale in 3-inch stringers	2	65
Limestone, gray, very fossiliferous	4	69
Shale, silty, clayey, gray	9	78
Shale, gray-brown	5	83

Limestone, gray	2	85
Limestone, gray, fossiliferous	3	88
Shale, black	2	90
Shale, gray	2	92
Limestone, gray, soft, fossiliferous	20	112
Shale, dark-gray	20	132
Limestone, gray, fossiliferous	4	136
Shale, gray	6	142
Limestone and shale, gray	3	145
Shale, soft, gray	31	176
Limestone, very hard, fossiliferous	11	187
Shale, gray	9	196
Limestone, gray	2	198
Shale, gray	7	205
Limestone, hard, gray, fossiliferous; 1-ft. shale break at 209 ft.	7	212
Fredericksburg group:		
Goodland limestone:		
Limestone, very light gray to white, shell fragments and calcite crystals	64	276
Limestone, light-gray; gray clayey shale	3	279
Trinity group:		
Paluxy sand:		
Shale, brownish-gray; clay	3	282
Shale, brown; clay	8	290
Shale, gray, mottled-reddish-brown to greenish-brown, silty to clayey	38	328
Sand, brown to white, fine-grained; contains water	4	332
Sand, as above, but medium-grained to somewhat coarse	5	337

7S26E-20

Test hole no. 5, SE¼SE¼SE¼ sec. 20. Sample log.

	Thickness (feet	Depth (feet)
Woodbine formation:		
Clay, reddish-brown with light-gray streaks	5	5
Clay, red; clay stringers, brown, sandy, tuffaceous	5	10
Clay, reddish-brown and gray, with small pisolitic iron concretions, tuffaceous	5	15
Clay, brown and gray, with manganese streaks, tuffaceous	4	19
Clay, tuffaceous	1	20
Washita group and Kiamichi formation, undifferentiated:		
Limestone, light-gray, with shell fragments; some clay, light-gray, calcareous	5	25
Limestone, light-gray, with shell fragments	3	28
Limestone, gray, with clay stringers, blue-gray, and shell fragments	4	32
Shale, dark-gray, with limestone stringer, gray	3	35
Shale, dark-gray, clayey, calcareous	8	43
Shale, dark-gray, with shell fragments	4	47
Shale, as above, with thin limestone stringers	4	51
Limestone, gray, shell fragments; pyrite; clay stringer, gray, at 55 ft.	8	59
Shale, gray	3	62
Limestone, gray, with shell fragments	1.5	63.5
Shale, gray, clay	.5	64
Limestone and shale, each about 1 ft. thick, interbedded	6	70

Shale, dark-gray	10	80
Limestone, gray, hard, shell fragments, with 6-in. clay break in middle and many small iron concretions	5	85
Limestone, gray, very hard, breaks into fine pieces	2	87
Shale, dark-gray, shell fragments	3	90
Limestone, gray, shell fragments	10	100
Limestone, as above, with thin shale breaks	5	105
Shale, dark-gray with 1-ft. limestone stringer	5	110
Shale, dark-gray	19	129
Limestone, dark-gray, shell fragments	2	131
Shale, dark-gray	12	143
Limestone, gray, shell fragments	2	145
Limestone, gray, with shale stringers	6	151
Goodland limestone:		
Limestone, white and very light gray, shell fragments (excessive shale caving)	9	160
Limestone, light-gray (water at 165 ft.; 1.5 gpm bail-tested at 173 ft.)	13	173
Limestone, light-gray, shell fragments; some light-gray to white clay marl	7	180
Limestone, light-gray, with small black spots, some greenish-gray clay (cavings?)	3	183
Limestone, as above, with brown and maroon clay streaks (cavings?)	6	189
Limestone, light-gray, with shells	11	200
Shale, dark gray, clay	4	204
Shale, light-gray	9	213
Paluxy sand:		
Clay, greenish-gray, slightly silty	4	217
Clay, gray with reddish-brown streaks	6	223
Clay, bluish-gray, with brown and reddish-brown streaks, some sand	2	225
Clay, mottled, blue, gray, and reddish-brown	6	231
Clay, brown, with reddish-brown, gray, and green spots and some very fine sand	6	237
Clav and sand; clay is varicolored	7.5	244.5
Sandstone, very fine-grained, gray, soft	1	245.5
Clay, silty, buff	8.5	254
Coal (lignite)	1	255
Clay, silty	4	259
Sand, gray, fine	3	262

7S26E-25

McLendon no. 1 Perry. SE¼SW¼SE¼ sec. 25.
Sample log.

	Thickness (feet)	Depth (feet)
Samples start at		50
Woodbine formation:		
Shale, red, tuffaceous	80	130
Tuff, gray, micaceous, carbonaceous	10	140
Shale, red tuffaceous	10	150
Washita group and Kiamichi formation, undifferentiated:		
Lime, soft, pinkish	10	160
Shale, blue, soft, micaceous	10	170
Lime, gray, soft, fossiliferous	20	190
Shale, blue, soft, micaceous, fossiliferous	30	220
Goodland limestone:		
Limestone, earthy, chalky white, few fossils	10	230
Limestone, gray, in part oolitic	20	250
Limestone, gray; few fossils	10	260

Limestone, gray with pinkish cast, fossiliferous	25	285
Limestone and shale, gray, with asphalt stain	15	300
Limestone, gray, fossiliferous	15	315
Trinity group:		
Paluxy sand:		
Shale, sandy, greenish-gray, much glauconite	5	320
Shale, sandy, red and greenish-gray	25	345
Sand, medium to coarse, much pyrite	2	347
Shale, blue-gray, platy, micaceous	10	357
Sand, medium to very coarse, white, loose	13	370
Shale, blue-gray, platy, soft, micaceous	30	400
Sand, medium to large, clear, angular	15	415
Shale, blue-gray, platy, micaceous	5	420
Sand, brown, well-sorted, cemented in clusters by calcite, medium to very coarse, angular	20	440
Shale, blue-gray, micaceous, platy, soft	40	480
Shale, red, micaceous	20	500
Shale, blue-gray, micaceous, platy, soft	40	540
Shale, mottled, red, blue-gray, micaceous, platy, soft	20	560
Shale, blue-gray, micaceous, platy, soft	10	570
Shale, mottled, red, blue-gray, micaceous, platy, soft	20	590
Sand, limy, fine to medium, tight	10	600
Shale, red	10	610
Shale, brown	10	620
Shale, mottled, red and blue; many large flakes of mica	40	660
Shale, blue-gray	10	670
Shale, red	10	680
Shale, mottled, red, blue, brown	70	750
Shale, blue-gray, micaceous, soft	10	760
Shale, mottled, red, blue, brown	150	910
De Queen limestone:		
Limestone, gray, sugary	10	920
Shale, red and blue	20	940
Limestone, gray	20	960
Shale, red, purple	30	990
Limestone, gray	5	995
Shale, red, purple	10	1,005
Limestone, gray	5	1,010
Shale, red, purple; streaks of limestone	15	1,025
Gypsum	5	1,030
Anhydrite	5	1,035
Limestone, gray	5	1,040
Anhydrite and limestone	10	1,050
Shale, red, gray	20	1,070
Shale, gray	20	1,090
Shale, red, gray	15	1,105
Limestone, gray	10	1,115
Holly Creek formation:		
Shale, red, gray	130	1,245
Limestone, gray	5	1,255
Sand, medium, tight	115	1,370
Conglomerate, large loose gravel	20	1,390
Shale, green and black	10	1,400
Conglomerate, large loose gravel	10	1,410
Shale, gray	10	1,420
Conglomerate, large loose gravel	95	1,515
Paleozoic strata:		
Stanley(?) shale:		
Shale, bluish-black, hard	230	1,745T.D.

7S27E-29

Test hole no. 6. SW¼NW¼ sec. 29. Sample log.

	Thickness (feet	Depth (feet)
Woodbine formation:		
Clay and gravel and cobbles, red, silty, clay; quartz and novaculite gravels ranging in size from fine gravel to 7-in. cobbles scattered through the clay	10	10
Clay and gravel, red sticky clay and small pebbles	10	20
Clay, red, silty to sticky	4	24
Shale, red, hard, "soapy feeling," with lenses of softer gray-green shale and red silt which was not represented in samples	16	40
Shale, gray-green, clayey	2	42
Washita group and Kiamichi formation, undifferentiated:		
Shell bed, oyster shells cemented by hard, light-gray limestone. Woodbine formation caving badly	3	45
Shale and limestone, blue-gray shale and light-gray, hard limestone, interbedded	5	50
Limestone, light-gray, hard	4	54
Limestone, as above but harder with hard and soft streaks. Woodbine formation caved badly from 42-60 ft.	6	60
Shale, and limestone, interbedded blue-gray shale and light-gray, hard limestone	25.5	85.5
Limestone, blue, very hard	1	86.5
Limestone, bedded	1.5	88
Shale, blue	3	91
Limestone, bedded	6	97
Shale, blue	3	100
Limestone	1	101
Shale, blue	3	104
Limestone and shale, interbedded	2	106
Goodland formation:		
Limestone, white, "chalky"	19	125
Clay, white, calcareous	3	128
Limestone and clay, white, soft, "marl" and calcareous clay	14.5	142.5
Limestone, as above but harder	1.5	144
Limestone, gray-white	17	161
Paluxy sand:		
Shale, red, gray-green, black	8	169
Shale, pink, white, red, gray-green and black, clayey	4	173
Shale, as above but with scattered pebbles	1	174
Shale, sand. mottled clay shale with fine silty sand	5	179

No permeable materials were encountered below the base of the weathered zone. There is little chance of obtaining more than a gpm of fresh potable water in this area.

8S24E-32

Test hole no. 8, SW¼SW¼ sec. 32. Sample log.

	Thickness (feet)	Depth (feet)
Alluvium:		
Clay and silt, red to yellow, roughly gradational from top to base, mostly silt	7	7
Sand, brown and white (brown color probably due to limonite), fine- to medium-grained at top, coarser at base	30	37
Sand and gravel, brown and white; sand is generally quartz, gravel is partially arkosic, roughly gradational from coarse-grained sand at top to 0.75-in. pebbles at base	9	46
Sand and clay and gravel, clay-cemented gravel; sand may be cavings	1	47
Tokio formation:		
Shale, gray	8	55
Shale and cobbles, gray-blue shale, 4-in. yellow quartzite cobbles; cobbles apparently are scattered through the shale. Cobbles showed as cuttings 50 ft. below	5	60
Shale; blue-gray shale particles in washed cuttings resemble sand	25	85
Shale and sandstone, shale as above; sandstone is white, cemented, quartzitic	5	90
Shale, blue-gray, with occasional "hard streaks"	45	135

8S24E-34

Test hole no. 4, NE¼SE¼ sec. 34. Sample log.

	Thickness (feet)	Depth (feet)
Terrace deposits:		
Sand, red, with some clay and silt and sandstone pebbles	3	3
Clay, red and yellow, silty	17	20
Sand and gravel, gradational from fine silty sand in upper part to 1-in. gravel at base, but poorly sorted, with much silt and clay from top to base	15	35
Tokio formation:		
Shale, blue-gray, clayey	6	41
Sandstone, dirty white, hard	2	43
Shale, blue-gray, clayey	9	52
Sandstone, blue-gray and red, upper portion harder than lower portion; red sandstone may be from cavings	14	66
Shale, blue-gray, clay	9	75
Shale and sandstone, blue-gray clay shale, numerous brown and white hard sandstone stringers 1-12 in. thick	27	102
Woodbine formation:		
Shale and cobbles; shale as above forms matrix for 4-in. quartzite cobbles	8	110
Shale and sandstone, blue-gray shale with 2- to 12-in. gray to dirty white sandstone stringers; sandstones are tuffaceous	140	250
No sample. Hard zone but no hard cuttings; probably basal gravel of Woodbine formation	5	255
Washita group:		
Shale, blue-gray, darker than above, showing fossils indicative of Washita group	5	260

APPENDIX B

Stratigraphic Sections in
Choctaw and Southern McCurtain Counties, Oklahoma,
measured by Charles S. Fair, 1950

Township 5 South

1. Sec. 32, T. 5 S., R. 22 E. Cut on west side of section-line road in the NE¼.

Trinity group:

	Thickness (feet)
Sand, well-sorted, medium-grained, cross-bedded, white brown. Contains small nodules of highly oxidized indurated sandstone	11.0

2. Sec. 19, T. 6 S., R. 20 E. North side of U. S. Highway at crossing of Fort Towson quarry road, 1 mile east of Fort Towson, in Choctaw County.

Washita group, including Kiamichi formation of Fredericksburg group:

Limestone marl, alternating, brown; marl is thin and coquinoid	4.0
Limestone, alternating beds of dense hard blue less consolidated shell beds, fossiliferous; contains mainly *Gryphea*	6.9
Ironstone, red to pink, dense, fossiliferous; includes pelecypods and gastropods; marks break between Goodland and Washita group, including Kiamichi formation of Fredericksburg group	0.2

Goodland limestone:

Limestone, bluish-white, nonresistant	10.5
Limestone, grayish-white with brown tint, compact, irregularly bedded; weathers in nodular fragments, fossiliferous, includes gastropods and pelecypods	4.5

3. Sec. 14, T. 6 S., R. 21 E. Cut on east side of road in vicinity of SW cor.

Trinity group:

Clay, white, streaked with red ferruginous sand	3.0
Sand, reddish-brown, well-sorted, medium-grained, cross-bedded	2.0

4. Sec. 22, T. 6 S., R. 21 E. Cut on north side of main road leading from Valliant to Wright City.

Goodland limestone:

Limestone, irregularly bedded, light-gray. Dips one degree to the south	10.5

5. Sec. 26, T. 6 S., R. 21 E. Cut on north side of road in the NW cor.

Goodland limestone:

Limestone, white, fossiliferous	6.0

Trinity group:

Clay, bluish-gray, marly at top; contains nodules of sand	19.0
Clay, sandy, red	1.0

6. Sec. 26, T. 6 S., R. 21 E. Escarpment in field on north side of half-section-line road in NW¼.

Goodland limestone:

Limestone, dense, bluish-gray, fossiliferous, mostly pelecypods. Caps escarpment	1.0
Limestone, irregularly bedded, weathering out in knobby fragments, white with reddish tinge, fossiliferous; includes gastropods, echinoids, and pelecypods	10.5

7. Sec. 30, T. 6 S., R. 21 E. Bluff on north side of section-line road in the SE¼.

Goodland limestone:

Limestone, moderately hard, chalky, pale-orange, fossiliferous; includes gastropods, rudistids, pelecypods, and ammonites	2.0
Limestone, irregularly bedded, chalky; weathers in nodular or angular fragments, sparsely fossiliferous	16.5
Limestone, soft, marly, very light gray to bluish-gray	12.5

8. Sec. 34, T. 6 S., R. 22 E. Cut on east side of section-line road in the SW¼NW¼.

Goodland limestone:

Limestone, hard, bluish-gray; solution pits on surface; weathers in large, rectangular boulders	2.5
Limestone, white with brownish tinge; weathers in angular fragments, pea size to boulder size	25.0

Trinity group:

Clay, yellowish-brown, sandy in places	10.5

Township 7 South

9. Sec. 15, T. 7 S., R. 21 E. East bank of Garland Creek on north side of the section-line road.

Washita group:

Limestone, dense, brown, "rotted" weathered surface	1.7
Clay, brown, marly	1.9
Limestone, grayish-white, dense, fossiliferous	0.5
Clay, black	0.2
Limestone, white, fossiliferous	0.8
Clay, black	0.1
Limestone, bluish, dense; has pitted weathered surface, highly fossiliferous	0.7
Limestone, marly, brownish-white, nonresistant	3.0
Limestone, bluish-white, fossiliferous	1.8
Clay, black	0.2
Limestone, bluish-white with brown streaks on weathered surface, white on fresh surface, fossiliferous	1.0
Clay, black	0.6
Limestone, bluish-white, fossiliferous, exposed thickness	0.6

10. Sec. 14, T. 7 S., R. 23 E. Bluff overlooking Little River south of McCurtain Limestone Quarry.

Goodland limestone:

Limestone, compact, coarse, crystalline, light-orange; weathered surface, rough, sooty gray; has solution furrows, disseminated brownish-orange flakes; upper 5 ft. oolitic, fossiliferous; includes pelecypods, gastropods, ammonites	8.0
Limestone, chalky, white with blue or orange tint; fine crystalline black and orange-brown flakes disseminated throughout; weathers in small nodular fragments, solution furrows; sparsely fossiliferous	40.0

Trinity group:

Clay, sandy, reddish-brown and purplish-red	2.0

11. Sec. 29, T 7 S., R. 23 E. West bank of stream a few hundred yards north of section-line road in SW¼.

Quaternary deposits:

Gravel; contains tuffaceous sand pebbles; variable thickness; maximum thickness exposed	6.0

Woodbine formation:

Sand, tuffaceous, noncalcareous, cross-bedded, unconsolidated, jointed; most joints are vertical and contain a light-gray clay; weathers in irregular blocks due to jointing; contains red earth-clay masses up to 0.8 inch in diameter near the bottom of the bed	7.3
Clay, dark-gray with brown streaks, noncalcareous, jointed	0.6
Sand, tuffaceous, noncalcareous, jointed, similar to bed 8	0.5
Clay, dark-gray, exposed thickness	0.2
Sand, quartz grains, gray, poorly consolidated, exposed thickness	1.0
Ironstone, dense, brown	0.1

Washita group:

Limestone, hard, fossiliferous	1.5
Clay, light-brownish-gray, calcareous; fossil fragments included	0.8

12. Sec. 14, T. 7 S., R. 24 E. Bluff on east side of U. S. Highway 70 just south of the Little River bridge.

Goodland limestone:

Limestone, white, irregularly bedded

Trinity group:

Clay, very sandy, dark yellowish-orange	10.5
Limestone, marly, grayish-white, ledger former	0.6
Clay, weathers brown	2.5
Sandstone, light-brown, medium-grained, fairly sorted	0.5
Clay, sandy, yellowish-gray	0.5
Sand, grayish-orange to dark-yellowish-orange; contains angular chunks of clay and small nodules of well-consolidated sandstone, medium-grained, moderately well-sorted; distinct cross-bedding at top, obscure cross-bedding at bottom	23.5
Clay, impure, sandy, yellowish-brown with green streaks	4.5
Sandstone, compact, consolidated, light-brown	1.3
Clay, brownish-gray on fresh surface, brown on weathered surface	1.0

13. Sec. 20, T. 7 S., R. 27 E. Exposed along stream which empties into Little River here near middle of section.

Goodland limestone:

Limestone, dense, massive, grayish-white on fresh surface, sooty gray on weathered surface, fossiliferous; includes some rudistid pelecypods	10.0
Limestone, irregularly bedded, chalkier and less resistant than overlying bed, fresh color white, weathered color grayish-white	11.5

Township 8 South

14. Sec. 1, T. 8 S., R. 22 E. Cut on west side of section-line road in the NE¼NE¼.

Woodbine formation, sand member:

Sand, dark-red, gravel lenses; separated from bed 1 by an angular unconformity, poor sorting of sand grains, faint bedding parallel to gravel lenses; gravel poorly sorted, pebble sizes up to 1 inch in diameter; pebbles are mostly quartz and novaculite, with a ratio of about 20 quartz pebbles to one novaculite pebble	17.5
Sandstone, light-brown, silty; grains poorly sorted, angular, jointed; a light-gray argillaceous sand deposited along the joints, some gravel at base of bed, a few pebbles scattered throughout the bed	6.0

15. Sec. 1. T. 8 S., R. 23 E. Large stream ravine in the NE¼SW¼SW¼.

Quaternary deposits:

Gravel, irregularly bedded, intercalated with streaks of silty material	6.0
Clay, brown and gray, mottled	3.3

16. Sec. 10, T. 8 S., R. 23 E. Stream bed on south side of section-line road in the NE¼NE¼NW¼.

Woodbine formation:

Sand, tuffaceous	1.5
Sand, tuffaceous; contains pebbles; exposed thickness	0.5
Sand, tuffaceous, calcareous cement	2.0
Sand, tuffaceous; contains pebbles; distinct ledge former	1.0
Sand, tuffaceous	0.5

17. Sec. 11, T 8 S., R. 23 E. West bank of stream in the NE¼SW¼.

Quaternary deposits:

Gravel, caps bluff, maximum thickness exposed	4.0

Woodbine formation:

Sand, tuffaceous, noncalcareous	11.0

18. Sec. 11, T. 8 S., R. 23 E. Cut on south side of section-line road in the NE¼.

Late Quaternary deposits:

Colluvium, gravel-bearing	2.8

Woodbine formation:

Clay, purple-mottled, tuffaceous and stringers, most prevalent near top	10.8
Clay, whitish-gray, jointed, containing purple streaks	0.2

19. Sec. 15, T 8 S., R. 23 E. High, northwestward-facing bluff at the SE corner of the section.

Tokio formation:

Topsoil, light-brown, sandy	2.2
Sand, light-gray, argillaceous; contains iron-cemented sandstone particles and novaculite pebbles	8.2

Woodbine formation:

Clay, purplish-red, weathers in angular fragments	23.1
Clay, silty, reddish-brown, similar to bed 3	7.7
Clay, sandy, reddish-brown; contains pebbles of novaculite and tuffaceous sand; pebbles are concentrated in lower 2 feet of the bed, but are sparse throughout the lower 5 feet; sandy at top; contains light-bluish-gray streaks of clay	15.5
Clay, bluish-gray and brown, mottled; contains brown streaks which resemble tuffaceous material; top of bed appears to be an erosional surface	1.5
Sand, tuffaceous, greenish-brown, moderately coarse-grained, cross-bedded; contains thin films of black organic material	3.9

20. Sec. 7, T. 8 S., R. 26 E. Cut to north side of road, going up east side of hill in the SE¼NW¼.

Tokio formation:

Sand, fine, silty, brown with gray streaks and mottled effect, cross-bedded, slightly more resistant than underlying shales, lower part massive, upper part interbedded with thin gray and brown sandy shales	5.7
Clay, sandy, brown and light- to dark-gray interbedded; weathers in small thin shaly plates, some sandy layers hard, up to 0.2 foot in thickness	5.2
Sand, hard, thin, resistant, iron-cemented	0.2
Clay, silty, light-gray and brown, mottled; weathers in small, thin plates, becoming sandy and including petrified wood at top	9.5
Shale, interbedded with sandy shale, light-gray to red; sandy shales form small distinct ledges	4.3
Clay, light-gray, earthy, thin-bedded; contains brown and black streaks; upper 1.8 ft. sandy and irregularly bedded	7.0

21. Sec. 7, T. 8 S., R. 26 E. Cut on south side of road, going west up hill in the SE¼NW¼.

Quaternary deposits:

Soil and weathered material	4.0

Tokio formation:

Sand, indurated, resistant ledge former; weathers in thin plates	1.0
Sand, loose, brown with dark-red inclusions	2.0
Sand, silty, brown with gray streaks	1.6
Clay, light-gray, laminated, weathering in small shaly plates	5.2
Sand, silty, brown with some gray streaks and mottled effects	5.2

INDEX

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