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Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma

by

CHARLES W. WILSON, JR.,
Geologist of the United States Geological Survey

with a chapter on

Carboniferous Stratigraphy

by

NORMAN D. NEWELL,
Geologist of the Oklahoma Geological Survey

Prepared under cooperative arrangement between Oklahoma Geological Survey and the United States Geological Survey

Norman

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ERRATA

Page 6. Fourth line under Figure 3, "overlay" should read "overlap."

Page 14. Description under Figure 2, last line, the word "cuest" should be "cuesta."

Page 18. Last paragraph, second line, first word, should read "southwest" instead of "southeast."

Page 44. Line seven from top of page, should follow line one.

Page 55. In line eleven from top of page, the word "number" should read "member."

Page 64-65. Last line on page 64 should follow line 6 at top of page 65.

Page 102. Line 7, the words "composed of" should read "enclosed in."

Page 108. Sentence beginning in fourth line from bottom of page should read "The average daily production***."

Page 152. Well No. 4, under T. 15 N., R. 18 E., should be "NE NE NW."

Page 162. Measured section 21, "McAlester shale" should be inserted as heading above "Shale (M_4), between third and fourth lines of this section.

In the sixth line of section 21, "M_1a" should read "M_4a".

Page 163. Line 12, the thickness should read "1.5" instead of ".15".

Page 174. First line under section 54 at top of page, should read "Boggy-Savanna formations."

Page 182. Under section 79, sixth line below Brentwood limestone member, "Archimedes" should read "poorly preserved auloporoids."

Where the equivalent of the lower Hartshorne sandstone is shale, it is referred to the (A_8) division of the underlying Atoka, as on pages 170 and 178, measured sections 43 and 67.

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GEOLOGY OF THE MUSKOGEE-PORUM DISTRICT MUSKOGEE AND McINTOSH COUNTIES, OKLAHOMA*

ABSTRACT

This report describes the geography and geology of an area of about 560 square miles in Muskogee and McIntosh Counties, Oklahoma.

The consolidated rocks exposed at the surface are of Mississippian and Pennsylvanian age. The Mississippian rocks are represented only by a small exposure of the Pitkin limestone. The Pennsylvanian rocks, which cover practically the entire district, are divided into the Hale, Bloyd, Atoka, Hartshorne, McAlester, Savanna, and Boggy formations, and these are further divided into several members. Unconsolidated deposits, consisting of terrace sand and terrace gravel of Quaternary (?) age, rest unconformably upon the edges of the exposed Paleozoic strata in some places. Along Arkansas and Canadian Rivers are flood-plain silt and sand of late Quaternary (Recent) age. As a guide to subsurface work the rocks from pre-Cambrian to Mississippian encountered in wells are described briefly.

Collections of Pennsylvanian marine invertebrate fossils were made from the Atoka, McAlester, and Savanna formations. Faunal lists from these formations are included, and conclusions as to the correlation and age of these rocks are given.

The prevailing feature of the structure of this area is a regional dip of about 2° WSW., modified locally by differential uplift, or tilting, of crustal blocks whose longest dimension is in a west-southwest direction. The surface rocks are ruptured or sharply bent along the margins of the blocks by dip faults and associated monoclinal folds.

This area is a mature to late mature erosional plain with many cuestas and some hogbacks and buttes rising above the general level. The cuestas, hogbacks, and buttes, whose tops stand about 750 feet above sea level, are remnants of an upper level of erosion. The general plain forms an extensive level at about 550 feet above sea level. A third and lower level, at 500 feet, has been developd in the immediate valleys of the rivers and the larger creeks.

* Published by permission of the Director of the United States Geological Survey.

The coal beds that crop out in the district are too thin to be of other than local economic importance. The writer has correlated these beds with the Hartshorne, Stigler, and Secor coals of Coal, Atoka, Pittsburg, Latimer, Haskell and Le Flore Counties. The Stigler (or McAlester) and Secor coal seams are the best in this district and are now being mined at several localities. The distribution and thickness of the coal seams, the location of the outcrops, and the extent to which they have been prospected and mined are described for each township.

The district has been drilled for oil and gas since 1894. The history of development and production and the producing oil and gas sands of each field in the district are given. The Dutcher sands have been correlated with the lower sandstone members of the Atoka formation; the Booch sand with the Warner sandstone member of the McAlester shale; and the Bartlesville sand with the Bluejacket sandstone member of the Boggy formation. Practically no oil has been found south of T. 14 N. Small but profitable production of oil and gas is to be expected wherever the structure is favorable in Tps. 14 and 15 N. Profitable production of gas is to be expected in Tps. 10, 11, 12, and 13 N.

Some preliminary information on miscellaneous mineral resources was obtained during 1936 by a mineral survey, a Works Progress Administration project sponsored and supervised by the Oklahoma Geological Survey.

Sand and gravel occur in several deposits along the west bank of Arkansas River, and a good grade of building and plaster sand was found in the bed of Coody Creek, south of Muskogee. Limestone is not abundant, the thickest beds being found in restricted outcrops of the Pitkin and Morrow. Several thin beds occur in the Savanna and lower Boggy formations, which might be used as local sources of crushed stone, building stone and agricultural limestone.

Clay shale is well distributed over the district, and has been used for making brick and tile at Muskogee. Most of the sandstone members that crop out in the district are suitable for building stone, and have been extensively used.

The Muskogee-Porum district is moderately supplied with underground water, which is obtained from nearly all rock types, and in all formations, including river alluvium. A surprisingly large number of wells produce water from shale, with reported capacities equal to those of sandstone wells. Water supplies in many parts of the district can probably be augmented by drilling to deeper horizons.

INTRODUCTION

Scope and Purpose of Report. This report represents the results of a geologic survey of an area of about 560 square miles in Muskogee and McIntosh Counties, Oklahoma, in the former territory of the Creek and Cherokee Nations. (See fig. 1.) The pri-

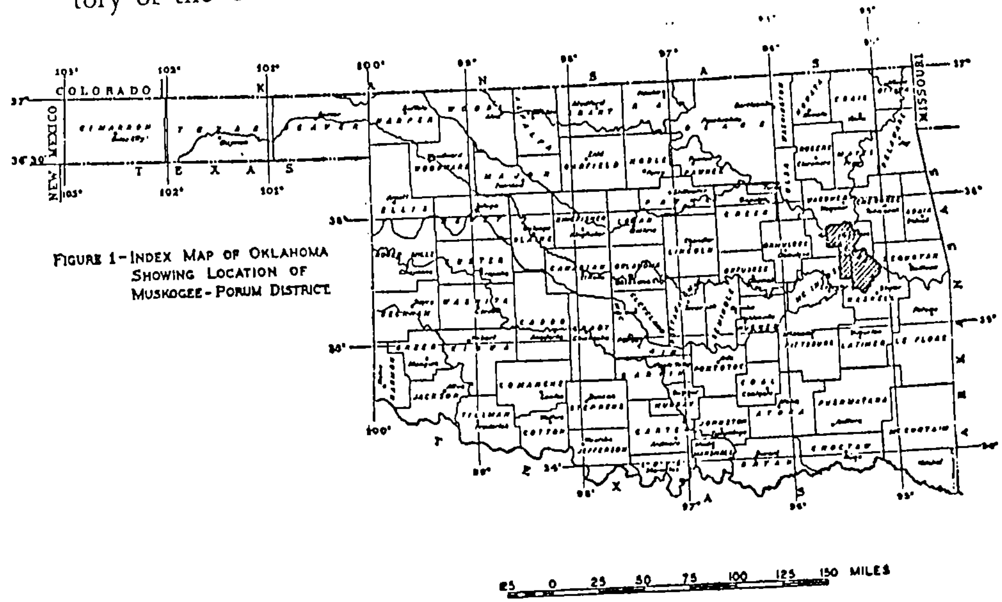


FIGURE 1-INDEX MAP OF OKLAHOMA SHOWING LOCATION OF MUSKOGEE-PORUM DISTRICT

mary purposes of the survey were: (1) to examine and map the mines and outcrops of the coal beds in order to make possible more accurate valuation of the coal resources of restricted Indian lands within the area, and more intelligent leasing of such Indian lands as are subject to mineral leases; (2) to trace the named formations of the Coalgate-Poteau region of southern Oklahoma northward and correlate them with the formations of northeastern Oklahoma; (3) to determine the age and correlation of several producing oil sands; (4) to map the structural features likely to be of interest in the development of the oil and gas resources of the area; and (5) to study fossils present in the various formations.

Location of the Area. The area described in this report includes most of Muskogee County, together with Tps. 11 and 12

N., R. 18 E., in McIntosh County. Most of the area is included in the Muskogee and Sansbois quadrangles, but the western halves of Tps. 14 and 15 N., R. 17 E., lie in the Okmulgee quadrangle.

Accessibility. The area is easily accessible by the St. Louis-San Francisco Railway, the Kansas, Oklahoma & Gulf Railway, the Missouri-Kansas-Texas Railroad, and the Midland Valley Railroad, which radiate north, west and south from Muskogee in the northern part of the area. The Midland Valley Railroad runs across the entire area, from Muskogee southward, through Keefeton, Warner, Porum, and Briartown.

The area can readily be entered from almost any direction by the main roads, U. S. Highway No. 64, from Tulsa to Muskogee, crosses the northern part of the area. It then runs southward from Muskogee to Warner, where it turns eastward, crosses Arkansas River at Webbers Falls, and continues to Sallisaw, Oklahoma, and Fort Smith, Arkansas. U. S. Highway No. 62 from Okmulgee joins U. S. Highway No. 64 a short distance west of Yahola, coincides with it to Muskogee, and thence runs northeastward to Tahlequah, Oklahoma and Fayetteville, Arkansas. U. S. Highway No. 69 crosses the area in a direction slightly east of north connecting Muskogee with McAlester to the southwest and Wagoner, Vinita, and Miami to the north. State Highway No. 2 follows the route of U. S. Highway No. 64 southward from Muskogee as far as Warner, from which place State Highways Nos. 2 and 10 continue jointly southward to Whitefield, at which place No. 10 turns east to Stigler, while No. 2 continues southward to Kinta and Wilburton.

The primary road system is supplemented by the many section-line roads, which give access by automobile to every section except a few in the more rugged parts.

Previous investigations. The earliest noteworthy reports on the geology of this general region were those of Drake[1] and Taff[2].

1. Drake, N. F., "A Geological Reconnaissance of the Coal Fields of the Indian Territory": *Am. Philos. Soc. Proc.* Vol 36, No. 156, 1897.
2. Taff, J. A., "The Southwestern Coal Field": *U. S. Geol. Survey* 22d *Ann. Rept.*, pt. 3, p. 373, 1902. "Progress of Coal Work in Indian Territory": *U. S. Geol. Survey* Bull. 260, pp. 382-401, 1905.

These reports dealt mainly with the producing coal districts to the south and were of a reconnaissance nature so far as the Muskogee-Porum district was concerned. Other reports, also of a reconnaissance nature but dealing primarily with the geology of Muskogee County, were made by Taff,[3] Taff and Shaler,[4] and Siebenthal[5]. Summary descriptions of the local coal resources[6] and of the oil and gas resources[7] have been published by the Oklahoma Geological Survey.

The most recent papers dealing with the area and rocks discussed in this report are by Wilson[8], Dane and Hendricks[9], and Hendricks, Dane and Knechtel.[10]

Papers dealing in part with the geology of Muskogee County have been published in the Research bulletins of the State University of Oklahoma and in the Bulletin of the American Association of Petroleum Geologists. Further reference to them will be made in the discussions of the special subjects with which they deal.

Present Investigation. The present investigation, which was a cooperative project of the United States Geological Survey and the Oklahoma Geological Survey, was undertaken during the summers of 1929 and 1930 as a continuation of the mapping done by W. T. Thom, Jr., in the Quinton-Stigler-Poteau area. The sandstone and shale members and coal beds of that area, which had

3. Taff, J. A., *U. S. Geol. Survey Geol. Atlas, Muscogee Folio* (No. 132), 1906.
4. Taff, J. A., and Shaler, M. K., "Notes on the geology of the Muscogee oil field, Indian Territory": *U. S. Geol. Survey Bull.* 260, pp. 441-445, 1905.
5. Siebenthal, C. E., "Mineral Resources of Northeastern Oklahoma": *U. S. Geol. Survey Bull.* 340, pp. 187-228, 1908.
6. Shannon, C. W., and Others, "Coal in Oklahoma": *Okla. Geol. Survey Bull*, 4, 1926.
7. Snider, L. C., "The Geology of East-Central Oklahoma with Special Reference to the Occurrence of Petroleum and Natural Gas": *Okla. Geol. Survey Bull.* 17, 1914.
Shannon, C. W., and Others, "Petroleum and Natural Gas in Oklahoma": *Okla. Geol. Survey Bull.* 19, *pt.* 2, pp. 331-339, 1917.
Soyster, H. B., and Taylor, T. C., "Oil and Gas in Oklahoma, Muskogee County": *Okla. Geol. Survey Bull.* 40, Vol. 3, pp. 377-398, 1930.
8. Wilson, C. W., Jr., "Age and Correlation of Pennsylvanian Surface Formations, and of Oil and Gas Sands of Muskogee County, Oklahoma": *Bull. Amer. Assoc. Petro. Geol.*, Vol. 19, pp. 503-521, 1935.
9. Dane, C. H. and Hendricks, T. A., "Correlation of the Bluejacket Sandstone, Oklahoma": *idem.* Vol. 20, pp. 312-314, 1936.
10. Hendricks, T. A., Dane, C. H. and Knechtel, M. M., "Stratigraphy of Arkansas-Oklahoma Coal Basin": *idem.* Vol. 20, pp. 1342-1356, 1936.

been mapped by Thom and correlated with the different members and coal beds of the formations in the McAlester district, were traced northward by the writer from Canadian River across the Muskogee-Porum district.

The mapping was done on a scale of 2 inches to the mile. Township plats surveyed by the General Land Office of the Department of the Interior in 1897 were transferred to plane-table sheets, which were used as base maps.

The method of mapping employed involved the making of traverses by pacing, by automobile speedometer and by plane table. The coal mines and the exposures of the coal beds were located by means of stadia traverses that were run from known section corners. Exposures of sandstone and shale were located by speedometer traverses where the section line roads were usable and by pace traverses elsewhere.

Acknowledgements. The writer takes this opportunity to acknowledge his indebtedness to W. T. Thom, Jr., H. D. Miser and T. A. Hendricks for advice and suggestions during the field work and the preparation of the report; likewise to acknowledge the cooperation and assistance of C. H. Dane, H. I. Smith, G. H. Girty, H. J. Duncan, G. I. Bystrom and Ira E. Lynch, of the United States Geological Survey; Chas. N. Gould, director of the Oklahoma Geological Survey at the time of the investigation; B. F. Howell, of Princeton University; and S. W. Lowman, A. H. Hanson, Frank C. Greene, Edward Bloesch, C. W. Sanders, Jr., Robert H. Dott, A. I. Levorsen, and others actively interested in the geology of eastern Oklahoma. Thomas L. Metcalf, of the Oklahoma Geological Survey, rendered efficient assistance in the field during the summers of 1929 and 1930.

GEOGRAPHY

Topographic Features. The maximum regional relief of the Muskogee-Porum district is about 500 feet, the altitude ranging from 1,000 feet above sea level in the Belle Starr Mountains, 2 miles west of Porum, and 850 feet in the Rattlesnake Mountains to 500 feet in the valleys of Arkansas and Canadian Rivers.

The prevailing topographic form is an undulating plain above which rise many cuestas, hogbacks, and buttes. The altitude of this plain averages close to 600 feet above sea level, except where it is broken by the higher prominences and by the lower wide valleys of Arkansas and Canadian Rivers and the larger creeks. From south to north across the area the belts of flat land between the cuestas become broader and the cuestas are lower; thus there is a change from a rolling, undulating surface to an open, featureless plain. This plain is remarkably well developed south of Muskogee.

The cuestas are characterized by steep faces, or escarpments, opposed by gentle back slopes that descend gradually from the crest of the cuesta to the level of the plain. The cuestas have a general north-northwest trend. Their escarpments commonly face northeastward, and the back slopes, which are practically dip slopes, descend southwestward. The greatest relief of a single escarpment is in the Belle Starr Mountains, where there is an abrupt drop of nearly 300 feet. Ordinarily the escarpments range between 50 feet and 250 feet in height, and most of them rise about 100 feet above the surface of the surrounding plain. In the northern part of the area, where the flat surface of the plain is less broken by escarpments and their relief is much less, the cuestas are less prominent features of the landscape.

The hogbacks are fewer than the cuestas and have much lower escarpments and shorter and steeper back slopes. This difference in shape and height is due to the greater dip of the resistant strata that hold up the hogbacks. The hogbacks are well illustrated by the ridges extending from sec. 22, T. 11 N., R. 19 E., northeastward to sec. 31, T. 12 N., R. 20 E., and by the ridges south of Spaniard Creek. The hogbacks strike east in some places and northeast in others, in contrast to the general north-northwest strike of the cuestas. The hogbacks parallel the major structural features of the area.

The buttes are small, flat-topped hills, preserved by a capping of horizontal massive sandstone. The most typical buttes found in the area are in T. 14 N., R. 17 E. Here they are about 2 miles away from the cuestas with which they once were connected.

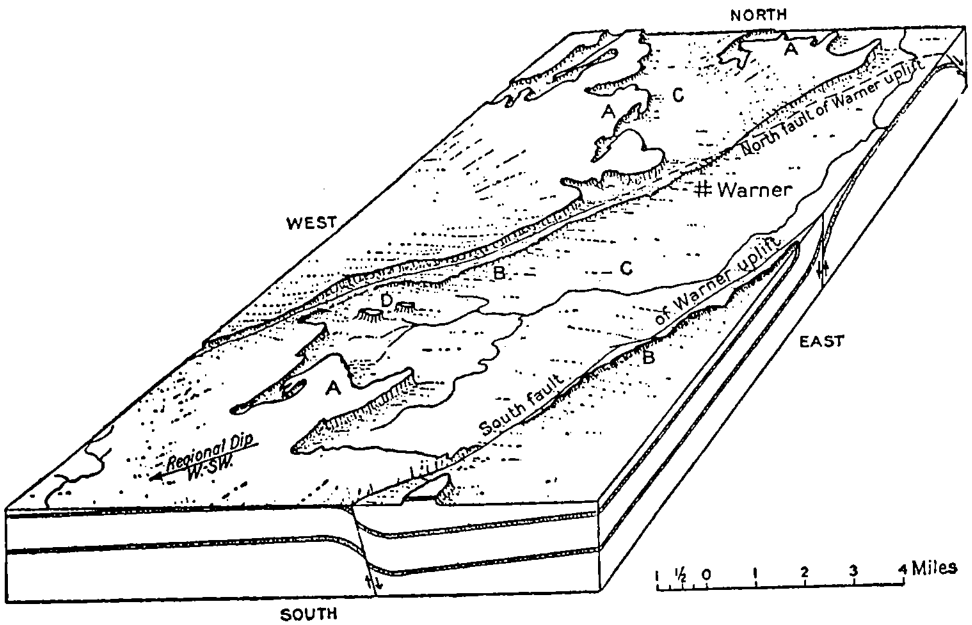


FIGURE 2. Block Diagram of Tps. 11 and 12 N., Rs. 18 and 19 E., showing relationship of topography to structure and lithology. A. Northeastward-facing cuestas, in general at right angles to regional dip. B. Hogbacks of resistent sandstone along monoclinal folds. C. Strike valley developed by erosion of shales. D. Buttes: erosion remnants separated by erosion from the cuest with which they were once connected.

The higher and more rugged cuestas are covered with timber, most of which is oak of moderate size. Among such timbered areas are the Rattlesnake Mountains, the Belle Starr Mountains, and the escarpments or bluffs, along Arkansas and Canadian Rivers. The plains, hogbacks, and buttes are commonly timberless.

Drainage. The Muskogee-Porum district is well drained by Arkansas and Canadian Rivers and their tributaries. Arkansas River, which is the larger of the two, flows across eastern Oklahoma in a general southeasterly direction and forms the northern and eastern boundaries of the area. The major tributaries of Arkansas River that either cross or have their source in the Muskogee-Porum district are Pecan Creek, Spaniard Creek, Dirty Creek,

Sam Creek, and Coody[11] Creek, the last two of which join before reaching the river. Dirty Creek has four tributaries in the area: Butler Creek, Timberleg Creek, Georges Fork, and South Fork.

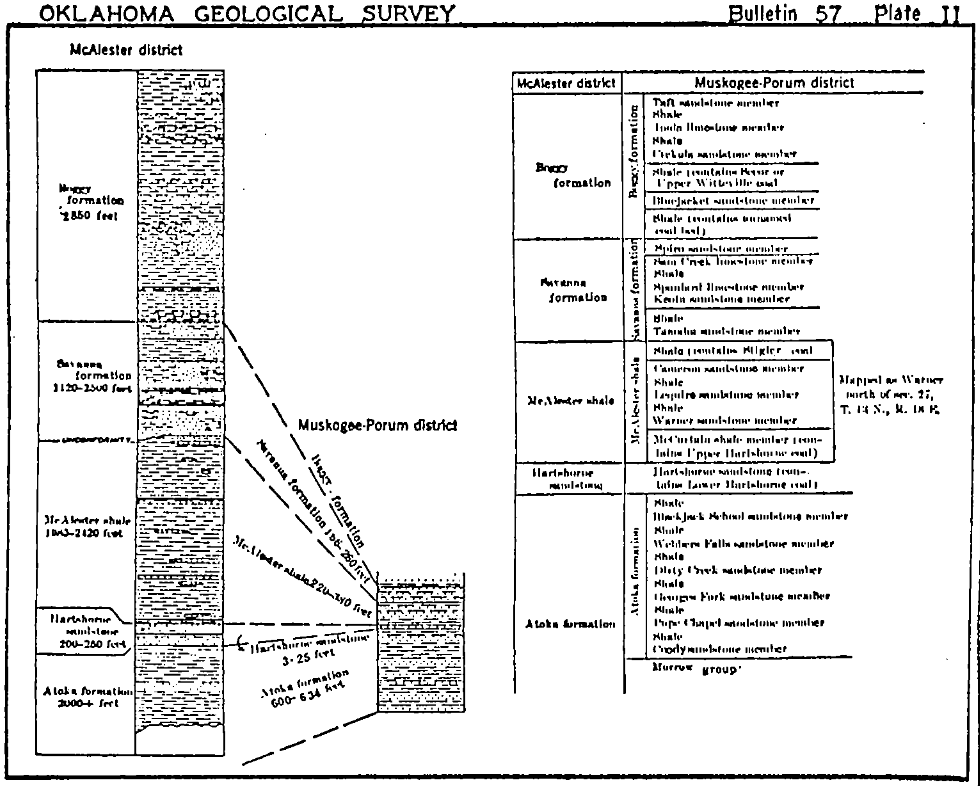
Canadian River, which forms the southern and southeastern boundaries of the area, flows east-northeastward across eastern Oklahoma and empties into Arkansas River in sec. 2, T. 11 N., R. 21 E. The major tributaries of Canadian River that assist in the drainage of the area are Possum Hollow Creek, Schoolhouse Creek, Belle Starr Creek, Duchess Creek, and Mud Creek, of which the last two join before reaching the river.

Surface stratigraphy

The Paleozoic rocks exposed in the Muskogee-Porum district belong, in ascending order, to the Pitkin limestone, of late Mississippian (Chester) age; and the Morrow group, Atoka formation, Hartshorne sandstone, McAlester shale, Savanna and Boggy formations, of lower Pennsylvania age. (Plate I). The Morrow, Atoka and Hartshorne have been commonly correlated with the Pottsville group of the Appalachian coal basin; and the McAlester, Savanna, and Boggy with the lower part of the Allegheny formation.[12] In a recent publication[13] it has been suggested that, on the basis of its flora, the Hartshorne should be correlated with the lower part of the Allegheny formation. The correlation with units of Pennsylvanian age mapped in the McAlester district is shown in Plate II.

The Atoka formation was named and described by Taff and Adams after a study of the type section at Atoka, Oklahoma. The Hartshorne sandstone, McAlester shale, and the Savanna and Boggy formations were named and described by Taff after a study of the type sections at Hartshorne, McAlester, and Savanna, in Pitts-

11. Spelled "Coata" on topographic map of the Muskogee quadrangle.
12. Gould, C. N., "Index to the Stratigraphy of Oklahoma": *Okla. Geol. Survey Bull.* 35, pp. 38-42, 1925.
13. Hendricks, T. A., and Read, C. B., "Correlations of Pennsylvanian Strata in Arkansas and Oklahoma Coal Fields": *Bull. Amer. Assoc. Petro. Geol.*, Vol. 18, p. 1056, 1934.



Columnar sections and table showing the correlation and northward convergence of the units of Pennsylvanian age mapped in the McAlester and Muskogee-Porum districts. The section in the McAlester district is from Hendricks, T. A., "Geology and Coal Resources of the McAlester District, Oklahoma": *U. S. Geol. Survey Bull.* 874, 1937.

burg County, and along Boggy Creek, in Atoka and Coal Counties. Taff[14] made no attempt to subdivide any of these formations into members.

As a result of the present investigation the writer has been able to correlate and map in detail the formations present in this area. Previously the McAlester, Savanna, and Boggy were regarded as constituting the succession of Carboniferous rocks in

14. Taff, J. A., and Adams, G. I., "Geology of the Eastern Choctaw Coal Field, Indian Territory": *U. S. Geol. Survey 21st Ann. Rept., pt* 2, p. 273, 1900.
Taff, J. A., "Geology of the McAlester-Lehigh Coal Field, Indian Territory": *U. S. Geol. Survey 19th Ann. Rept., pt.* 3, pp. 436-438, 1898.

the southern part of the area, which is included in the Sansbois quadrangle: and the Pitkin, Morrow, Winslow, and Boggy were regarded as constituting the succession in the northern part of the area, which is in the Muskogee quadrangle. The Savanna formation was shown as extending northward only to the west-central part of T. 12N., R. 19E. in the Sansbois quadrangle.

As a result of the present investigation the strata in the Sansbois quadrangle previously mapped as McAlester shale have been found to contain strata that represent not simply the McAlester shale but also the Atoka formation and Hartshorne sandstone. The Savanna formation was found to extend northward across the Muskogee-Porum district. The formations and the members recognized in this area are given in Plate III.

The remapping and subdivision of the Winslow formation of this area into the Atoka, Hartshorne, McAlester, Savanna, and basal portion of the Boggy, and the northward extension of the Savanna formation afford information as to the southern correlatives of the Cherokee shale.

Unconsolidated deposits of Quaternary (?) age rest unconformably upon the Carboniferous strata locally in the Muskogee-Porum district. These deposits include terrace sand deposits that occur within 5 miles of Canadian River and which probably may be correlated with the Gerty sand of the Coalgate, Stonewall and other quadrangles. Small exposures of terrace gravel deposits of unknown age, but probably of approximately the same age as the terrace sand deposits, occur at several localities. Flood-plain silt of late Quaternary (Recent) age extends along the flood plains of Arkansas and Canadian Rivers and their larger tributaries.

CARBONIFEROUS SYSTEM

by

NORMAN D. NEWELL

assisted in the field by A. H. Hanson

The rocks exposed in the Muskogee-Porum district should be of exceptional interest to all students of the Pennsylvanian series. The indurated rocks range from uppermost Mississippian (Chester) through the Morrow group to the middle part of the Boggy formation in the Pennsylvanian Des Moines group. The Des Moines sediments are particularly well exemplified near Muskogee and in the region to the west, comprising probably the finest section of fossiliferous marine sediments of this age in North America. Unquestionably the Des Moines rocks of northeastern Oklahoma, including the Muskogee-Porum district, deserve the consideration of stratigraphers as a possible standard section for comparison with equivalent rocks elsewhere.

The following table indicates the relative age and customary classification of the rocks in the Muskogee-Porum district. The relative rank accorded to units corresponds to the classification of the Carboniferous system adopted by the United States Geological Survey. Some other geological organizations regard the Pennsylvanian rocks as constituting a system of which the principal subdivisions, such as Des Moines, are series.

Viewed regionally the Muskogee-Porum district lies on the southeast slope of the Ozark uplift and on the north flank of the Ouachita geosyncline,[15] occurring geographically between two classic sections, the enormously thick section of the McAlester region in southeastern Oklahoma, and the partly equivalent Cherokee shale sections in southeastern Kansas. Naturally the sediments of the Muskogee-Porum district incorporate features of both the

15. Schuchert & Dunbar, "Text Book of Geology," Third Ed., Part II, pp. 124, 129, 176, 1933.

Many Oklahoma and Arkansas geologists prefer the term "Arkansas Valley Coal Basin" for the trough of Pennsylvanian sedimentation in east-central Oklahoma.

geosynclinal facies to the south and the stable platform facies to the north.

TABLE I.

GENERAL CLASSIFICATION OF ROCKS EXPOSED IN THE MUSKOGEE-PORUM DISTRICT.

Series	Group	Formation	Appalachian Equivalents
Pennsylvanian	Des Moines	Boggy Formation	Allegheny
		Savanna formation	
		McAlester shale	
		Hartshorne sandstone	
		Atoka formation	Pottsville
	Morrow	Bloyd formation Hale formation	
Mississippian	Chester	Pitkin limestone Fayetteville shale	Mississippian

The lower Des Moines section of the Muskogee-Porum district treated herein has a composite thickness at the outcrop of about 1,450 feet, thickening enormously to more than 10,000 feet in the McAlester region 40 miles to the southward, and thinning to less than 200 feet in southeastern Kansas, there comprising approximately the lower one-third of the Cherokee shale of Kansas. Not all the Muskogee section is represented in Kansas, however, as will be shown later.

The lower Des Moines section of the Muskogee-Porum district is noteworthy for its considerable thickness, large number of fossiliferous beds and relative freedom from recognizable stratigraphic breaks, being in these respects markedly superior to the equivalent beds in the Kansas Cherokee.

The stratigraphic section in the deeper part of the geosyncline near McAlester is vastly thicker, and therefore, presumably more complete than the equivalent section in the Muskogee-Porum district. However, the structural conditions are relatively much more complex in the McAlester region. The Pennsylvanian rocks of this area are described and mapped in detail, in Bulletin 874 of the United States Geological Survey.

The first critical study of the Des Moines stratigraphy of the Muskogee-Porum region was that of Charles W. Wilson, Jr.[16] and his excellent work furnishes the foundation on which the present chapter rests. The nomenclature employed here and the correlations of units with the divisions of the geosynclinal area to the south are essentially his. Without Wilson's detailed geological map, reproduced, with minor revisions, as Plate I of this report, this study would have been impossible.

During the present investigation a detailed study of the stratigraphic column was made in the belief that the Muskogee-Porum district may some day become classic, and the information obtained be of immediate use to petroleum geologists interested in eastern Oklahoma.

Acknowledgments. The field work on which this portion of the report rests was done during the summer of 1936, while the writer was in the employ of the Oklahoma Geological Survey. Invaluable assistance was rendered by the staff of the State Mineral Survey, a WPA project sponsored by the Oklahoma Geological Survey, and much of the credit for the results of this investigation belongs to A. H. Hanson, consulting geologist of Muskogee, and supervisor of the Mineral Survey in Muskogee County. His considerable knowledge of the geology of the Muskogee area and his untiring assistance in the field contributed very markedly to the success of this work. To the various members of the Mineral Survey who assisted in the field, sincere thanks are extended, and the courteous co-operation of Mr. Glenn R. V. Griffith, District supervisor of the Mineral Survey is especially acknowledged.

Dr. C. W. Wilson, Jr., made a special trip to Muskogee, and spent a very helpful day in the field, clarifying a number of questionable points. For this and his courteous attitude toward the present amplification of his previous work, the writer is extremely appreciative. Finally, gratitude is expressed to Mr. Robert H. Dott, Director of the Oklahoma Geological Survey, not only for fostering this work as a special project of that organization, but also for aid in the field and for continued interest in the development of the investigation.

16. Wilson, Charles W., Jr., "Age and Correlation of Pennsylvanian Surface Formations, and of Oil and Gas Sands of Muskogee County, Oklahoma": *Bull. Amer. Assoc. Petro. Geol.*, Vol. 19, pp. 503-520, 1935.

General Considerations. Unfortunately some of the member names employed in this report are none too well established. Several of the subdivisions of the McAlester and Savanna formations were named by Thom in unpublished work in the Quinton-Stigler-Poteau area, which is separated from the Muskogee-Porum district to the north by the valley of Canadian River. Definitions of these rock units based on descriptions at the type localities have never been published, and the adoption of these new terms in the Muskogee-Porum district is attended by the possibility of erroneous correlation or different usage across the valley of Canadian River. No work was done south of Canadian River during the course of the present investigation.

The stratigraphic thicknesses given here are considerably less than those given by Wilson, which are based largely on sub-surface records[17] taken from logs of wells drilled to the west of the outcrops. The stratigraphic section undergoes a marked northeastward convergence toward the Ozark uplift, so that, in general, most outcrop measurements, particularly in the Atoka formation, are distinctly less than well log measurements taken to the west of the outcrop area. Discrepancies in measurements of the Savanna and lower Boggy beds are not so marked, since these divisions crop out farther away from the flank of the Ozark uplift than underlying units.

It should be noted that the measured sections (Plate III) are incomplete in certain townships due to lack of outcrops in the areas involved. For example the middle and lower Atoka beds do not crop out in Tps. 10 and 11 N., and the Atoka subdivisions could not be recognized in the rather complete files of driller's logs available. Wilson's generalized sections[18] are subject to some revision in the light of the more complete data obtained during the present investigation.

17. Wilson, Charles W. Jr., Personal Communication.
18. Wilson, Charles W., Jr., *Idem.* pp. 505 and 514, 1935.

Mississippian Series

Rocks of Mississipian age underlie the entire Muskogee-Porum district but crop out only in a small area along the bluff of Arkansas River in secs. 28, 33, and 34, T. 13 N., R. 20 E. These outcrops comprise the Pitkin limestone, the youngest formation of Chester age. Instructive outcrops of the Pitkin are numerous in the area immediately east of the Muskogee-Porum district.

The Pitkin limestone consists of massive beds of crinoidal granular limestone interbedded with thin layers of dove-gray lithographic limestone, especially well developed at the base of the formation, and a few obscure partings of gray calcareous shale. In the region under discussion massive limestones of the Morrow group rest disconformably on the Pitkin. The Morrow limestones and their faunas are superficially so like the Pitkin that field identification of the Mississippian-Pennsylvanian boundary is commonly difficult.

Physical evidence for the unconformity which separates the Pitkin from the Morrow beds can generally be found in good outcrops and in this work the top of the Pitkin was identified by the irregular unconformable contact, rather than by fossils.

The full thickness of the beds classed here as Pitkin ranges from about 75 to 85 feet in the Muskogee-Porum district.

Pennsylvanian Series

Morrow Group

The heavy limestones of the Pitkin generally are overlain disconformably by similar massive limestones of the upper part of the Morrow group, less commonly by siltstone, sandstone or conglomerate of the lower Morrow division. The Morrow beds do not crop out widely in the area but are restricted to the Arkansas River bluff in secs. 28, 33, and 34, T. 13 N., R. 20 E. and in the area north and south of the northeast corner of T. 14 N., R. 19 E.

The Morrow section is well developed in the Muskogee area and is widely exposed in the Tahlequah quadrangle to the east.

Although these outcrops are not far from the type section in western Arkansas the beds appear to be variable, and so little work has been done on the Morrow group in northeastern Oklahoma that only a tentative correlation of the subdivisions is suggested, based chiefly on sequence.

A particularly well exposed section of the Morrow beds can be seen along State Highway 10 over the Braggs Mountain escarpment in sec. 29, T. 15 N., R. 20 E.

At this place the Morrow group is about 120 feet thick, of which the lower half is mainly limestone and the upper half shale. At the base of the section occurs 6 feet of conglomeratic sandstone, which because of its arenaceous character and position is tentatively classed with the Hale formation of the typical Morrow section. This basal conglomerate, resting disconformably on the Pitkin limestone, is overlain by 40 feet of massive crinoidal limestone containing *Pentremites.* This limestone seemingly has its counterpart in the Brentwood limestone member of the Bloyd shale of Arkansas. The heavy limestone is overlain by 68 feet of shale, in the midst of which is a 3-foot bed of hard bluish-gray limestone, lithologically like the Kessler limestone member of the Bloyd shale of the Arkansas type section.

The outcrops of the Morrow beds in T. 13 N., R. 20 E. are so unlike those just described that the two sections at present can be only tentatively correlated. The base of the Morrow is provisionally drawn at the base of 20 feet of interbedded unfossiliferous black shale and limy siltstone. These beds are underlain by 85 feet of light gray massive limestone of the Pitkin and display the first marked break in type of sediments above the base of the Pitkin.

The basal division of the Morrow group is overlain by 8 feet of cross-bedded oolitic limestone, which is followed by 20 feet of shale and sandstone. Collectively these beds are referred to the Hale formation because of their dominantly clastic character.

The next division recognized in this section consists of two 20-foot limestones, lithologically like the Brentwood, separated by

25 feet of shale. The two limestones and intervening shale are here correlated with the Brentwood member of the Bloyd shale. The upper 110 feet of the Morrow consist of shale with cross-bedded coquinoid limestone near the base, possibly equivalent to the Kessler member.

Because of the highly fossiliferous character and excellent exposures of the Morrow beds in northeastern Oklahoma these sediments deserve much more attention from stratigraphers than they have thus far received.

Des Moines Group

Only the lower units of the Des Moines group crop out in the Muskogee-Porum district, younger Des Moines beds being found to the west of the area in the direction of the regional homoclinal dip. Throughout northeastern Oklahoma these sediments consist chiefly of thick shales, relatively thin but resistent sandstone beds, and minor amounts of limestone.

Atoka Formation

The Atoka has been successfully subdivided by Wilson[19] into 12 divisions, all of which are recognized in the following treatment. In ascending order the divisions are: Coody sandstone member (Coata sandstone of Wilson), unnamed shale, Pope Chapel sandstone member, unnamed shale, Georges Fork sandstone member, unnamed shale, Dirty Creek sandstone member, unnamed shale, Webbers Falls sandstone member, unnamed shale, Blackjack School sandstone member, unnamed shale.

Outcrop measurements in the northeastern part of the area indicate a thickness of around 600 feet for the Atoka. Probably the formation is somewhat thicker in the subsurface, off the slopes of the Ozark uplift.

Broadly viewed the Atoka beds have certain characteristics that suggest depositional environment unlike that in which later beds were formed. Many of the sandstone beds, and most of the shales are relatively dark in color, ranging from black to olive-

19. Wilson, Charles W., Jr., *Op. cit.*, pp. 505-507, 1935.

gray. The sandstones in many instances are relatively fine-grained, and firmly cemented by calcium carbonate so that they are harder than ordinary sandstones. The greenish-gray or greenish-black of the unweathered sandstones is at least partly produced by ferrous iron oxide, although some of the black shales are undoubtedly carbonaceous.

The almost total absence of coal beds in the Atoka formation is noteworthy and not without historical significance. Apparently coal forming conditions did not prevail in the region as a whole until the close of Atoka time. Only one coal is known in the Atoka of the Muskogee-Porum district, and it occurs at the extreme top, immediately below the Hartshorne sandstone.

A number of fossiliferous horizons were noted in the Atoka sediments, and extensive collecting at these fossiliferous beds should yield a large fauna. No less than seven fossiliferous limestones occur at various horizons, and in addition several of the sandstones are fossiliferous.

A particularly characteristic element of the Atoka sandstone faunas is the abundance, at some horizons, of curious "worm" markings on bedding planes. These are closely similar to or identical with, the Devonian *Taonurus caudagalli* (Vanuxem). Inasmuch as these fossils are locally abundant in the Blackjack, Webbers Falls, Dirty Creek, Georges Fork, and other, unnamed, sandstones of the Atoka, but were not encountered in any other Pennsylvanian sandstones, *Taonurus* is regarded by the writer as reasonably diagnostic of the Atoka formation as compared with other Pennsylvanian sediments in Oklahoma and Kansas.

So far as present information indicates, the brachiopod genus *Mesolobus* does not occur in the Atoka, first appearing in collections from the Savanna formation, where it is represented by several specimens of *Mesolobus striatus* (Weller and McGehee).

Many opinions have been voiced regarding the correlation of Atoka beds with the classic section in Kansas, some individuals regarding the basal Cherokee of Kansas as being the equivalent to much or all of the Atoka, whereas other students have postulated a northward transgressive overlap of the Des Moines beds out of the Ouachita geosyncline at the base of the Atoka sediments. According to the latter theory the Atoka beds were probably never deposited as far north as the Kansas border but progressively drop out in that direction.

The Little Cabin sandstone member[20] near the base of the Cherokee shale produces a prominent escarpment across northeastern Oklahoma. In order to discover the Muskogee equivalent of the Little Cabin sandstone this bed was mapped southward from Vinita to Wagoner where its relation to certain key units can be recognized.

The Little Cabin sandstone was found to be, in all probability the same as the Warner sandstone member[21] of the middle McAlester, and certainly no older than the Hartshorne sandstone. The first persistent sandstone below the Little Cabin, in northeastern Oklahoma, is regarded as the upper bed of the Blackjack sandstone member[22] of the Atoka formation. Toward the north the Little Cabin, or Warner, converges gradually with the base of the Pennsylvanian until it approaches and is locally in contact with the top of the Mississippian in southeastern Kansas. (See Figure 3, p. 40). According to these data it is concluded that the Cherokee in Kansas includes no part of the Atoka, and probably does not contain beds older than middle McAlester. Much of the Atoka section wedges out toward the north with astonishing abruptness in the southern part of T. 18 N., R. 18 E., and as nearly as could be determined, only the uppermost members (Blackjack sandstone and younger) extend to the northward. These units exhibit relatively slight wedging or variation, and finally are overlapped, near the Kansas Boundary, by the conformable shale below the Little Cabin sandstone.

20. Cooper, C. L., "The Correlation of Coals in Oklahoma and Kansas". *Proc. Okla. Acad. Sci.*, Vol. 7, p. 161, 1927.

Weidman, S., "The Miami-Picher Zinc-Lead District, Oklahoma", *Okla. Geol. Survey Bull.* 56, p. 23-24, 1932.

21. Wilson, Charles W., Jr., *op. cit.*, p. 508, 1935.

22. *Idem.*, p. 506, 1935.

Coody sandstone member and overlying shale[23]. The basal division of the Atoka formation is a massive, buff sandstone, locally conglomeratic, called the Coody sandstone member. This sandstone is clearly unconformable with the underlying Morrow group as evidenced by the irregular contact between the two divisions and by the northward overlap of the Coody on successively lower parts of the Morrow group.

The Coody sandstone is especially noteworthy for the marked development, at least locally, of chert pebbles, and coarse, gritty quartz sand. Marine fossils, especially mollusks, are relatively common in the unit although they are invariably molds and ordinarily are not well preserved. Most noteworthy is an excellent cephalopod fauna which occurs at this horizon south of Fort Gibson and southeast of Muskogee in T. 15 N., R. 20 E. The fossils were collected by Prof. C. L. Foster of Bacone College and identified by A. K. Miller at the University of Iowa. Dr. Miller comments on the similarity of these cephalopods to forms found in the lower Atoka near Clarita, Oklahoma, in the Ada region:

> There is nothing particularly diagnostic in the collection, but the abundant ammonoids contained are strikingly similar to specimens of *Gastrioceras* from the vicinity of Ada and there is no good reason to doubt that these two faunas are closely similar in age. . . . It (the Muskogee collection) contains a representative of *Pronorites* that apparently is conspecific with the Ada representative of that genus. Still, in the Coody collection there are several nautiloid genera, *Solenochilus*, *Domatoceras*, *Metacoceras*, and probably *Endolobus*, which, insofar as I am aware, have not been found in the Atoka of the Ada region. All in all, then, I would say that whereas the Coody fauna is probably not greatly different in age from that of the goniatite-bearing beds of the Atoka of Ada and vicinity, it would be difficult from the material I am studying to point out very conclusive evidence for the correlation of these two horizons.[24]

23. *Idem.*, p. 507. This unit was named from a stream one mile south of Muskogee, incorrectly designated "Coata Creek" on the topographic map of the Muskogee quadrangle. Correction in spelling to "Coody" to conform to local usage, is made herewith.

24. Miller, A. K., letter of July 16, 1936.

Unlike some of the other Atoka sandstones the Coody is ordinarily a friable, although massive, sandstone, ranging in thickness from about 15 feet to an observed maximum of about 115 feet. The division is not invariably a compact unit as evidenced by a thin, ferruginous limestone and thin shale partings in the sequence in sec. 1, T. 14 N., R. 19 E.

The shale (A_1)[25] immediately above the Coody sandstone is ordinarily dark gray or greenish-gray flaky unfossiliferous shale. Ordinarily it contains no resistent beds, but a thin sandstone was observed near the middle in sec. 33, T. 13 N., R. 20 E. The measured thickness ranges from 35 to 72 feet.

Pope Chapel sandstone member and overlying shale[26]. The Pope Chapel sandstone member is characteristically a hard, calcareous, greenish-gray, to buff sandstone. Locally it is cross-bedded, and rarely it contains molds of pelecypods, and *Spirifer occidentalis.* It ranges in thickness from 10 to 20 feet.

The shale (A_2) above the Pope Chapel sandstone is highly variable in lithologic character and in thickness. For example near Pope Chapel school in sec. 23, T. 12 N., R. 19 E., the unit is chiefly black flaky carbonaceous shale grading upward to greenish argillaceous shale with clay-ironstone concretions. The entire division measures 85 feet at this place. In sec. 8, T. 12 N., R. 20 E., the lower half contains thin beds of olive-colored siltstone in gray sandy shale, and at least one thin bed of limestone. The upper half consists of olive-colored argillaceous shale containing limonite concretions. The unit (A_2) is well exposed in road cuts along the north line of sec. 1, T. 14 N., R. 19 E., where it consists of argillaceous shale with a thin calcareous sandstone above the middle, and thin, fossiliferous limestone (A_2a) and calcareous shale near the top. In this section the whole shale unit is about 65 feet thick.

25. Such designations are used throughout this and subsequent discussions to refer to unnamed units described in measured sections (Appendix B), and figured in graphic sections (Plate III).
26. Wilson, Charles W., Jr., *op. cit.*, p. 507.

Well logs to the west of outcrops show a common thickness of about 100 feet for the shale, indicating the general thickening of Atoka sediments away from the flanks of the Ozark uplift.

Georges Fork sandstone member and overlying shale[27]. Ordinarily the Georges Fork sandstone member is a hard calcareous greenish-gray to black, unfossiliferous sandstone having a thickness of 3 to 5 feet. A maximum thickness of 15 feet was measured in sec. 7, T. 14 N., R. 20 E., on the east bluff of Arkansas River, with bottom and top contacts well shown. In sec. 1, T. 14 N., R. 19 E., and surrounding area the Georges Fork is reddish-brown, cross-bedded sandstone, 15 feet thick, and much more massive than in the southern outcrops.

The shale (A_3) above the Georges Fork sandstone appears to be highly irregular in character and thickness in outcrops. An excellent exposure of the unit occurs along the west line of sec. 13, T. 12 N., R. 19 E., where it consists of 100 feet of olive-colored argillaceous shale with limonite concretions, and contains a very thin sandstone at the middle. The unit (A_3) is similar in sec. 7, T. 14 N., R. 20 E., except that a slabby, granular, bluish limestone, 9 inches thick, occurs near the middle, while at the NW cor. sec. 3, T. 14 N., R. 19 E., a white, fine-grained limestone (A_3a) 3 feet thick, occurs at the top. This surprisingly thick and pure limestone may be equivalent to the slabby limestone found in sec. 7, T. 14 N., R. 20 E., in which event, the upper half of the unit has thinned to almost nothing in sec. 3, T. 14 N., R. 19 E., where the interval between the Georges Fork and Dirty Creek sandstones is not over 52 feet.

Dirty Creek sandstone member and overlying shale.[28] The Dirty Creek sandstone member exhibits certain changes from south to north across the Muskogee-Porum district. In T. 12 N., R. 20 E., and T. 13 N., R. 20 E. the unit is black to greenish-buff in color. The sandstone is invariably filled with markings like *Taonurus caudagalli*, so that the division is particularly distinctive. The

27. *Idem.*
28. *Idem.*

fossil worm borings are absent from the unit, at least locally in T. 14 N., R. 20 E., but other fossils, chiefly a species of *Juresania,* occur in calcareous layers in the sandstone. In this area the Dirty Creek sandstone attains a thickness of 15 feet. The sandstone is relatively thin in T. 14 N., R. 19 E., ranging from 3 to 8 feet, and is buff, calcareous, and unfossiliferous.

The overlying shale (A_4) is relatively uniform, having a thickness of from 22 to 30 feet, as determined by measurements taken in T. 12 N., R. 20 E.; T. 13 N., R. 20 E.; T. 14 N., R. 19 E., and T. 14 N., R. 20 E. The shale is greenish-gray, argillaceous, and contains limonite concretions. The section exposed in the central part of sec. 19, T. 13 N., R. 20 E., is uncommon in that a local reddish, fossiliferous limestone, 1.5 feet thick (A_4a) occurs 14 feet below the Webbers Falls sandstone. The base of the shale is not exposed in this locality.

Webbers Falls sandstone member and overlying shale.[29] Without question the Webbers Falls sandstone member is lithologically the most uniform and distinctive unit in the Atoka formation. The correlation of the lower Cherokee units in northeastern Oklahoma and southeastern Kansas rests on the high degree of certainty with which the Webbers Falls sandstone can be identified as far north as the latitude of Wagoner.

Originally described as a sandstone, the Webbers Falls is more accurately classed as a siltstone, having peculiar characteristics. Ordinarily the rock is dark green to black where unweathered, changing to gray or grayish-buff on exposure. Generally the individual layers are relatively thin and weather into small angular fragments and blocks which have a striking resemblance to deeply weathered chert. In fact such fragments are highly siliceous. The fresh rock also appears siliceous, but to a lesser degree, and is commonly so highly calcareous and carbonaceous that it might well be termed a carbonaceous, silty limestone. In the more calcareous phases, poorly preserved marine fossils: crinoid stems, brachiopods and pelecypods are relatively common. The Webbers Falls locally contains irregular trails and the more regular type of boring classed as *Taonurus,* but these fossils are commonly absent.

29. Wilson, Charles W., Jr., *op. cit.*

The Webbers Falls differs from other black or green sandstone divisions in the Atoka chiefly in the characteristically fine texture and curious mode of weathering. A bed much higher in the Atoka (A_6b), may locally be confused with the Webbers Falls member, but generally the former is a comparatively thin and pure limestone. Locally, however, because of its carbonaceous character, it superficially resembles the Webbers Falls.

The Webbers Falls sandstone is so distinctive throughout the Muskogee-Porum district that its identification in the little known region to the north, across the valley of Arkansas River, seems fairly certain. The outcrops in the bed of Verdigris River beneath the bridge at Okay (Rex bridge) northeast of Muskogee appear to belong to the Webbers Falls member, and the thin, highly fossiliferous limestone at that place occurs in the A_6 shale just above the Webbers Falls. The Webbers Falls division was noted at a number of places between Okay and the area east of Wagoner and is in every respect typical throughout the outcrop.

The unit was not seen northeast of Wagoner in the north part of T. 18 N., R. 19 E., and is apparently cut out by overlap, as suggested by the following evidence: The fact that the first sandstone above the Webbers Falls, presumably some part of the Blackjack sandstone sequence, converges markedly with the Webbers Falls to the northward across Tps. 16 and 17 N. In sec. 6, T. 17 N., R. 19 E. the Blackjack (?) sandstone member is very conglomeratic, filled with chert pebbles, and lies but 5 feet above the Webbers Falls sandstone. The Webbers Falls and all the underlying Atoka disappear a short distance to the northward, whereas the Blackjack (?) sandstone continues at least as far as Vinita, where it rests directly on Chester beds. The first prominent sandstone above this Blackjack (?) sandstone in northeastern Oklahoma, is the Little Cabin sandstone, correlated here with the Warner sandstone member of the McAlester shale.

The Webbers Falls sandstone ranges in thickness from about 10 to 15 feet in several widely scattered measurements.

The dominantly shale section above the Webbers Falls contains several units which are relatively persistent. At the base occurs a bed of relatively dark, silty, to argillaceous shale ranging from about 10 to 25 feet thick. It is overlain by an olive to gray sandstone ranging from 3 to 10 feet in T. 14 N., Rs. 19 and 20 E., where these beds are best exposed. Next in succession occur 20 to 30 feet of gray shale overlain by a persistent black sandstone 10 to 20 feet thick. This sandstone contains irregular worm trails and may be locally confused with the Webbers Falls division, but is much coarser than the latter.

Throughout the outcrop area in T. 14 N., R. 19 E. there are two persistent limestone beds in the shales above the previously mentioned black sandstone. The lower of these, (A_6a), is a thin, ferruginous, sparsely fossiliferous bed of about 3 inches, occurring some 8 to 20 feet above the black sandstone. The second limestone (A_6b), lying 10 to 25 feet above the lower one, is relatively prominent and was recognized in T. 14 N., R. 20 E., as well as several places in T. 14 N., R. 19 E. This division generally consists of two limestones and an intervening thin, calcareous shale. The lower bed varies from pure, fine-grained, gray limestone, to massive, black, carbonaceous limestone, having a thickness of 2 to 4 feet. The upper bed is commonly a thin, crinoidal, ferruginous limestone of only a few inches, but locally, as in sec. 14, T. 14 N., R. 19 E., is a 2-foot carbonaceous, silty limestone. The shales below and above the A_6a limestone are generally black, carbonaceous, and silty.

The upper unit in this shale succession (A_6), best developed in T. 14 N., Rs. 19 and 20 E., is an argillaceous, gray shale about 85 feet thick. Ordinarily the shale is uninterrupted by sandstones, but thin sandstones, a few inches thick, may be observed locally.

The description above, drawn chiefly from abundant observation in T. 14 N., Rs. 19 and 20 E., does not apply to the few rather unsatisfactory outcrops in T. 13 N., Rs. 19 and 20 E. In

this area the interval between the Webbers Falls and the Blackjack School member amounts to 100 feet or less, as compared with a total of about 190 feet in the area to the north. Limestones were not observed in any part of the unit in T. 13 N. and the section is interrupted by a few erratic beds of olive and buff sandstone.

Blackjack School sandstone member and overlying shale.[30] Results of the present investigation indicate that the Blackjack division contains several relatively thin sandstones separated by prominent shales, rather than constituting a single, heavy bed of sandstone, as indicated by Wilson. Blackjack School, at the type locality in sec. 9, T. 11 N., R. 19 E., is built on prominent, scarp-forming, relatively thin-bedded sandstone, 9 feet thick, but another, equally prominent sandstone occurs 15 feet below.

Because of the impossibility of tracing individual sandstone beds in this part of the section it is proposed here to redefine "Blackjack," applying the name to the successions of sandstones and shales midway between the Webbers Falls sandstone and the Hartshorne sandstone.

The Blackjack School succession consists of three to four erratic buff or greenish sandstones separated by dark gray silty shale, measuring in aggregate from 60 to 85 feet. The individual sandstones are commonly no more than 2 feet thick, but range up to a maximum of about 10 feet. In T. 14 N., R. 19 E. the second sandstone below the top is filled with a *Taonurus* like *caudagalli*, but this fossil appears to be rare or absent in the Blackjack farther south.

Throughout the Muskogee-Porum area the Warner sandstone member of the McAlester shale, is one of the most conspicuous units, and the next prominent sandstone below it normally is the Hartshorne. At the latitude of Muskogee the Hartshorne sandstone is either absent, or so obscure that it was not recognizable in an area of extensive Quaternary deposits. Presumably the first conspicuous sandstone below the Warner in this area is part of the Blackjack School member.

30. Wilson, Charles W., Jr., *op. cit.*, p. 506, 1935.

North of Okay, on the north side of Verdigris River, two scarp-forming sandstones occur above the characteristic Webbers Falls sandstone. The upper of these two is believed to be the Warner sandstone, because of its general position and lithologic similarity to the typical Warner sandstone, and the lower one must therefore be either Hartshorne or some part of the Blackjack sequence. The latter correlation is most tenable because of the apparent absence of the Hartshorne, and presence of the Blackjack east of Muskogee along Arkansas River.

North of Okay the Blackjack (?) unit occurs some scores of feet above the Webbers Falls sandstone. Farther north, however, the two divisions converge rather abruptly, but uniformly, until they are separated by only 5 feet of shale in sec. 6, T. 17 N., R. 19 E. Still farther north the Webbers Falls sandstone and all underlying Des Moines beds are missing, due apparently to overlap by the Blackjack (?). The latter unit makes a distinct escarpment at least as far north as the area east of Vinita, generally resting directly on Mississippian shales. At a highway cut 3 miles east of Vinita the basal sandstone of the Cherokee is about 4 feet thick and is filled with *Taonurus*. This fossil was not seen in undoubted Hartshorne, but is common in the upper part of the Blackjack. Presumably this basal sandstone near Vinita is part of the Blackjack. The sandstone at this place rests on a thin coal bed, and if this sandstone is truly the Blackjack, the coal is probably the oldest Des Moines coal in the region, since the oldest coal in the Muskogee-Porum district occurs at the base of the Hartshorne sandstone. The Blackjack (?) bed apparently drops out northeast of Vinita, and is probably overlapped by overlying shales.

A relatively thick shale (A_0) occurs at the top of the Atoka formation, lying between the Blackjack and Hartshorne sandstones. So far as known it contains no limestone nor prominent sandstone beds, but consists of gray, sandy to argillaceous shale, containing, locally at least, limonite concretions. A thin coal occurs at the extreme top of the unit in Tps. 13 and 14 N., R. 19 E., which, judging by its stratigraphic position may be the correlative of the lower Hartshorne coal of the McAlester region. This coal has especial interest in being stratigraphically the lowest coal in the Des Moines group in the Muskogee-Porum district. Outcrop sections measured in Tps. 13 and 14 N. indicate a thickness of 60 to 80 feet for this shale unit.

Hartshorne Sandstone

In the Muskogee-Porum district the Hartshorne sandstone is a highly variable unit, recognizable chiefly by its position below the prominent Warner sandstone. The Hartshorne sandstone ranges in thickness between 3 and 25 feet within the Muskogee-Porum district.

Ordinarily the Hartshorne sandstone displays a pale olive-buff color on fresh exposure, changing to buff on weathering. Locally the unit is relatively shaly and thin-bedded, elsewhere it is calcareous and brittle, and in the latter phase commonly white to light gray with only a faint olive tint. Locally the sandstone is ripple marked, but such markings are not especially distinctive of the unit. Fossil plant debris is relatively more common in the Hartshorne than in many of the other sandstones, and fossil invertebrates appear to be lacking or quite rare.

In T. 10 N., R. 20 E. the Hartshorne sandstone contains considerable sandy shale and the beds assigned to the unit measure somewhat more than 25 feet in thickness. Toward the north the formation is considerably thinner, probably due to gradation of lower sandstone beds into sandy shale. In T. 11 N. the beds assigned to the Hartshorne are 11 feet thick, consisting of slaty and shaly greenish sandstone. In T. 12 N., Rs. 19 and 20 E. the sandstone ranges from a massive blocky unit of 10 feet or more down to as little as 3 feet of soft sandstone. Some hint of the way in which the lower beds of the Hartshorne may become quite shaly is given by outcrops in sec. 35, T. 12 N., R. 20 E. At this place the formation consists of two thin, but relatively resistent sandstones separated by 18 feet of sandy shale. Probably the upper thin sandstone is locally the only recognizable part of the formation. Through T. 12 N. a coal bed, the upper Hartshorne coal, occurs immediately on top of the Hartshorne sandstone, effecting a positive index for recognition of the upper contact of the formation. In Tps. 13 and 14 N. the Hartshorne ordinarily consists of about 10 feet of massive, gray, calcareous sandstone.

The Hartshorne was not positively identified in the latitude of Muskogee nor to the northward, and it is believed to be represented in this area only by shale or very obscure sandstone, though future work may disclose that the Hartshorne sandstone extends north of Arkansas and Verdigris rivers. The possibility that the supposed Blackjack sandstone in the area north of Verdigris River is in reality Hartshorne, cannot be ignored. The presence of coal in the top of the upper shale division (A_6) of the Atoka shortly below the Hartshorne in the southern part of the Muskogee-Porum district, and beneath the bed of sandstone in question near Vinita, is suggestive. Considering all the evidence at present in hand, however, the lowermost sandstone in the Cherokee shale division north of Wagoner is provisionally referred to the Blackjack.

McAlester Shale

The McAlester shale consists of a heterogeneous succession of shales and several persistent sandstone units of unequal prominence. Four coal beds occur in the McAlester shale, but of these only the upper one, the Stigler or upper McAlester coal, is notably persistent. The McAlester shale ranges from 220 feet in the northern part of the area to 380 feet in the southern part.

Listed in ascending order, the subdivisions of the McAlester formation recognized in the Muskogee-Porum district are as follows, oldest member at bottom:

Shale (M_4) (Stigler coal at base)
Cameron sandstone member
Shale (M_3)
Lequire sandstone member
Shale (M_2) (local coal and sandstone at base)
Warner sandstone member
McCurtain shale member (upper Hartshorne coal at base and local coal near top)

McCurtain shale member.[31] This unit consists almost entirely of shale, unbroken by resistent beds. The lower half is commonly dark gray to black, slabby and silty, and contains abundant unfossiliferous clay-ironstone concretions. The upper half is argillaceous, and buff to greenish, and concretions are not generally abundant. A thin coal bed ranging from an inch or so to more than one foot occurs at the base of the McCurtain division in Tps. 12 and 13 N. Because of its position immediately above the Hartshorne sandstone this coal is correlated with the upper Hartshorne coal south of Canadian River. Apparently the coal is absent in both the northern and southern parts of the Muskogee-Porum district.

Another thin coal bed locally occurs near the top of the McCurtain shale member in Tps. 13 and 15 N. Probably it is present also in T. 14 N., but suitable exposures below the Warner sandstone were not found in this area. The coal is of no economic importance.

Like most of the Pennsylvanian divisions in the region the McCurtain shale shows marked northward thinning, decreasing in thickness from 200 feet in T. 10 N., to about 80 feet in T. 14 N. The thickness of the unit in T. 15 N. is not known because the lower boundary, defined by the Hartshorne sandstone, was not recognized that far north.

Warner sandstone member and overlying shale.[32] The Warner sandstone member produces one of the most prominent escarpments in the Muskogee-Porum district, being comparable in this respect to the Bluejacket and Taft sandstones of the lower Boggy formation. The sandstone generally consists of massive, buff, calcareous and hard sandstone ranging in total thickness at measured outcrops from about 5 feet to 30 feet. The sandstone is commonly ferruginous, containing large irregular limonite-cemented concretionary masses up to 2 feet across. These concretions are typically hollow, weathering into curious twisted and contorted forms.

31. Wilson, Charles W. Jr., *op. cit.*, p. 508, 1936.
32. *Idem*, p. 508.

Fossil plants occur in the sandstone locally. In Tps. 12, 13, and 14 N., a thin-bedded sandstone up to 10 feet thick occurs a few feet above the scarp-forming sandstone of the Warner and a thin coal bed occurs in the intervening 5-foot shale.

The two sandstones and intervening shale and coal were all included by Wilson[33] in the Warner division to facilitate mapping. However, the upper sandstone is relatively local and is so non-resistent that it is never seen in the Warner escarpment, having been weathered far back in the direction of the dip. Furthermore the thin shale and fairly persistent coal bed between the two sandstones indicates that more than a single depositional unit is involved. Therefore the term Warner is here restricted to the scarp-forming, massive, lower sandstone.

Certain obstacles stand in the way of tracing individual units continuously northward from the Muskogee-Porum district into the lower Cherokee section of northeastern Oklahoma. The broad valleys of Arkansas and Verdigris rivers at their confluence bound the Muskogee-Porum district on the north. A fault of considerable, but unknown displacement is believed to coincide with the valley of Arkansas River north of Muskogee. Finally a further complication arises in a heavy mantle of Quaternary deposits that flanks the valley on both sides, effectively obscuring outcrops of indurated rocks.

Unquestioned Warner sandstone occurs at the bridge of U. S. Highway 69, across Arkansas River 2 miles northeast of Muskogee. In this area the Warner is the first conspicuous sandstone below the Bluejacket. Owing to lack of outcrops north of Arkansas River the Warner is not recognizable for several miles, coming to view again a mile or so northwest of Okay. Northward from Gibson Station, in T. 16 N., R. 18 E., past Wagoner, the first prominent sandstone below the Bluejacket makes a good escarpment. This same sandstone is the second one above the Webbers Falls sandstone in the area between Gibson Station and the latitude of Wagoner. Inasmuch as the Warner sandstone was definitely rec-

33. Personal communication.

ognized as far north as Arkansas River, some distance north of exposures of undoubted Hartshorne, it seems probable that of the two the Warner would be the more persistent. Therefore the correlation of the second conspicuous sandstone above the Webbers Falls, and the first conspicuous one below the Bluejacket in the area north of Arkansas and Verdigris Rivers, with the Warner sandstone seems justified.

Reconnaissance mapping northward from Wagoner (see fig. 3) in an area of relatively simple structural conditions, indicates that the Warner sandstone is continuous with the Little Cabin sandstone of northeastern Oklahoma. From Wagoner northward the Warner (Little Cabin) sandstone gradually converges with the top of the Mississippian rocks, due to the regional northward overlap of the Pennslyvanian on Mississippian, until it rests directly on the Mississippian in southeastern Kansas.

The suggested correlation of the Warner with the Little Cabin sandstone appears to be substantiated by subsurface correlations made by Wilson[34], who correlates the Warner sandstone with the subsurface "Booch sand," extending the Booch sand far northward to the Kansas line, where it clearly is the Little Cabin sandstone of outcrop terminology.

The shale (M_2) above the Warner sandstone is characteristically gray to buff and silty to argillaceous. It ranges from 50 or 60 feet in the southern part of the area to 25 feet in T. 13 N. North of T. 13 N., the upper limit, defined by the Lequire sandstone member, is not recognizable so this shale is not a usable division in the northern area. A thin coal bed occurs at the base of the shale in Tps. 12, 13, 14 and 15 N., and in this area a thin, black or gray shale 2 or 3 feet thick overlies the coal. Throughout the extent of the coal, except in T. 15 N., a prominent, thin-bedded, buff, unfossiliferous sandstone lies 2 or 3 feet above it. This sandstone ranges from about 3 to 10 feet, and being relatively non-resistent it is invariably eroded back from the Warner escarpment.

34. *Op. cit.*, p. 514, 1935.

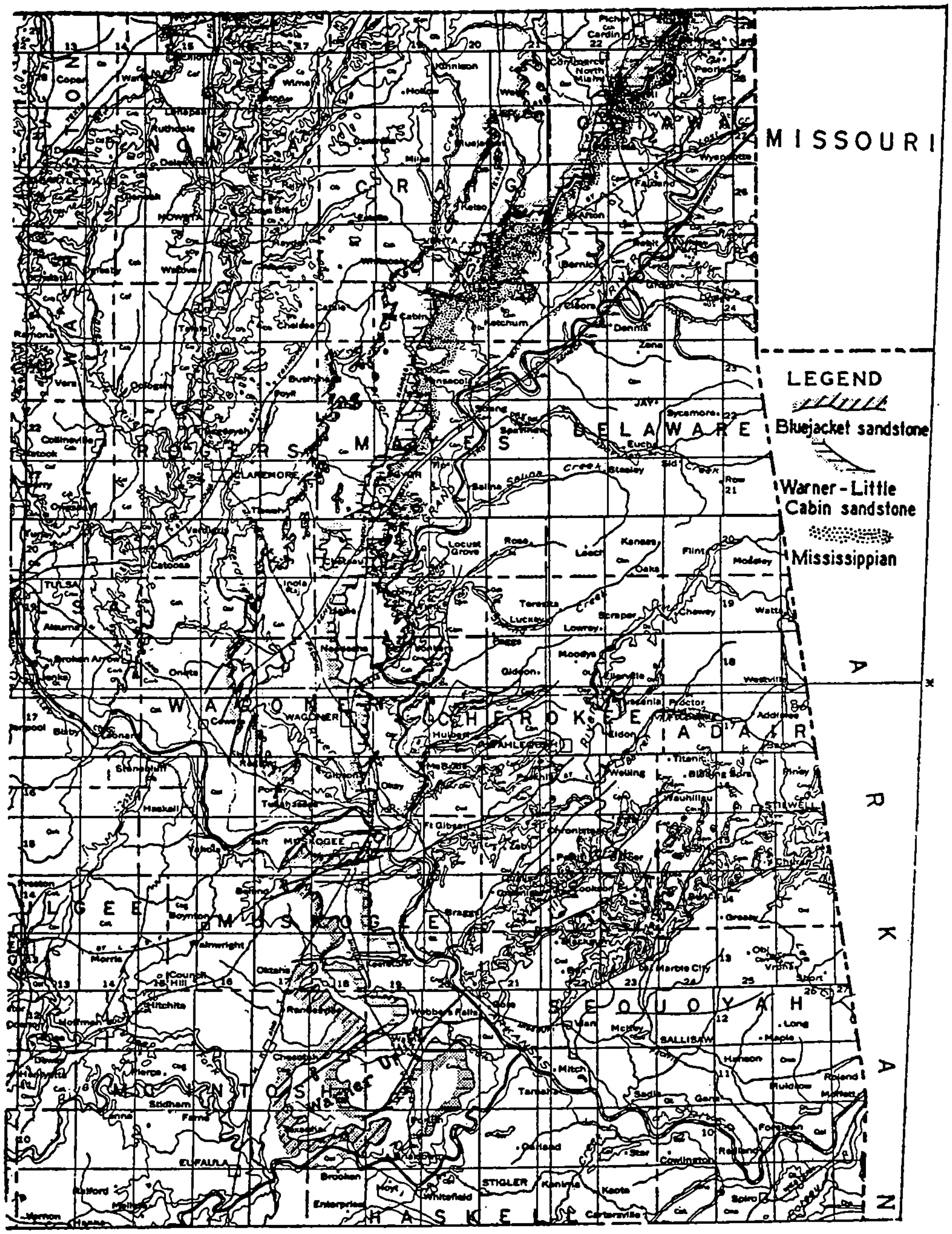


FIGURE 3. Geologic map of a portion of northeastern Oklahoma, with the trace of the outcrops of the Warner-Little Cabin and Bluejacket sandstones, and the top of the Mississippian, showing overlap of the Warner-Little Cabin north of Wagoner. Warner-Little Cabin mapped from Verdigris River to Vinita by Newell, assisted by Hanson, 1936.

The occurrence of a relatively persistent coal bed between two sandstones, the Warner below and the less persistent sandstone above, suggests that the upper sandstone should not be classed with the Warner as a single depositional unit. The equivalents of the post-Warner shale (M_2) in Tps. 14 and 15 N., will be discussed under the treatment of the shale (M_4) above the Cameron sandstone.

Lequire sandstone member and overlying shale.[35] The Lequire sandstone member is a single buff sandstone unit ranging from 8 or 10 feet in the latitude of T. 10 N. to 3 feet and less at its northern terminus in T. 13 N. Apparently the Lequire thins out and is replaced by shale to the northward. Where the unit is relatively thin it is generally blocky and hard, but locally it consists of thin-bedded buff sandstone. In the southern part of the area it generally is slabby to thin-bedded. Fossils were not observed in the Lequire sandstone.

The overlying shale (M_3) is almost invariably poorly exposed within the region, so that its detailed characters are not well known. Apparently it consists chiefly of 20 to 60 feet or more of gray to buff silty and sandy shale. The bounding units, Lequire and Cameron sandstones, disappear in the northern part of the Muskogee-Porum district, so that this shale unit cannot be differentiated north of T. 13 N. The northern correlatives will be discussed in the following paragraphs.

Cameron sandstone member and overlying shale.[36] The Cameron sandstone member is a relatively uniform buff, unfossiliferous sandstone ranging ordinarily from 3 to 5 feet, relatively platy and calcareous and sufficiently resistent to make a distinct low escarpment. Generally the Cameron sandstone is a well defined unit, but locally in T. 13 N., R. 18 E., it consists apparently of two thin blocky sandstone beds separated by 10 feet of sandy shale.

35. Wilson, Charles W. Jr., *op. cit.*, p. 506.
36. *Idem*, p. 507.

The overlying shale (M_4) contains the Stigler coal near the base. The coal ordinarily lies from a few inches to about 5 feet above the Cameron sandstone, ranging in thickness from a thin, knife-edge streak to nearly 2 feet. The Stigler coal invariably overlies an underclay. The coal becomes thin and obscure toward the northern part of the area so that its indentification in T. 14 N., is not entirely certain. A thin coal was observed about 10 feet below the Tamaha sandstone in sec. 11, T. 14 N., R. 18 E., which is thought to be the northern extension of the Stigler bed. It was not recognized in T. 15 N., nor to the northward.

In the southern part of the area a thin limestone, or calcareous shale (M_4a) occurs upon or shortly above the Stigler coal. It is best developed in T. 10 N., R. 19 E., where it was seen near the SW cor. sec. 26. The limestone here is dark gray to brown, ferruginous and coquinoid, having a thickness of about 6 inches, and in this area occurs about 12 feet above the Stigler coal. A thin limestone or calcareous fossiliferous shale observed immediately above the Stigler coal in Tps. 11 and 12 N., is thought to be the northward extension of this limestone (M_4a).

Ordinarily that part of the shale above the thin limestone is carbonaceous, grading upward into gray argillaceous shale containing clay-ironstone concretions.

Marked northward convergence is exhibited by the Cameron and Tamaha sandstones. The intervening shale is 60 feet thick in T. 10 N., 50 feet in T. 11 N., 45 feet in Tps. 12 and 13 N., and 20 feet thick in T. 14 N. This convergence is also well displayed by the section between the Warner and Tamaha sandstones, which measures 160 feet in T. 10 N., 120 feet in T. 11 N., 140 feet in Tps. 12 and 13 N., 100 feet in T. 14 N., and 27 feet in T. 15 N.

In the northern part of the Muskogee-Porum district, where the Lequire and Cameron sandstones disappear the post-Cameron shale (M_4) cannot be separated from underlying shales.

Where the Lequire and Cameron sandstones are absent the shale between the Warner and Tamaha sandstones is generally gray and argillaceous, except for previously mentioned sandstone shortly above the Warner.

Savanna Formation

The Savanna formation is dominantly shale with subordinate but persistent thin sandstones, limestones, and coal beds. It ranges in thickness in the area from 166 in the northern to 260 feet in the southern part. The following divisions of the Savanna formation are recognized in the Muskogee-Porum district, given in ascending order, oldest at the bottom:

Spiro sandstone member
Shale
Sam Creek limestone member
Shale (local coal and limestone at top)
Spaniard limestone member
Shale (coal at top)
Keota sandstone member (including persistent limestone and coal)
Shale (coal and local limestone near base)
Tamaha sandstone

Apparently the Boggy rests unconformably on the Savanna formation north of T. 11 N., where a considerable section of lower Boggy units seemingly is overlapped by higher beds. This overlap is further considered under Boggy formation.

Tamaha sandstone member and overlying shale.[37] The basal sandstone of the Savanna formation, is a relatively thin but uniform bed of buff, rippled, flaggy, and calcareous sandstone. Local irregularities exist, probably due to conditions of weathering, so that in places along the Tamaha outcrop the sandstone is shaly or very thin-bedded. The unit is unfossiliferous, and is surprisingly uniform in thickness, varying generally between 3 or 4 feet, but locally attaining a thickness as great as 8 feet in T. 14 N.

Ordinarily the overlying shale (S_1) is silty to argillaceous, and buff or gray in color, containing abundant unfossiliferous ironstone concretions. The unit contains more sand in the extreme

37. Wilson, Charles W. Jr., *op. cit*, p. 509, 1935.

southern part of the area. A thin coal bed, from 5 to 15 feet 13 N., and probably is also present in T. 12 N. Ordinarily the shale immediately above the coal is carbonaceous. A local thin limestone bed separates the coal from overlying carbonaceous shale in sec. 13, T. 13 N., R. 18 E.

Keota sandstone member and overlying shale.[38] The Keota above the Tamaha sandstone was observed in Tps. 10, 11, and sandstone is unquestionably an unnatural division in the area studied. Inasmuch as there was no opportunity to examine the Keota sandstone member at the type locality, south of Canadian River, a revision of the unit, based only on the section in the Muskogee-Porum district would be most premature. A persistent coal and overlying limestone occur in the midst of the Keota division, as mapped by Wilson in the southern part of the area. Traced northward the lower sandstone of the section becomes sporadic, and at many localities is absent. Where this lower sandstone of the Keota is absent the unnamed coal has been arbitrarily selected as the basal unit.

At most outcrops in the latitude of T. 10 N., the Keota division consists of three relatively calcareous, blocky, buff sandstone beds separated by relatively thicker arenaceous gray shales, the whole including some 25 feet or more of beds. However in the northeast part of sec. 22, T. 10 N., R. 19 E., the lower half of the division is shaly sandstone, separated from a thin upper sandstone by 15 feet of shale containing an obscure coal near the middle. Fossiliferous concretions occur in the upper part of this shale.

Good outcrops of the Keota are lacking across T. 11 N., but in sec. 10, T. 12 N., R. 18 E., it consists of six separate units, as indicated in the following table:

38. *Idem.*, p. 509.
This is a restriction of the grouping shown on the geologic map (Pl. I), which shows all the beds between the base of the Keota and the base of the Spiro sandstones in one pattern.

TABLE II.
GENERALIZED SECTION OF THE KEOTA SANDSTONES MEMBER IN SEC. 10, T. 12 N., R. 18 E.

Sandstone, calcareous	4.0
Shale, gray, silty	11.0
Limestone, ferruginous	0.2
Coal	0.2
Shale, gray, with underclay at top	4.0
Sandstone, buff, shaly and slabby	9.0
	28.4

The thin limestone is not to be confused with the Spaniard limestone, which occurs just above the Keota.

The lower sandstone is generally absent in Tps. 13 and 14 N., but the coal, limestone, and upper Keota beds are quite persistent and uniform. In this area the upper sandstone of the Keota, together with the Spaniard limestone above makes a low escarpment. The sandstone is commonly rippled, platy, and calcareous, measuring from 3 to 5 feet. Invertebrate fossils are not uncommon in the sandstone. Locally in secs. 9 and 10, T. 15 N., R. 18 E., the lower sandstone of the Keota is present. In the southern part of the Muskogee-Porum district the lower sandstone is the scarp-forming part of the Keota. The top of the Keota sandstone member generally is easy to identify by the occurrence of the persistent Spaniard limestone a short distance above. The Keota member, where complete, ranges in thickness from about 40 feet in T. 10 N., to about 18 feet in T. 15 N.

Near Wagoner in T. 17 N., a 5- to 10-foot platy, buff sandstone occurs beneath a limestone which is believed to be the Spaniard bed, and if this identification is correct, the underlying sandstone is the upper sandstone of the Keota member.

Immediately above the Keota "sandstone," and separating it from the Spaniard limestone occur 2 to 5 feet of gray and buff sandy shale. A thin coal and underclay were observed at the top of the shale in Tps. 10, 13 and 15 N. This part of the section is generally very poorly exposed so that in all probability the coal may ultimately be found, at least locally, in Tps. 11, 12 and 14 N.

Because of the characteristic occurrence of coal immediately below limestone in the McAlester, Savanna and Boggy formations the several thin and similar limestones in this part of the column may readily be confused. Such confusion is especially possible with the Spaniard limestone and the persistent unnamed limestone in the Keota. The two limestones are separated by only a few feet of sandstone and shale.

Spaniard limestone member and overlying shale.[39] The Spaniard limestone member is one of the most uniform and persistent limestones in the local geologic column. According to the present interpretation this limestone is continuous from Canadian River at least as far north as Wagoner, and probably extends much farther into the Cherokee section of northeastern Oklahoma.

Outcrops of the limestone are scarce in the southern part of the area because of the small thickness of the unit, and because the outcrop swings westward out of the studied area around the Warner uplift in T. 11 N.

In T. 10 N. the Spaniard limestone consists of about 9 inches of ferruginous red limestone filled with the relatively narrow and subquadrate *Marginifera missouriensis* (Girty).

The outcrops of Spaniard limestone in T. 12 N., are quite different from those in T. 10 N., being correlated on the basis of position in reference to the top of the Keota member. In T. 12 N., the limestone is fine-grained, dark gray, blocky, and contains numerous crinoid stems. Fusulinids of moderate size and specimens of *Campophyllum* occur sporadically in various localities. The observed thickness in the township ranges from 4 to 10 inches.

Fusulinids and the horn coral *Campophyllum* are more common in T. 13 N., R. 18 E., although not abundant. The limestone is dense, gray, blocky, and is mottled by inclusions of light-gray calcareous nodules of probable algal origin. The unit measures from 10 to 12 inches.

39. Lowman, S. W., "Cherokee Structural History in Oklahoma": *Tulsa Geol. Soc. Digest*, p. 31, 1933. Wilson, C. W., Jr., *op. cit.*, p. 510, 1935.

A collection of fusulinids from the Spaniard limestone just south of Muskogee was given to Dr. Charles Ryniker for identification. Dr. Ryniker writes:

> Some two weeks ago I examined twenty thin sections made from this material. Eighteen of these twenty sections are identified as *Fusulina girtyi* (Dunbar and Condra), or very close forms; one, tentatively as *Fusulina meeki* var. *robusta* (Dunbar and Condra); and one, tentatively as *Fusulina megista* (Thompson).
>
> The finding of this typical Marmaton assemblage in the Spaniard limestone is the greatest surprise to me. An earlier, and profuse occurrence of *Fusulina girtyi* was the last thing I would have expected.

The thickness of the Spaniard limestone increases in T. 14 N., R. 18 E., to about 2 feet, with corals and fusulinids common but not abundant. This thickness is maintained in T. 15 N., R. 18 E., where the Spaniard in its upper few inches is somewhat shaly, and contains numerous fossils. In this area fusulinids were not observed, but specimens of *Campophyllum* are exceedingly aboundant and are associated with a cylindrical sponge similar to *Heliospongia*.

In the vicinity of Wagoner a fine-grained, bluish limestone, having a thickness of about 2 feet and filled with *Campophyllum* is widely distributed. Certain outcrops of this limestone in sec. 7, T. 17 N., R. 18 E., and vicinity are classed as Morrow on the state geologic map. Inasmuch as the limestone in this locality occurs above the Warner sandstone of McAlester age it cannot be regarded as older than upper McAlester. The relative position between the Warner and Bluejacket sandstones, the lithologic character, and the abundance of *Campophyllum,* strongly indicate a correlation of this bed with the Spaniard limestone member of the Savanna formation. There is no other limestone in the Muskogee-Porum district that is similar to it.

Between the Spaniard limestone and the Sam Creek limestone above, as restricted in this paper, occurs a silty, or argillaceous, gray and buff shale (S_2), ordinarily containing clay-ironstone concretions. Thin, concretionary, fossiliferous and ferruginous limestones, originally classed with the Sam Creek limestone, occur in the upper part. These beds are erratic and discontinuous. At the top there occurs locally a thin coal and underclay, or simply the underclay. This coal and underclay horizon, indicating emergence, logically separates the variable fossiliferous limestones and shales below from the single persistent fossiliferous limestone, the Sam Creek, above.

The shale unit in T. 10 N., is 60 feet thick, consisting in ascending order of 50 feet of dark gray silty shale below, overlain by 1 foot of ferruginous crinoidal limestone, and 10 feet of shale with a coal and underclay near the middle.

The unit is eroded away from the Warner uplift in T. 11 N., R. 18 E., and because of poor outcrops could not be traced to the westward around the uplift. However, a satisfactory correlation of these beds north and south of the uplift can be made on the basis of the relationship to the underlying beds.

In T. 12 N., R. 18 E., the division is 50 to 58 feet thick, with a thin calcareous, silty, layer near the top, filled with molds of *Marginifera missouriensis, Spirifer opimus,* and fenestellids. No coal nor underclay in this part of the section was observed in the area.

The thickness decreases to about 30 feet in T. 13 N., R. 18 E. In this area three separate bands of fossiliferous concretionary limestone and ironstone occur in the upper half of the somewhat sandy shale. The shales in the lower part of this zone of concretionary beds are abundantly fossiliferous, containing *Mesolobus striatus, Prismopora serrata, Marginifera missouriensis, Astartella* sp., *Trachydomia* sp., and abundant robust crinoid stems. Dark gray to black underclay occurs at the top of the division in this latitude.

In the northern part of the area the thickness of the division ranges from 30 to 40 feet, decreasing in general toward the north, in harmony with the northward convergence that characterizes most of the section.

Fossils, including *Mesolobus striatus,* are relatively common in the upper part of the division in the northern part of the area, being generally associated with limy bands or concretionary layers. Neither coal nor underclay was seen at the top of the S_2 shale in Tps. 14 and 15 N.

Sam Creek limestone member (restricted) and overlying shale. According to the original definition[40] 8 feet, 7 inches of limestones and shales were included in the Sam Creek limestone member at the type locality along Sam Creek in sec. 15, T. 14 N., R. 18 E. Extensive work on this unit during the current investigation indicates that only the upper 6-inch limestone of the original definition is at all persistent, the lower beds being relatively local and grading laterally into concretionary limestone and clay-ironstone. In T. 13 N., and to the southward, coal and underclay occur sporadically beneath the upper limestone of the original definition. Obviously the region was completely emerged at a time between the deposition of the lower and upper parts of the limestone sequence.

In the belief that stability will be better served by altering the original definition it is suggested that the term Sam Creek be restricted to the thin persistent limestone immediately below the Spiro sandstone. At the type locality this unit, as redefined, consists, in ascending order, of 9 inches of reddish-brown limestone filled with *Marginifera* (most persistent bed), 9 inches of silty, gray and buff shale, and 5 inches of sparsely fossiliferous, rusty and silty limestone.

Outcrops in sec. 15, T. 10 N., R. 19 E., correlated with the Sam Creek limestone, exhibit two thin limestones of 2 or 3 inches each, separated by 2 feet of exceedingly fossiliferous limy shale containing *Prismopora serrata, Mesolobus striatus,* etc. The Sam Creek cannot be traced from T. 10 N., northward because it is eroded from the Warner uplift in T. 11 N., R. 18 E. Attempts to trace the limestone to the westward around the uplift were unsuccessful, due to poor outcrops and lack of time. The Sam

40 Lowman, S. W., unpublished manuscript. Wilson, Charles W. Jr., *Bull. Amer. Assoc. Petro. Geol.* Vol. 19, p. 510, 1935.

Creek of the area south of the Warner uplift is identified by reference to the underlying beds, particularly a coal bed and underclay which can be recognized at the same horizon north of the uplift.

The unit consists of red, hematite-stained limestone filled with *Marginifera missouriensis* and *Spirifer opimus* throughout the area north of the Warner uplift in Tps. 12, 13, 14 and 15 N. Ordinarily the thickness varies between about 6 inches and 1 foot. In the extreme northern part of the area the unit appears to be less ferruginous and has a gray to buff color instead of the usual red color.

The Sam Creek limestone member is overlain by about 15 feet of gray silty shale in the latitude of T. 10 N., but apparently this shale thins out toward the north, because in T. 12 N., the Spiro sandstone member rests directly on the Sam Creek limestone.

Spiro sandstone member.[41] The Spiro sandstone member is now thought by Wilson[42] and others to be the uppermost unit in the Savanna formation, though the precise correlation of the Savanna-Boggy boundary north of Canadian River cannot yet be made with certainty. This correlation is based on the fact that the Bluejacket sandstone in the area south of Canadian River occurs some 200-260 feet above the top of the Savanna formation, and the first heavy sandstone below the Bluejacket in that region apparently is the Spiro sandstone member of the Savanna formation.

Except in the extreme southern part of the Muskogee-Porum district, along Canadian River, the Spiro sandstone is thin and non-resistent, resting directly on the Sam Creek limestone. The heaviest development of the sandstone in the area studied occurs in the river bluffs in sec. 33, T. 10 N., R. 19 E., where the Spiro sandstone consists of 20 feet of massive, cliff-forming sandstone. Within a fourth of a mile to the northward, the unit is only 4

41. Wilson, Charles W. Jr., *Idem*, p. 509.

42. *Idem.*, personal communication.

feet thick and is reduced to about 2 feet of soft sandstone in section 15 of the same township. To the northward the Spiro retains a fairly constant thickness of 2 to 4 feet, and across all the remaining part of the area is non-resistent and shaly. The sandstone generally grades downward into the Sam Creek limestone, and contains fossils, especially fenestellid bryozoans, in the lower more calcareous layers.

Boggy Formation

Strata classed as lower Boggy, constitute the youngest Pennsylvanian rocks exposed in the Muskogee-Porum district.

The boundary between the Savanna and Boggy formations recognized in this report is not the same as that given by Wilson in 1935, who regarded the Bluejacket sandstone as the uppermost member of the Savanna formation. Dane and Hendricks[43] have shown recently that the Bluejacket sandstone lies within the Boggy formation, about 200 to 350 feet above the Savanna in the area south of the Muskogee-Porum district. Following this reclassification, Wilson[44] now regards the Spiro sandstone, which is the first heavy sandstone below the Bluejacket in the area south of Canadian River, as the topmost member of the Savanna formation, and such classification is adopted here. The problem of correlation is not a simple one, involving apparently a hitherto unrecognized overlap in the lower part of the Boggy, between the Spiro and Bluejacket. Extrapolation toward the south of the conditions in the southern part of the Muskogee-Porum district suggests that strata may exist between the Spiro and Bluejacket south of Canadian River that are absent farther north.

Evidence for Boggy overlap. Various writers have predicted a hiatus at or near the base of the Boggy shale in northeastern Oklahoma, without however, supplying satisfactory evidence of such a break. That such a hiatus actually exists is suggested, but not proved, by the data at hand, which are however, subject to

43. Dane, C. H., and Hendricks, T. A.; "Correlation of Bluejacket Sandstone, Oklahoma": *Bull. Amer. Assoc. Petro. Geol.*, Vol. 20, pp. 312-314, 1936.

44. Wilson, Charles W. Jr., Personal communication.

more than one interpretation. One hundred sixty feet of strata at the base of the Boggy in T. 10 N. are lacking in T. 12 N. and to the northward. The outcrop of these and associated strata swing far to the westward in T. 11 N. around the block-faulted Warner uplift. Exposures around the uplift are poor and the subdivisions could not be traced continuously to determine how they are lost, whether by overlap or by convergence and gradation into shale. Either interpretation is puzzling in view of the fact that the Spiro-Bluejacket section is relatively uniform north of T. 11 N. and there is no marked convergence nor any indication of hiatus.

The data at hand are interpreted to indicate that a hiatus exists at or near the base of the Boggy south of T. 11 N. and at the base of the Boggy north of T. 11 N. The abrupt apparent wedging and loss of 160 feet of heterogeneous lower Boggy strata across T. 11 N. is best explained by a postulated structural shelf or terrace which occupied the location of the present Warner uplift in T. 11 N. during early Boggy time. Such a steep basinward slope toward the south could have produced abrupt overlap in T. 11 N. with consequent loss of strata at the base of the overlapping Boggy. According to this interpretation the slope of the terrace flattened out north of T. 11 N., so that rocks above the hiatus were laid down in beds parallel to those below, and indications of overlap are therefore obscure or lacking in the northern area.

Lower Boggy section in T. 10 N. The lower part of the Boggy formation in T. 10 N., R. 19 E., appears to contain divisions at the base which are not represented in the area to the northward (B_1 to B_5). The shale unit immediately below the lower Boggy coal (B_6), appears to be a widely overlapping unit which rests directly on the Spiro member of the Savanna formation north of T. 11 N.

The lower Boggy section exposed in T. 10 N., R. 19 E., is summarized in the following table:

TABLE III.

GENERALIZED SECTION OF LOWER BOGGY BEDS IN T. 10 N., R. 19 E.

	Feet	
Lower Boggy beds		
Limestone, carbonaceous, platy, contains large ramose bryozoans and some pelecypods	0.7	(B_6)
Coal	0.3	
Shale, gray, underclay at top	2.0	
Sandstone, shaly, containing limonite concretions	5.0	
Shale, gray, silty, lenticular, ranging up to	6.0	(B_4)
Limestone, granular, ranging up to	0.2	
Shale, sandy, gray, with limonite concretions	20.0	
Limestone, brown, shaly, filled with crinoid stems, *Prismopora*, *Mesolobus striatus*, *Spirifer opimus and Marginifera missouriensis*	0.8	
Coal	0.1	
Shale, gray, silty, underclay at top	3.0	
Sandstone, blocky, hard, filled with Stigmaria	2.0	
Shale, silty, gray, contains clay-ironstone concretions	40.0	(B_3)
Siltstone, hard, calcareous, filled with molds of *Marginifera missouriensis*	1.0	(B_2)
Shale, poorly shown	75.0	(B_1)
Savanna formation		
Spiro sandstone member		

Persistent divisions of the lower Boggy. 120 to 220 feet below the Bluejacket sandstone member occurs a shale that appears to be a widely overlapping unit. It is some 160 feet above the Savanna formation in T. 10 N., and rests directly upon the top member of the Savanna formation north of T. 11 N. (See Plate III). This unit (B_6), which consists of from 18 to 40 feet of silty and gray clay shale, ordinarily is poorly exposed because of its position at the base of the Bluejacket escarpment.

Above the overlapping shale unit is a distinctive succession of beds (B_7) recognizable entirely across the Muskogee-Porum district. At the base occurs a thin coal, the "lower Boggy" coal, and underclay. The coal is mined locally at a number of places near Porum, Warner, and Muskogee. The coal is overlain by a thin, but exceedingly persistent limestone, which is ordinarily somewhat non-resistent and carbonaceous. The common occurrence of *Neospirifer cameratus* and a broad and sulcate *Marginifera* like *M. muricatina* in this limestone is noteworthy, because these fossils appear to be either rare or lacking in lower horizons. The limestone rarely exceeds 6 inches in thickness.

The limestone is overlain by a distinctive black fissile shale having a variable thickness averaging probably, about 25 feet. This shale grades upward into black or dark gray flaky shale ranging up to about 60 feet thick. The flaky shale generally contains abundant clay-ironstone concretions. The succeeding 40 to 60 feet of beds are composed of buff to gray silty shale grading upward into very sandy shale, which is overlain by the Bluejacket sandstone member.

The entire interval (B_7) between the lower Boggy coal and the base of the Bluejacket ranges from about 220 feet in T. 10 N., to about 120 feet in T. 15 N.

Bluejacket sandstone member and overlying shale.[45] As already indicated, recent work by Dane and Hendricks[46] has established a correlation of the Bluejacket sandstone of the Muskogee-Porum district with a sandstone "200-250 feet above the top of the Savanna sandstone in Tps. 7 and 8 N., R. 18 E." In other words the Bluejacket sandstone member occurs in the Boggy formation, well above the base.

The Bluejacket sandstone is of especial interest because its prominent escarpment can be followed to the Kansas line, where the relative position of the sandstone in the Cherokee formation of Kansas has been determined. It is now regarded as equivalent to the "Columbus sandstone" of the Kansas Cherokee by geologists working in southeastern Kansas.

A prominent escarpment, ranging in height from nearly 300 feet in the southern part of the area, to about 150 feet in the northern part is produced by the outcropping edge of the Bluejacket.

Ordinarily the unit consists of massive buff, soft sandstone with irregular and relatively flat cross-bedding. In many places cross-bedding is absent or very obscure. Locally the sandstone becomes thin-bedded and shaly, and it is somewhat lenticular, ranging from an observed thickness of 20 feet up to more than 60 feet.

45. McCoy, A. W., *Bull. Amer. Assoc. Petro. Geol.*, Vol. 5, p. 548, 1921. Gould, Charles N., "Index to the Stratigraphy of Oklahoma"; *Okla. Geol. Survey, Bull.* 35, p. 64, 1925.

46. Dane, C. H., and Hendricks, T. A.; *Bull. Amer. Assoc. Petro. Geol.*, Vol. 20, pp. 312-314, 1936.

In general the sandstone lacks the characters of a "channel sand," although slight channelling was observed at the base of the unit in sec. 33, T. 12 N., R. 18 E., and in sec. 19, T. 12 N., R. 19 E. No evidence of an extensive hiatus at the base of the Bluejacket could be detected.

Boggy section above the Bluejacket sandstone member. Beds immediately above the Bluejacket sandstone crop out only in the northwestern part of the area. A detailed study, extending to the top of the Taft sandstone number, some 200 feet above the Bluejacket, was made only in Tps. 14 and 15 N.

A minable coal occurs 20 feet or more above the top of the Bluejacket sandstone in the vicinity of Summit and Crekola. The coal is underlain by underclay, which in turn rests on gray silty and sandy shale (all grouped as B_8). Farther north, near Taft, in T. 15 N., the coal appears to rest almost directly on the Bluejacket, and the same situation seems to obtain at Porter in T. 16 N. Wilson classes this coal as the Secor bed. According to Dane and Hendricks,[47] the Secor coal in the Quinton-Scipio district to the south of the Muskogee-Porum district occurs some 100 to 200 feet above the Bluejacket sandstone.

Immediately overlying the Secor coal in the northwestern part of the Muskogee-Porum district, occurs a thin shale (B_9), ranging in observed outcrops from about 6 to 20 feet. Ordinarily this shale is sandy throughout, but contains a thin carbonaceous and fossiliferous layer at the base near Summit, in T. 14 N.

Crekola sandstone member and overlying shale.[48] This unit consists of thin-bedded, soft buff sandstone, ranging from about 4 to 10 feet in thickness at measured outcrops. The sandstone appears to be unfossiliferous.

47. *Op. cit.*, p. 313.

48. Wilson, Charles W., Jr., *op. cit.*, p. 511, 1935.

Between the Crekola sandstone and the Inola limestone above occurs 5 to 10 feet of sandy buff shale, at the top of which, occurs a thin coal and underclay (B_{10}). Wilson's[49] report that this shale is black was not confirmed.

Inola limestone member and overlying shale.[50] This limestone takes its name from the village of Inola, Rogers County, Oklahoma. It is exposed as an outlier on a high hill in sec. 10, T. 19 N., R. 17 E., one mile east of Inola.

If the outcrops in the Muskogee-Porum area have been correctly identified, this limestone is evidently quite persistent. The name Inola is applied in this area to a blocky, even, bluish-gray bed of fine-grained limestone, 1 foot thick. Recognizable fossils are ordinarily rare except for a sponge which resembles *Heliospongia.* Because of the position in the broad plain at the foot of the Taft sandstone escarpment, outcrops of the Inola bed are discontinuous and located only with difficulty. The southern extent of the bed is unknown, but it is entirely typical in the latitude of T. 13 N., and probably extends considerably farther south.

Overlying the Inola limestone is a shale (B_{11}), measuring about 180 feet in the northwestern part of the Muskogee-Porum district, that contains black, fissile concretionary shale at the base, grading upward through black flaky shale to gray silty and argillaceous shale near the middle. Above the middle occurs a thin but resistent sandstone that ordinarily makes an obscure terrace in the Taft sandstone escarpment. It is sufficiently prominent in Tps. 14 and 15 N., R. 17 E., that it is shown on the geologic map. The upper third of this shale division consists of silty to sandy shale.

Taft sandstone member.[51] The Taft sandstone forms a prominent escarpment, ranging up to 200 feet in height above the Crekola-Inola plain. At the type locality in T. 15 N., the unit

49. Wilson, Charles W., Jr., *Bull. Amer. Assoc. Petro. Geol.*, Vol. 19, p. 511, 1935.
50. Lowman, S. W., "Lower and Middle Pennsylvanian Stratigraphy of Oklahoma, East of the Meridian and North of the Arbuckle Mountains": *Tulsa Geological Society Summaries and Abstracts of Technical Papers.* (1932). Wilson, Charles W., Jr., *op. cit.*, (footnote), p. 504; 511, 1935.
51. Wilson, Charles W., Jr., *op. cit.*, p. 510.

consists of about 20 feet of coarse-grained massive sandstone. The upper third of the division consists of silty to sandy shale. Farther south, in T. 14 N., a series of massive sandstones and interbedded shales, amounting in aggregate to some 80 feet of beds, surmounts the Taft escarpment. Probably the outcrops around the village of Taft are equivalent only to the lower part of the sandstone section in T. 14 N. Further detailed work along the Taft escarpment is needed to determine the logical boundaries of the Taft member.

QUATERNARY (?) SYSTEM[52]

Unconsolidated deposits rest unconformably upon the edges of the exposed Paleozoic strata in some places. These deposits are of three types: terrace sand deposits, terrace gravel deposits, and flood-plain silt. The terrace sand and gravel were laid down during an older cycle of erosion than the present one, at a time when the rivers and their tributaries were flowing at a higher level than they flow today. The flood-plain silt was deposited much more recently.

Terrace sand deposits. About 50 feet above the general level of the present flood plain of Canadian River are interstream areas covered with fine-grained white, yellow, or much more commonly, red sand and small local pockets of white sandy clay. Many of the sand grains making up this deposit are rounded, pitted, and frosted, indicating that at some time after the disintegration of the parent sandstone and during their transportation and accumulation the grains were subjected to the erosive action of the wind.

These sand-covered areas are found in T. 10 N., Rs. 19 and 20 E., and T. 11 N., Rs. 20 and 21 E., and are nowhere more than 5 miles from Canadian River. The altitude of the sand ranges from 550 to 575 feet.

The terrace sand deposits resemble the Gerty sand[53] of the Coalgate, Stonewall, and other quadrangles in appearance, and in

52. This and succeeding discussions by C. W. Wilson, Jr.
53. This name, formerly spelled Guertie, is now spelled Gerty, in accordance with a decision of the United States Geographic Board.

relation to Canadian River. For this reason it is believed that the sand deposits of the Muskogee-Porum district may be correlated with the Gerty sand, this correlation indicating contemporaneous deposition by Canadian River.

Taff,[54] who originally named this sand for the exposures at Gerty, in the Coalgate quadrangle, Oklahoma, gave the age of the sand as Neocene (?). So far as is known the only fossil that has been found in the Gerty sand was an elephant tusk discovered on the south line of sec. 10, T. 3 N., R. 5 E., in the Stonewall quadrangle. This elephant tusk suggests that the Gerty sand is of Pleistocene age.[55] At Red Springs, southeast of Steedman, in the western part of the Coalgate quadrangle, numerous bones of a mastodon and teeth of *Mammut americanum* have been found. No Gerty sand has been mapped at this locality and it has not been definitely determined whether these animals lived during the deposition of this sand.

Terrace gravel deposits. The deposits of terrace gravel occur in only two areas sufficiently large to be mapped. One of these extends from sec. 10, T. 11 N., R. 18 E., southeastward to sec. 28, T. 11 N., R. 19 E., lying close to the base of the cuestas formed by the Cameron and Warner sandstone members. The other extends from sec. 14, T. 13 N., R. 18 E., east-southeastward to sec. 27, T. 13 N., R. 19 E. The gravel lies between altitudes of 550 and 600 feet and averages slightly higher above the present river level than the terrace sand.

These gravel deposits are composed of more or less rounded pebbles and boulders of sandstone, which have been cemented by iron oxides.

The age of the terrace gravel cannot be definitely determined, as no fossils have been found in the deposits. Its altitude and location in relation to those of the terrace sand suggest that the two deposits are of approximately the same age.

54. Taff, J. A., *U. S. Geol. Survey Geol. Atlas, Coalgate folio* (No. 74), p. 4, 1901.
55. Morgan, G. D., "Geology of the Stonewall Quadrangle, Oklahoma": *Bureau of Geology Bull.* 2, p. 144, Norman, Okla., 1924.

QUATERNARY SYSTEM

Flood-plain silt. The flood-plain silt which is the youngest deposit in the area, extends along Arkansas and Canadian Rivers. It is widely exposed in the broad flood plain of these two rivers in the vicinity of Webbers Falls and in the flood plain of Arkansas River north and east of Muskogee. The deposit is composed of silt and fine sand. It is very difficult in some places to distinguish between this alluvium and the residual soil of the consolidated rocks.

The flood-plain silt is of late Quaternary (Recent) age.

Subsurface stratigraphy

The extent, thickness, lithologic character, and correlation of the formations commonly present in wells drilled for oil in the Muskogee-Porum district are given here briefly in order that the reader may have some conception of the strata that do not crop out anywhere in the area. The succession of strata is shown in the graphic well logs given in Plates VI and VII. These strata range in age from pre-Cambrian to Mississippian. Most of the data for this description were obtained from previous publications.[56]

PRE-CAMBRIAN

The writer knows of only two wells in the Muskogee-Porum district that have been drilled through the entire section of the sedimentary strata into the underlying granite. One of these two wells was drilled on the Tilly farm, in the NE¼SW¼ sec. 28, T. 15 N., R. 19 E., by H. F. Campbell and was completed April 13, 1923. This well encountered granite at a depth of 3,375 feet, and its total depth was 3,690 feet. The other well was drilled by E. C. Lantz on the farm of R. L. Rulison, in the NW¼ sec. 4, T. 15 N., R. 18 E., and was completed in May, 1923. Granite was

56. White, L. H., "Subsurface Distribution and Correlation of the Pre-Chattanooga ("Wilcox" sand) Series of Northeastern Oklahoma": *Okla. Geol. Survey Bull.* 40, Vol. 1, pp. 21-40, 1928. Soyster, H. B., and Taylor, T. G., "Oil and Gas in Oklahoma, Muskogee County": *Okla. Geol. Survey Bull.* 40, Vol. 3, pp. 377-398, 1930. Cram, I. H., "Cherokee and Adair Counties": *Okla. Geol. Survey Bull.* 40, Vol. 3, pp. 531-586, 1930.

encountered in this well at a depth of 2,970 feet, and the total depth was 4,605 feet.

The age of this granite is generally believed to be pre-Cambrian. It is a reddish-brown, mottled, medium- to fine-grained granite and resembles the granite exposed at Spavinaw, Okla., about 42 miles north-northeast of Muskogee. The granite is essentially composed of red orthoclase feldspar, quartz, hornblende, and biotite. It has been shown in wells that encounter the granite that there is but a comparatively thin layer of weathered material between the granite and the overlying limestone.

CAMBRIAN

Reagan (?) sandstone. A sandstone considered by some to be the Reagan may overlie the granite locally, although generally the Arbuckle limestone rests directly upon the granite.

CAMBRIAN AND ORDOVICIAN

Arbuckle limestone. The Arbuckle limestone has a maximum thickness in Muskogee County of 1,500 feet. As revealed in well cuttings, it consists of medium- to fine-grained white crystalline dolomitic, cherty, siliceous limestone. The insoluble residue consists largely of quartz and chert fragments, with an occasional quartz crystal.

The Turkey Mountain "sand" of the drillers is generally considered to be a porus bed overlying the Arbuckle limestone. The "sand" may be 25 feet or more in thickness, although owing to its occurrences in lenses it is missing locally. It consists of a very porous, soft siliceous crystalline dolomite. The color is gray to white. In the Muskogee-Porum district only a few wells have been drilled to this horizon, and none of them have yielded oil or gas in commercial quantities.

ORDOVICIAN

Burgen sandstone. The Burgen sandstone is usually massive, light gray to yellowish brown, and fine-grained, and its thickness in some places is as much as 100 feet. It generally consists

of quartz grains so well cemented as to prevent the sand from being a suitable reservoir for oil.

Tyner formation. An alternating sequence of shales, sandy shale, dolomite, and minor amounts of sandstone, comprising the Tyner formation, with a total thickness slightly in excess of 90 feet was measured by Cram[57] along Illinois River, northeast of Tahlequah. In that area, the formation may be divided into three parts: lower, consisting of dolomite and sandy shale; middle, consisting of green shale with thin beds of dolomite interbedded; and upper, consisting of chert and cherty dolomite, overlain by dolomitic limestone. A very similar, though thicker section was penetrated by a well in sec. 25, T. 16 N., R. 19 E., approxmiately 8 miles northeast of Muskogee. A red shale is found in most wells in northeastern Oklahoma at the base of the middle member.

The Tyner formation is equivalent to part of the Simpson group of the Arbuckle Mountain area of south-central Oklahoma, and contains the prolific "Wilcox" oil sand,[58] though the exact position of the latter in the Tyner section is somewhat in doubt. Cram[59] suggests that a red shale found below the thick "Wilcox" sand section of the Wewoka-Seminole area is the same as the red shale found in well cuttings in northeastern Oklahoma, at the base of the middle Tyner, but Cram's section shows the Tyner to be sparingly sandy and devoid of any thick sandstones.

Cram's subdivisions were roughly identified in logs of wells drilled in the Muskogee-Porum district, and recognized as: lower Tyner, Wilcox sand and upper Tyner.

The lower Tyner is predominantly composed of green and red shale. Near the top a small amount of green sand may be present, but near the base the formation becomes more dolomitic. The thickness ranges from 90 to 150 feet.

57. Cram, Ira H., "Cherokee and Adair Counties," *Okla. Geol. Survey Bull.* 40, Vol. 3, pp. 531-586, 1930.

58. The Ordovician formation called "Wilcox sand" by the drillers of this region should not be confused with the widespread Eocene Wilcox group of the Gulf Coast.

59. *op. cit.*, p. 545.

The "Wilcox sand" probably extends throughout the entire Muskogee-Porum district. However, it thins to the northeast, and in the northwest corner of SE¼ sec. 12, T. 15 N., R. 18 E., the greatest thickness found was only 2 feet. It is not over 50 feet thick in any part of the area and is commonly less than 15 feet. The sand is characterized by a high percentage of uniform fine angular grains accompanied by small, fairly well rounded grains and a few large rounded, etched grains. The grains are practically all quartz. The Wilcox has yielded commercial quantities of oil and gas in this area.

Overlying the "Wilcox sand," and belonging to the upper Tyner is a series of brown to gray sandy dolomitic limestone interstratified with some green shale and thin sandstone members.

Fite limestone. Above the Tyner, in the Illinois River section, Cram[60] identified a hard, light gray, sub-lithographic limestone, which together with the overlying Fernvale, Taff had originally included in the upper part of the Tyner. Cram named this the Fite limestone, and suggests its correlation with at least part of the "Simpson dense lime" of the subsurface of the greater Seminole area.

Equivalents of the Fite and the underlying upper Tyner dolomitic limestones were classified by White[61] as "post-Wilcox" Simpson. A thickness of 15 feet of these units was found between the "Wilcox" and the "white lime" in a well of the York Oil and Gas Company in the SE¼ sec. 12, T. 15 N., R. 18 E.

Fernvale. The "white lime," which is also known by the drillers as the "Buttermilk lime," is of Richmond age and is the equivalent of the Fernvale limestone of Arkansas, Tennessee, and other states. This limestone is white or grayish white. The coarse white drill cuttings permit the formation to be easily recognized. Its thickness in the Muskogee-Porum district ranges from 30 to 50 feet.

60. *op. cit.*, p. 546-48.
61. White, Luther H., "Subsurface Distribution and Correlation of the Pre-Chattanooga ("Wilcox" sand) Series of Northeastern Oklahoma." *Okla. Geol. Survey Bull.* 40, Vol. 1, p. 32, 1928.

Sylvan shale. The Sylvan shale is a light-blue calcareous shale, which at some places has a greenish tinge. The maximum thickness in the Muskogee-Porum district is probably not over 50 feet, and the average is not over 30 feet. It is not present in the northern part of the area (T. 15 N. and part of T. 14 N). Where the Sylvan is absent the Chattanooga shale rests directly upon the "white lime" or older formations. The absence of the Sylvan shale may be noted in the graphic well logs of the Sommerville, Robinson, and Muskogee oil and gas fields. (See Pl. VI.)

SILURIAN

St. Clair marble. The St. Clair marble is present in the southern half of the Muskogee-Porum district but is absent in Tps. 14 and 15 and part of T. 13 N. Its color ranges from yellowish blue to pinkish white. It increases in thickness to the south, reaching its maximum thickness of 150 feet only in the southern part of the area.

DEVONIAN (?)

Chattanooga shale. The Chattanooga shale is a black bituminous fissile shale, which ranges in thickness from 20 to 100 feet. Because of its uniform lithology and wide extent the black shale is a very useful marker for drillers. This shale was deposited across the truncated edges of the underlying formations that in this area had been tilted to the south and southeast, owing to uplift of the Ozark dome at some time after the deposition of the St. Clair marble. The areal extent of the pre-Chattanooga formations is shown by White[62] and Cram.[63]

At the base of the Chattanooga shale occurs a lenticular sand or sandy limestone, known as the Misener sand, and equivalent to the Sylamore sandstone of northeastern Oklahoma and northwestern Arkansas. It is extremely local, and productive of oil in only a few places in the Muskogee-Porum district.

62. White, L. H., *op. cit.*
63. Cram, Ira H., *op. cit.*, fig. 107.

CARBONIFEROUS

Mississippian

Boone limestone and overlying beds. The writer did not attempt to separate the Boone limestone and the beds commonly known as the Mayes formation in the graphic well logs included in this report. They are commonly termed collectively "Mississippi lime" by the drillers. In the well logs of the Muskogee-Porum district their total thickness ranges from 60 to 150 feet.

As the Boone thins rapidly from the area of outcrop, in the extreme northeast corner of Muskogee County, toward the west and southwest[64] it is very probable that the greater part of the "Mississippi lime" is Mayes. The thickness of the Boone is probably only a few feet, but in the southwestern part of the Muskogee-Porum district and also in other parts of the area it may be completely absent. In a well drilled in the SE¼ sec. 2, T. 14 N., R. 18 E., 15 feet of the white cherty limestone typical of the Boone was logged. In a well drilled in the SE¼ sec. 12, T. 15 N., R. 18 E., 24 feet of Boone limestone was found at a depth of 1,545 feet.

The Mayes formation or the "black lime" of the drillers is considered by some geologists to be post-Boone in age, by others to be a phase of the upper Boone and possibly younger beds. It is composed predominantly of black sandy, micaceous, and argillaceous limestone interbedded with black shale. The thickness increases from the outcrop toward the west.[65]

Fayetteville shale. The Fayetteville shale is composed of black bituminous shale with a few intercalated strata of sandstone and limestone. The thickness in the Muskogee-Porum district ranges from 60 to 180 feet. The Fayetteville shale is a useful formation to drillers, as its black shale between the "black lime" and the Morrow formation ("brown lime") is easy to recognize.

vented collecting from them. The Morrow fauna has been de-

64. Buchanan, G. S., "The Distribution and Correlation of the Mississippian of Oklahoma": *Bull. Amer. Assoc. Petro. Geol.*, Vol. 11, p. 1314, 1927.

65. Buchanan, G. S., *op. cit.*, p. 1316.

Paleontology

Marine invertebrate fossils were collected from practically every fossiliferous zone in the area, except the Morrow group and Pitkin. Most of the fossils were obtained from the limestones, shale, and sandstones of the Atoka, McAlester and Savanna formations. Although the limestones and calcareous shales of the Morrow and Pitkin are exceedingly fossiliferous, lack of time prescribed by Mather.[66] Part of the material on which he based his descriptions was collected just across Arkansas River from the Muskogee-Porum district.

Plant fossils were found at several horizons. The Hartshorne sandstone especially, contains great quantities of plant fragments, some of which are well preserved.

The fossils were identified by the writer. G. H. Girty kindly gave invaluable advice in this work and checked many of the specific identifications.

The faunas were classified according to their facies. The three types of facies found were associated with shale in the Atoka and McAlester; with sandstone in the Atoka and McAlester; and with limestone in the Savanna. The environments in which these faunas lived were recently described by Moore.[67]

ATOKA FORMATION

Sandstone faunas:

Fauna 1. Collected from a 6-inch stratum of blocky sandstone lying a few feet beneath the Georges Fork sandstone member, in the SW corner of sec. 29, T. 13 N., R. 20 E.:

Michelinia eugeneae
Orbiculoidea convexa
Orbiculoidea stoutella
Derbya crassa
Marginifera muricatina
 var. missouriensis
Chonetina sp.
Linoproductus sp.
Productus sp. undet.
Cancrinella boonensis var.
Neospirifer cameratus?
Spirifer rockymontanus
Edmondia aspinwallensis
Edmondia gibbosa

66. Mather, K. F., "The Fauna of the Morrow Group of Arkansas and Oklahoma": *Denison Univ., Sci. Lab., Bull.*, Vol. 18, pp. 59-284, 1915.

67. Moore, R. C., "Environment of Pennsylvanian Life in North America": *Bull. Amer. Assoc. Petro. Geol. Bull.*, Vol. 13, pp. 459-487, 1929.

Leda meekana
Leda sp. undet.
Parallelodon tenuistriatum
Pinna peracuta
Conocardium aliforme
Pteria sp.
Myalina perattenuata
Myalina perniformis
Myalina swallowi
Myalina wyomingensis
Schizodus cuneatus?
Schizodus sp. undet.
Schizodus aff. S. wheeleri
Aviculopecten aff. arkansanus
Aviculopecten sp. undet.
Deltopecten? hertzeri
Acanthopecten carboniferus
Lima retifera
Allorisma sp. undet.
Cypricardinia carbonaria
Pleurophorus angulatus
Pleurophorus subcostatus
Pleurophorus taffi
Pleurophorus tropidophorus
Pleurophorus tropidophorus var.
Astartella compacta?
Astartella concentrica
Bellerophon sp. undet.
Euomphalus sp. undet.
Naticopsis sp. undet.
Pleurotomaria sp. undet.
Bulimorpha nitidula?
Metacoceras sp. undet.
Orthoceras sp. undet.
Pseudorthoceras knoxense?

The fauna of this surprisingly fossiliferous sandy facies is dominated by pelecypods, 29 species having been collected. Gastropods and brachiopods are both abundant. Such genera as *Martinia, Composita, Ambocoelia, Squamularia,* and *Leiorhynchus* appear to be absent in this particular facies. The most abundant genera are *Astartella, Chonetina, Pleurophorus, Spirifer,* and *Myalina. Astartella concentrica, Chonetina sp.,* and *Pleurophorus tropidophorus* are present in great numbers.

FAUNA 2. Dirty Creek sandstone member, SW¼ sec. 11, T. 12 N., R. 20 E.:

Lophophyllum profundum
Agassizocrinus? sp. undet.
Derbya crassa
Derbya robusta
Derbya sp. undet.
Hustedia brentwoodensis
Hustedia mormoni
Hustedia sp.
Lindstroemella patula
Neospirifer cameratus?
Punctospirifer spinosa?
Punctospirifer kentuckyensis
Spirifer rockymontanus
Acanthopecten carboniferum
Deltopecten? hertzeri
Deltopecten scalaris
Deltopecten texanus
Bellerophon crassus
Bellerophon sp. undet.
Pleurotomaria carbonaria
Pleurotomaria sp. undet.
Platyceras occidentale?

In this fauna brachiopods and pelecypods are both abundant, and gastropods are common. The most outstanding genera are *Hustedia, Deltopecten,* and *Bellerophon.*

FAUNA 3. Webbers Falls sandstone member, NE¼ sec. 34, T. 12 N., R. 19 E.:

Archaeocidaris
Fragments of Bryozoa
Juresania sp. undet.
Fish scales?

A microscopic examination of thin sections of this very fine-grained calcareous sandstone reveals the great abundance of spines of the echinoid genus *Archaeocidaris.*

FAUNA 4. Blackjack School sandstone member, SW corner of sec. 16, T. 11 N., R. 19 E.:

Lophophyllum profundum
Composita subtilita
Derbya crassa
Marginifera muricatina
Astartella concentrica

FAUNA 5. Blackjack School sandstone member, SW¼ sec. 17, T. 11 N., R. 19 E.:

Linoproductus sp.
Streblopteria sp. undet.
Astartella sp. undet.
Bellerophon sp. undet.

FAUNA 6. Blackjack School sandstone member, NE corner of sec. 8, T. 11 N., R. 19 E.:

Composita subtilita
Juresania nebrascensis
Marginifera muricatina
M. muricatina var. missouriensis
Schizophoria resupinoides
Spirifer sp. undet.
Aviculopecten sp. undet.
Euphemus carbonarius
Platyceras occidentale?

FAUNA 7. Blackjack School sandstone member, NW¼ sec. 6, T. 11 N., R. 19 E.:

Lophophyllum profundum
Chonetina sp.
Composita subtilita
Leiorhynchus rockymontana
Leiorhynchus rockymontana var.
Marginifera muricatina var. missouriensis
Martinia sulcata
Orbiculoidea missouriensis
Conularia crustula

Shale faunas:

FAUNA 8. Specimens of *Lophophyllum, Phillipsia,* and *Marginifera* were found in an iron-concretion layer in the dark-blue fissile shale above the Blackjack School sandstone member in sec. 21, T. 15 N., R. 19 E.

MCALESTER SHALE

Sandstone faunas:

FAUNA 9. The only fauna characteristic of a sandy facies found in the McAlester shale was collected from a thin sandstone layer above the Warner sandstone member in the southwest corner of sec. 11, T. 13 N., R. 19 E. The Warner sandstone member contains marine fossils in the NE¼ sec. 7, T. 15 N., R. 19 E.

Lophophyllum profundum
Marginifera muricatina
  var. missouriensis
Astartella varica?
Leda bellistriata
Lima retifera
Platyceras sp. undet.
Metacoceras cornutum
Phillipsia sp. undet.

Shale faunas:

FAUNA 10. Collected from a thin zone of calcareous shale (M_4) immediately above the Stigler coal in a coal pit in the center of sec. 17, T. 12 N., R. 19 E. This calcareous shale grades upward into a dark fissile shale that is unfossiliferous.

Fenestella sp. undet.
Prismopora serrata
Rhombopora sp. undet.
Septopora biserialis
Lingula sp. undet.
Prothyris elegans
Edmondia gibbosa
Leda bellistriata
Leda inflata
Leda meekana
Leda prolongata
Pteria longa
Pteria ohioensis
Pteria sp.
Pteria aff. P. sulcata
Schizodus alpinus?
Schizodus sp. undet.
Solenomorpha sp.
Solenomya radiata var.
Solenomya soleniformis?
Deltopecten? hertzeri
Deltopecten interlineatus
Deltopecten occidentalis
Deltopecten? scalaris
Aclisina conditi
Aclisina swallowana
Euphemus carbonarius
Patellostium marcouianum
Metacoceras cornutum
Metococeras sp.
Sphaerodoma brevis?
Sphaerodoma paludiniformis?
Bairdia
Healdia
Youngiella
Conodonts

The species occurring most abundantly in this calcareous shale are those obviously characteristic of a muddy facies. The fauna is largely made up of pelecypods, only one specimen of brachiopod having been found. In addition to the pelecypods there are, however, numerous bryozoans, gastropods, and ostracodes. The commonest genera are *Pteria, Deltopecten, Leda, Edmondia, Patellostium, Healdia, Youngiella,* and several genera of bryozoans.

FAUNA 11. Collected from pit of Trojan Coal Co., in the SE¼ sec. 13, T. 11 N., R. 19 E.; from the same horizon as fauna 10.

Fenestella sp. undet.
Prismopora serrata
Prismopora triangulata
Rhombopora sp. undet.
Septopora biserialis
Lindstroemella patula
Lingula sp. undet.
Orbiculoidea meekana
Deltopecten? hertzeri
Deltopecten? interlineatus

Deltopecten occidentalis
Deltopecten scalaris
Edmondia gibbosa
Edmondia? glabra
Leda bellistriata
Leda cf. L. arata?
Leda meekana
Leda prolongata
Nucula anodontoides
Pleurophorus oblongus var.
Pleurophorus spinulosus
Pteria longa
Pteria ohioensis
Pteria sulcata
Pteria sp.
Schizodus sp. undet.
Solenomya radiata var.
Solenomya soleniformis
Euphemus carbonarius
Patellostium marcouianum
Sphaerodoma brevis
Metacoceras cornutum
Bairdia acetalata
Bairdia trojana
Bythocypris bisoni
Bythocypris bullifera
Bythocypris pediformis
Bythocypris tomlinsoni
Cytherella calcar
Cytherella missouriensis
Healdia limacoidea
Healdia longa
Jonesina gregaria?
Waylandella mcalesterensis
Youngiella knighti
Youngiella puncta
Youngiella specafera
Conodonts

FAUNA 12. At several horizons in the shale members of the McAlester shale there are thin but very fossiliferous layers, including many beds filled with iron concretions, some of which contain fossils. The forms found most abundantly are *Lophophyllum profundum, Phillipsia,* and branching crinoid stems. The "trilobite zone" mentioned by McCoy[68] as occurring in this formation in Muskogee and Mayes Counties is probably one of these layers.

SAVANNA FORMATION

Limestone faunas:

FAUNA 13. Collected from the Sam Creek limestone member of the Savanna, a 10-inch dense shelly limestone, which grades upward into thinly laminated unfossiliferous shale; exposure in the SE corner of sec. 1, T. 14 N., R. 17 E.:

Lophophyllum profundum
Ambocoelia planiconvexa
Chonetes sp.
Chonetina verneuilianus
Composita subtilita
Derbya crassa
Hustedia mormoni
Juresania nebrascensis
Leiorhynchus rockymontana
Leiorhynchus rockymontana var.
Martinia contracta
Martinia sulcata
Marginifera muricatina
Mesolobus sp.
Neospirifer cameratus?
Orbiculoidea missouriensis
Spirifer rockymontanus
Squamularia perplexa
Edmondia sp. undet.
Lima krotowi
Lima retifera

68. McCoy, A. W., "A Short Sketch of the Paleogeography and the Historical Geology of the Mid-Continent Oil District and its Importance to Petroleum Geology": *Amer. Assoc. Petro. Geol. Bull.*, Vol. 5, p. 548, 1921.

The predominance of brachiopods, which are represented by 16 species, as contrasted with 4 species of pelecypods, is normally to be expected in the fauna of such a typical shelly facies. The genera that are abundantly represented are *Marginifera, Leiorhynchus, Spirifer, Martinia, Composita, Orbiculoidea, Hustedia, Ambocoelia, Lima,* and *Edmondia.* The species that appear to be most characteristic of this facies are *Marginifera muricatina, Leiorhynchus rockymontana, Neospirifer cameratus?, Spirifer rockymontanus, Orbiculoidea missouriensis, Martinia sulcata, M. contracta,* and *Composita subtilita.* It is perhaps a significant fact that *Mesolobus sp.* is rare in this fauna, as well as in all other faunas in this area.

STRATIGRAPHIC SIGNIFICANCE OF THE FAUNAS

The marine invertebrate faunas found at certain horizons in the Pennsylvanian strata of the Western Interior coal field have been described from several localities. Few attempts, however, have been made to determine the stratigraphic significance of these described faunas. This is due partly to the presence of many so-called "long-range species" that are found throughout the Pennsylvanian series; such species include *Lophophyllum profundum, Rhombopora lepidodendroides, Ambocoelia planoconvexa, Derbya crassa, Orbiculoidea missouriensis, Linoproductus sp., Juresania nebrascensis, Composita subtilita, Hustedia mormoni, Punctospirifer kentuckyensis, Neospirifer cameratus?,* etc. Girty has done extensive work on the faunas in Oklahoma, Arkansas, Missouri, and Texas; Beede and Rogers in Kansas; Moore and Plummer in Texas; Mather in Arkansas and Oklahoma; and many others have contributed. As a result the formations of the lower part of this series have been zoned to a certain extent upon the basis of a few key fossils, whose time of abundance seems to have been relatively short. It is the aim of the present writer to add a further bit to the store of knowledge.

The faunas to be reviewed were collected from the Atoka formation, the McAlester shale, and the Savanna formation. As the fossils from these three formations were found in rocks of

different facies: the fossils from the Atoka having been found almost exclusively in sandstone, those from the Savanna in limestone, and those from the McAlester chiefly in shale, the writer does not believe it possible to draw conclusions from these fossils as to the difference in age and correlation between these formations at this time.

The fauna of the Morrow group, which underlies the Atoka formation, has been described by Mather.[69] In summarizing his remarks upon the fauna of the Morrow, Mather states:

> A critical examination of the Morrow fauna makes evident its position as transitional between the faunas which have been considered typical of the later Mississippian and of the earlier Pennsylvanian times. The reference of the Morrow group to the early Pottsville appears to be verified by the faunal evidence from the associated limestones. The fauna is essentially a mingling of two assemblages of animals —one group composed of forms of a Mississippian type and the other including those forms which are typical of the Pennsylvanian epoch. The former may be conveniently referred to as the residual element and the latter as the proemial element.

Mather lists 20 species characteristic of the residual Mississippian element and 49 species that are typical of the proemial Pennsylvanian element. Of the 20 species considered to represent a residual Mississipian element not one was found in the collections from the Atoka, McAlester, and Savanna formations. Of the 49 species of the proemial Pennsylvanian element only 10 were found in the sandstones of the Atoka formation and 12 in the shales and limestones of the McAlester shale and Savanna formation. The species of the Morrow found also in the Atoka and in the McAlester and Savanna are as follows:

69. Mather, K. F., "The Fauna of the Morrow Group of Arkansas and Oklahoma": *Denison Univ., Sci. Lab., Bull.,* Vol. 18, pp. 59-284, 1915.

ATOKA	McALESTER and SAVANNA
Lophophyllum profundum	Campophyllum torquium
Michelinia eugeneae	Lophophyllum profundum
Hustedia brentwoodensis	Rhombopra lepidodendroides
Orbiculoidea missouriensis	Orbiculoidea missouriensis
Cancrinella boonensis	Juresania nebrascensis
Juresania nebrascensis	Squamularia perplexa
Schizophoris resupinoides	Spirifer rockymontanus
Spirifer rockymontanus	Aviculopecten? interlineatus
Pleurophorus tropidophorus	Deltopecten? hertzeri
Euphemus carbonarius	Deltopecten occidentalis
	Leda bellistriata
	Euphemus carbonarius

The closest overlying fauna that has been described is that of the Wewoka formation,[70] which contains 22 of the 58 species found in the Atoka formation and 21 of the 52 species found in the McAlester shale and Savanna formation of the Muskogee-Porum district. In the analysis of this fauna Girty refers to the following species as fairly common to abundant: *Lophophyllum profundum, Leiorhynchus rockymontana, Astartella concentrica, Nuculopsis ventricosa,* and *Phanerotrema grayvillense.* Of these the first three are common in the Atoka, McAlester, and Savanna formations, but the last two were not found in any of these three formations. In conclusion, Girty says:[71]

> The general composition of the Wewoka fauna, the presence of *Chonetes mesolobus,* and the absence of Meekella and like forms, suggests an early stage of the Pennsylvanian, and the fauna resembles the faunas of the early Pennsylvanian much more closely than those of the late Pennsylvanian of the upper Mississippi Valley * * *.

Comparison of the faunas of the Atoka, McAlester and Savanna formations with the subjacent and superjacent faunas leads the writer to the conclusion that the faunas of the Atoka, McAlester and Savanna may be distinguished from the subjacent Morrow fauna by the complete absence of the residual Mississippian fauna, by the absence of a large percentage of the proemial Pennsylvanian element, and by the introduction of the new forms that are typical of the lower Pennsylvanian but that did not appear until after the deposition of the Morrow beds.

70. Girty, G. H., "Fauna of the Wewoka Formation of Oklahoma": *U. S. Geol. Survey Bull.,* 544, 1915.

71. *Idem,* p. 14.

Also, the faunas of the Atoka, McAlester and Savanna formations may be distinguished from the superjacent fauna of the Wewoka formation by the great abundance of *Marginifera muricatina* in the Atoka, McAlester and Savanna formations and its scarcity in the Wewoka (three or four specimens from each of two or three localities); by the relative abundance of *Mesolobus sp.* in the Wewoka and the scarcity (only two specimens) of that form in the Atoka, McAlester and Savanna formations; by the abundance of *Nuculopsis ventricosa* and *Phanerotrema grayvillense* in the Wewoka, and the complete absence of the species from the Atoka, McAlester and Savanna formations; and last by the difference in the faunas as a whole, only 40 percent of the fossils of the Atoka, McAlester and Savanna formations occurring in the Wewoka.

It should be noted that the importance of some of the differences between the faunas of the Wewoka formation and the Atoka, McAlester and Savanna formations, shown by this preliminary study, may be more apparent than real, since Hendricks[72] reports that *Mesolobus sp.* is abundant, and *Nuculopsis ventricosa* and *Phanerotrema grayvillense* are fairly abundant in these formations in the McAlester district.

Beede and Rogers[73] describe the Cherokee shale (stage A of series 1) as being characterized by a great predominance of *Marginifera muricata* and abundant *Squamularia perplexa, Composita subtilita, Chonetes mesolobus,* and *Ambocoelia planiconvexa.* They designate series 1, including stage A (Cherokee shale) and stage B (Fort Scott limestone up to the base of the Bethany Falls limestone), the "*Chonetes mesolobus* zone." They call stage A the "*Marginifera muricata* zone" and stage B the "*Chaetetes milleporaceus* zone."

As a result of the present work the writer believes that the "*Marginifera muricata* zone" is characteristic of both the Atoka

72. Hendricks, T. A., personal communication.

73. Beede, J. W., and Rogers, A. F., "Coal Measures Faunal Studies: Faunal Divisions of the Kansas Coal Measures": *The Univ. Geol. Survey of Kansas,* Vol. 9, pp. 318-385, 1908.

and McAlester formation (lower part of Cherokee), but that the "*Chonetes mesolobus* zone" begins at a horizon in the Cherokee shale higher than that of the Savanna sandstone.

The writer has checked over the faunas of the members of the Pottsville formation of Ohio[74] in order to try to determine if any definite correlation is possible. No such correlation is attempted here, but the writer wishes to call attention to the close similarity of faunas. Of the 58 species identified from the Atoka formation of the Muskogee-Porum district, 34 were described from the Pottsville of Ohio; most of the 17 species not found were closely related if not identical with species listed from Ohio. Of the 52 species identified from the McAlester shale and Savanna sandstone of the Muskogee-Porum district, 34 were described from the Pottsville of Ohio.

Structure

REGIONAL FEATURES

The Muskogee-Porum district is located at the junction of two major structural provinces, the Ozark dome, and the Ouachita folded and faulted belt. The southwest dip of the strata on the southwestward-plunging axis of the Ozark dome gradually merges in the immediate vicinity of the area into the west dip of the strata of the Prairie Plains homocline. The east-west folds and faults produced by the Ouachita orogeny become less perceptible toward the north and grade into the gently westward dipping strata of the Prairie Plains homocline. The movements in the Ozark and Ouachita provinces have influenced the development of the structure of this area.

It is well known that the structural features of this general region are more pronounced in older formations than in younger formations. In the Muskogee-Porum district, as elsewhere, the folds and faults decrease in intensity upward through the conformable sandstones and shales of the Atoka, Hartshorne, McAlester,

74. Morningstar, Helen, "Pottsville Fauna of Ohio": *Ohio Geol. Survey, 4th ser., Bull.* 25, 1922.

Savanna, and Boggy formations. The writer agrees with Bloesch[75] in believing that this decrease is due to recurring deformation during the deposition of the Atoka, Hartshorne, McAlester, Savanna, and Boggy formations, which, though not of sufficient intensity to produce a marked sedimentary break, or unconformity, nevertheless caused each successively higher, younger formation to have gentler dip and less pronounced structural features. Supplementary evidence confirming this belief is the slight thinning of the stratigraphic section over anticlinal axes and the thickening of the section over synclinal axes.

The prevailing feature of the structure of the Muskogee-Porum district is a regional dip of about 2° WSW., modified locally by differential uplift (tilting) of crustal blocks whose longest dimension is in a west-southwest direction. In consequence of this tilting the surface rocks are ruptured or sharply bent along the margins of the blocks by dip faults and monoclinal folds.

FAULTS

The major faults of the Muskogee-Porum district (see fig. 4) mark the margins of six crustal blocks, each of which is about 6 miles wide. One of these blocks is tilted to the north; two are tilted to the south; and the remaining three, the Warner uplift, the graben block between the Keefeton and Sam Creek faults, and the horst between the Sam Creek and Muskogee faults, have remained more or less level. All these blocks slope westward with the low dip common to the region. The faults that delimit the blocks are described from south to north as follows:

An unnamed fault having a downthrow to the southeast apparently extends along Canadian River in Tps. 10 and 11 N., Rs. 20 and 21 E., and determines the location and direction of the river. This fault is associated with the Vian anticline.[76] The fault extends from sec. 1, T. 10 N., R. 20 E., northeastward to sec. 2, T. 11 N., R. 21 E. It was not possible to find enough outcrops in

75. Bloesch, Edward, "Unconformities in Oklahoma and Their Importance in Petroleum Geology": *Amer. Assoc. Petro. Geol. Bull.*, Vol. 3, pp. 253-285, 1919.
76. Snider, L. C., "Geology of East-Central Oklahoma": *Okla. Geol. Survey Bull.* 17, pp. 11-16, 1914.

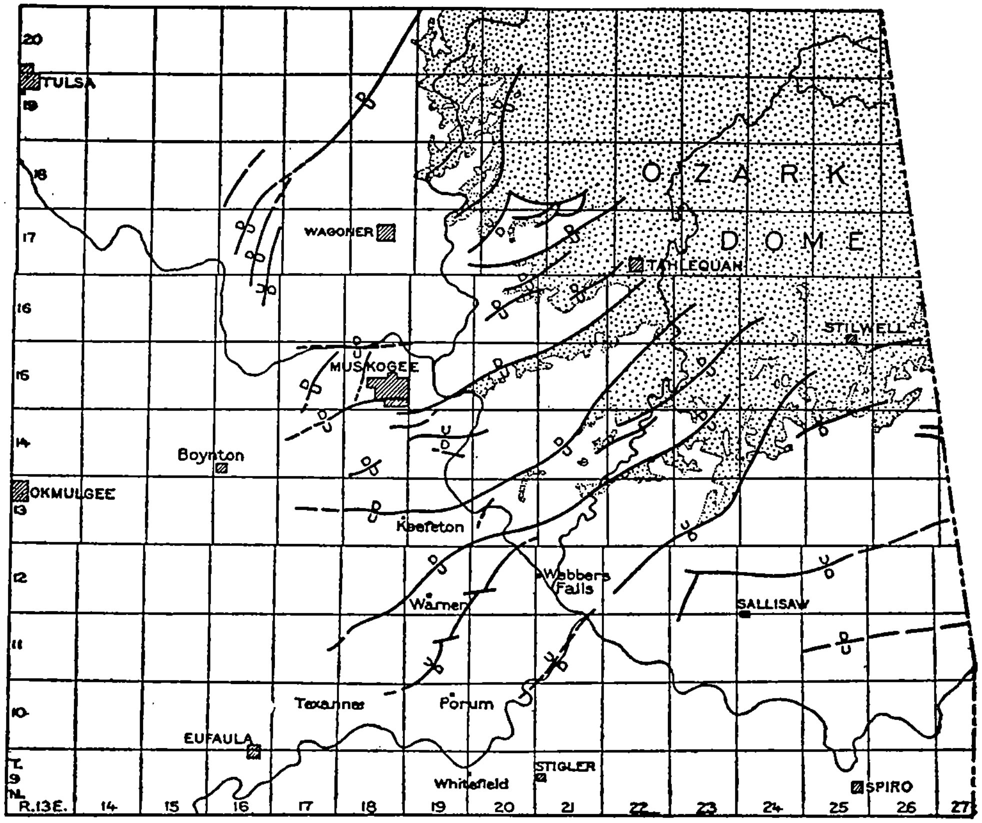


FIGURE 4. Outline map of northeastern Oklahoma showing the faults on the plunging southwest nose of the Ozark Dome.

the flood plain of Canadian River to determine the course and exact nature of the structure more than approximately, but a comparison of the writer's field notes and structure maps with those of W. T. Thom, Jr., for the area across the river in Haskell County, indicates the presence of either an extremely sharp monoclinal fold or, more probably, a fault. The presence of this fault may best be detected by its effect upon the Warner sandstone member of the McAlester shale and the associated members. Along the northwest side of the river the Warner sandstone member holds up a long unbroken cuesta with an altitude close to 750 feet. On the southeast side of the river there are several exposures of the Warner sandstone member extending from sec. 7, T. 10 N., R. 21 E., northeastward to sec. 25, T. 11 N., R. 21 E., and probably beyond. These exposures occur along the crest of a small anticline mapped by Thom. Along the line where the upper part of this sandstone disappears beneath the flood-plain silt the sandstone is dipping to the northwest. A northwestward projection of this dip without the intervening postulated fault would carry the sandstone several hundred feet beneath the known position of the same sandstone on the northwest side of the river. As the exposures of the strata affected are some distance from the trace of the buried fault it does not seem feasible to estimate the amount of downthrow.

The *south fault of the Warner uplift,* which has a downthrow to the southeast, strikes about N. 32° E., extending southwestward from sec. 3, T. 12 N., R. 20 E., to sec. 6, T. 10 N., R. 19 E. This fault cuts all the strata that lie between the Keota sandstone member of the Savanna formation and the Pope Chapel sandstone member of the Atoka formation. In sec. 6, T. 10 N., R. 19 E., the fault probably passes into a monoclinal fold at the surface. In secs. 3, 4, 9, 16, and 17, T. 12 N., R. 20 E., the writer was unable to map the trace of the fault plane, and it may be that here also the fault line is expressed at the surface as a monoclinal fold. Between secs. 3 and 20, T. 12 N., R. 20 E., the fault, or more probably monoclinal fold, lies within the outcrop of the Pope Chapel sandstone member and overlying shale of the Atoka formation and extends parallel to the strike of that member. In sec. 19, the main fault is offset by a small cross fault that has a strike of about N. 80° E. This cross fault is upthrown to the north and is limited in extent to secs. 19 and 20. In secs. 28 and 33, T. 11 N., R. 19 E., the fault causes a very interesting relation between the Warner sandstone member and the Bluejacket sandstone member. The very slightly tilted Bluejacket member caps a flat-topped hill in the central part of the S½ sec. 33. The Warner member extends southwestward from the NE¼SE¼ sec. 28 across the southern part of the section and dips within this distance from 2° to 10° SSE. The slight dip of the Bluejacket sandstone and strong dip of the Warner sandstone within about half a mile have suggested to certain workers the presence of a marked unconformity between the two sandstone members[77] Between sec. 19, T. 12 N., R. 20 E., and sec. 11, T. 11 N., R. 19 E., the surface trace of the fault extends parallel to the strike of the Blackjack School and Webbers Falls sandstone members. An interesting feature of this portion of the fault is the more or less straight and parallel hogbacks formed by the Hartshorne sandstone and the Warner sandstone member of the McAlester shale, about a quarter of a mile east of the surface trace of the fault. The sandstones in the hogbacks dip about 12°-25° ESE. From sec. 11 to the northeast corner of sec. 15, T. 11 N., R. 19 E., the fault is offset to the west a distance of about 2,000 feet by a small cross fault, which is limited to secs. 11, 14, and 15 of this township.

The *north fault of the Warner uplift* strikes about N. 57° E. and extends southwestward across the area from sec. 22, T. 13 N., R. 20 E., to sec. 18, T. 11 N., R. 18 E. Between sec. 31, T. 13 N., R. 20 E., and sec. 20, T. 12 N., R. 19 E., this fault is expressed at the surface as a monoclinal fold in which the strata are sharply flexed downward to the north along the line of subsurface faulting. Within this distance the strata lying between the Pope Chapel sandstone member of the Atoka formation and the Warner sandstone member of the McAlester shale are affected. From sec. 20, T. 12 N., R. 19 E., southwestward to sec. 7, T. 11 N., R. 18 E., the fault comes to the surface and within this distance reaches a maximum throw of 200 feet down to the northwest. Throughout most of this distance the Cameron sandstone member and the overlying shale are brought up along the southeast side of the fault and lie in contact at the surface with the Keota sandstone member of the Savanna formation.

The *Keefeton fault* has an east-west strike and crosses the area near the center of T. 13 N., Rs. 18 and 19 E. Between sec. 15, T. 13 N., R. 19 E., and sec. 17, T. 13 N., R. 18 E., the throw of the fault is about 600 feet down to the north. West of sec. 17 the throw becomes less. From sec. 14, T. 13 N., R. 19 E., to sec.

77. Powers, Sidney, "Structural Geology of Northeastern Oklahoma": *Jour. Geol.*, Vol. 39, p. 125, 1931.

13, T. 13 N., R. 18 E., the McCurtain shale member of the McAlester shale has been faulted with the downthrow on the north side of the fault, and is in contact throughout this distance with the Webbers Falls and Blackjack School members of the Atoka formation and the shales overlying both sandstone members. In secs. 14, 15, 16, and 17, T. 13 N., R. 18 E., the Warner sandstone member of the McAlester shale, the Tamaha and Keota sandstone members of the Savanna formation, and the shale overlying each of these three sandstone members have been dropped on the north side of the fault and are in contact with the McCurtain shale member. In sec. 17, T. 13 N., R. 18 E., the Bluejacket sandstone member of the Boggy formation has been dropped on the north side of the fault to the level of the Warner sandstone member of the McAlester shale, causing the cuestas held up by these massive sandstones to appear as if they joined. It is at this locality that much of the previous trouble in the north-south correlation of the sandstones in this area has been encountered. These two sandstones, though very different, are faulted so close together that without careful comparison of their lithology, checking of the well logs, and study of the sequence of strata both above and below, they might easily be accepted as correlative. The writer wishes to acknowledge here his indebtedness to A. H. Hanson,[78] of Muskogee, who first realized the true importance of the Keefeton fault. The dip of the plane of this fault is as low as 60° in secs. 13 and 14, T. 13 N., R. 18 E. Wells drilled in these sections and in secs. 17, 18, 19, and 20, T. 13 N., R. 19 E., on the downthrown side of the fault and within half a mile of its outcrop, cut the fault plane and strike the gas horizon at about the same depth as wells started on the upthrown side of the fault. Logs of some of the wells that intersect the fault plane show that the stratigraphic section has been shortened several hundred feet. (See Pl. VII).

The *Sam Creek fault* has an east-west strike across T. 14 N., R. 19 E. In the eastern part of the township the throw is about 150 feet, and the downthrown side is to the south; along the

78. Personal communication.

west township line the throw becomes negligible. From this line the fault continues as a subsurface break with no offset in the surface strata and bends toward the southwest, crossing secs. 13, 14, 22, 23, and 27, T. 14 N., R. 18 E. Even though the surface strata in these sections are not broken, the trace of the fault can be located just south of the anticline formed as a drag fold on the upthrown side. In the northeast corner of sec. 13, T. 14 N., R. 18 E., the Warner sandstone member, which there is about 30 feet thick, medium-grained, and irregularly bedded, changes sharply to thinly and regularly bedded fine-grained sandstone about 10 feet thick. In secs. 28, 33, 32, and 31, T. 14 N., R. 18 E., the surface strata are again broken, but the relative movement is here reversed, the downthrown side being to the north. The hinge of this pivotal fault is close to the escarpment of the Bluejacket sandstone member along the east line of sec. 28, west of which the throw abruptly increases.

The *Coody Creek fault* extends from the NE¼ sec. 5, T. 14 N., R. 19 E., westward to the west line of sec. 11, T. 14 N., R. 18 E. The throw of this fault is down to the north and is about 90 feet. The McCurtain and Warner members of the McAlester shale and the Tamaha and Keota members of the Savanna formation are cut at the surface by this fault.

Under the name *"Muskogee fault"* are included two faults that may be designated as the Muskogee fault (north) and the Muskogee fault (south). These two faults are separate and distinct at the surface, but as they have been previously mapped as parts of one continuous fault and as they form, together, a break between two of the major fault blocks of the area, the writer describes them under the same name. The Muskogee fault (south) enters the area in sec. 26, T. 15 N., R. 19 E., but is covered by the alluvial silt of Arkansas River from that locality to N½ sec. 2, T. 14 N., R. 18 E., in which section it abruptly dies out. The presence of this fault beneath the alluvium was determined by the study of well logs. The throw is as much as 600 feet, and the downthrown side is to the north. The Muskogee fault (north) probably begins abruptly in the SE¼ sec. 30, T. 15 N., R. 19 E., and extends west-southwest into sec. 8, T. 14 N., R. 17 E., beyond which it could not be accurately traced. The downthrown side is to the north. The throw is about 250 feet in sec. 33, T. 15 N., R. 18 E., but gradually lessens to the west until the fault becomes untraceable. From the SW¼ sec. 25, T. 15 N., R. 18 E., southwestward to sec. 10, T. 14 N., R. 17 E., the Crekola sandstone member and the overlying shale of the Boggy formation are in turn faulted down to the level of the McCurtain shale member and the Warner sandstone member of the McAlester shale and the Tamaha and Keota sandstone members of the Savanna formation, as well as that portion of the Boggy formation underlying the Crekola sandstone. Associated with the Muskogee fault (south) in sec. 2, T. 14 N., R. 18 E., are two small faults that offset the Warner sandstone member, lifting it to the level of the Keota member.

A small north-south fault extends from sec. 9 to sec. 28, T. 15 N., R. 18 E. The throw is down to the east and is probably less than 30 feet. The displacement of this fault is shown by logs of wells drilled in the vicinity of the fault. In the SW¼ sec. 21 the Bluejacket sandstone member has been offset several hundred feet.

The *Pecan Creek fault* is first traceable at the surface in the northeast corner of sec. 14, T. 15 N., R. 17 E., from which it extends southwestward. It cannot be traced beyond sec. 4, T. 14 N., R. 17 E. The throw of this fault, which is down to the northwest, is about 200 feet in sec. 14, T. 15 N., R. 17 E., where the Crekola sandstone member of the Boggy formation is faulted down to the level of the shale lying between the Bluejacket and Keota sandstones. Southwestward from this section the throw rapidly becomes less until the fault can be traced no farther.

In secs. 23 and 26, T. 14 N., R. 17 E., there are two small faults, and in secs. 17, 20, 21, and 28, there are three others. All of these strike northwest. They are parallel, and all have the downthrown side to the northeast. Four of them are less than a mile in length; the fifth is about 2 miles. The presence of these faults was detected by the offset in the escarpment held up by the Taft sandstone member of the Boggy formation. The trend of these faults is similar to the trend of the *en echelon* faults in Seminole, Okfuskee, and Creek Counties and other parts of Oklahoma.[79]

An unnamed east-west fault is believed to extend along the valley of Arkansas River, entering the Muskogee-Porum district near the middle of sec. 1, T. 15 N., R. 18 E., and extending westward to the south line of sec. 4, T. 15 N., R. 17 E., and beyond. The throw is down to the north. The presence of this fault was determined by the difference in depth at which certain beds were encountered in wells drilled south of the fault as compared with those drilled north of the fault (secs. 1, 2, 3, and 6, T. 15 N., R. 17 E.). Because these wells are at some distance from the trace of the buried fault no estimate of the amount of throw is made. The most noticeable surface evidence of this fault is the offset of the Bluejacket sandstone member and associated strata. In T. 15 N., R. 17 E., south of the river, the Bluejacket sandstone member forms an escarpment in secs. 9 and 10; if this escarpment were projected westward along the strike the base of the sandstone would be cut by the fault near the southwest corner of sec. 4. North of the river the first exposure of this sandstone is in the NW¼ sec. 2, from which the sandstone holds up an escarpment trending northeastward. If this escarpment were projected southwestward along the strike, the base of the sandstone would be cut by the fault in the SW¼ sec. 3. This would suggest that the Bluejacket sandstone member had been offset about 1¼ miles at the surface.

FOLDS

The Muskogee-Porum district contains several major monoclinal folds (asymmetric synclines and anticlines) and numerous small, gentle folds whose limits and axes are difficult to define and trace.

79. Fath, A. E., "The Origin of the Faults, Anticlines, and Buried 'Granite Ridge' of the Northern Part of the Mid-Continent Oil and Gas Field": *U. S. Geol. Survey Prof. Paper* 128, pp. 77-84, 1921.

The major asymmetric folds extend completely across the area and divide it into broad crustal fault blocks. At places the faults change to monoclinal folds. The strike of such faults and folds ranges from N. 45° E. to east. Ordinarily one limb of such a fold has a steep dip (5° to 45°) and the other limb a very gentle dip (not more than 2°). The steeply dipping limbs are rarely more than a mile across, but the gently dipping limbs average about 5 miles. The Porum syncline, the Rattlesnake Mountains syncline, and the Spaniard Creek syncline illustrate this type of fold.

The axis of the *Porum syncline* extends from sec. 19, T. 10 N., R. 19 E., northeastward in the general direction of Webbers Falls. The steep northwestern limb of this fold, which shows dips as high as 25°, is associated with the downthrown side of the south fault of the Warner uplift. The broad, gently sloping southeastern limb of this syncline has a dip that is commonly a little less than 2° NW. Along the axis of this fold members of the Savanna formation extend as far northeastward as sec. 18, T. 11 N., R. 20 E.

The *Warner uplift* is a raised block between faults on the north and south. The strata are relatively flat-lying on this uplift, except for the gentle westward regional dip. Close to the north fault the strata are flexed steeply northward, and in localities where the fault passes locally into a monoclinal fold they dip unbroken into the steeply dipping limb of the Rattlesnake Mountains syncline. In a similar way the flat-lying strata are flexed steeply southward at the south fault; and where this fault passes into a monoclinal fold the strata dip unbroken into the steep limb of the Porum syncline.

A similar downward flexure is found on the upthrown side of the Keefeton fault in secs. 13 and 24, T. 13 N., R. 17 E., where the Bluejacket sandstone member, which is approximately horizontal on the pronounced cuesta a mile to the east, dips steeply northward, only to be cut off by the fault at the bottom of the dip slope. On the downthrown sides of the Sam Creek and Muskogee faults the strata are flexed upward, and on the upthrown sides of these faults the strata are flexed downward.

The axis of the *Rattlesnake Mountains syncline* extends across the area from sec. 31, T. 12 N., R. 18 E., northeastward to sec. 19, T. 13 N., R. 20 E. The steep southeastern limb of this asymmetric syncline is associated with the north fault of the Warner uplift. Along the axis of the fold members of the Savanna formation extend as far northeastward as sec. 17, T. 12 N., R. 19 E.

The axis of the *Spaniard Creek syncline* extends from sec. 14, T. 13 N., R. 19 E., westward to sec. 12, T. 13 N., R. 18 E. The steeply dipping southern limb of this asymmetric fold is associated with the downthrown side of the Keefeton fault. The dip along the cuesta held up by the Warner sandstone member just north of the Keefeton fault ranges from 4° to 17°.

The minor, local folds commonly range in strike from N. 20° E. to east. Two of the best examples of this group are the anticline whose axis is just south of the north line of T. 13 N., R. 19 E., and the Taft anticline, in secs. 17, 18, and 19, T. 15 N., R. 17 E. The axis of the Taft anticline extends from a point near Taft northeastward to the SE¼ sec. 8, T. 15 N., R. 17 E. The dip of the strata on the flanks of this small fold is probably everywhere less than 4°. The Sommerville oil and gas field has been developed on this anticline.

JOINTS

The joints, which are very abundant in the massive but regularly bedded sandstones, seem usually to be referable to two main systems, one striking about N. 37° W. and the other about N. 85° E.

RELATION OF THE FOLDS AND FAULTS

The genetic relationship between monoclinal folds and the faults that cut them was recognized by Taff[80] and described by him as follows: "Such relations between the folds and faults point strongly to the probability that the same forces produced the two types of structure and that their occurrences were closely related in time." The present writer, after a detailed examination of the field relations between these folds and faults, also came to the conclusion that they were formed by contemporaneous stresses.

80. Taff, J. A., *U. S. Geol. Survey Geol. Atlas, Tahlequah Folio* (No. 122), p. 3, 1905.

Economic geology

COAL RESOURCES

The coal beds that crop out in the Muskogee-Porum district are too thin to be of other than local economic importance, but they will supply the needs of the local market. The Stigler (McAlester) and Secor coal seams are the best in this district and are now being mined at several localities. Very little detailed work has been done previously on the distribution and correlation of these coals. The results of the writer's studies are given herewith.

Distribution and Correlation of the Coal Beds

The principal coal beds found are in the McAlester shale [Stigler (McAlester) and upper Hartshorne coals], and the Boggy formation [Secor coal]. The correlations of these coals with those in the McAlester, Howe-Wilburton, and Stigler-Poteau districts, in Coal, Atoka, Pittsburg, Latimer, Haskell, and Le Flore Counties, were made after consultation with W. T. Thom, Jr., T. A. Hendricks, and C. H. Dane. The writer has also traced the coal beds across the areas intervening between those mapped by Thom, Hendricks, Dane, and himself, including the Stigler-McAlester coal and several overlying sandstones from the southwest corner of the Sallisaw quadrangle northeastward to the northeast corner of T. 7 N., R. 23 E., and the Secor (upper Witteville) coal and associated sandstones from sec. 13, T. 6 N., R. 16 E., northeastward to sec. 15, T. 7 N., R. 17 E.

McAlester shale. The thickest coal bed in the McAlester shale is correlated with the McAlester coal of the McAlester district and with the Stigler coal of the Stigler-Poteau district. This coal bed, which occurs 10 feet above the top of the Cameron sandstone member (mapped with the Warner sandstone member toward the north), has been prospected and mined at numerous localities along its outcrop as far north as sec. 13, T. 14 N., R. 18 E. Its thickness, which is greater in the southern part of the area, ranges from 11 to 24 inches.

A coal bed that ranges from 9 to 11 inches in thickness occurs locally in the Warner sandstone member and has been prospected and mined in sec. 13, T. 13 N., R. 18 E., and sec. 4, T. 13 N., R. 19 E. Coal was reported at a similar horizon in a water well near Warner. A coal bed 4 to 6 inches thick in the shaly sandstone of this member is exposed at several localities and has been prospected in secs. 11 and 12, T. 14 N., R. 18 E.

A coal bed that is correlated with the upper Hartshorne coal of the McAlester district occurs a few feet above the top of the Hartshorne sandstone. This bed ranges from 9 to 12 inches in thickness. It has been mined in sec. 35, T. 12 N., R. 20 E. Exposures of the coal were seen in sec. 10, T. 11 N., R. 20 E., and sec. 19, T. 12 N., R. 20 E., but no mining had been done at those localities. An old mine was reported at this horizon in sec. 20, T. 15 N., R. 19 E., but the coal was not seen.

Boggy formation. A coal bed occurs in the lower part of the Boggy formation a few feet above the top of the Bluejacket sandstone member. This coal is correlated by the writer with the Secor coal of the McAlester district, with the upper Witteville coal of the Howe-Wilburton district, and with the Jones Creek (Massey or Blocker) coal of the McCurtain district. In the southwest corner of T. 12 N., R. 18 E., where it has been mined at several localities, the coal is about 28 inches thick. It has also been mined in sec. 3, T. 13 N., R. 18 E., where it is 16 inches thick. This coal also crops out in sec. 9, T. 13 N., R. 18 E. It has been mined and prospected in secs. 19 and 31, T. 14 N., R. 18 E.; sec. 25, T. 15 N., R. 17 E., where it is 12 inches thick; and secs. 8, 9, 11, 14, and 16, T. 15 N., R. 17 E., where it is 11 inches thick.

A coal bed in the lower part of the Boggy shale [at base of (B_7) shale] between 120 and 220 feet below the Bluejacket sandstone member has been prospected and mined at many localities along the escarpments of the Belle Starr and Rattlesnake Mountains, and in sec. 2, T. 13 N., R. 18 N.; in secs. 6, 10, and 15, T. 14 N., R. 18 E.; secs. 21 and 22, T. 15 N., R. 18 E.; and sec. 13, T. 15 N., R. 17 E. The thickness of the coal averages close to 10 inches.

Analyses of the Coal

Analyses of samples of the Stigler (McAlester) coal are given below. These samples were taken in the pit of the Trojan Coal Co., sec. 18, T. 11 N., R. 20 E., by H. I. Smith and W. W. Fleming, of the United States Geological Survey, and the analyses were made by H. M. Cooper.

	As received	Air dried	Moisture free	Moisture and ash free
Proximate analysis:				
Moisture	2.3	1.3	....	....
Volatile matter	30.5	30.8	31.2	33.5
Fixed carbon	60.6	61.2	62.0	66.5
Ash	6.6	6.7	6.8	....
	100.0	100.0	100.0	100.0
Ultimate Analysis:				
Hydrogen	5.5	5.5	5.4	5.8
Carbon	77.8	78.6	79.6	85.4
Nitrogen	1.5	1.5	1.5	1.6
Oxygen	4.9	3.9	2.9	3.1
Sulphur	3.7	3.8	3.8	4.1
Ash	6.6	6.7	6.8	....
	100.0	100.0	100.0	100.0
Calorific value:				
Calories	7,839	7,917	8,022	8,606
British thermal units	14,110	14,250	14,440	15,490

Specific gravity of coal, 1.330.
Softening temperature of ash, 2340° F.

The Stigler (McAlester) coal in the pit of the Trojan Coal Co. was measured and sampled at two points by J. E. Moose and W. R. Rutherford.[81]

Sample A. was cut from the face of the coal at the middle of the pit, and sample B at a point 300 yards east of the middle

81. Moose, J. E., and Searle, V. C., "A Chemical Study of Oklahoma Coals": *Okla. Geol. Survey Bull.* 51, pp. 1-112, 1929.

of the pit. The overburden at both points was 18 feet thick (shale 6 feet, clay 12 feet), and the floor was shale.

	A Ft.	B Ft.
Bony coal	0.33	0.29
Coal	1.50	1.50
	1.83	1.79

Analyses of a composite of samples A and B made in the laboratory of the department of chemistry of the University of Oklahoma showed the following:

	As received	Moisture free
Proximate analysis:		
Moisture	2.8	....
Volatile matter	29.2	30.0
Fixed Carbon	59.6	61.4
Ash	8.4	8.6
Sulphur	3.8	3.9
Air-drying loss	2.2	....
Calorific value:		
Calories	7,650	7,875
British thermal units	13,780	14,170
"Unit" British thermal units	15,790	....

Mining

The coal is mined principally by stripping the overburden by means of scrapers or, in one locality, by a steam shovel. Most of the strip pits are narrow, elongated belts following the outcrop of the coal bed. Mining is continued down the dip until the overburden becomes too heavy for the scrapers. The coal has been mined in a few localities by slope and drift methods. At present the only two slope mines, which are in sec. 12, T. 10 N., R. 19 E., 1 mile east of Porum, are abandoned. Drift mines are used where the coal crops out on the side of a hill. The only shaft

mine in the area is in sec. 31, T. 12 N., R. 18 E.; the shaft there is 42 feet deep.

The most active mine at the present time is that of the Trojan Coal Co., in sec. 13, T. 11 N., R. 19 E., and sec. 18, T. 11 N., R. 20 E. This pit is equipped with steam shovels for stripping the overburden and for loading coal. An outlet for the coal is afforded by a short spur track to the Midland Valley Railroad. Another active mine is in sec. 6, T. 14 N., R. 18 E., where the "lower Boggy" coal is being stripped.

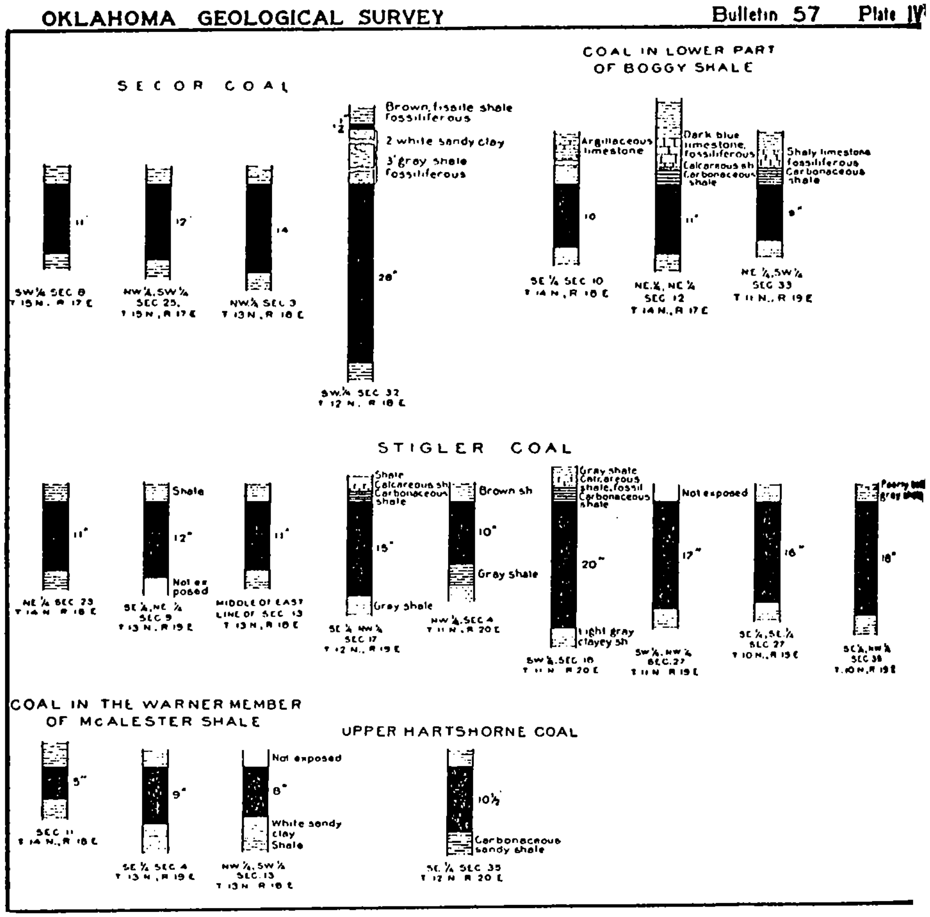
Stripping is the method of mining best adapted for the coal beds of the area, as they are too thin to be mined profitably by underground methods. In the past the ratio followed in general stripping practice has been approximately 1 inch of coal to 8 inches of overburden. The most favorable localities for stripping are in the broad, flat synclines, where the coal beds are likely to be close to the surface over large areas. The best localities of this kind are in the Porum syncline (Stigler coal); in the Rattlesnake Mountains syncline (Secor and Stigler coals); in the northwestern part of T. 13 N., R. 19 E. (Stigler coal); and near sec. 25, T. 15 N., R. 17 E. (Secor coal).

Township Descriptions

The following descriptions of the Muskogee-Porum district give the distribution and thickness of the coal seams, the location of the outcrops, and the extent to which the coal seams have been prospected and mined in each township. The purpose of these descriptions is to afford a detailed appraisal of the coal resources of the district. Only the coal beds that are more than 6 inches thick are described in this report. The townships are described in order from south to north. Sections measured at the localities indicated in the text by an asterisk (*) are given on Plate IV.

T. 10 N., R. 19 E.

The coal in the lower part of the Boggy shale crops out at several localities in T. 10 N., R. 19 E., along the escarpment of the Belle Starr Mountains, which are capped by the Bluejacket



Coal sections in the Muskogee-Porum district, Oklahoma.

sandstone member as here mapped. The coal is about 220 feet below this sandstone and is 10 inches thick. The outcrop of the coal is ordinarily concealed by loose fragments of shale and sandstone, but its approximate line of outcrop can be estimated from the mapped line of contact of the sandstone and the underlying shale. (See Plate I).

In sec. 35 the line of outcrop of the Stigler coal encircles the two hills that are capped by the Keota sandstone member. The coal has been prospected in the NE¼SW¼ sec. 35, but the thick-

ness at this locality could not be ascertained. In the SE¼NW¼ sec. 35*, a drift mine has been driven back under the hill. The coal in this mine is 18 inches thick. Around the northern of the two hills the coal has been prospected in the SE¼SE¼ sec. 27*, (thickness 16 inches), in the SW¼SW¼ sec. 26 (thickness 19 inches), and in the SW¼NW¼ sec. 35. It has been stripped along the outcrop in the SE¼SW¼ sec. 26 and the SE¼SW¼ and NE¼NW¼ sec. 35. As the coal crops out close to the bottom of the hill it cannot be successfully mined by stripping except in a very narrow belt along the outcrop. The average thickness of the coal in the strip pits is 18 inches, and the thickness of the overburden ranges from 5 to 10 feet. Extensive mining in this particular locality can be accomplished only by drift mines.

In the northeast corner of sec. 13 and at the middle of the east line of sec. 12 the coal has been taken out by slope mining. Along the east line of the SE¼ sec. 12, between the two slope mines, which are now deserted, the coal has been stripped along the outcrop for a distance of about 2,000 feet. The thickness of the coal could not be measured, but the overburden is about 5 to 7 feet. If the coal is more than 1 foot thick the gentle dip of the coal seam on the east limb of the Porum syncline and the proximity of the coal to the surface would permit more extensive stripping. Near the center of sec. 6, on the west limb of the Porum syncline, a coal seam that is undoubtedly the Stigler coal was reported to have been found in a water well at a depth of 38 feet.

T. 10 N., R. 20 E.

The Stigler coal was not located at any place in T. 10 N., R. 20 E., except in a small prospect pit in the SW¼SW¼ sec. 6. The approximate trace of the coal extends through secs. 7 and 6.

The horizon of the upper Hartshorne coal crosses the township from sec. 32 north-northeastward to sec. 2, but no exposures of the coal were found.

T. 11 N., R. 18 E.

The Secor coal is poorly exposed in T. 11 N., R. 18 E., but the trace of the line of outcrop is drawn through secs. 6 and 5, the location being determined by the relation to the base of the dip slope of the Bluejacket sandstone member as mapped. Some strip mining is being done in the NW¼ sec. 5. As the overburden would be relatively thin, the coal could probably be successfully mined by stripping. The thickness of the coal is probably about 28 inches.

A small isolated area of the Stigler coal has been preserved along the upthrown (south) side of the north fault of the Warner uplift. Its southern limit extends through secs. 3 and 2 of this township and northward into sec. 35, T. 12 N., R. 18 E. The coal has been mined in a small strip pit on the creek bank in the eastern part of the NE¼ sec. 3.

The horizon of the upper Hartshorne coal crosses secs. 1, 2 and 12, but the coal is not exposed.

T. 11 N., R. 19 E.

The coal in the lower part of the Boggy which crops out around the north end of the Belle Starr Mountains in T. 11 N., R. 19 E., has been prospected in the NE¼SW¼ sec. 33*. At this locality the coal is 9 inches thick.

The trace of the outcrop of the Stigler coal crosses sec. 36, but no exposures of the coal were found in that section. In the SE¼ sec. 13 the coal is being extensively stripped by the Trojan Coal Co. The coal ranges from 18 to 24 inches in thickness, and about 10 to 15 feet of overburden is being stripped from above it. From the center of sec. 13 the coal extends through secs. 14, 23, 22, 27, and 28 until cut off in the SE¼NE¼ sec. 28 by the south fault of the Warner uplift. The only exposure between this point and the Trojan coal pit is in the SW¼NW¼ sec. 27*, where the coal has been prospected in the bed of a small creek and is 17 inches thick. The gentle dip along the axis of the Porum syncline and the relative shallowness of the coal make this outcrop adaptable for stripping.

The horizon of the upper Hartshorne coal extends southwestward from sec. 1 to sec. 28, whence it turns northwestward, passing out of the township in the SW¼ sec. 7. No exposure of the coal is known in this township.

T. 11 N., R. 20 E.

The outcrop of the Stigler coal enters T. 11 N., R. 20 E., in sec. 31 and extends northward through secs. 30, 19, and 18. The coal has been mined in a small strip pit about 650 feet south of the center of sec. 30, where the thickness of the seam could not be measured. The coal has also been stripped in a narrow belt along the outcrop extending from the SW¼NW¼ sec. 30 to the SW¼SW¼ sec. 19, a distance of 2,350 feet. The thickness could not be measured at any place as the pits contained water. The overburden ranges from about 6 to 20 feet in thickness. The eastern half of the strip pit of the Trojan Coal Co. is in the SW¼ sec. 18* of this township and the western half in sec. 13, T. 11 N., R. 19 E. The thickness of the coal in the strip pit is about 20 inches and that of the overburden about 12 to 15 feet. The gentle dip and the nearness of the coal to the surface make stripping practicable in this part of the township. In secs. 17 and 20 there is a small outlier of this coal, the extent of which is difficult to ascertain, owing to the scarcity of outcrops. An outcrop in the NW¼NE¼ sec. 20 shows 11 inches of coal exposed in a creek bank. Near the middle of the south line of sec. 17 coal was reported to have been found in a water well at a depth of 18 feet. In secs. 4 and 5 there is another isolated basin of coal, which has been prospected at several localities in the NW¼ sec. 4* and the SE¼ sec. 5. The thickness of the coal, as measured at five localities, is 9 to 11 inches. The overburden is 3 to 10 feet thick.

The horizon of the upper Hartshorne coal extends northward from sec. 35 through secs. 34, 27, 28, 21, 22, 15, 10 and 2. The only exposures are found along a creek in the SE¼NE¼ sec. 10. At the only locality where it could be measured the coal is 7 inches thick. The line of outcrop of the coal was interpolated approximately from this section northward to Gritt's, in sec. 35, T. 12 N., R. 20 E.

T. 11 N., R. 21 E.

No coal is known to be present in T. 11 N., R. 21 E.

T. 12 N., R. 18 E.

The Secor coal has been stripped along the outcrop in T. 12 N., R. 18 E., for a distance of about 1,750 feet in a discontinuous narrow belt in the SW¼ sec. 32*, where it averages 28 inches in thickness. The overburden in the strip pits ranges from 3 to 12 feet. The approximate line of outcrop of the coal continues through secs. 31, 29, 30, and 19. The shallowness and thickness of the coal make the locality favorable for stripping. The coal has also been mined by shaft in the SE¼SW¼ sec. 31, at a depth of 42 feet. The thickness is about the same here as it is in sec. 32. The amount of coal that has been removed from this shaft mine would not be sufficient to affect stripping seriously.

The coal seam in the lower part of the Boggy formation, which averages between 9 and 10 inches in thickness, has been prospected at several localities along the escarpment of the Rattlesnake Mountains. The coal is about 150 feet beneath the Bluejacket sandstone as herein mapped.

A small area of the Stigler coal is present in the SW¼ sec. 35, just south of the north fault of the Warner uplift. This area is continuous with that in sec. 2, T. 11 N., R. 18 E. The outcrop of the coal also extends across the northeastern corner of the township through secs. 12, 11, 2, and 3. An old strip pit was reported to be in the southeast corner of sec. 3 but could not be located.

The horizon of the upper Hartshorne coal crosses sec. 36, but the seam is not exposed.

T. 12 N., R. 19 E.

A 9-inch seam of the coal in the lower part of the Boggy formation has been prospected along the north side of the Rattlesnake Mountains in sec. 19, T. 12 N., R. 19 E.

The outcrop of the Stigler coal extends from the SW¼ sec. 20, where it is cut off by the north fault of the Warner uplift, through secs. 17, 18, and 7. The coal has been stripped in a narrow belt along the outcrop for a distance of about 5,300 feet northwestward from the center of sec. 17* to the middle half of the north line of sec. 18. The coal is 14 to 16 inches thick, and the overburden is 2 to 8 feet thick. Another small strip pit was found in the southwest corner of sec. 7, but the thickness of the coal could not be measured. This area presents conditions favorable for some stripping, which would be limited by the closeness to the overlying Tamaha sandstone.

A coal bed in the Warner sandstone member of the McAlester shale was reported at a depth of 20 feet in a water well in the NE¼NW¼ sec. 29.

The horizon of the upper Hartshorne coal crosses the township from sec. 31 northeastward to sec. 2, but the coal, if present, is not exposed.

T. 12 N., R. 20 E.

The upper Hartshorne coal is the only coal bed found in T. 12 N., R. 20 E. It has been stripped at two localities in the SE¼ sec. 35*. The coal ranges from 10 to 11½ inches in thickness. The overburden, which is about 10 feet, is too thick to permit much stripping. The coal is also exposed by the north side of the highway in the SW¼SW¼ sec. 20, where it is 12 inches thick. The interpolated outcrop of the coal extends through secs. 28, 29, 30, and 31, but the only exposure is that in sec. 20.

T. 13 N., R. 18 E.

The Secor coal has been stripped in the NW¼ sec. 3*, T. 13 N., R. 18 E., where it is about 14 inches thick and the overburden is about 5 feet. The outcrop of the coal in secs. 3 and 4 probably encircles the small outlier of a sandstone low in the Boggy formation. At another outcrop, in the NW¼ sec. 9, 13 inches of coal is exposed.

The coal in the lower part of the Boggy formation probably crops out below the Bluejacket sandstone member across secs. 33, 32, 31, 30, 19, 20, 17, and 18, but it could be located only by a small prospect pit in the NW¼NW¼ sec. 20, where its thickness could not be measured . From sec. 18, the coal is offset along the Keefeton fault one mile, to the SW¼SE¼ sec. 17, and thence the outcrop probably continues across secs. 17, 16, 10, and 2. It has been stripped for a short distance along the outcrop in the SW¼ sec. 2. As the pits were deserted the coal could not be seen.

The outcrop of the Stigler coal crosses sec. 35, and the seam has been stripped near the center and in the NW¼. The coal was not seen but was reported to be about 16 inches thick. It no doubt continues across secs. 27, 28, 29, 20, and 17. From sec. 17 the coal is offset by the Keefeton fault eastward to the SE¼ sec. 15, from where the outcrop continues toward the east through secs. 14 and 13. The coal has been stripped in the NW¼ sec. 14, and has been prospected at the middle of the east line of sec. 13*, where it is 11 inches thick. The same coal has been mined in five small strip pits near the center of sec. 1. The thickness of the coal could not be measured at any of the pits but is probably about 12 inches. The overburden averages about 5 feet in thickness . The gentle dip and the shallowness of the coal are favorable for stripping near the outcrop, but within a short distance the coal is covered by the overlying Tamaha sandstone, which makes the overburden too great to be handled.

Another coal bed, 8 inches thick is found in the Warner sandstone member of the McAlester shale in the NW¼SW¼ sec. 13*.

T. 13 N., R. 19 E.

The outcrop of the Stigler coal extends from west to east near the center of secs. 18, 17, 16, and 15, T. 13 N., R. 19 E., paralleling the south limb of the Spaniard Creek syncline, which has a steep dip (10°). The coal has been prospected and locally stripped in the NW¼SW¼ sec 18 and the SE¼NW¼ sec. 16. Its thickness is about 11 or 12 inches. On the north limb of the Spaniard Creek syncline the outcrop of the coal crosses secs. 15, 9, 5, and 6. It has been mined in small strip pits in the NW¼NW¼ sec. 15, in the SE¼NE¼ sec. 9* (thickness 12 inches), in the SE¼SE¼ sec. 5 (thickness 8 inches), and in the NW¼SW¼ sec. 6. The low dip of the north limb of the syncline makes that limb more favorable for stripping than the south limb.

Another coal seam in the Warner sandstone member of the McAlester shale crops out in secs. 4 and 5, where the dips are steeper. It has been stripped in the NE¼ sec. 4 (thickness 11 inches) and prospected in the SE¼ sec. 4* (thickness 9 inches). An outcrop of this coal is found at the middle of the east line of sec. 5 (thickness 9 inches). The closely overlying upper part of the Warner sandstone member would prevent extensive stripping.

The horizon of the upper Hartshorne coal crosses secs. 35, 34, 27, 28, 33, 32, 31, and 30, but the coal is not exposed.

T. 13 N., R. 20 E.

No coal is known in T. 13 N., R. 20 E.

T. 14 N., R. 17 E.

The Secor coal bed crosses secs. 24, 14, 15, 10, and 11, T. 14 N., R. 17 E., but no exposure was found. In the SW¼NW¼ sec. 11 the coal is offset eastward to sec. 25, T. 15 N., R. 18 E., by the Muskogee fault. The chief difficulty in the stripping of this coal in Tps. 14 and 15 N., is the proximity of the overlying Crekola sandstone member.

The coal in the lower part of the Boggy formation crops out in secs. 1 and 12 and has been mined in several small strip pits in the NE¼NE¼ sec. 12*. It is 11 inches thick and is overlain by a thin fossiliferous limestone. The thickness of the overburden is less than 10 feet. Mining could be accomplished by stripping if the thickness of the coal should warrant mining.

T. 14 N., R. 18 E.

The trace of the Secor coal crosses T. 14 N., R. 18 E., in secs. 32, 31, 29, 20, 19, and 18. The coal has been prospected and mined in small strip pits in the SE¼NE¼ sec. 31 (6 to 10 feet of overburden); in the NW¼SE¼ sec. 19 (3 to 6 feet of overburden); and in the NW¼NW¼ sec. 19. The thickness could not be measured at any of these pits. It is possible that there may be a small area of this coal in the S½ sec. 34.

The outcrop of the coal in the lower part of the Boggy formation extends across secs. 35, 26, 27, 22, 14, 15, 11, 10, 3, 4, 5, and 6.

The coal has been prospected and mined in small strip pits in the SE¼ sec. 15 (thickness could not be measured) and in the SE¼ sec. 10* (thickness 10 inches). It is now being stripped in the SW¼ SW¼ sec. 6 (thickness 11 inches). As no exposures are found between secs. 3 and 6 the outcrop is approximated from its relation to the base of the dip slope of the Keota sandstone member. The flat dip of the coal seam and the proximity of the coal to the surface over a large area are extremely favorable for stripping, but the coal is probably too thin to warrant mining.

The outcrop of the Stigler coal crosses secs. 36, 25, 24, 23, 13, and 14. It has been prospected in the NW¼ sec. 25 and the NE¼ sec. 23*, where the overburden is 3 to 6 feet thick. An exposure of the coal in the road along the west line of the SW¼ sec. 13 shows the seam to be 11 inches thick. The Stigler coal was not recognized north of this exposure, but probably extends to the north line of sec. 11.

Locally, as in sec. 11*, a coal seam is present in the Warner sandstone member.

T. 14 N., R. 19 E.

The Stigler coal is exposed in secs. 31 and 32 and has been prospected in the SW¼ sec. 31 and the NW¼SW¼ sec. 32. The thickness is about 12 inches.

The horizon of the upper Hartshorne coal crosses the township, but no exposures were found.

T. 15 N., R. 17 E.

The outcrop of the Secor coal crosses T. 15 N., R. 17 E., in sec. 24, 25, 26, 35, 34, and 33, where it is cut out by the Pecan Creek fault. It has been stripped in a narrow belt for a distance of about 1,300 feet along the outcrop in the NW¼SW¼ sec. 25*, where the overburden is 3 to 6 feet thick. The coal is 12 inches thick. The coal is undoubtedly brought near to the surface in secs. 27, 28, and 33, where it would encircle three sides of the southwestward-plunging anticline on the downthrown (west) side of the Pecan Creek fault, but no trace of it was found. The coal is exposed in the SW¼ sec. 14, to which it has been offset on the downthrown side of the Pecan Creek fault. From this section the outcrop crosses secs. 11, 10, 15, 9, 16, 8, 17, and 18. The coal has been prospected and mined in small strip pits in the NE¼SW¼ sec. 14, the NE¼NW¼ sec. 14, the SW¼ sec. 11, the NE¼NE¼ sec. 16, the SE¼ sec. 9, and the SE¼SE¼ sec. 8. Along the river in the SW¼ sec. 8*, three drift mines have been driven back under the bluff. The thickness of the coal in the strip pits and drift mines is very close to 11 inches. The Crekola sandstone member is 12 to 15 feet above the coal in this township.

The outcrop of a coal bed in the Keota-Sam Creek section of the Savanna formation crosses the NE¼NE¼ sec. 13 and has been stripped in a small strip pit by the side of the road on the east line of sec. 13. The thickness of the coal could not be measured.

T. 15 N., R. 18 E.

The outcrop of the Secor coal probably extends across the southern part of the town of Muskogee and across the remainder of T. 15 N., R. 18 E., from east to west. So far as is known the coal is not actually exposed in this township.

The coal in the lower part of the Boggy formation is covered by alluvium in the eastern part of the township and is first located along the north line of sec. 22. The outcrop continues westward from sec. 22 to secs. 21, 16, 17, and 18. It has been mined in small strip pits in the north-central part of sec. 22 and in the NW¼NW¼ sec. 21. The thickness of the coal could not be measured, as it was not exposed in the old pits. Conditions are suitable for stripping, but the coal is probably too thin to warrant mining.

T. 15 N., R. 19 E.

The coal in the Warner sandstone member of the McAlester formation crosses T. 15 N., R. 19 E., but is covered by alluvial deposits. It was reported as having been mined in the SE¼ sec. 20, but the coal could not be seen.

OIL AND GAS RESOURCES

Correlation and description of the oil and gas sands

One of the original purposes of the study of the Muskogee-Porum district was to determine the age and correlation of the several producing oil and gas sands of the district. These include the Dutcher, Booch, Taneha, Tucker, and Bartlesville sands. The depth to these sands and their correlation are shown on the graphic well logs in Plates VI and VII.

In order to determine the characteristic features of each sand the writer made a microscopic examination of the sand grains and of thin sections of the sandstones prepared by the department of geology of Princeton University.

Dutcher sands. It is generally agreed among geologists that the Dutcher sands represent sandstone members of the Atoka formation. These sands, which occur in the lower part of the Atoka, are too irregular in extent and thickness to be accurately correlated for any great distance. "Stray sands" have been logged in this part of the formation, making definite correlation very difficult. The following correlations between subsurface sands and surface formations are made tentatively:

	Sandstone members of the Atoka formation
Gas sand	Dirty Creek
Bad Hole sand	Georges Fork
Muskogee sand	Pope Chapel
Timber Ridge sand	Coody

The "lime marker," which is logged above the Dutcher sands, is in part the subsurface equivalent of the Webbers Falls sandstone member of the Atoka formation. The calcareous shale above the Webbers Falls sandstone member is often logged with the lime marker.

The Muskogee sand of the Dutcher sand series, (here correlated with the Pope Chapel sandstone member of the Atoka formation), is made up of angular (rarely subangular) grains of clear, colorless quartz, many of which have well-developed crystal

faces and some of which are almost perfect crystals. It is exceedingly "clean" sand, containing practically no accessory minerals. Its grains are locally partly coated with red, brown, and yellow iron oxides, which serve both as cement and as coloring agents. They range in diameter from 0.25 to 0.5 millimeter and average close to 0.35 millimeter.

The angularity and interlocking character of the grains and the marked development of crystal faces are due to secondary enlargement of the grains. The secondary border surrounding an original grain is optically continuous with that grain, but the secondary enlargement is recognized in the thin sections by the thin, dark boundary line between the original and secondary quartz, by the fewer minute inclusions in the secondary border, by the way in which the grains are intergrown, and by the change in outline from the original subangular grain to the grain showing the form of a more or less complete crystal.

Booch sand. The Booch, Taneha, or Tucker sand is here correlated with the Warner sandstone member of the McAlester shale. The Booch sand has formerly been correlated by some workers with the Hartshorne sandstone and by others with sandstones of the McAlester shale. The northward surface tracing of these sandstone members by Thom, Hendricks and the writer, from their type localities in Atoka and Coal Counties, Oklahoma, and the subsurface correlation of this sand from the oil and gas fields west and northwest of Muskogee County to its outcrop in Muskogee County demonstrate definitely the correlation stated above.

The interval between the Booch sand (Warner sandstone member of the McAlester shale) and the Bartlesville sand (correlated with the Bluejacket member of the Boggy formation), as measured at the surface in Muskogee County is 750 feet in T. 10 N.; 640 feet in T. 11 N.; 450 feet in T. 13 N.; 425 feet in T. 14 N.; and 250 feet in T. 15 N. The interval between the Warner sandstone and the top of the Morrow group as measured at the surface in Muskogee County averages 750 feet in T. 13 N.; 650 feet in T.

14 N.; and 700 feet in T. 15 N. The interval between the Booch sand and the top of the Morrow is found to be considerably greater in logs of wells drilled south and west of the area of outcrop.

The Booch sand is composed of angular grains of clear, colorless quartz with many well-developed crystal faces due to secondary enlargement of the original subangular grains, a few subangular grains of quartz composed of an aggregate of argillaceous material, and many flakes of white mica. It is very ferruginous and the grains are cemented and colored by the light- to dark-brown coating of iron oxide. The grains range in diameter from 0.1 to 0.5 millimeter and average close to 0.3 millimeter.

Bartlesville sand. The subsurface correlation of the Bartlesville sand (whose equivalent, the Bluejacket sandstone member of the Cherokee formation is shown on the state geologic map) with the Salt sand of the Okmulgee district has long been recognized. This sand has been correlated by many writers with the Savanna formation but by others with sandstone members of the McAlester shale. As a result of the work of Thom, Hendricks, Dane and the writer, the lowest sandstone member of the Boggy formation has been traced from the type locality of the Boggy formation northward to Arkansas River and there correlated with the Bluejacket sandstone member of the Cherokee shale on the north side of the river. The Bluejacket sandstone member, which is the surface equivalent of the Bartlesville sand, is therefore here demonstrated to be the lowest sandstone member of the Boggy formation of the region described in this report, which lies south of Arkansas River.

In the correlation of the Bartlesville sand and its surface equivalent, the Bluejacket sandstone member of the Boggy formation, the significance of three limestones was demonstrated by S. W. Lowman. The Inola limestone member of the Boggy formation, which is found by surface measurements to be 25-40 feet above the top of the Bluejacket sandstone member, was found only as far south as sec. 7, T. 13 N., R. 18 E. North of that locality it appears in scattered exposures. The Spaniard and Sam Creek limestone members of the Savanna formation are found the length of the Muskogee-Porum district. The Sam Creek limestone member lies about 410 feet below the Bluejacket sandstone member in T. 10 N.; about 145 feet in T. 15 N. The Spaniard limestone member lies about 470 feet below the Bluejacket sandstone member in T. 10 N. and 165 feet in T. 15 N., and ranges from 20 to 60 feet below the Sam Creek limestone member.

In some localities west and northwest of Muskogee County the Bartlesville sand has been logged as appreciably thicker than 40 feet. It is possible that a part of the 40 feet of Boggy shale that lies between the Inola limestone member and the top of the Bluejacket sandstone member and a part of the 50 to 100 feet of Boggy formation that lies below the base of the Bluejacket sandstone member are locally sandy and hence have been logged with the normal 40 feet of Bluejacket sandstone.

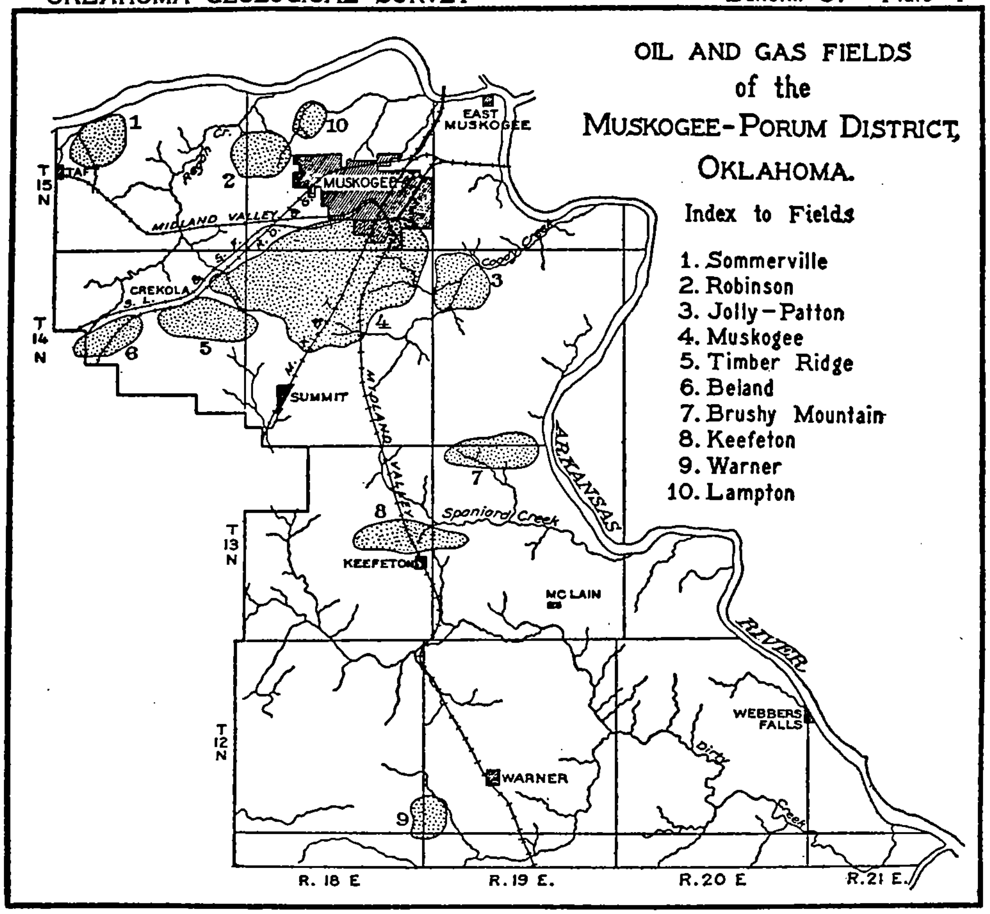
The Bartlesville sand is composed of angular grains of clear quartz, which have been secondarily enlarged. In addition, it contains many subangular grains of plagioclase feldspar, both fresh and decomposed, and many white mica flakes. The grains of quartz and feldspar range in diameter from 0.1 to 0.25 millimeter and average close to 0.2 millimeter.

History of development

The Muskogee-Porum district was first tested for oil and gas in 1894. This test was made by the Cudahy Oil Co. in the townsite of Muskogee. The resulting pool was not developed until 1904, however, because of the difficulty of obtaining legal title to the land. Since that date the area has been prospected with varying but never spectacular success. The development and production of the oil and gas fields of Muskogee and McIntosh Counties have been described by Taff and Shaler,[82] Taff,[83] Shannon,[84]

82. Taff, J. A., and Shaler, M. D., "Notes on the Geology of the Muskogee Oil Fields, Indian Territory": *U. S. Geol. Survey Bull.* 260, pp. 441-445, 1905.
83. Taff, J. A. *U. S. Geol. Survey Geol. Atlas, Muskogee Folio* (No. 132), 1906.
84. Shannon, C. W., "Petroleum and Natural Gas in Oklahoma": *Okla. Geol. Survey*

OKLAHOMA GEOLOGICAL SURVEY Bulletin 57 Plate V



Oil and gas fields of the Muskogee-Porum district.

Mills-Bullard,[85] Clark,[86] and Soyster and Taylor.[87] Recent developments include the opening of a new gas field about 2 miles southwest of Warner, of the Lampton oil and gas pool in secs. 8, 9, 16 and 17, T. 15 N., R. 18 E., and the finding of deeper

Bull. 19, *pt.* 2, pp. 331-339, 1917.

85. Mills-Bullard, Bess, "Digest of Oklahoma Oil and Gas Fields": *Okla. Geol. Survey Bull.* 40, Vol. 1, pp. 101-276, 1928.

86. Clark, R. W., "Oil and Gas in Oklahoma, McIntosh County": *Okla. Geol. Survey Bull.* 40, Vol 3, pp. 149-158, 1930.

87. Soyster, H. B., and Taylor, T. G., "Oil and Gas in Oklahoma, Muskogee County": *Okla. Geol. Survey Bull.* 40, Vol. 3, pp. 377-398, 1930.

production in the Beland field, secs. 16 and 17, T. 14 N., R. 17 E. Increased activity in the opening of gas fields followed the laying of a gas pipe line across the area, from Tulsa to Stigler, a few years ago.

The location and extent of the oil and gas fields are shown on Plate V, where they are designated by numbers corresponding to those used below. Logs of wells in these fields are given on Plates VI and VII.

SOMMERVILLE FIELD (1)

Location: Secs. 8, 9, 16, 17, 18, 19 and 20, T. 15 N., R. 17 E.

Surface altitude: 500-650 feet.

Surface stratigraphy: Crekola and Bluejacket sandstone members of the Boggy formation.

Structure: Taft anticline, whose axis trends northeastward across the field.

Depth to sands: Booch sand, 500-550 feet; Dutcher sands, top 930-1,070 feet, base 1,380-1,440 feet (the Muskogee and Timber Ridge sands, which are the most productive sands in the field, range in depth from 1,250 to 1,440 feet); "Wilcox" sand, 1,880-2,010 feet; Burgen sand, 1,995-2,160 feet.

Development and production:[88] The discovery well, which was the only oil well in this gas field, was drilled in the NE¼ sec. 17. This well produced 375 barrels on September 9, 1926, but was plugged by January 1, 1928. The productive sand, which was probably the Timber Ridge sand, was found at a depth of 1,439 to 1,450 feet. A well completed January 13, 1927, in the NW¼NE¼ sec. 17, yielded 2,000,000 cubic feet of gas from the Muskogee sand at a depth of 1,260 to 1,278 feet, and 50,000,000 cubic feet of gas with a rock pressure of 545 pounds from the Timber Ridge sand at a depth of 1,433 to 1,434 feet. Another well in the SW¼NW¼ sec. 17, which was completed February

88. Data mainly from Soyster, H. B., and Taylor, T. G., "Oil and Gas in Oklahoma, Muskogee County": *Okla. Geol. Survey Bull.* 40, Vol. 3, p. 396, 1930.

17, 1927, produced 28,800,000 cubic feet of gas with a rock pressure of 450 pounds from the Timber Ridge sand at 1,382 to 1,393 feet. These two wells were the largest in the field in 1928. The maximum production of the field up to 1928 was about 100,000,000 cubic feet a day.

ROBINSON FIELD (2)

Location: Secs. 18 and 19, T. 15 N., R. 18 E.; and secs. 13 and 24, T. 15 N., R. 17 E.

Surface altitude: 500-650 feet.

Surface stratigraphy: Bluejacket sandstone member of the Boggy formation, Keota sandstone member of the Savanna formation and intervening shale.

Structure: Small, local anticlines whose axes trend northeastward. The prevailing dip in the field is to the south.

Depth to sands: Booch sand, 300-450 feet; Dutcher sands, top 850-1,020 feet, base 1,190-1,475 feet: "Wilcox" sand, 2,030 feet.

Development and production: The first well in this field was drilled in the SE¼SE¼ sec. 13 during the fall of 1914. The initial production was 750 barrels. At the end of 2 years this well was still producing 150 barrels daily. The oil sand, which was either the Muskogee or the Timber Ridge, was found at 1,325 to 1,343 feet. In another sand (higher in the Dutcher series of sands) at a depth of 1,080 to 1,108 feet, 2,000,000 cubic feet of gas were found. Several wells were drilled around the discovery well, but none were completed as producers. In sec. 18 two wells were drilled, each of which had an initial yield of 12 barrels from either the Muskogee or the Timber Ridge sand, at a depth of 1,310 to 1,328 feet. In 1915 a well was completed in the NE¼NW¼ sec. 19, and yielded 800 barrels from a producing sand at a depth of 1,256 to 1,274 feet.

Gravity of the oil: 41°-42° Baume'.

JOLLY-PATTON FIELD (3)

Location: Secs. 5, 6, 7, and 8, T. 14 N., R. 19 E.

Surface altitude: 510 to 560 feet.

Surface stratigraphy: Blackjack School and Webbers Falls sandstone members of the Atoka formation.

Structure: Local anticlines on the horst between the Muskogee and Sam Creek faults.

Depth to sands: Dutcher sands, top 365 feet, base 700-820 feet; "Wilcox" sand, 1,310-1,460 feet.

Development and production: This field was discovered in August, 1920 in the NW¼ sec. 8. The initial production of the first well was 150 barrels. The sand, which was probably the Timber Ridge sand, was found at a depth of 662 to 674 feet. After the discovery 14 wells were completed as producers. As several dry holes were drilled, operations stopped. In April, 1926, however, interest was renewed when a 150-barrel well was brought in near the NW corner of the SW¼ sec. 5. Production came from the Timber Ridge sand, which was encountered at a depth of 718 feet. This extension of the original Jolly-Patton field is locally called the "Bradley pool." By September, 1927 a total of 16 wells had been drilled, but the maximum production was obtained in August, 1927, when 280 barrels of oil were produced daily. The original field was still further expanded in February, 1928, when a 150-barrel well was completed in the SW¼NW¼ sec. 6. The producing sand was found at a depth of 500 feet, close to the top of the Dutcher series of sands.

Gravity of the oil: 43° Baume'.

MUSKOGEE FIELD (4)

Location: Northern part of T. 14 N., R. 18 E.; secs. 32, 33, 34, and 35, T. 15 N., R. 18 E.; and NE. corner of T. 14 N., R. 17 E. The western part of this field is called the "Chicken Farm field."

Surface altitude: 525-650 feet.

Surface stratigraphy: McCurtain shale member and Warner sandstone member of the McAlester shale and Tamaha and Keota sandstone members and shales of the Savanna formation.

Structure: The field lies along the northern border of the southward-tilting horst between the Muskogee fault on the north and the Sam Creek fault on the south. Drilling is bounded along the northern border by the Muskogee fault, except where a well drilled north of the surface trace of the fault cuts the fault plane and enters the productive sands at practically the same depth as a well started south of the fault trace. On the east and west the field is limited to a broad terrace formed by flattening of the westward regional dip. A half dome occurs on this broad terrace in secs. 33 and 34, T. 15 N., R. 18 E., and secs. 3 and 4, T. 14 N., R. 18 E. The more favorable territory lies along the axis of the anticline formed by the upper half of the monoclinal fold associated with the fault.

Depth to sands: Booch sand, ranges from surface outcrop to 490 feet but over most of the field is close to 450 feet; Dutcher sands, top 600-980 (?) feet, base, 1,000-1,490 feet; "Wilcox" sand, 1,540-2,118 feet; Burgen sand, 1,740-2,020 feet. (Many of the logs in parts of this field show abnormally thick formations, possibly indicating subsurface faulting or local thickening of the strata.)

Development and production: This field was discovered in 1894, when two wells were drilled by the Cudahy Oil Co. In one of these wells a sand was found at a depth of 665 feet, which after being shot yielded 12 barrels of oil a day. Another sand, found at a depth of 1,100 feet, when similarly treated yielded 60 barrels a day. Active drilling started in 1904, and during that year more than 30 productive wells were drilled. Their combined capacity was estimated by Taff and Shaler at 1,000 barrels a day. By 1905 the pool had been fairly well tested, and operations began to slacken. In 1906, however, the field was extended to the southwest, and drilling continued for several years in spite of the varied production. Practically one-third of the wells drilled were gas producers. During 1913 the Muskogee field produced about 421,750 barrels of crude oil. The production for individual months ranged from 1,010 to 1,244 barrels. In 1913 the Prairie Pipe Line Co. ran 1,500 to 1,600 barrels a day from its leases, but in 1928 this had decreased to about 21 barrels a day. In 1928 the field

was producing only about 225 barrels a day. During 1914 development was much curtailed, and such wells as were drilled showed very light production. The average initial capacity at that time was probably not over 15 or 16 barrels.

Gravity of the oil: 42° Baume'.

TIMBER RIDGE FIELD (5)

Location: Secs. 10, 11, 12, 13, 14 and 15, T. 14 N., R. 17 E.

Surface altitude: 600-700 feet.

Surface stratigraphy: Bluejacket sandstone member of the Boggy formation.

Structure: This field has been developed along the upthrown side of the Muskogee fault.

Depth to sands: Booch sand, 460-500 feet; Dutcher sands, top 1,000(?)-1,040 feet, base 1,390-1,580 feet; "Wilcox" sand 2,190 feet.

Development and production: The discovery well was drilled about January, 1910 in the SE¼ sec. 11. A second well, which was a gas well, was drilled in the NW¼ sec. 13. Development of this field was practically completed by 1912. The production of the field at first was about 800 barrels of oil a day but has since declined to about 20 barrels. Individual wells produced from 50 to 250 barrels when first completed. Individual wells produced about 7,000,000 cubic feet of gas a day each. The productive sands are the Timber Ridge sand, 1,540-1,560 feet; Muskogee sand, 1,480-1,510 feet; Bad Hole sand, 1,385-1,407 feet; and a gas sand from 1,050 to 1,100 feet.

BELAND FIELD (6)

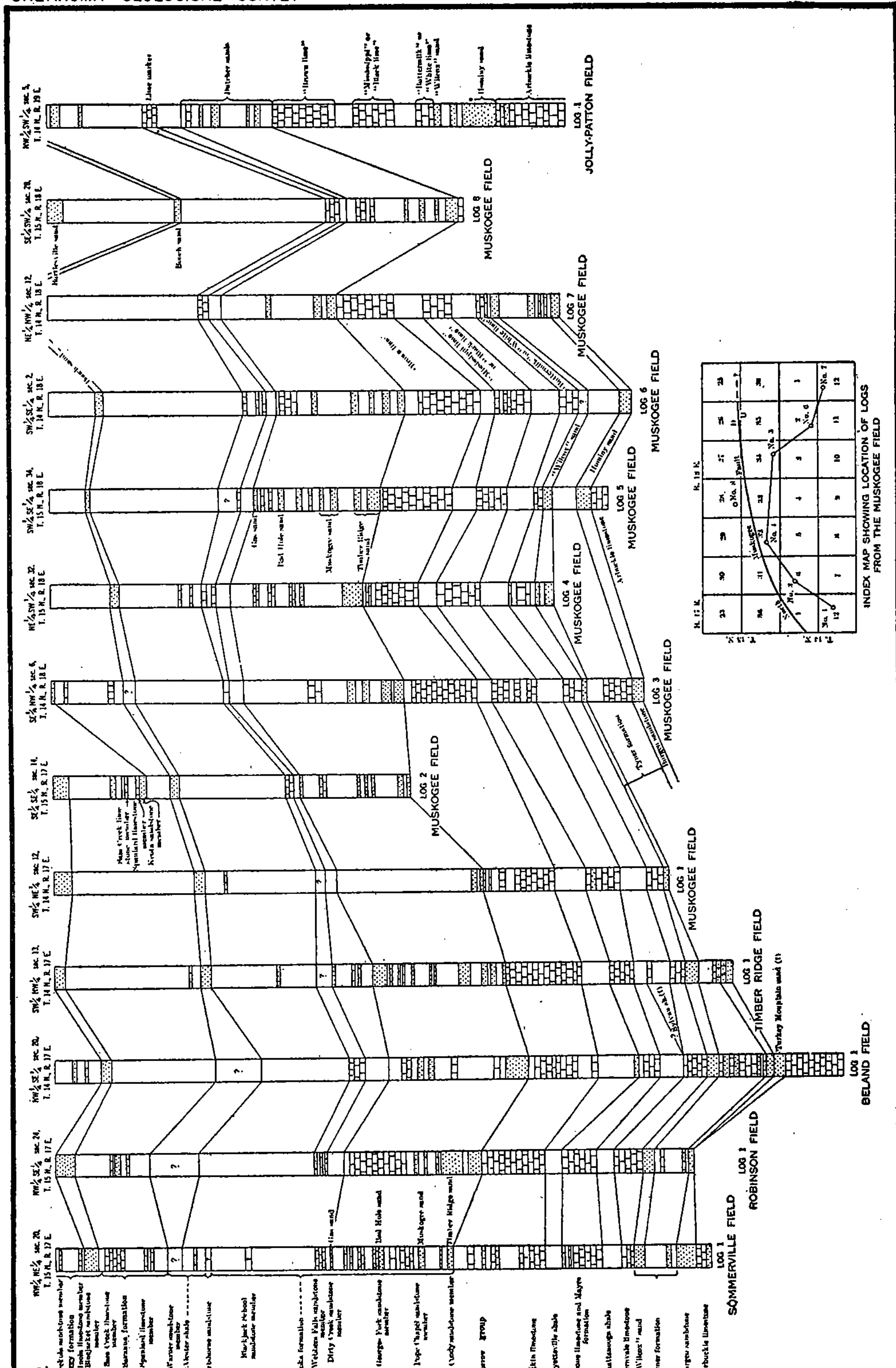
Location: Secs. 16, 17, 18, 19, 20 and 21, T. 14 N., R. 17 E.

Surface altitude: 600-650 feet.

Surface stratigraphy: Crekola and Taft sandstone members of the Boggy formation and the intervening beds.

Structure: An anticline associated with the upthrown side of the Muskogee fault.

OKLAHOMA GEOLOGICAL SURVEY Bulletin 57 Plate VI



Graphic well logs showing the correlation of the oil and gas sands of the Sommerville, Robinson, Jolly-Patton, Muskogee and Timber Ridge fields,

Depth to sands: Booch sand, 540-560 feet; Dutcher sands, top 1,020-1,160 (?) feet, base 1,440-1,650 feet; Misener (?) sand, 1,877-1,918 feet; "Wilcox" sand, 2,270 feet.

Development and production: The first well was drilled in the SE¼NW¼ sec. 16. The well was completed to a depth of 1,400 feet in October, 1913. After being shot it produced 10 barrels a day. Wells in this field have been small but have held up well. The average initial production was about 20 barrels a day. In 1928 the production was only about 5 barrels a day. Gas produced from the Booch sand (525 feet) averaged about 200,000 cubic feet a day. During the early history of the field the productive oil sands were the Timber Ridge sand and the Muskogee sand.

Gravity of the oil: 35-36.9° Baume'.

Within recent years, considerable production has been developed in secs. 16 and 17, from a sandy limestone 3 to 8 feet thick, found at depths ranging from 1,877 to 1,918 feet. The producing horizon occurs between the Chattanooga and Sylvan shales, and is thought to be equivalent to the Misener sand of other parts of Oklahoma, though some geologists refer it to the Hunton limestone.

Fourteen producing wells had been completed by the middle of May, 1936, with initial production of 30 to 100 barrels per day, after acidation. Production in the Misener sand is found on the top of the anticline, adjacent to the fault, and a short distance down the south flank.

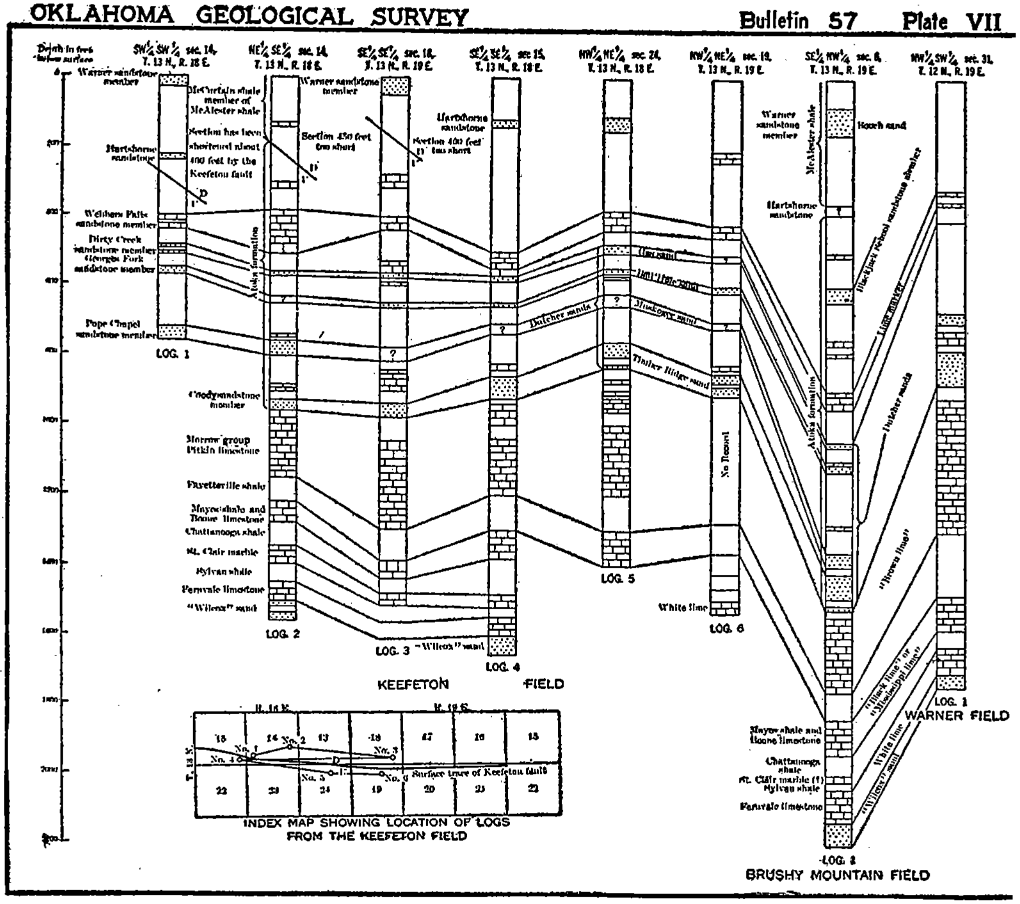
Gravity of the oil: 41.6 to 44° Baume'.

BRUSHY MOUNTAIN FIELD (7)

Location: Secs. 32 and 33, T. 14 N., R. 19 E.; and secs. 3, 4 and 5, T. 13 N., R. 19 E.

Surface altitude: 575-650 feet.

Surface stratigraphy: Warner sandstone member of the McAlester shale.



Graphic well logs showing the correlation of the oil and gas sands of the Brushy Mountain, Keefeton and Warner fields, Muskogee and McIntosh Counties, Oklahoma.

Structure: A local anticline whose axis trends east-west across secs. 3, 4, 5 and 6, T. 13 N., R. 19 E.

Depth to sands: Booch sand, 440-600 feet; Dutcher sands, top 940-980 feet (as deep as 1,100 feet in logs not reproduced in Plate VII), base 1,480-1,518 and 1,320-1,530 feet (average close to 1,500 feet); "Wilcox" sand, 2,130 feet.

Development and production: This field, which is predominantly a gas field, was opened in February, 1916 with a gas well in the SE¼ sec. 33. The initial daily production of this well was

7,000,000 cubic feet of gas with a rock pressure of 590 pounds. In 1929 several wells were being drilled.

KEEFETON FIELD (8)

Location: Secs. 13, 14, 23 and 24, T. 13 N., R. 18 E.; and secs. 18 and 19, T. 13 N., R. 19 E.

Surface altitude: 550-600 feet.

Surface stratigraphy: McCurtain shale and Warner sandstone members of the McAlester shale; Blackjack School sandstone member of Atoka formation; and Quaternary (?) terrace gravel.

Structure: This field has been developed along a faulted monoclinal fold (Keefeton fault), whose axis trends east-west. Although the surface trace of the Keefeton fault extends across the field, the dip of the fault plane is sufficiently low to allow wells drilled on the downthrown side of the fault (but close to the outcrop of the fault plane) to pass through the fault plane and enter the productive sands at practically the same depths as in the wells started on the upthrown side of the fault. This is shown in logs 1, 2, and 3 of this field (Pl. VII).

Depth to sands: Dutcher sands, top 482-565 feet (in some as deep as 650 feet), base 838-980 feet (in some as deep as 1,020 feet); "Wilcox" sand, 1,500-1,620 feet.

Development and production: This gas field was located in December, 1925. The producing sand, which was probably the Muskogee sand, was found at a depth of 748 to 759 feet and at first yielded 12,000,000 cubic feet of gas a day.

WARNER FIELD (9)

Location: Sec. 36, T. 12 N., R. 18 E. and sec. 31, T. 12 N., R. 19 E.

Surface altitude: 600 feet.

Surface stratigraphy: Blackjack School sandstone member of the Atoka formation; Hartshorne sandstone; and McCurtain shale member of the McAlester shale.

Structures Monoclinal fold on the north limb of the Warner uplift.

Depth to sands (only one log): Of the Dutcher series, the Muskogee sand is found at 670 feet, and base of sand series 880 feet; "Wilcox" sand, 1,700 feet.

Development and production: The first well in this field was drilled in the NW¼SW¼ sec. 31, T. 12 N., R. 19 E. In 1930 a small gas field was being opened north of the location of the first well. The production of gas, which comes from the Muskogee and Timber Ridge sands of the Dutcher series of sands, averages close to 10,000,000 cubic feet a day.

LAMPTON FIELD (10)

Location: Secs. 8, 9, 16 and 17, T. 15 N., R. 18 E.

Surface altitude: 525-575 feet.

Surface stratigraphy: Tamaha and Keota sandstone members of the Savanna formation; Warner sandstone member of the McAlester shale; and river alluvium.

Structure: Small local anticline.

Depth to sand (only two logs): Dutcher sands, productive part, 750 feet.

Development and production: This pool produces both oil and gas. A well in the NW¼SW¼ sec. 9, T. 15 N., R. 18 E., was completed June 1, 1927, with a production of 4,500,000 cubic feet of gas daily and a rock pressure of 260 pounds. Another gas well in the SW¼SW¼ sec. 9, T. 15 N., R. 18 E., was completed in December, 1927. In March, 1930 an oil well with an initial production of 200 barrels a day was completed in the NE¼ SW¼ sec. 9, T. 15 N., R. 18 E.

Gravity of the oil: 44° Baume'.

Prospects for future production

Small, but profitable, production of oil and gas is to be expected where the structure is favorable in Tps. 14 and 15 N. Profitable production of gas is to be expected in Tps. 10, 11, 12, and 13 N. Practically no oil has been found in the area south of T. 14 N.

Most of the favorable parts of the area have already been tested, and active fields have been developed. In the oil fields there has been a steady decline in production until many of them are practically exhausted. Recently, however, there has been a marked increase of interest in the further development of fields producing gas and in the location of new gas fields. The Warner uplift will, no doubt, yield more gas when further developed. The small dome in secs. 29, and 32, T. 10 N., R. 20 E., also seems to present possibilities.

MISCELLANEOUS MINERAL RESOURCES

by

Robert H. Dott

Introduction

Some preliminary information on miscellaneous mineral resources of the Muskogee-Porum district is available as a result of a mineral survey made during 1936. This survey was a project of the Works Progress Administration, sponsored and directed by the Oklahoma Geological Survey. The investigations were made by clients from the relief rolls under the supervision of geologists, and the results are in all respects preliminary and incomplete. They are, none the less, valuable, and for that reason, are included here.

The work in Muskogee County was supervised by A. H. Hanson, who also assisted Dr. Wilson and Dr. Newell in their field investigations, and the work in McIntosh County was supervised by Leon Davis. General supervision was given by Charles R. Eckes and Glenn R. V. Griffith, district supervisors of the Muskogee district.

SAND AND GRAVEL

The gravel deposits reported are restricted to recent bars along the west bank of the Arkansas River, and composed of material which was probably washed down by floods from the large deposits in the bed of Grand River. Data are available on only four such deposits, of which the one located in secs. 13, 14 and 24, T. 13 N., R. 19 E. (fig. 5), is the most important.

Wilson[89] reports Quaternary (?) terrace gravels, which contain sandstone pebbles, in T. 11 N., R. 18 E., and T. 13 N., R. 19 E., northwest of Porum, and in the vicinity of Keefeton, respectively (Plate I), but no reports on these deposits were made by the mineral survey.

89. This report, p. 58.

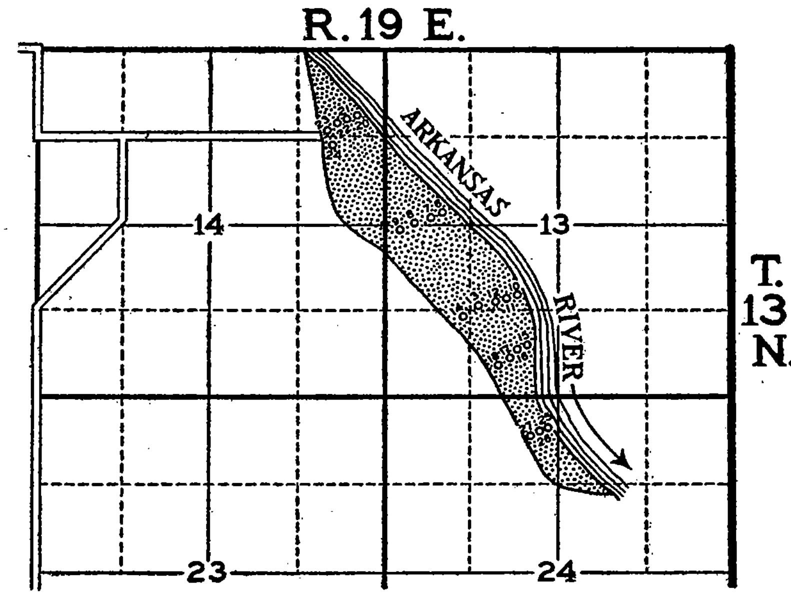


FIGURE 5. Sketch map of large gravel deposit in sec. 13, 14 and 24, T. 13 N., R. 19 E., showing locations of samples.

The only sand reported is located in the alluvial area along Coody Creek, SE¼ sec. 35 and SW¼ sec. 36, T. 15 N., R. 18 E., south of Muskogee. Summary information of these gravel and sand deposits is given in Table IV.

TABLE IV

PRELIMINARY DATA ON GRAVEL AND SAND, MUSKOGEE-PORUM DISTRICT, MUSKOGEE COUNTY, OKLAHOMA

LOCATION			Estimated cu. yds.	Sample No.	Overburden Feet	Thickness Feet	Wash Loss	Approximate Screen Analysis of Washed Sample* Percent Retained on Screen										
Section	Twp.	Rge.						2½″	2″	1½″	1″	¾″	½″	¼″	20	50	100	200
NE¼ 12	12N	20E																
SW¼, NW¼, 18	12N	21E	50,000	1		5.0	0.28		0.76	3.06	17.92	14.44	11.39	3.92	4.72	42.22	0.97	0.42
S½ 16	13N	20E		2		2.0	05.0			3.50	5.00	4.00	4.50	4.25	38.75	37.50	2.25	0.25
				3		6.0	06.0				4.83	3.50	3.33	3.50	26.84	52.84	5.33	0.33
				4		8.5	09.0				0.80	1.80	1.40	1.40	13.00	75.60	5.60	0.40
				5		8.0	04.0		2.67	5.33	9.67	5.67	5.00	5.50	24.33	39.50	2.00	0.33
W½ 13	13N	19E		6		3.8	7.0			2.00	7.25	9.37	10.75	8.75	27.00	31.75	2.50	0.63
				7		5.0	9.0		4.00	4.00	9.14	3.43	3.86	3.71	34.29	39.00	2.29	0.28
				8		1.3	11.0			4.50	16.88	10.88	8.87	8.75	21.37	22.00	2.37	0.38
				9		2.0	8.0		1.86	2.86	11.43	7.29	5.43	4.57	28.71	34.28	3.14	0.43
				10		4.0	9.0		2.28	3.43	7.86	6.14	5.29	5.14	18.29	46.28	5.00	0.28
				11		3.5	4.0				1.17	3.00	4.33	5.33	42.50	39.33	3.50	0.84
				12		4.5					4.00	8.86	8.86	8.43	32.71	34.57	1.86	0.71
				13		1.5	9.0			10.00	16.50	8.75	8.38	9.12	26.75	18.63	1.25	0.62
				14		4.0	11.0			3.33	10.56	4.58	4.86	5.42	18.61	49.65	2.64	0.35
				15		6.0	6.0			3.25	11.12	8.00	8.38	7.56	22.63	35.50	3.06	0.50
				16	1.1	9.5	5.0			0.71	12.00	9.86	8.43	8.71	26.29	31.57	2.00	0.43
				17		1.0	9.0			1.28	6.57	8.86	7.00	6.57	30.43	35.43	3.29	0.57
				18		3.0	7.0				7.71	12.29	12.29	10.00	26.00	27.29	2.71	0.71
E½, NE¼ 14	13N	19E																
				19		4.0	4.0		2.44	9.00	25.75	11.25	10.81	10.00	16.00	11.38	0.97	0.42
			29,000	20		2.0	06.0		1.79	7.50	13.14	5.00	5.07	6.00	18.14	39.71	3.43	0.22
				21		2.0	07.0		2.25	5.69	11.31	8.19	6.69	7.81	25.00	30.25	2.62	0.19
				22		7.7	05.0	4.69	1.69	7.44	16.00	7.81	8.12	8.12	18.19	26.25	1.44	0.25
				23	1.3	8.9	11.0	8.63	2.81	10.44	16.00	6.27	6.56	6.13	15.94	25.31	1.44	0.37
				24	1.1	8.5	08.0	2.69	1.94	2.12	8.75	6.37	5.81	6.87	24.81	39.00	1.31	0.31

TABLE IV, *Continued.*

PRELIMINARY DATA ON GRAVEL AND SAND, MUSKOGEE-PORUM DISTRICT, MUSKOGEE COUNTY, OKLAHOMA

LOCATION			Estimated cu. yds.	Sample No.	Overburden Feet	Thickness Feet	Wash Loss	Approximate Screen Analysis of Washed Sample* Percent Retained on Screen										
Section	Twp.	Rge.						2½″	2″	1½″	1″	¾″	½″	¼″	20	50	100	200
N½ 24	13N	19E	9,690	25		2.5					4.33	6.00	10.17	9.64	38.18	27.83	3.83	0.33
				26		5.5					2.20	3.80	6.60	6.40	43.00	34.20	3.00	0.80
				27		3.0					1.16	2.16	4.17	6.17	48.33	34.67	2.67	0.67
SW¼ 13	14N	19E																
NW¼ 24	14N	19E	400	28					0.70	0.40	4.10	3.90	5.80	7.90	41.1	35.2	0.60	0.30
SE¼ 35	15N	18E		29	1.8	16.2	4.5							0.2	6.5	94.00	3.4	0.90
SW¼ 36	15N	18E		30	3.0	5.0	2.0							0.1	0.5	92.50	5.3	1.60
				31	1.3	5.6	9.0							2.0	7.5	78.75	8.0	3.75
				32		4.0	0.5							0.5	4.3	91.00	3.5	0.70

(*) Screen analyses by Leslie Snow, Testing Engineer of Mineral Survey Crew.

LIMESTONE

Deposits of limestone are rare in the Muskogee-Porum district, for the rocks exposed consist mainly of sandstones and shale, but such limestone beds as are present have been described by Newell.[90] Of these, the Pitkin limestone and the limestone members of the Morrow group are best suited to commercial uses, though their outcrops in this district are so limited in area, and so inaccessible, that it would be difficult to develop them profitably.

Four other limestones, the Spaniard, Sam Creek, Inola and a thin bed just above the lower Boggy coal are described by Newell, and though thin, they are widespread, and may be of considerable importance as local sources of agricultural limestone. The Spaniard and Inola appear to be best adapted to this use. These beds crop out in areas where the soils are deficient in lime, and which are considerably removed from other limestone sources. By crushing and grinding this rock in community crushers and mills, as local enterprises, agricultural limestone can be made available to farmers in western Muskogee and eastern McIntosh counties, whereas transportation costs on material shipped in from the outside might be prohibitive. The outcrops of these beds are shown on Plate I.

Many exposures of the Sam Creek, Spaniard and lower Boggy limestones are found at the foot of, or up the slope of the high escarpment capped by the Bluejacket sandstone, and are therefore rather inaccessible. In the vicinity of Porum, north of Keefeton and around Muskogee however, outcrops of Spaniard and Sam Creek are widespread, and considerable quantities of both beds could be quarried at little expense. The Inola limestone should be readily available in many parts of Tps. 14 and 15 N., R. 17 E. The lower Boggy limestone might be profitably worked in conjunction with the underlying coal.

These thin limestones are often less pure than material ordinarily recommended for agricultural purposes. The lower Boggy

90. This report, pp. 22-24, 46-50, 53 and 56.

TABLE V

CHEMICAL COMPOSITION OF LIMESTONE SAMPLED BY MINERAL SURVEY*

SAMPLE NO.	LOCATION			PROBABLE MINERAL COMBINATION—PERCENT								Ca & Mg COMPUTED AS CARBONATES		BED	LAB. NO.
	SECTION	TWP.	RGE.	CaO	MgO	SiO_2	Fe_2O_3	Al_2O_3	MnO_2	CO_2	H_2O	$CaCO_3$	$MgCO_3$		
1	S. line SW-SE 15	10N	19E	39.80	1.18	19.20	4.66	1.73	0.09	32.52	0.62	71.03	2.47	Local limestone, 10' below Sam Creek	378
2	do 15	10N	19E	24.22	0.90	34.60	12.87	2.67	0.11	19.98	4.82	43.22	1.88	Sam Creek	379
3	S½-S½-SW 33	13N	18E	39.32	1.90	7.60	10.09	3.93	0.09	32.92	4.19	70.17	3.97	Sam Creek	369
4	do 33	13N	18E	44.92	1.32	7.90	7.43	0.35	0.78	36.68	0.52	80.16	7.43	do	370
5	do 33	13N	18E	36.80	1.78	9.40	13.70	1.93	1.63	30.81	4.13	65.67	3.72	do	371
6	do 33	13N	18E	49.92	1.18	4.70	3.86		0.36	40.46		89.09	2.47	Spaniard	373

* Analyzed in Geological Survey Laboratory, under direction of Robert H. Locke, chief chemist, of the WPA State Mineral Survey.

bed is impure and the Sam Creek is rather high in iron, but the Spaniard and Inola should fall within the range of usable material. No samples from the Inola have been analyzed, but analyses of several samples of the Spaniard and Sam Creek are given in Table V.

CLAY SHALE

Clay shales have been used in the Muskogee-Porum district for many years in the manufacture of brick, and the district contains large quantities of this material. At the present time one plant, owned by the Muskogee Clay Products Company and located at the north edge of Muskogee, is in operation. The plant has a capacity of 50,000 bricks per day, and makes common brick, face brick, rough red brick, paving brick and all sizes of building tile. Another plant, owned by the same company has been shut down for a number of years.

The mineral survey did not devote any particular attention to this phase of the investigation, but several deposits were reported, and two analyses are available. These data are given in Table VI and VIa.

Several analyses of samples from localities listed in Table VI indicate the material is so low in alumina and high in silica that it cannot be classed as clay, but rather as sandy shale. These are omitted from Table VIa. The sample from locality 1 is the only one listed which is sufficiently high in alumina to be of interest to the ceramic industry, while the material at locality 12 contains 42.81% calcium and magnesium carbonates, and probably could be classed as a native wool rock.

TABLE VI
SHALE DEPOSITS REPORTED BY MINERAL SURVEY

Locality No.	Location				Formation	Member	Newell's Reference	Remarks
	Section		Twp.	Rge.				
1	NW-NE-NW	9	10N	19E	Boggy	Below coal		
2	NE-NW-NE	27	10N	19E	Savanna	Above Tamaha ss.	S_1	Outcrops on small hill, suitable for road metal
3	NE-NE-SE	27	10N	19E	do	do	S_1	Quarried for road metal by CWA
4	SW-NW-SE	29	10N	19E	Lower Boggy	Below Coal		Used for road metal by CWA and FERA
5	C-NE-NW	35	10N	19E	McAlester	Above Lequire ss.	M_2	Quarried for road metal by CWA
6	NW-SW-NW	26	11N	20E	Atoka	Above Blackjack ss.	A_6	Used on USIS project
7	SE-NE-NE	3	12N	19E	McAlester	McCurtain sh.		Used for road metal
8	SE-SE-SE	13	12N	19E	do	do		Used for road metal
9	NW-NW-SW	18	13N	19E	McAlester	Above Warner ss.		Suitable for road metal
10	NE-SE	24	13N	19E	Atoka	Above Webbers Falls ss.	A_5	do
11	NW-SW	3	14N	17E	Boggy	Above Inola ls.	B_{11}	Black shale, suitable for road metal
12	SE-NW-NW	15	14N	18E	Boggy	Above coal	B_7	Sub wool rock
13	SW-SW-SW	22	14N	19E	Atoka	Above Blackjack ss.	A_6	Used for road metal
14	SE	30	14N	15E	McAlester	McCurtain (?) sh.		Used for road metal
15	NE-NE-NW	32	15N	17E	Boggy	Below thin ss.	B_{11}	Being used for road metal
16	SW-SW-SW	36	15N	17E	do	Just below Taft ss.	B_{11}	do

TABLE VIa.
CHEMICAL COMPOSITION OF CLAY AND SHALE.

LOCALITY NUMBER	1	12
LABORATORY NUMBER	440	1052
Probable Mineral Combinations	Percent	
Al_2O_3	21.72	5.65
SiO_2	60.38	46.64
Fe_2O_3	3.93	5.65
MnO_2	0.17	0.09
CaO	1.58	23.00
MgO	2.26	0.84
H_2O	6.00	0.06
CO_2	3.71	18.97

In 1929-30, samples were collected from this district by John S. Redfield, of the Oklahoma Geological Survey, in the course of a state-wide survey of clays and shales of Oklahoma, and were tested at the Engineering Experiment Station of the Oklahoma A. and M. College, Stillwater, under the direction of Leonard F. Sheerar.[91] The following quotations are from this report, with some minor corrections of stratigraphic nomenclature in conformity with the present report:

A sample of *lower Boggy*[92] shale was obtained on the east side of the hills west and north of Porum. The shale is exposed for 35 feet.

SAMPLE NO. 115

Sec. 4, T. 10 N., R. 19 E. County: Muskogee.
Geologic formation: *Lower Boggy.*
Working properties: Fair plasticity, easy to mold.
Tempering water: 19.1%.
Drying linear shrinkage: 3.5%.
Drying volume shrinkage: 10.8%.
Average transverse strength: 324 lbs. per sq. in.

Burning Temperature in Cones	Per Cent Linear Shrinkage	Per Cent Volume Shrinkage	Per Cent Porosity	Hardness	Color[93]
08	1.6	4.8½	27.7—	steel	9″b
06	3.9	11.3	20.8	>steel	11″
04	5.4	15.4	15.9	>steel	11″i
02	6.4	18.0	14.3	>steel	9″k
1	7.2	20.1	11.6	>steel	9″k
3	7.6	21.2	7.2	>steel	7″k

Overburning temperature: Cone 3 (2174°F-1190°C).
Best burning range: Cone 06 to Cone 02 (1886°F-1030°C to 2030°F-1110°C).
Total linear shrinkage: 9.5% at Cone 02 (2030°F-1110°C).
Possibilities: Common brick, sewer pipe.
Remarks: Low drying shrinkage and moderate firing shrinkage. Color not suitable for face brick.

91. Sheerar, E. F., and Redfield, J. S., "The Clays and Shales of Oklahoma": *Okla. Agric. and Mech. College, Engineering Publication*, Vol. 3, No. 5, Sept., 1932, pp. 172-176.
92. Italics by R. H. D., indicating revised classification.
93. Ridgway Color Scale. See Sheerar and Redfield, *op. cit.*, pp. 33-36.

In the vicinity of Briartown *a bed of the McAlester shale* five to seven feet thick underlies a 20 *inch* coal seam (*Stigler*) over an areal extent of six to eight sections. A sample from this area was submitted by Mr. D. B. Henderson of Muskogee.

SAMPLE NO. 401

NW Sec. 35, T. 10 N., R. 19 E. County: Muskogee
Geologic formation: McAlester.
Working properties: Fair plasticity, easy to mold.
Tempering water: 20.5%.
Drying linear shrinkage: 6.3%.
Drying volume shrinkage: 20.0%.
Average transverse strength: 311 lbs. per sq. in.

Burning Temperature in Cones	Per Cent Linear Shrinkage	Per Cent Volume Shrinkage	Per Cent Porosity	Hardness	Color
010	.0	.0	27.9	<steel	17″f
08	.9	2.8	27.3	steel	15″f
06	2.1	6.4	19.4	>steel	15″f
04	3.3	10.2	17.9	>steel	15″f
02	3.2	9.8	15.9	>steel	15″f
1	3.8	11.8	15.3	>steel	17″d

Overburning temperature: Above Cone 1 (2102°F-1150°C).
Best burning range: Cone 08 to Cone 1 (1814°F-990°C to 2102°F-1150°C).
Total linear shrinkage: 9.5% at Cone 1 (2102°F-1150°C).
Possibilities: Common and face brick, pottery.
Remarks: A dirty buff color but satisfactory otherwise.

The McAlester shale was sampled in the vicinity of Warner, where it occurs beneath the *Stigler* coal. The overburden consisted of eight feet of shale and a 19-inch coal seam. The shale bed sampled was eight feet thick.

SAMPLE NO. 18

Sec. 17, T. 12 N., R. 19 E. County: Muskogee
Geologic formation: McAlester.
Working properties: Fair plasticity, lean and gritty, easy to mold.
Tempering water: 19.4%.
Drying linear shrinkage: 5.6%.
Drying volume shrinkage: 17.8%.
Average transverse strength: 380 lbs. per sq. in.

Burning Temperature in Cones	Per Cent Linear Shrinkage	Per Cent Volume Shrinkage	Per Cent Porosity	Hardness	Color
010	—.2	—.6	24.1	<steel	11′d
08	—.1	—.3	24.6	<steel	11′d
06	1.6	4.9	21.3	steel	15″d
04	3.0	8.7	19.8	>steel	15″d
02	3.2	9.3	19.0	>steel	15″
1	3.3	9.7	17.4	>steel	15″d

Overburning temperature: Above Cone 1 (2102°F-1150°C).
Best burning range: Cone 06 to Cone 1 (1886°F-1030°C to 2102°F-1150°C).
Total linear shrinkage: 8.4% at Cone 1 (2102°F-1150°C).
Possibilities: Face brick, stoneware, pottery.
Remarks: An excellent buff-burning clay with good drying and burning properties.

A shale which is similar to that which underlies the shale of No. 116 was sampled in Sec. 9 west of where the previous sample was taken. This shale has a larger drying shrinkage and burns to a more open structure.

SAMPLE NO. 117

Sec. 9, T. 14 N., R. 17 E. County: Muskogee
Geologic formation: *Boggy* (*B11 of Newell's Sections*).
Working properties: Fair plasticity, easy to mold.
Tempering water: 31.2%.
Drying linear shrinkage: 8.1%.
Drying volume shrinkage: 26.5%.
Average transverse strength: 315 lbs. per sq. in.

Burning Temperature in Cones	Per Cent Linear Shrinkage	Per Cent Volume Shrinkage	Per Cent Porosity	Hardness	Color
08	1.9	5.6	41.9	steel	11″b
06	3.6	10.4	28.7	>steel	11″b
04	8.5	23.3	24.8	>steel	11″
02	6.8	19.1	22.8	>steel	9″
1	6.4	18.2	21.4	>steel	9″
3	8.4	23.2	20.2	>steel	11″i

Overburning temperature: Cone 3 (2174°F-1190°C).
Best burning range: Cone 06 to Cone 1 (1886°F-1030°C to 2102°F-1150°C).
Total linear shrinkage: 13.4% at Cone 1 (2102°F-1150°C).
Possibilities: Common and face brick, paving brick.

The Muskogee Pressed Brick Company formerly operated a plant at Crekola, eight miles southwest of Muskogee. Dry press brick were manuactured from a blue, uniform shale. This plant was operated only a few years. The shale is reported to be an excellent material for sewer pipe and it is reported that the W. S. Dickey Clay Company of Kansas City owns 30 acres of land in this region. Sample No. 116 was taken from the old pit of the above plant.

SAMPLE NO. 116

NW Sec. 10, T. 14 N., R. 17 E. County: Muskogee
Geologic formation: *Boggy* (*B11 of Newell's Sections*).
Working properties: Plasticity slightly short, easy to mold.
Tempering water: 47.5%.
Drying linear shrinkage: 5.9%.
Drying volume shrinkage: 18.2%.
Average transverse strength: 513 lbs. per sq. in.

Burning Temperature in Cones	Per Cent Linear Shrinkage	Per Cent Volume Shrinkage	Per Cent Porosity	Hardness	Color
08	3.1	9.0	26.4	<steel	9″b
06	7.2	20.0	15.1	steel	11″
04	9.5	25.8	6.9	>steel	11″i
02	9.4	25.6	5.0	>steel	11″i
1	10.1	27.4	3.6	>steel	11″i
3	8.8	24.2	3.8	>steel	7″i

Overburning temperature: Cone 3 (2174°F-1190°C).
Best burning range: Cone 04 to Cone 3 (1958°F-1070°C to 2174°F-1190°C).
Total linear shrinkage: 14.4% at Cone 02 (2030°F-1110°C).
Possibilities: Common and face brick, sewer pipe.

A water well drilled on the property of E. O. Gillam in the vicinity of Taft exposed 25 feet of blue shale. A second well reported 80 feet of this shale.

SAMPLE NO. 14

Sec. 28, T. 15 N., R. 17 E. County: Muskogee
Geologic formation: *Boggy*.
Working properties: Medium plasticity, coarse sandy texture, easy to mold.
Tempering water: 27.6%.
Drying linear shrinkage: 7.7%.
Drying volume shrinkage: 25.0%.
Average transverse strength: 534 lbs. per sq. in.

Burning Temperature in Cones	Per Cent Linear Shrinkage	Per Cent Volume Shrinkage	Per Cent Porosity	Hardness	Color
06	4.4	12.6	24.6	<steel	13″b
04	4.3	11.4	19.6	<steel	9″i
02	5.2	14.7	19.5	<steel	9″k
1	7.7	21.4	14.3	steel	11″m
3	7.5	20.8	14.0	steel	11″m
5	9.7	26.3	6.8	steel	11″m

Overburning temperature: Above Cone 5 (2246°F-1230°C).
Best burning range: Cone 04 to Cone 3 (1958°F-1070°C to 2174°F-1190°C).
Total linear shrinkage: 14.1% at Cone 3 (2174°F-1190°C).
Possibilities: Common brick, paving brick.

Clays from *the lower Boggy, below the Bluejacket sandstone* have been worked at Muskogee by the Standard Brick Company. When visited in the summer of 1931 the plant was shut down. The writer was advised that the plant would reopen as soon as business conditions warranted. The plant is located inside the city limits on the Kansas, Oklahoma and Gulf Railroad. The raw material is a blue to black shale high in carbonaceous material. The face of the pit shows 20 feet of shale with little overburden. This shale has good working properties and burns to a good, red color. Due to the high carbon content, considerable care is required in burning to prevent the formation of black cores. The plant is equipped with sufficient machinery to allow a production of 100,000 brick per day. Common and face brick are manufactured by the stiff mud process.

The equipment includes three 9-foot dry pans, elevators and stationary screens, pug mill, auger machine, two repress machines, drying tunnels and round, down-draft kilns. Sample No. 9 is representative of the shale used by this company.

SAMPLE NO. 9

Sec. 23, T. 15 N., R. 18 E. County: Muskogee.
Geologic formation: *Boggy*.
Working properties: Medium plasticity, sandy texture, easy to mold.
Tempering water: 21.9%.
Drying linear shrinkage: 3.8%.
Drying volume shrinkage: 11.8%.
Average transverse strength: 340 lbs. per sq. in.

Burning Temperature in Cones	Per Cent Linear Shrinkage	Per Cent Volume Shrinkage	Per Cent Porosity	Hardness	Color
010	1.3	3.9	34.2	<steel	11″d
08	3.7	10.8	29.4	<steel	11″b
06	5.2	14.9	24.5	steel	11″i
04	7.3	20.4	15.8	>steel	9″i
02	8.1	22.5	14.5	>steel	
1	8.2	22.6	15.3	>steel	

Overburning temperature: Cone 1 (2102°F-1150°C).
Best burning range: Cone 06 to Cone 1 (1886°F-1030°C to 2102°F-1150°C).
Possibilities: Common and face brick, hollow tile.

BUILDING STONE

The Muskogee-Porum district abounds in rock suitable for building purposes, and it has been used extensively since the area was first settled. Many of the older buildings and residences in Muskogee and the smaller towns were built of sandstone cut from conveniently located outcrops in the vicinity. More recently, numerous quarries have been opened for material to be used on projects of various Federal agencies. The material has come into considerable use by the WPA for building National Guard armories in Muskogee, Haskell and Boynton, and for masonry work on bridges and culverts. Some of it has been crushed to surface farm-to-market roads and quantities have been used by the soil erosion service for the construction of baffles to retard gullying and washing. The Resettlement Administration has employed the stone for home construction, masonry work around wells, out buildings, etc. In addition, native stone is gaining increasing popularity as a veneer for private residences.

Sandstone is the most abundant, the most readily accessible, and most easily-worked of the building stones in the district, and quarries can be opened almost at will in any locality. Limestone is also very popular, especially for use as a veneer in constructing private residences, but only a limited amount is available in the Muskogee-Porum district.

The Pitkin limestone, and the limestone members of the Morrow group, would be excellent for this purpose, but exposures are too inaccessible to justify commercial development. The Spaniard and Inola limestones could be worked out in thin slabs, and would be highly desirable for veneer work, but are limited in extent and quantity. The other thin, impure limestones of the Pennsylvanian would probably not be suitable for building stone.

TABLE VII

BUILDING STONE REPORTED BY MINERAL SURVEY

Locality No.	Location: Section		Twp.	Rge.	FORMATION	MEMBER	Thickness of Layers	REMARKS
1	SE	4	10N	19E	Boggy	Lower boggy	4"-10"	Quarried for WPA culverts and bridges. Light brown, fine texture, medium hard.
2	N½	26	10N	19E	Savanna	Keota (?) ss.		Could be cut into blocks. Some parts may be too hard. Ledge 1-5 feet thick.
3	SE	35	10N	19E	McAlester	Lequire (?) ss.		Good for building stone. Soft. Ledge 5-20 feet thick.
4	NE	10	11N	20E	McAlester	Warner ss.	3"-18"	Good grade sandstone. Ledge 2-10 feet thick.
5	N½	26	11N	20E	Hartshorne			Good building stone.
6	Cen. line	22	11N	20E	McAlester	Warner ss.		do
7	SW-SW	28	11N	20E	McAlester	do		Quarry. Excellent building stone.
8	NE & SE	33	11N	20E	McAlester	do		Hard.
9	SE-NW	6	12N	19E	McAlester	do	3"-8"	
10	Center	15	12N	19E	Atoka	Blackjack ss.	3"-18"	
11	S½	19	12N	19E	Boggy	Base Bluejacket ss.	6"-18"	
12	NE-NW	3	12N	20E	Atoka	Coody ss.	4"-15"	
13	N½	6	12N	20E	Atoka	Georges Fork ss.	4"-20"	Quarried for bridges on farm-to-market roads.
14	S½	7	12N	20E	Atoka	Pope Chapel ss.	4"-12"	Red color.
15	W½	9	12N	20E	Atoka	Coody ss.	6"-18"	Red color.
16	NW. cor.	16	12N	20E	Atoka	Coody ss.	3"-12"	
17	NW	17	12N	20E	Atoka	Pope Chapel ss.	3"-8"	
18	E½	3	13N	18E	Boggy	Bluejacket ss.		Good for masonry work on bridges and culverts.
	W½	10	13N	18E	Boggy			
19	Near center	12	13N	18E	Savanna	Keota ss.	10"-12"	3 houses in vicinity built of it. Red color.
20	NE-SE	19	13N	18E	Savanna	Spiro (?) ss.	Massive	Being crushed for road metal. Yellow color.
21	NW	20	13N	18E	Savanna	Keota (?) ss.		Being used for roads.
22	N½	22	13N	18E	McAlester	Warner ss.	4"-up	Good for masonry.
23	NE cor.	28	13N	18E	McAlester	do	12"-18"	Being quarried. Easily worked, good bedding planes.
24	N½	4	13N	19E	McAlester	Warner ss.	6"-12"	Gray color.

TABLE VII, *Continued.*
BUILDING STONE REPORTED BY MINERAL SURVEY

Locality No.	Location: Section	Twp.	Rge.	FORMATION	MEMBER	Thickness of Layers	REMARKS
25	S½ 15 & 16	13N	19E	McAlester	Warner (?) ss.		Quarried for culverts, farm-to-market roads.
26	S½ 21	13N	20E	Atoka	Pope Chapel ss.	12″	Gray color.
27	SW-NE 9	14N	17E	Boggy	Taft ss.	Massive	Quarried for building stone and soil erosion work.
28	N½ 5	14N	17E	Boggy	Below Taft ss.		Good for building stone.
29	SE-SE 15	14N	17E	Boggy	Ab. Crekola (?) ss.	3″-6″	Quarried for soil erosion work.
30	NW 20	14N	17E	Boggy	do		Good for building stone.
31	27 & 28	14N	17E	Boggy	Taft ss.	18″	Has been quarried for buildings in vicinity.
32	N½ 17	14N	18E	Boggy	Bluejacket ss.		Quarry in NE-NE.
33	SW 30	14N	18E	Boggy	Crekola ss. or above	8″-12″	Used for building stone.
34	SW 31	14N	18E	Boggy	Crekola (?) ss.	2″-8″	Has been quarried for building.
35	NE 32	14N	18E	Boggy	Bluejacket ss.		Good building stone.
36	28 & 33	14N	19E	McAlester	Warner ss.	thin to massive	Could be worked easily.
37	9 & 10	15N	17E	Boggy	Bluejacket ss.	3″-12″	
38	SW-SE 13	15N	17E	Boggy	do	Massive	Used in armories at Muskogee & Haskell. Blasted out.
39	NE-NW 24	15N	17E	Boggy	Crekola ss.	Massive	Used in armories at Muskogee & Boynton. Cuts easily.
40	SW 36	15N	17E	Boggy	Taft ss.		Quarried for soil erosion work. Could be cut into building stone.

WATER RESOURCES

Data on approximately 475 representative rural water wells and springs were obtained by the mineral survey crews, filling in a questionnaire at each farm house visited. These data are not all that might be desired for a scientific study of underground water conditions, having been assembled by untrained relief workers, depending on the memory and opinions of farm owners and tenants. The mass of information available, and the rather definite nature of some of the inquiries, however, should give a fairly good idea of average conditions, and the data are included here in the hope that they may be useful to residents of the district.

Information on depths should be fairly reliable, since most wells in the district are equipped with bucket, rope and pulley. The estimates of capacity are very rough, being in most instances, little more than the farmer's guess, and are of value only for comparative purposes, while the information on quality of water represents only the opinion of the user. The reports on the effects of drouth should be reliable, since people depending on wells for water supplies would be extremely conscious of their failure, and the investigation was made during a period of protracted drouth.

Identification of the water-bearing horizon of each well was made from the data on the depth of the well, and reference to Plates I and III of this report, together with information on the aquifer contained in the questionnaire. Many of these identifications are only approximations.

Some well reports, and a few chemical analyses of water were kindly furnished by the Resettlement Administration, Region VIII, [see Table IX] and analyses of municipal supplies were furnished by the Department of Chemistry, Oklahoma A. and M. College. [See Table X].

The data on underground water resources contained in this report should be of use in attempting to supplement existing supplies, or in finding new ones, by drilling to deeper water-bearing horizons. The productivity of different aquifers has been roughly evaluated, and the possibilities of water from, and the probable depth to deeper horizons can be determined from the tables in Appendix A.

The Muskogee-Porum district is moderately supplied with underground water, though some areas are more abundantly supplied than others. Each geological formation in the area appears to carry water, and 36 different members, made up of sandstone, shale, sandy shale, Quaternary sand and alluvium are reported as furnishing the water for wells recorded from this region.

Of the wells listed, 219 produce from sandstone, 175 from shale, 25 from sandy shale and 57 from Quaternary sand, alluvium and valley fill. The number producing from shale, and the quantity of water produced is surprisingly large, for clay shale is ordinarily too impervious to absorb or give up much water. Since this is an area of considerable faulting and folding, it is probable that the shales are considerably fractured, and therefore more porous than ordinarily.

Wells producing from any given formation are located on or close to the outcrop of that formation. In general, wells producing from the Atoka formation are located in the eastern part of the district, and on the Warner Uplift, and those producing from the Boggy formation are located along the west side of the district, while those producing from the Hartshorne, McAlester and Savanna formations are to be found in the central area. Water from alluvial sand and gravel is found in wells drilled on the flood plain of Arkansas River.

No part of the district appears to be better supplied with water from a particular horizon of the consolidated rocks than another. Large and small wells seem to be about equally distributed throughout the various townships, so for the present purpose, only the average ability of the different aquifers to produce water over the entire district is considered. Local variations may be noted in the tables. The largest average production comes from wells in river alluvium on the east margin of the district.

TABLE VIII

IMPORTANT AQUIFERS IN THE MUSKOGEE-PORUM DISTRICT.

FORMATION	MEMBER	NUMBER OF WELLS REPORTED	AVERAGE CAPACITY GALLON DAY	NO CHANGE DURING DROUTH %	QUALITY SOFT %	QUALITY HARD %	ROCK
Recent	Alluvium	51	3,495	88	30	70	Sand, gravel
Boggy	B_{11}	19	830	63	74	26	74% shale & sandy sh.
	Bluejacket ss.	22	570	60	55	43	Sandstone
	B_7	40	620	65	45	55	92% shale & sandy sh.
Savanna	S_1	15	830	80	27	67	Shale
McAlester	Cameron ss.	12	576	84	53	47	Sandstone
	Lequire ss.	24	300	83	71	29	Sandstone
	M_2	15	108	93	13	87	Shale
	Warner ss.	40	458	82	50	50	Sandstone
	McCurtain sh.	54	1,010	82	45	55	Shale
Hartshorne sandstone		14	1,100	79	64	36	Sandstone
Atoka	A_6	13	319	77	31	69	85% shale
	Blackjack ss.	22	570	59	41	59	Sandstone
	A_5	14	489	64	64	36	65% shale & sandy sh.
	Coody ss.	13	251	55	85	15	Sandstone

Of the 36 members or horizons which produce water in the district, 21 are reported in less than 12 wells each. For this reason, based on the data at hand, 15 are regarded as most important. These include:

Of the 15 most important aquifers, the McCurtain shale, river alluvium, Warner sandstone, lower Boggy shale (B_7) and the Bluejacket sandstone, are reported in 35 or more wells each. In order of average capacity, alluvium is most productive, followed by the McCurtain shale, Bluejacket sandstone, lower Boggy shale and Warner sandstone, while the Hartshorne sandstone, reported in but 14 wells, ranks next to alluvium in average capacity, and the shales S_1 and B_{11}, of the Savanna and Boggy respectively, with 15 and 19 wells reported, rank higher than the Bluejacket sandstone.

Hard and soft water seems to be about equally common in both sandstones and shales, though there is a slight tendency of the water from sandstone to be softer than that from shale, while water from the river alluvium is commonly hard. A few of the reports indicate slight mineralization, described as iron, soda, sulphur, "gyp", "copperas," salty and brackish. A few are listed as unfit for human use, and one as killing plants. No chemical analyses are available to indicate the true nature of the minerals present.

Drouth seems to affect wells from the different aquifers about equally, there being no striking relationship between the nature of the rock composing the aquifer and decline in capacity, though there is a slight suggestion that shale wells maintain their production better than sandstone wells. 88% of the alluvial wells reported no change during drouth.

Springs. 22 of the 475 reports were on springs. These have been included in the above tabulation and discussion, but merit brief mention. They are distributed over the entire area, and are not restricted to rocks of any particular formation. Estimated capacities range from 40 to 4,000 gallons per day, and most of them are reported to suffer no effects of drouth, while the water from all but three of them is recorded as soft.

TABLE IX.
CHEMICAL ANALYSES OF WATER FROM RURAL WELLS.

CONSTITUENT	PARTS PER MILLION										
	A*	B	C	D	E	F	G	H	I	J	K
$MgCO_3$ & $CaCO_3$	192										
$NaCO_3$	8										
$NaSO_4$	220										
NaCl	97										
Ca									104	137	9
Mg									33	31	6
Na+K (Calculated as Na)									57	31	233
Cl									34	31	105
SO_4									31	37	12
Chlorides		23	308	38	25	6	11	224			
HCO_3									514	559	481
Total Solids	492	1010	2597	1910	683	359	854	4697	541	617	616
M. O. Alkalinity	192	399	368	284	536	102	308	560	422	458	394
Soap Hardness	184	288	1200	694	75	57	128	328	367	452	41

* Analyzed in laboratory of Oklahoma Geoloegical Survey under direction of Robert H. Locke. Other analyses from Resettlement Administration, Region VIII.

TABLE IX-a.
LOCATION OF WATER SAMPLES.

ANALYSIS	SEC.	R.	T.	WELL NUMBER (APPENDIX A)
A.	18	10 N.,	20 E.	17
B.	7	14 N.,	17 E.	4
C.	18	14 N.,	17 E.	11
D.	14	15 N.,	17 E.	5
E.	15	15 N.,	17 E.	8
F.	33	15 N.,	17 E.	27
G.	33	15 N.,	17 E.	28
H.	33	15 N.,	17 E.	29
I.	3	15 N.,	18 E.	2
J.	10	15 N.,	18 E.	5
K.	10	15 N.,	18 E.	6

MUNICIPAL WATER SUPPLIES

Porum. The town of Porum is supplied from several small lakes located in the NW¼ sec. 2, T. 10 N., R. 19 E., supplemented during time of drouth, by water from a well owned by the Choctaw Cotton and Oil Company, located in the NW¼SE¼ sec. 11 of the same township, as indicated by the following letter:

> Porum does not have a town owned well, but during periods of drouth when the Porum lakes fail, the Choctaw Cotton and Oil Company permits the town to use water from the well on its gin property. The well is reputed to produce 15,000 gallons per day, is 120 feet deep, the depth to static head is 21 feet, and production is not affected by drouth. The water is medium hard, and has a sulphur taste. The well was completed in shale.
>
> (signed)
>
> Dan H. Coodey, Field Supervisor
> State Mineral Survey
>
> Porum, Oklahoma
> April 12, 1937

The aquifer is evidently the shale unit M_4 of Newell's classification, in the upper part of the McAlester shale.

Analyses of water samples from this well on two different dates, and from the Porum lake, were kindly furnished by Dr. O. M. Smith, head of the Department of Chemistry of the Oklahoma A. and M. College, and are given in the following table:

TABLE X.
CHEMICAL ANALYSES OF MUNICIPAL WATER AT PORUM

IONIC ANALYSIS PART PER MILLION	PORUM LAKE MAY 6, 1929	CITY WELL* MAY 6, 1929	CITY WELL* AUGUST 5, 1930
Ca	29.8	97.0	8.0
Mg	20.6	48.0	1.0
Na	10.0	261.0	385.0
Fe	3.0	0.2	trace
HCO_3	11.0	-------	-------
SO_4	158.0	400.0	82.5
Cl	10.0	148.0	61.0
NO_3	-------	177.0	-------
Free CO_2	-------	10.0	-------
Hypothetical Combinations			
$CaCO_3$	11.5	238.0	20.0
$CaSO_4$	95.3	5.0	-------
$MgCO_3$	-------	-------	3.0
$MgSO_4$	101.7	235.0	-------
Na_2CO_3	-------	-------	708.0
Na_2SO_4	10.7	306.0	121.0
NaCl	16.4	244.0	101.0
$NaNO_3$	-------	242.0	-------
SiO_2	4.0	12.0	trace
Fe_2O_3	-------	0.3	trace
Total Solids	236.0	1,282.0	953.0
Total Solids (evap.)	-------	1,308.0	978.0
Soap Hardness	-------	484.0	48.0
M. O. Alkalinity	-------	238.0	692.0
Turbidity	650.0	180.0	5.0
pH	6.0	-------	-------

* Analyzed by International Filter Company.

Muskogee. Water for the city of Muskogee is taken from Grand River, five miles northeast of the city. Chemical analyses of samples taken on two different dates were supplied by Dr. O. M. Smith, and are given in the following table:

CHEMICAL ANALYSIS OF MUNICIPAL WATER AT MUSKOGEE

HYPOTHETICAL COMBINATIONS PARTS PER MILLION	SAMPLE 1* JULY 14, 1931	SAMPLE 2 MAY 10, 1934
$CaCO_3$	99.0	64.0
$CaSO_4$	7.0	53.0
$MgSO_4$	29.0	23.0
Na_2SO_4	11.0	-------
NaCl	32.0	20.0
SiO_2	5.0	80.0
Fe_2O_3	-------	4.2
Total Solids	176.0	164.0
Total Incrusting Solids	133.0	144.0
Total Hardness	134.0	124.0
Alkalinity		
Methyl Orange	101.0	35.0
Phenolphthalin	-------	30.0

* Analyzed by United States Geological Survey.

APPENDIX A

PRELIMINARY WATER WELL DATA
IN THE
MUSKOGEE-PORUM DISTRICT

T. 10 N., R. 19 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	Reference	Remarks
1	NW NW SW	1	drilled	80	20	1,000	soft	no change	shale	M_4	
2	SE SE NE	2	do	80	30	1,500	do	do	shale	M_4	
3	NW SW SE	2	dug	22	12	1,500	hard	do	shale	S_1	
4	NW SE SW	2	drilled	185	110	500	do	do	sandstone		
5	SE SE SE	3	do	40	15	100	do	do	shale	S_2	
6	NE SW SW	3	dug	70	35	2,000	do	do	shale	B_7	
7	SW SW NE	4	drilled	72	14	300	soft	do	shale	B_7	
8	NE NW SW	4	do	71	52	500	hard	do	sandstone	B_7	
9	SE SE SW	5	dug	50	25	1,000	do	do	shale	B_4	
10	SW SW SW	5	drilled	50		500	do	lowers	shale	B_4	
11	SE NW NE	5	do	50	20	500	do	no change	shale	S_2	
12	NW NW SW	6	do	35	10	1,500	do	do	shale	M_4	
13	SW SW SW	6	do	60	30	200	soft	lowers	Cameron ss.		
14	SE SE NE	8	do	75	40	200	hard	no change	shale	B_7	
15	SW SW NE	8	do	98	85	100	do	fails	shale	B_7	
16	NE NW SE	9	do	64	30	300	soft	no change	sandstone	B_7	
17	SW SE SE	9	do	85	45	200	do	do	shale	B_7	
18	NW NW SW	12	do	30	10	500	hard	do	shale	S_1	
19	NW SE NE	14	do	120	30	1,500	sulphur, soda	do	coal & shale	M_4	
20	SE NW SE	14	do	125	120	50	soft	do	coal & shale	S_1	
21	SE NW SE	14	do	46	15	1,000	do	do	shale	S_1	
22	SW NE SW	16	do	148	80	250	hard	lowers		B_7	
23	SE SE NE	17	do	68	3	2,000	soft	no-change	sandy shale	B_7	
24	NE NE SW	17	do	100	80	50	hard	fails	clay	B_7	
25	NW SE SE	17	do	75	30	500	do	no change	sandy shale	B_7	
26	SE SE SW	18	do	60	40	1,500	soft	do	shale	B_7	
27	SW SW NE	19	dug	12	5	1,500	do	lowers	valley fill		Belle Starr Canyon
28	SE SE SW	20	drilled	85	50	250	hard	do	shale	B_7	
29	SW SW SW	21	do	60	30	500	do	do	shale	B_3	
30	SE SW SE	21	do	60	40	300	do	do	shale	S_2	
31	NE NW NE	23	do	1,256	25	2,000	hard, sulphur	no change	Cameron ss.		Drilled for gas. Heavy water 40-100′ and lower. Coal @ 200′ & 400′ sh. gas @ 200′.
32	SW SW SE	24	do	60	40	500	hard	lowers 1/4	McCurtain sh.		
33	NE NW NW	24	do	105	20	500	do	no change	Warner ss.		
34	NW NW NE	25	do	56	20	2,000	do	do	McCurtain sh.		
35	SW NW SW	25	do	30	25	2,000	soft	do	McCurtain ? sh.		
36	NE NE NE	26	dug	40	15	1,500	hard	no change	shale	M_2?	
37	NW NW SE	26	drilled	75	25	1,000	soft	do	shale	M_2?	
38	NW SE NW	26	do	65	30	2,000	do	do	shale	S_1	
39	NE NE NE	27	do	60	25	250	sulphur	lowers	shale	S_1	
40	NE SW SE	27	do	75	50	500	hard	no change	shale	S_1	
41	SW NE SW	28	spring	3	flows	500	soft	do	alluvium		
42	NW NE SE	28	dug	21	18	500	do	do	Keota ss.		
43	SW NW SW	29	drilled	68	40	500	do	do	Lower Boggy sh.	?	
44	SE NE SE	29	dug	14	8	500	do	do	alluvium ?	?	
45	SE NE SE	29	dug	12	6	100	do		alluvium ?	?	
46	SE NE NE	29	drilled	75	20	250	hard	lowers	Lower Boggy sh.	?	
47	SE SW SE	29	do	90	40	500	do	no change	Keota ss. ?		
48	SW SW SW	30	do	36	8	1,500	do	do	Lower Boggy sh.	?	
49	NW SE SW	30	do	60	35	150	do	fails	Lower Boggy sh.	?	
50	NE NE NW	31	do	64	35	250	do	lowers	?	?	
51	NE NE NE	32	driven	20	14	2,000	do	no change	alluvium		
52	NE NE NE	33	drilled	68	25	500	do	do	shale	S_2	
53	SE NE NW	34	do	50	20	1,500	do	do	alluvium?		
54	NW NE SW	35	driven	18	12	2,000	do	do	alluvium?		
55	NW NE NE	35	dug	22	18	1,000	soft	do	Quaternary sd.	?	Drilled to 72′ in search of coal.
56	SE SE NE	36	dug	19	9	1,000	hard, iron	do	Quaternary sd.		

T. 10 N., R. 20 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	Reference	Remarks
1	SW SE NE	3	driven	30		300	hard	no change	alluvial sand		Edge river bottom in tributary
2	NE SE NE	3	dug	30	25	600	soft	do	Blackjack ss.		
3	NE NW SW	4	drilled	140	40	100	hard	lowers 1/2	McCurtain sh.		
4	NW SW NW	5	do	33	10	500	do	no change	shale	M_2?	
5	NW NE NE	5	do	50	15	500	do	do	McCurtain sh.?		
6	SW NE SE	6	do	40	20	500	do	do	Lequire ss.?		
7	SW SW SW	6	do	96	50	500	do	lowers	Lequire ss.?		
8	NW NE NW	7	do	65	30	2,000	do	no change	coal ?	M_2	
9	NW NW NW	9	do	140	80	750	do	do	McCurtain sh.		
10	NW SW NW	9	do	185	80	500	do	do	McCurtain sh.?		
11	NW NW SW	10	dug	30	25	1,000	hard	no change	alluvium		
12	SW NW SW	16	drilled	105	50	500	do	do	?	A_3?	
13	SE NE SE	17	do	40	20	500	soft	do	sandstone	A_6	
14	SW SW SE	17	do	38	18	500	hard	do	McCurtain sh.		
15	NW NW NE	18	do	45	18	1,000	hard brackish	do	shale	M_2?	
16	SW SE SE	18	do	80	50	500	soft soda	do	McCurtain sh.		
17	SW NE SE	18	do	80	30	500	hard	do	McCurtain sh.		
18	NE SE SW	20	do	65	25	1,000	do	do	shale?	A_3?	
19	SE NW SE	20	do	60	40	1,000	soft soda	do	shale	A_3?	
20	SE SE SE	20	dug	40	35	250	hard brackish	do	alluvium		
21	SW NW NW	28	dug	33	28	400	soft	do	alluvium		
22	SE NE NE	29	do	46	42	300	do	do	alluvium		
23	NW SW SW	31	do	30	25	2,000	hard	do	alluvium		

T. 11 N., R. 18 E., McINTOSH COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	SE SE SE	1	drilled	40	8		hard	no change	shale	A_6	
2	SW SW SW	1	dug	40	32		soft	fails	shale	A_6	
3	SW SE SW	2	drilled	35	8		hard	no change	McCurtain sh.		
4	SE SW SE	3	dug	45	25		do	do	McCurtain sh.		
5	NW SE SW	4	drilled	50	20		do	do	shale	M_2?	
6	NW NW NW	5	do	40	15		do	do	Boggy shale		
7	SW SW SW	6	do	35	7		soft	do	Bluejacket ss.		
8	SW NW NW	7	drilled		7		do	do	sandstone		
9	NE NW SW	8	do	65	30		hard	do	shale	M_2?	
10	SW SE SE	9	do	50	15		do	do	McCurtain? sh.		
11	SE SE SW	10	do	48	38		gyp?	fails	McCurtain sh.		
12	SE SE SE	11	do	40	30		hard	do	McCurtain sh.		
13	SE SW SE	15	do	30	15		soft	no change	Lequire? ss.		
14	SE SW SE	16	do	40	30		hard	fails	shale	M_2?	
15	SW NW NE	18	do	65	30		do	no change	Warner? ss.		
16	NW NW NW	18	do	70	25		soft	do	sandstone	B_7?	
17	SE SE SE	18	do	40	30		hard	fails	Lequire? ss.		
18	NW NW NW	19	do	40	20		do	do			
19	NE SE SE	20	do	20	2		do	no change	Lequire? ss.		
20	NE NW NW	20	do	70	26		do	do	shale?	M_2?	
21	SW NW NW	21	do	35	20		soft	do	Lequire? ss.		
22	SW SE SE	22	drilled	40	20		soft	no change	Lequire? ss.		
23	SW SW SW	23	do	50	10		do	do	Lequire? ss.		
24	NW SW SW	24	do	30	8		do	do	McCurtain sh.		
25	SE SW SW	28	do	80	30		hard	do	Warner ss.		
26	SW NW NW	29	do	63	9		soft	do	shale	M_2?	
27	SW SW SW	29	do	30	6		do	do	Lequire? ss.		
28	SE SE SE	30	do	40	12		do	do	Lequire? ss.		
29	SE SE SE	31	drilled	50	30		soft	no change	Lequire? ss.		
30	NW NW NW	32	do	50	36		do	do	Lequire? ss.		
31	SW SW NW	32	do	40	30		do	fails	shale	M_4?	
32	NW NW NE	32	do	40	10		do	no change	Lequire? ss.		
33	NW NW NW	33	do	30	20		hard	do	Lequire ss.		
34	NE NE SW	34	do	20	00		soft	do	Lequire ss.		
35	NW NW NW	36	do	55	15	1,000	hard iron	no change	McCurtain sh.		

T. 11 N., R. 19 E., MUSKOGEE COUN

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	NE NW SE	1	drilled	35	8	500	soft	lowers 2/3	Warner ss.		
2	SE NW SE	4	dug	40	15	150	do	fails	sandstone	A_5?	
3	SW NW SW	5	do	56	31	200	do	do	sandstone	A_5?	
4	SW SE NW	6	drilled	40	15	250	do	no change	Blackjack ss.		
5	SE SE SE	7	do	75	60	65	hard sulphur	do	shale	A_6	
6	SE SE SW	7	do	60	20	500	hard	lowers 3/5	Blackjack? ss.		
7	SE NE SE	8	do	60	10	500	soft	no change	shale?	A_5?	
8	NW NW NW	9	do	30	20	1,000	do	do	Blackjack? ss.		
9	SW SE NE	9	do	72	10	250	do	do	sandstone	A_5?	
10	SE SE SW	10	do	60	20	500	hard gyp	do	?	A_5?	
11	SE SE NE	11	do	22	flows	1,500	hard iron	do	Warner ss.		
12	NW NW SW	13	dug	22		400	hard	lowers 2/3	shale	M_4	
13	NE NE NE	14	drilled	60	35	300	do	no change	?	M_3?	
14	NW NE NE	17	do	50	20	2,000	do	do	Dirty Cr. ss.		
15	NE NE SE	17	do	80	40	250	soft	do	shale?	A_3?	
16	NW NW NW	18	do	65	8	500	hard	do	shale	A_6	
17	SW SE SE	18	do	35	15	500	do	lowers 3/5	shale	A_6?	
18	SE SE SW	19	do	45	10	2,000	hard salty	no change	McCurtain sh.		
19	NW NE SE	19	do	35	15	1,000	soft	lowers 1/2	McCurtain sh.?		
20	SW SE SE	19	do	40	30	150	soft	fails	McCurtain sh.		
21	SW SE NE	20	do	40	30	100	hard	no change	shale	A_6	
22	NE SE SE	22	do	55	10	1,500	do	do	shale	M_2	
23	NE NE SW	22	do	70	flows	450	soft	do	Warner ss.?		¼ mi. east of fault
24	SW SW SW	23	do	38	3	1,000	hard	do	shale & coal	M_4	
25	SW SE SE	23	do	32	12	500	do	do	shale	S_1?	
26	NE SE SE	24	do	70	15	1,000	do	do	shale?	M_2?	
27	NE NE NE	24	dug	15	12	1,000	soft	do	shale & gravel		
28	SW NE SW	25	do	40	15	2,000	hard	do	shale	S_1?	
29	SE NE NE	25	do	12	9	1,000	do	do	shale	S_1?	
30	NE NW NW	27	drilled	35		600	do	do	Warner ss.		
31	SE NE SE	28	dug	40	10	1,500	do	do	shale	M_4	
32	NE NE SW	29	drilled	96	40	1,500	do	do	McCurtain sh.		
33	NE NE NE	29	do	46	20	300	do	do	shale	A_6	
34	NE NE SW	30	do	120	50	500	hard	do	McCurtain sh.		
35	NW SW SW	31	do	60	10	1,000	medium	do	shale	M_2?	
36	SE SW SW	32	drilled	65	50	100	hard	fails	Warner ss.		Near fault
37	NW NW NE	33	do	45	11	1,000	do	no change	shale	S_2?	Near fault
38	NW SE NE	33	dug	20	8	500	do	do	Lower Boggy sh.		
39	SE SE SW	34	drilled	90	25	500	do	do	shale	S_2?	Water kills plants
40	NE NW NE	36	do	50	12	1,000	soft	do	Cameron ss.?		

T. 11 N., R. 20 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	SW NW SE	2	drilled	57	30	250	soft	no change	sandstone	A_6?	
2	NW NE SE	3	spring	6	2	200	do	do	Warner ss.		
3	SW NE NW	4	drilled	30	18	150	do	do	Lequire ss.		
4	SW NE SW	5	do	45	30	150	do	fails	Lequire ss.		
5	SE NE SW	6	dug	45	20	500	do	no change	Warner ss.		
6	NE NW SW	7	drilled	52	25	300	do	do	Warner ss.		
7	NW NW SE	8	do	68	30	350	do	do	Lequire ss.		
8	SW NE SW	10	dug	55	30	200	hard	do	McCurtain sh.		
9	SW NW NE	12	do	30	13	150	soft	do	Quaternary sand		
10	SW SW SE	13	drilled	89	40	1,200	do	lowers	Blackjack ss?		
11	SW NW NW	14	do	120	40	500	do	no change	shale	A_8	
12	NW NW NW	16	do	40	20	400	do	do	Warner ss.		
13	NE NE NE	18	do	36	15	400	do	do	Lequire ss.?		
14	SE SW SE	19	do	90	15	1,000	do	do	Warner ss.?		
15	NE NE SE	22	do	52	30	2,000	do	do	Hartshorne? ss.		
16	NE NW NW	24	do	35	20	400	do	do	shale?	A_6?	
17	NE NE NE	27	do	45	15		hard	do	shale	A_6	
18	SW SE SW	28	do	54	35	600	soft	do	McCurtain sh.		
19	NE NE NE	29	do	50	30	1,000	hard	do	McCurtain sh.		
20	NW SW SW	30	do	90	60	100	do	lowers 1/2	Lequire ss.?		
21	SE SE NW	31	do	65	40	250	do	no change	shale	M_2	
22	NE NW SE	33	do	54	10	1,000	soft	do	McCurtain sh.		
23	NW SE SW	33	do	50	30	500	copperas soft	do	McCurtain sh.		
24	SW SW NW	34	spring	12	9		hard	do	Warner ss.		
25	SE NE SE	35	drilled	25	12	400	do	do	alluvium		
26	NE SW NW	36	dug	23	14	1,000	do	do	alluvium		

T. 11 N., R. 21 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	SE SE SE	7	drilled	52	50	400	soft	no change	alluvium		
2	SW NW SW	8	do	70	45	2,000	do	do	alluvium		
3	SW NE NE	9	driven	36	28	2,000	hard	do	alluvium		
4	SE SW SW	16	drilled	38	20	1,000	soft	do	alluvium		
5	NW NE NE	17	do	40	30	400	do	do	alluvium		
6	NW NW NW	17	do	60	20	25	do	do	alluvium?		
7	NE NE SW	18	do	65	35	2,000	hard	do	shale	A_8	
8	SE SE NE	18	do	105	90	200	hard (alum)	lowers 1/2	shale	A_3?	
9	SE SW SE	19	dug	30		40	hard	fails	alluvium		
10	SW NW SW	21	drilled	55	30	250	do	no change	alluvium		
11	NW NW NE	30	dug	53	45	200	do	lowers 1/2	sandy shale	A_3?	

T. 12 N., R. 18 E., McINTOSH COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	NE NE SE	1	drilled	50	15		hard	never dry	Warner ss.		
2	NE NW NE	6	do	100	25	1,000	soft	lowers 2/3	sandy shale?	B_7	
3	NW NE NW	7	do	40	25		do	never dry	Bluejacket ss.?		
4	SE SE SW	9	do	85	25		hard	do	sandy shale	B_7	
5	SW SE SW	9	spring				soft	do	Bluejacket ss.		
6	NW NE NW	11	drilled	60	30	1,000	hard, iron	no change	shale?	M_2	
7	SW SW NW	13	do	30	25	20	hard	do	Keota ss.		
8	SE NE SW	15	do	50	30	500	do	do	sandy shale?	B_7	
9	SW SE SW	16	do	150	25		soft	never dry	sandy shale?	B_7	
10	SW SW SE	17	do	105	75		hard	do	sandy shale	B_7	
11	SE SW SW	18	do	60	40		do	do	shale	B_7	
12	SE SW SE	19	do	65	10		do	plenty	Bluejacket ss.		
13	SE SW SE	20	do	50	40		soft	do	shale	B_7	
14	SE SE SE	21	do	70	40		hard	do	shale	B_7	
15	SW SW SE	22	do	40	30		do	do	Bluejacket ss.		
16	SE SW SW	23	do	20	8		soft	do	Bluejacket ss.		
17	SW NE NW	24	do	65	50		do	fails	sandy shale	B_7	
18	SW NE NE	25	do	50	15		do	never dry	sandy shale	B_7	
19	NW NW SW	26	dug	35	30		do	plenty	Bluejacket ss.		
20	SW SW NW	27	drilled	40	30		do	do	Bluejacket ss.		
21	NW NW SW	28	do	20	15		do	do	Bluejacket ss.		
22	SE NE NE	29	do	30	20		hard	low	Bluejacket ss.		
23	NW SE NE	30	do	85	60		do	never dry	Bluejacket ss.		
24	SW SW SE	31	do	25	15		do	plenty	shale?		
25	SW SE SE	32	do	40	12		do	do	shale	B_7?	
26	NW NE NW	33	do	100	15		soft	do	shale?	B_7?	
27	NE NE SE	35	do	65	40		hard	fails	McCurtain sh.		
28	NW SW NE	36	do	25	15		soft	never dry	Warner? ss.		
29	NW SW NE	36	spring				do	do	Hartshorne ss.		

T. 12 N., R. 19 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	NW NW SW	2	drilled	62	45	150	soft	fails	McCurtain sh.		
2	NW SW NE	3	dug	45	30	500	do	no change	McCurtain sh.		
3	SE SW SE	4	drilled	50	35	200	do	do	McCurtain sh.		
4	NE SW NW	5	do	45	20	125	gyp?	do	McCurtain sh.		
5	SW SE NW	6	dug	40	15	300	do	do	McCurtain sh.		
6	SW SE SE	7	drilled	45	20	500	soft	do	McCurtain sh.		
7	NW SW NE	8	dug	45	20	250	gyp?	do	Warner ss.		
8	SE SW NE	12	drilled	50	35	200	hard	fails	Pope Chapel ss.		
9	SE NW SE	13	dug	40	22	175	soft	fails	Pope Chapel ss.		

T. 12 N., R. 19 E., MUSKOGEE COUNTY—Continued.

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
10	NW NE NW	15	drilled	40	25	250	do	no change	Hartshorne? ss.		
11	NE NE NE	16	do	80	35	350	do	do	McCurtain sh.		
12	SE SE SW	17	do	55	30	300	do	do	Cameron ss.		
13	SE NE SE	18	do	55	20	500	hard	do	Cameron ss.		
14	SW SW NW	19	do	85	55	150	soft	fails	sandy shale	B_7	
15	SE SW SW	20	do	90	20	1,000	hard	no change	McCurtain sh.		
16	SE NW NW	20	do	46	28	200	gyp	do	Tamaha ss.		
17	SE NE NE	21	do	55	30	200	do	do	Blackjack ss.		
18	SE NW NE	23	do	40	15	150	do	do	Dirty Creek ss.		
19	NW SW SW	25	do	50	30	150	hard	do	Pope Chapel ss.		
20	NW NW SE	26	dug	63	40	200	gyp	fails	Georges Fork ss.		
21	SE SW NE	27	drilled	40	18	240	do	do	Dirty Creek ss.		
22	SW SE NE	28	do	50	30	500	do	no change	Dirty Creek ss.		
23	SW SW NE	29	do	50	28	150	do	do	Blackjack? ss.		
24	NE NE NW	29	do	118	30	500	hard sulphur	do	McCurtain sh.		
25	NW NE SW	30	dug	40	22	150	gyp	do	Warner ss.		
26	SW NE NE	32	drilled	55	35	250	hard	fails	Blackjack ss.		
27	NW SE SE	36	do	68	50	150	gyp	do	Blackjack? ss.		

T. 12 N., R. 20 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	NW NW NE	3	drilled	53	35	200	soft	fails	Coody? ss.		
2	SW NE SE	3	spring	4	1	50	do	no change	Dirty Creek ss.		
3	NE SE SW	4	do	10	2	500	do	do	Coody ss.		
4	NE NE SE	5	drilled	60	40	175	do	fails	Coody ss.		
5	NW SE SE	5	dug	50	35	300	do	do	Coody ss.		
6	SE NW SE	6	do	50	28	500	do	no change	Coody ss.		
7	NE SW NE	7	drilled	58	30	300	hard	fails	Coody ss.		
8	NW SE NW	7	spring	5	1	100	soft	no change	Pope Chapel ss.		On anticline.
9	NW NE NW	7	drilled	60	35	500	do	do	Coody ss.		In syncline.
10	SE SE SW	9	do	50	25	250	hard	fails	Dirty Creek ss.		
11	NE SE NW	9	do	55	40	150	soft	do	Coody ss.		
12	SE SE NE	11	do	32	18	250	hard	no change	alluvium		
13	SE SW SE	12	driven	25	10	500	do	do	alluvium		
14	NW NE NW	13	drilled	30	15	150	do	do	alluvium		
15	SW NW NE	16	dug	60	40	300	do	do	Georges Fork ss.		
16	NW SE NW	16	spring	6		350	soft	do	Dirty Creek ss.		
17	NE SE NE	17	drilled	56	30	200	do	do	Pope Chapel ss.		
18	NE NE SW	18	spring	7	flows		do	do	Pope Chapel ss.		
19	NE NE SE	19	drilled	40	25	100	do	fails	shale?	A_2	

T. 12 N., R. 20 E., MUSKOGEE COUNTY—Continued.

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
20	NE SE SW	21	do	30	10	300	hard	no change	sandy shale?	A_5	
21	SW NW SE	22	do	45	15	300	do	do	alluvium		
22	NW NE SE	23	driven	35	15	250	do	do	alluvium		
23	SW NW SE	24	do	35	15	225	do	do	alluvium		
24	SW SW NE	25	drilled	45	20	300	do	do	alluvium		
25	NE NE SW	26	do	45	30	150	do	fails	alluvium		
26	NE SW NW	27	do	40	25	300	do	no change	alluvium		
27	SE SE NW	28	do	40	30	200	do	fails	Blackjack ss.		
28	NW NE NE	28	do	60	35	500	do	no change	Webbers Falls? ss.		
29	SE NE SE	29	do	50	20	350	do	do	McCurtain sh.		
30	SE NW SW	30	do	60	45	125	gyp	fails	McCurtain sh.		
31	NE SE NW	31	do	54	30	250	hard	no change	McCurtain sh.		
32	NE SE NW	32	spring	5	1½	300	soft	do	Warner ss.		
33	NE NW SE	33	drilled	40	18	185	hard	do	Warner ss.		
34	SE NE SW	34	do	35	20	200	do	do	Warner ss.		
35	NW NE SW	36	drilled	55	30	225	do	fails	shale?	A_6?	

T. 12 N., R. 21 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	SW NW SW	20	driven	30	10	200	hard	no change	alluvium		
2	SW NW SW	29	drilled	43	20	300	do	do	alluvium		
3	NW NW SW	31	do	35	15	150	do	do	alluvium		
4	SW NE SW	33	do	45	28	300	soft	do	alluvium		

T. 13 N., R. 18 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	SW SW NW	1	dug	45	25	250	soft	no change	shale	S_1	
2	SW SW NE	1	drilled	180	flows	200	do	do?	Warner? ss.		Drilled for gas & plugged back to 100′
3	SE SE NE	2	do	35	15	500	hard	fails	shale	S_1	
4	SW NW NW	3	do	30	10	1,000	soft	never dry	Bluejacket ss.		Water in well No. 3 not used for drinking
5	SW SW SW	4	do	60	full	no limit	do	no change	Bluejacket ss.		
6	NE NE NE	5	do	40	20	1,200	do	do	Bluejacket ss.		
7	SE NE SE	6	do	40?	20	400	hard	do	Bluejacket ss.		
8	NW NW NW	7	do	65	18	4,000	soft	do	Bluejacket ss.		
9	SE SW SW	8	?	62	20	80	do	fails	Bluejacket ss.		
10	NW NW NE	12	drilled	38	12	200	do	no change	Tamaha ss.		
11	NW SW SW	13	dug	60	50	150	do	do	McCurtain sh.		

T. 13 N., R. 18 E., MUSKOGEE COUNTY—Continued.

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
12	SE SE SE	17		30	10	1,000	do	no change	McCurtain sh?		
13	NE NE NW	21	spring			1,400	do	do?	Warner ss.		
14	NW SE NW	22	do	3	00	80	do	do	Warner ss.		
15	NE SW SE	22	spring	3	2¼	40	do	fails	Warner ss.		
16	SE SE NW	24	drilled	40	20	300	hard	no change	Hartshorne ss.		
17	SW SW SW	24	dug	10	5	100	do	fails	Warner ss.		
18	SW SW SW	25	drilled	52	36	200	gyp	no change	Warner ss.		
19	NW SW NW	27	do	60	12	250	hard	never dry	Warner ss.		
20	SE SW SW	35	dug	25	21	150	do	no change	Lequire? ss.		

T. 13 N., R. 19 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	SE SW SE	3	drilled	115	70	500	soft	no change	Hartshorne? ss.		
2	SW SW SE	4	do	30	20	150	do	fails	Warner ss.		
3	SE SE SW	6	do	58	35	40	hard	no change	Tamaha ss.		
4	NE SE SE	7	do	50	30	200	soft	fails	Keota ss.		
5	NE NE NE	8	do	45	30	250	hard	do	shale	M_3	
6	SW SW NW	10	do	65	30	200	do	no change	Warner ss.		
7	NE SE SE	10	do	80	45	500	soft	do	Hartshorne? ss.		
8	NW SW SW	11	do	87	47	150	hard		Hartshorne? ss.		
9	SW SW SW	13	do	35	20	250	do	no change	alluvium		
10	NE NW SW	14	dug	60	45	800	soft	do	Warner? ss.		
11	SW NW NW	14	drilled	110	100	100	hard	fails	Warner ss.		
12	SW NW NW	15	do	65	35	200	soft	no change	Cameron ss.		
13	NW NE NW	15	drilled	52	30	250	soft	no change	Cameron ss.		
14	NW NE NE	15	do	65	20	500	do	do	Lequire? ss.		
15	NW NE NW	16	do	41	10	150	do	do	Cameron ss.		
16	NW SW NE	16	do	60	40	200	do	do	Lequire ss.?		
17	NE NE NE	16	do	85	30	5,000	do	do	Cameron & Lequire ss.		
18	NW NW NE	17	do	40	20	250	do	do	Cameron ss.		
19	SE SE SE	20	do	45	30	150	hard	fails	Blackjack ss.		
20	SW SE SE	21	do	50	20	1,000	soft	no change	Blackjack ss.		
21	NE SE NE	21	do	60	40	300	do	do	sandstone	A_3	
22	NW NW NW	22	do	40	20	800	do	do	Webbers Falls ss.		
23	SW SW NW	23	do	110	60	100	do	fails	sandstone	A_3?	
24	SW SW SW	24	do	45	32	200	do	no change	Webbers Falls ss.?		
25	SW NW SE	25	do	50	35	150	hard	fails	Blackjack ss.		
26	NE SE NE	26	do	55	35	520	soft	no change	Blackjack ss.		
27	NE SW NE	28	dug	45	20	1,500	gyp?	do	Hartshorne ss.		

T. 13 N., R. 19 E., MUSKOGEE COUNTY—Continued.

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
28	SW SW SW	28	drilled	58	30	500	soft	do	Blackjack ss.		
29	NE NW SE	28	dug	40	25	2,000	gyp?	do	Hartshorne ss.		
30	NW NW NE	32	drilled	55	35	500	hard	do	Blackjack ss.		
31	NE NE NE	33	do	45	25	2,000	soft	do	Hartshorne ss.		
32	NW NW NW	34	do	40	25	250	do	do	Hartshorne ss.		
33	NE NE NE	36	do	45	25	150	do	do	Blackjack ss.		

T. 13 N., R. 20 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	SE SW SE	16	driven	35	25	150	hard	no change	alluvium		
2	SW NW NE	20	spring	3	1	40	soft	do	Coody ss.		
3	SW SW NW	22	dug	45	30	300	hard	do	alluvium		
4	NW NW NW	27	drilled	55	30	300	do	do	alluvium		
5	SW SE SW	29	do	50	35	1,000	soft	do	Coody ss.		
6	SW SE NW	31	do	45	30	120	do	do	sandstone	A_3	
7	NW NW NW	32	do	50	30	300	do	do	Coody ss.		
8	SW SE NE	33	dug	40	20	500	do	do	alluvium		

T. 14 N., R. 17 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	SW NW SW	1	drilled	45	20	200	hard	no change	shale?	B_{11}	Adjacent to fault.
2	NE NW NW	2	do	60		600	do	lowers 3/4	shale?	B_{11}	
3	SE SE NE	7	do	65	12	1,000	soft	no change	shale?	B_{11}	
4	SE NE NE*	7							sandy shale		Analysis
5	SE SE NW	10	do	52	42		do	do	sandstone	B_{11}	
6	SE SE SW	11	do	60	15	400	do	lowers 2/3	shale?	B_7	
7	NW SW NW	12	do	80	20		hard	no change	shale?	B_7	
8	NW NW NE	14	dug	15	2	80	soft	fails	Bluejacket ss.		
9	SE SE SW	16	drilled	30	16	500	do	never dry	shale?	B_{11}	
10	NW NW SE	18	do	18	12	80	do	fails	Crekola? ss.		
11	NW NW*	18		21	10		hard	never dry	Crekola ss.		
12	SE NE SE	19	dug	24	8	2,000	soft	no change	Crekola? ss.		
13	NE SW SW	23	spring				do	do	Taft? ss.		Adjacent to fault
14	NE NE NE	25	dug	15	5	200	do	do	shale	B_{11}	
15	SE SE SE	25	do	22	8	400	hard	do	shale	B_{11}	
16	SW SW SW	27	drilled	98	15	1,500	soft	do	shale	B_{11}	
17	SE SE NE	29	do	80	20	1,500	do	lowers	Crekola? ss.		
18	SE NW NW	36	dug	13	10	200	do	no change	shale	B_{11}	

* Data furnished by Resettlement Administration, Region VIII.

T. 14 N., R. 18 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	SW SW SW	3	drilled	46	12	1,000	soft	no change	Keota ss.		
2	NW SE SW	4	do	70	12	1,200	soft gypy	do	Keota ss.		
3	NW NE NW	9	do	80	25	1,200	soft soda	do	Spiro ss.		
4	SW SW SW	11	do	95	10	6,000	soft sulphur		Keota ss.		Supplies 5 houses, one filling station
5	NW NW NW	12	do	100	40	80	soft	fails	Hartshorne ss.		
6	SW NE NE	13	do	90	70	800	hard	lowers	Hartshorne ss.		
7	NW SW NW	14	do	45	15	1,200	do	never dry	Keota ss.		
8	NW SW SW	15	dug	100?	8	2,000	soft	no change	Spiro ss.		
9	SE SE NW	16	drilled	70	50	250	hard	lowers	shale?	B_7	
10	SW SW SE	19	do	35	30	20	soft	no change	Bluejacket ss.		
11	SE NW NE	23	do	65	25	80	do	do	shale?	M_3?	
12	NE NE SE	24	do	85	40	2,000	hard	do	McCurtain sh.?		
13	SW SE SE	25	dug	40	12	2,500	soft	do	sandstone	M_{2-3}?	
14	SW SE SE	26	drilled	60	35	1,000	hard gyp	no change?	shale	S_1	
15	NW NW SW	26	do	100	75	40	hard	fails	Cameron ss.?		
16	NE NE NE	27	do	70	15	2,400	soft	no change	shale	M_4	
17	NE NW NE	28	do	55	25	1,200	do	do?	sandy shale	B_7	
18	SE SE SW	30	dug	40	20	600	hard	fails	Valley fill? or Bluejacket ss.?		Wet weather well.
19	SE SW SW	31	drilled	50	12	1,000	soft	no change	Bluejacket ss.		
20	SW NE NE	31	do	50	15	1,000	hard	do	shale	B_7	
21	SW SW SE	33	do	25	15	400	do	do	Bluejacket ss.		
22	NW NW NW	34	dug	8	4	150	soft	do	Bluejacket ss.		
23	SW SW SW	35	drilled	65	5	2,000	do	do	Spiro ss.		

T. 14 N., R. 19 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	SW SE SE	1	drilled	80	70	200	soft	no change	Cody ss.		
2	SW NW SW	2	do	45	20	200	hard	do	shale	A_2	Not good to drink.
3	SW SW NW	3	do	85	5	200	do	do	shale	A_3	
4	NW NE NW	4	do	85	15	1,000	do	do	Georges Fork ss.?		
5	NW NW NW	8	do	80	20	600	do	lowers	Blackjack ss.?		
6	SE NE NW	10	spring			600	do	no change	limestone	A_5b?	
7	NW NW NW	11	drilled	790	flows		hard soda	do	?		
8	SW SE NW	13	do	30	15	4,000	hard	do	alluvium		Waters 100 steers 80 hogs
9	SE SE NE	15	do	73	65		soft	never dry	Blackjack ss.		
10	NW NW NE	16	do	126	90	150	do	fails	?	A_5	
11	NW NW NW	17	do	96	30	1,000	hard	no change	Blackjack ss.?		
12	NW NE SE	18	do	80	40	1,000	do	do	Blackjack ss.		

T. 14 N., R. 19 E., MUSKOGEE COUNTY—Continued.

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
13	NW NE SE	19	do	93	40	1,200	do	do	sandstone?	A_2	
14	NW SE NE	20	do	90	35	800	do	do	?	A_8	
15	SE SE SW	21	do	60	18	600	do	lowers 4/5	?	A_5	
16	NW SE SE	22	do	130	105	240	do	never dry	shale	A_2	
17	SE NE NW	27	do	60	20	2,000	do	no change	Blackjack ss.		
18	NE SE NE	28	spring	20		4,000	soft	do	McCurtain sh.		
19	NW SE SE	29	2 springs	3		3,000	do	do	McCurtain sh.		
20	SE SW SE	29	dug	55	15	4,000	do	do	Hartshorne ss.		
21	SW SW SW	29	spring	3	¾″ strm		do	do	Warner ss.		
22	SE SW SE	32	drilled	100	flows		do	do	McCurtain sh.		Flows several thousand bbls. per day.
23	SE SW NW	33	do	60	25	2,000	do	do	McCurtain sh.		
24	SW NW SW	34	do	110	30	2,000	hard	do	McCurtain sh.		

T. 15 N., R. 17 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	SE SE SW	9	drilled	55	12	600	hard	lowers 2/3	shale	B_7	
2	NE SW SW	11	dug	35	20		soft	no change	Bluejacket ss.		
3	SE NE SW	11	do	40	30	320	hard	do	Bluejacket ss.		
4	NW SW SE	14	spring			200	soft	do	alluvium		
5	SW SW*	14	drilled	43	15		good	do	Bluejacket ss.		Analysis.
6	NE NW NE	15	do	60	25	400	soft	do	sandy shale	B_7	
7	NE NE NE	15	do	35	12	600	hard	lowers 2/3	Bluejacket ss.		
8	SE SE*	15	do	80	69		good	little change	sandy shale	B_7	Analysis.
9	NW SW NW	16	dug	23	15	80	hard	never dry	Bluejacket ss.		
10	SE NE NW	18	do	27	12	48,000	do	no change	alluvium		River bottom.
11	NE SE NW	18	do	27	12	48,000	do	do	alluvium		
12	SE SE NW	18	do	27	12	48,000	do	do	alluvium		
13	NE NE NE	20	do	30	20	240	do	fails	shale	B_{10}?	
14	NE NW SW	20	do	18	12	200	do	never dry	shale	B_9?	
15	SE SE NE	21	drilled	50	20	2,000	soft	no change	shale	B_{11}	
16	NW NE NE	23	do	40	15	400	hard	do	shale	B_7	
17	NE NE SE	25	do	40	10	200	soft	do	shale	B_9?	
18	NE SE NW	26	drilled	?	?	?	medium	never dry	?	?	Oldest well in vicinity
19	SW SW NW	26	drilled	65	50	400	hard	lowers	shale	B_7	
20	NW NW NW	27	dug	20		800	do	lowers 3/4	Bluejacket ss.		
21	NE NE NW	28	do	30	25	80	soft	fails	Valley fill?		In draw
22	NE SW NW	30	drilled	42		800	do	never dry	shale?	B_{11}	
23	SE SE NW	31	dug	35	14	2,000	hard	no change	sandy shale	B_{11}	

T. 15 N., R. 17 E., MUSKOGEE COUNTY—Continued.

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
24	NW NW NW	32	drilled	60		1,000	soft	no change	sandstone	B_{11}	
25	NE SW SW	32	drilled	80	40	1,000	do	do	sandstone	B_{11}	
26	SW SE SE	33	dug	26	15	200	hard	fails	Bluejacket ss.		
27	NW NW*	33	drilled	52	32		good	never dry	sandy shale	B_{11}	Analysis
28	NW NW*	33	do	33	20		do	do	sandy shale	B_{11}	do
29	NW NW*	33	do	23	10		iron	do	sandy shale	B_{11}	do
30	SE NW NE	34	do	90	40	800	hard	no change	sandy shale	B_7	
31	NE NE NW	35	do	50		1,000	medium	do	sandy shale	B_7	
32	NE SE SE	35	dug	25	20	200	soft	do	sandstone	B_{11}	
33	SE SW SW	36	drilled	65	15		do	never dry	sandstone	B_{11}	

* Data furnished by Resettlement Administration, Region VIII.

T. 15 N., R. 18 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	NE NE SE	3	pump	25		400	hard	never dry	alluvium		
2	SE NW*	3	driven	30	20		do	no change	alluvium		Analysis.
3	SW SW SE	8	dug	30	10	400	soft	fails	alluvium		
4	NE SE NW	10	spring		flows	1,500	hard	no change	alluvium		
5	NE NW*	10	driven	30	18		do	do	Warner ss.		Analysis.
6	SW NW*	10	drilled	90				do	Warner ss.?		Analysis.
7	SE NW NE	11	dug	65	63	10,000	hard	do	McCurtain sh.		
8	NW SW SE	11	drilled	110	70	4,000?	soft	do	McCurtain sh.		
9	NW SW SE	11	dug	65	40	4,000?	do	do	McCurtain sh.		
10	SW SE SE	12	drilled	40	20	800	do	do	Warner ss.?		
11	NW NE NE	13	do	40	30	400	do	do	Warner ss.		
12	NE NE NW	13	do	65	45	40	do	do	McCurtain sh.		
13	NE NE NW	14	do	40	20	400	do	fails	alluvium?		
14	SW NW NW	15	do	84	30	800	hard	never dry	Tamaha ss.		
15	NE NE SE	16	dug	60	20	200	soft	lowers	Keota ss.		
16	NE NE SE	16		105	40	320	do	lowers	shale	M_4?	Dug 60′, drilled 45′
17	NW NW NW	17	drilled	35	10	400	hard	lowers	shale?	S_1	
18	SW NW SW	18	do	150			do	no change	Spiro? ss.		
19	NE NE SE	18	do	62	32	120	soft	do	Keota ss.?		
20	SE SE NE	19	dug	9	8	20	do	do	shale	B_7	
21	NW NW NW	20	do	40	15	400	hard	do	Spiro ss.?		
22	NE NE SW	21	spring	1		1,400	soft	do?	Bluejacket ss.?		
23	SE NE NE	24	drilled	25	12	800	do	never dry	Bluejacket ss.?		
24	SW SW NW	29	dug	50	45	40	hard	fails	shale	B_9?	

T. 15 N., R. 18 E., MUSKOGEE COUNTY—Continued.

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Referece	Remarks
25	NE SE NE	30	drilled	60	10	400	do	never dry	Bluejacket ss.?		
26	SE NE NE	31	do	60	20	80	do	do	Bluejacket ss.?		
27	NW NE NE	32	do	65	25	400	do	do	Bluejacket ss.?		
28	NW SW SW	33	dug	65	12	40	soft	no change	McCurtain sh.		
29	NW SW SW	36	drilled	50	20	400	hard	do	Warner ss.?		

* Data furnished by Resettlement Administration, Region VIII.

T. 15 N., R. 19 E., MUSKOGEE COUNTY

Well No.	Location	Sec.	Type of Well	Depth Total	(feet) to Water	Est. Cap. Gallons Per Day	Relative Quality of Water	Effect of Drouth	AQUIFER Member	AQUIFER Reference	Remarks
1	NW SW SW	8	drilled	90	20		soft	no change	Warner? ss.		Can't pump dry.
2	NE NW NE	19	do	80	50	1,200	do	do	shale	B_7	
3	NE NW SE	20	do	50	20	400	do	do	Warner ss.?		
4	SW SE SW	28	do	38	22	600	do	do	McCurtain sh.		
5	NE SW NE	33	do	90	40	1,200	do	do	Warner? ss.		
6	NW NW SW	34	do	40	18	600	hard	do	alluvium		

Appendix B

STRATIGRAPHIC SECTIONS IN THE MUSKOGEE-PORUM DISTRICT

Measured by Norman D. Newell

TOWNSHIP 10 NORTH

1. SOUTH LINE SEC. 4, T. 10 N., R. 20 E.*

	Feet
McAlester shale.	
Warner sandstone member.	
Sandstone, slabby, with shale partings	25.0
McCurtain shale member.	
Shale, gray and buff	70.0
Shale, dark gray and black with clay ironstone concretions	80.0
Shale, covered, down to Hartshorne sandstone, about	50.0

2. ROAD CUTS IN NORTH PART OF SEC. 4, T. 10 N., R. 20 E.

	Feet
McAlester shale.	
Warner sandstone member.	
Sandstone, massive	15.0
McCurtain shale member.	
Shale, covered, computed at 225 feet, maybe less	225.0
Hartshorne sandstone.	
Sandstone, calcareous, greenish, somewhat blocky	2.5
Shale, buff and sandy	14.0
Sandstone, shaly, and hard sandy shale	25.0

3. WEST ½ SEC. 18, T. 10 N., R. 20 E.

	Feet
McAlester shale.	
Cameron sandstone member.	
Sandstone, platy	5.0

4. EAST LINE SEC. 4, T. 10 N., R. 19 E.

	Feet
Boggy formation.	
Bluejacket sandstone member.	
Sandstone, massive, and slabby	15.0
Shale (B_7).	
Shale, silty, dark gray below, sandy above	230.0
Shale, black, flaky, hard, filled with light gray calcareous concretions and bedded fossiliferous limonite	16.0
Limestone, carbonaceous, filled with *Marginifera muricatina* and *Spirifer cameratus*, *Hustedia*	1.5
Coal ("lower Boggy")	1.0
Shale (B_6), covered, underclay at top	25.0
Sandstone (B_5), micaceous, shaly	3.0
Arbitrary division (B_4).	
Shale, buff, sandy, with limonite concretions	8.0
Limestone, brown, crinoidal, filled with *Spirifer* and *Marginifera*	0.2
Shale, silty with limonite concretions, not well shown	25.0
Limestone, gray, shelly with *Marginifera missouriensis*, *Spirifer opimus*, crinoidal	0.3
Shale, covered, about	1.0
Coal	0.2
Shale, covered	3.0
Sandstone, slabby	4.0
Shale (B_3), poorly shown	

* Formations arranged in descending order, youngest at top.

5. NE PART SEC. 9, T. 10 N., R. 19 E. SCARP WEST OF PORUM.

	Feet
Boggy formation.	
Bluejacket sandstone member.	
Sandstone, massive	55.0
Shale (B_7).	
Shale, gray, silty, sandy above, argillaceous below	175.0
Shale, black, fissile below, flaky above, with fossiliferous limonite concretions and light gray, small limestone concretions in upper part	45.0
Limestone, carbonaceous, crinoidal, poorly shown	0.8
Coal ("lower Boggy")	1.0
Shale (B_6), gray, silty	20.0
Arbitrary division (B_5).	
Limestone, carbonaceous, filled with large ramose bryozoans, and pelecypods	0.8
Coal	0.2
Shale, gray, underclay at top	2.0
Sandstone, shaly, with limonite concretions	5.0
Arbitrary division (B_4).	
Shale, silty with limonite concretions	6.0
Limestone, lens of crinoidal bluish material	0.1
Shale, sandy with limonite concretions	20.0
Limestone, shaly, brown, full of crinoids, *Prismopora*, *Mesolobus striatus*, *Spirifer opimus*, *Marginifera missouriensis*	0.8
Coal	0.2
Shale, silty, underclay at top	3.0
Sandstone, blocky, hard, filled with *Stigmaria* and other plants	2.0
Shale (B_3).	
Shale, silty, gray, contains limonite concretions	35.0
Siltstone, calcareous, fossiliferous, filled with *Marginifera missouriensis* and *Spirifer opimus*	

6. SOUTH LINE SEC. 14 AND 15, T. 10 N., R. 19 E.

	Feet
Boggy formation.	
Sandstone (B_4), blocky, buff, filled with *Stigmaria* and other plants	2.0
Shale (B_3), gray, silty, partly covered, contains iron-stone concretions	40.0
Siltstone (B_2), calcareous, filled with calcareous shells and molds of *Marginifera missouriensis*, *Spirifer opimus* and *Linoproductus*	1.0
Shale (B_1), covered, computed at	75.0
Savanna formation.	
Spiro sandstone member.	
Sandstone, thin, poorly shown, makes bench	1.5
Shale (S_3), gray, silty	15.0
Sam Creek limestone member.	
Limestone, brown, filled with large ostracods	0.1
Shale, very fossiliferous, contains *Mesolobus striatus*, *Marginifera missouriensis*, *Spirifer opimus*, *Prismopora serrata*, fenestellids at top, crinoid stems and plates	2.0
Limestone, crinoidal	0.3
Shale (S_2).	
Shale, gray, silty	2.0
Coal, shaly	1.5
Shale, gray, upper part coaly with underclay	5.0

	Feet
Limestone, lower half gray, crinoidal, bluish where fresh, upper part yellow, weathers to limonite	1.3
Shale, light gray in upper part, dark gray in lower part, slightly carbonaceous, contains ironstone concretions in the lower part, computed at	50.0
Spaniard limestone member.	
Limestone, ferruginous, filled with *marginifera missouriensis*	.0.8
Coal, local	0.1
Shale, silty, underclay at top	2.0
Keota sandstone member.	
Sandstone, platy, shaly	3.0
Shale, gray, silty, contains thin coal smut in the middle	15.0
Sandstone, shaly and slabby, grades down to shale	25.0
Shale (S_1), sandy and silty.	

7. EAST ½ SEC. 12, SOUTH LINE SEC. 2, T. 10 N., R. 19 E.

Savanna formation.	
Keota sandstone member.	
Sandstone, under water tower at Porum, estimated at	20.0
Shale (S_1), covered, computed at	140.0
Tamaha sandstone member.	
Sandstone, platy	4.0
McAlester shale.	
Shale (M_4).	
Shale, covered, down to coal	45.0
Shale, calcareous, thin, hard, carbonaceous, contains few pelecypods (corresponds to M_4a limestone)	0.1
Coal (Stigler), seen in strip pits	1.7
Shale and underclay covered	4.0
Cameron sandstone member.	
Sandstone, poorly shown.	

8. NW¼ SEC. 35, AND SW¼ SEC. 26, T. 10 N., R. 19 E., ON HIGH OUTLIER

Savanna formation.	
Keota sandstone member.	
Sandstone, blocky, in three layers with interbedded shale	20.0
Shale (S_1).	
Shale, sandy and silty, middle part argillaceous, with heavy concretions of red ironstone	120.0
Coal	0.4
Shale, with underclay, somewhat silty toward top	18.0
Tamaha sandstone member.	
Sandstone, platy	3.0
McAlester shale.	
Shale (M_4).	
Shale, gray, silty with ironstone concretions	32.0
Limestone, lower one-half ferruginous, upper one-half dark gray, coquinoid, contains pelecypods	0.6
Shale, covered, lower part carbonaceous, estimated at	12.0
Coal	0.2
Shale, carbonaceous, gray, somewhat blocky	6.0
Coal (Stigler)	1.5
Shale, gray, sandy, underclay at top	6.0
Cameron sandstone member.	
Sandstone, platy	3.0

9. SW COR., SEC. 27, NW COR. SEC. 33, T. 10 N., R. 19 E., MEASURED ON HIGH OUTLIER NEAR SOUTH END.

	Feet
Savanna formation.	
Spiro sandstone member.	
Sandstone, massive, blocky, thins toward the north to four feet in less than a mile	20.0
Shale (S_3), covered	25.0
Sam Creek limestone member.	
Limestone, gray, platy, crinoidal	0.6
Shale (S_2).	
Shale, covered, contains slabs of silty limestone, possibly lower part of Sam Creek	25.0
Limestone, brown, filled with *Marginifera missouriensis*	0.1
Shale, silty, gray	9.0
Spaniard limestone member.	
Limestone, reddish brown, filled with molds of *Marginifera missouriensis*	0.3
Shale, sandy, poorly shown	10.0
Keota sandstone member.	
Sandstone, in three blocky beds separated by sandy shale	20.0
Shale (S_1).	
Shale, silty, with ironstone concretions at the base, less above	120.0
Coal	0.6
Underclay	0.5

10. SECS. 12, T. 10 N., R. 17 E., and 7, T. 10 N., R 18 E., AT WEST END OF WARNER UPLIFT

Boggy formation.	
Bluejacket sandstone member.	
Sandstone, massive	20.0
Shale (B_7).	
Shale, covered, black below, with brownish fossiliferous weathered limestone at base	172.0
Coal ("lower Boggy")	1.0
Shale (B_6), covered (includes Spiro? sandstone)	10.0
Savanna formation.	
Sam Creek limestone member.	
Limonite, filled with molds of *Punctospirifer, Aviculopecten, Composita, Dielasma, Spirifer opimus, Derbya, Juresania*	0.2
Shale (S_2), covered, estimated	48.0
Sandstone, slabby	5.0
Shale, covered	60.0
Sandstone, makes bench	2.0
Shale, covered	10.0
Limestone, slabby, blue, filled with small *Derbya*	3.0

TOWNSHIP 11 NORTH

11. NW COR. SEC. 9, T. 11 N., R. 19 E., ROADCUT TYPE LOCALITY OF BLACKJACK SANDSTONE.

Atoka formation.	
Blackjack sandstone member.	
Sandstone, platy, buff	9.0
Shale, sandy, buff	15.0
Sandstone, platy, buff, ½ to 1 foot of concretionary, ferruginous limestone at base	10.0

12. SW¼ SEC. 18, T. 11 N., R. 20 E., TROJAN COAL PIT

	Feet
Savanna formation.	
Tamaha sandstone member.	
Sandstone, flaggy, rippled	4.0
McAlester shale.	
Shale (M_4).	
Shale, sandy above, carbonaceous and flaky below, molluscan fauna in lower part	45.0
Limestone (M_4a), carbonaceous, contains pelecypods	0.1
Coal (Stigler)	1.5
Shale, hard, silty with underclay at top.	

13. SEC. 34, T. 11 N., R. 17 E. WEST END OF WARNER UPLIFT.

	Feet
Boggy formation.	
Bluejacket sandstone member.	
Sandstone, massive	40.0
Shale (B_7).	
Shale, very sandy at top, less sandy below	100.0
Shale, gray, silty and argillaceous	45.0
Shale, black, fissile.	

14. SEC. 25, T. 11 N., R. 19 E., ALONG CREEK BED AND WEST SIDE SEC. 30, T. 11 N., R. 20 E., AT COAL PIT.

	Feet
Savanna formation.	
Keota sandstone member.	
Sandstone produces scarp estimated at	10.0
Shale (S_1).	
Shale, sandy and dark gray, silty	45.0
Siltstone, fossiliferous	0.1
Shale, dark gray, silty with ironstone concretions estimated at	75.0
Shale, black, fissile	0.5
Coal	0.4
Shale, silty, estimated at	18.0
Tamaha sandstone member.	
Sandstone, rippled, blocky	4.0
McAlester shale.	
Shale (M_4).	
Shale, covered	45.0
Coal (Stigler)	1.5
Underclay.	

15. CENTER SOUTH LINE SEC. 3, T. 11 N., R. 20 E.

	Feet
McAlester shale.	
Shale (M_2), covered, erosional remnant.	
Warner sandstone member.	
Sandstone, shaly	20.0
McCurtain shale member.	
Shale, poorly shown.	

16. NE¼ SEC. 9, T. 11 N., R. 20 E., AND CENTER OF SEC. 4, T. 11 N., R. 20 E.

	Feet
McAlester shale.	
Arbitrary division (M_4).	
Coal (Stigler)	0.9
Shale and underclay	3.0
Cameron sandstone member.	
Sandstone, platy, calcareous	3.0
Shale (M_3), covered	30.0

	Feet
Lequire sandstone member.	
Sandstone, massive	3.0
Shale (M_2), covered	35.0
Warner sandstone member.	
Sandstone, thin bedded.	

17. NE¼ SEC. 20, T. 11 N., R. 20 E. CREEK BED.

	Feet
McAlester shale.	
Shale (M_4).	
Sandstone, shaly	2.0
Shale, gray, sandy	4.0
Shale, black, carbonaceous	1.0
Coal (Stigler)	1.0
Shale and underclay	2.0
Cameron sandstone member.	
Sandstone, massive, calcareous	5.0
Shale (M_3).	

18. SW COR. SEC. 22, T. 11 N., R. 20 E. HIGH ESCARPMENT.

	Feet
McAlester shale.	
Warner sandstone member.	
Sandstone, massive, cross-bedded	20.0
McCurtain shale member.	
Shale, mostly covered, carbonaceous and gray with clay ironstone concretions	190.0
Hartshorne sandstone.	
Shale, very sandy and platy	5.0
Sandstone, platy and greenish	6.0
Hartshorne sandstone?	
Shale, hard, sandy, base covered	10.0

TOWNSHIP 12 NORTH

19. NW¼ SEC. 10, T. 12 N., R. 18 E. NORTH SLOPE OF PINE VALLEY.

	Feet
Boggy-Savanna formations.	
Bluejacket sandstone member.	
Sandstone, heavy, slabby, limonite pebbles at base	20.0
Shale (B_7 and B_6).	
Shale, lower part covered, upper 60 feet very sandy	90.0
Shale, black, carbonaceous, some fissile, poorly shown	55.0
Shale, sandy, mostly covered (includes Spiro sandstone)	10.0
Sam Creek limestone member.	
Limestone, reddish, filled with *Marginifera*	0.4
Shale (S_2).	
Shale, silty, gray, partly covered	25.0
Ironstone bed, filled with pelecypods	0.3
Shale, gray, silty	40.0
Spaniard limestone member.	
Limestone, dark gray, crinoidal, contains fusulinids	0.3
Shale, covered, possibly contains coal	4.0
Keota sandstone member.	
Sandstone, upper part very blocky	4.0
Shale, covered, contains thin limestone and coal	8.0
Sandstone, thin bedded (probably base of Keota) about	20.0
Shale (S_1).	

20. CENTER SEC. 10, T. 12 N., R. 18 E. SOUTH SLOPE PINE VALLEY.

	Feet
Boggy formation.	
Bluejacket sandstone member.	
Sandstone, massive	15.0
Shale (B_7).	
Shale, sandy, some interbedded sandstone	30.0
Shale, covered, light gray, sandy	45.0
Shale, dark gray, silty	65.0
Shale, black, fissile	15.0
Limestone, carbonaceous, shaly, contains *Spirifer cameratus, Composita, Marginifera muricatina*	0.5
Coal ("lower Boggy")	0.6
Shale (B_6), gray, silty, sandy above with 1 foot of underclay at top	35.0
Savanna formation.	
Spiro sandstone member.	
Sandstone, silty, filled with fenestellids	2.0
Sam Creek limestone member.	
Limestone, reddish, filled with *Marginifera*	0.3
Shale (S_2).	
Shale, gray, silty with crinoid stems near the top	13.0
Shale, very fossiliferous, calcareous, contains *Spirifer cameratus, Marginifera missouriensis*, large crinoid stems	1.0
Shale, gray, silty	18.0
Limonite bed, fossiliferous, contains pelecypods	0.1
Shale, gray, silty, lower half covered, contains Spaniard limestone member	18.0
Keota sandstone member.	
Sandstone, upper part blocky	4.0
Shale, gray, silty	11.0
Limestone, brown, ferruginous, contains *Marginifera missouriensis*	0.2
Coal	0.2
Shale, gray with underclay at the top	4.0
Sandstone, shaly and slabby (probably base of Keota)	9.0
Shale (S_1).	

21. CENTER NORTH LINE SEC. 18, T. 12 N., R. 19 E. AT COAL PITS.

Savanna formation.	
Tamaha sandstone member.	
Sandstone, blocky, calcareous	4.0
Shale (M_4).	
Shale, covered, measurement compiled from test hole and outcrop	45.0
Shale, calcareous, fossiliferous (equivalent to M_3a ls.)	0.1
Coal (Stigler)	1.5
Shale with underclay at top	5.0
Cameron sandstone member.	
Sandstone, flaggy.	

22. SW SEC. 3, T. 12 N., R. 18 E.

Boggy formation.	
Bluejacket sandstone member.	
Sandstone, massive, with limonite pebbles at base	10.0
Sandstone, shaly	15.0
Shale (B_7).	
Shale, sandy, buff, silty below	50.0
Shale, black, carbonaceous or dark gray, flaky, some beds of fissile black shale, contains clay-ironstone concretions	50.0
Shale, covered	30.0

	Feet
Savanna formation.	
Spiro sandstone member.	
Sandstone	3.0
Sam Creek limestone member.	
Limestone, concretionary, contains *Marginifera missouriensis, Spirifer opimus, Linoproductus, Prismopora* and fenestellids	0.4
Sandstone, very fine, fossiliferous	2.0
Limestone, brown, fossiliferous	0.5
Shale (S_2).	
Shale, gray, hard, crinoid stems at top	15.0
Shale, brown, calcareous, filled with *Marginifera missouriensis, Spirifer opimus, Composita*, fenestellids	.15
Shale, gray, hard with limonite concretions	43.0
Shale, black, carbonaceous	2.0
Spaniard limestone member.	
Limestone, dark gray, hard, crinoidal, contains fusulinids, thin shale parting at middle	0.6
Shale, covered, possibly contains coal	3.0
Keota sandstone.	
Sandstone, slabby	3.0
Shale.	

23. NORTH LINE SEC. 4, T. 12 N., R. 18 E., ESCARPMENT.

Boggy formation.	
Bluejacket sandstone member.	
Sandstone, hard, even, slabby, calcareous	20.0
Shale (B_7 and B_6).	
Shale, gray, covered	55.0
Covered interval, upper two-thirds black carbonaceous shale, lower part contains gray sandy shale and coal fragments on slope, poorly exposed (Spiro sandstone covered)	85.0
Savanna formation.	
Sam Creek limestone member.	
Limestone, red, with *Marginifera missouriensis*, and *Spirifer opimus*	0.6
Shale (S_2).	
Shale, light gray, silty	10.0
Shale, light gray, hard, calcareous, silty, filled with molds of *Marginfera missouriensis*, fenestellids, and *Spirifer opimus*	2.0
Shale, dark gray, hard, silty	46.0
Spaniard limestone member.	
Limestone, gray, blocky, contains crinoid stems and *Campophyllum*	0.9
Shale, gray, argillaceous, poorly exposed	2.0
Keota sandstone member.	
Sandstone, calcareous, platy, rippled	2.0
Shale (S_1).	
Shale, sandy with limonite concretions	4.0
Shale, calcareous, contains fossils	1.0
Shale, covered, estimated at	60.0
Tamaha sandstone member.	
Sandstone, massive, exposed at spring in creek channel.	

24. EAST LINE SEC. 5, T. 12 N., R. 19 E., HIGHWAY EXPOSURES AT ESCARPMENT SOUTH OF KEEFETON.

McAlester shale.	
Warner sandstone member.	
Sandstone, slabby, poorly shown	20.0

	Feet
McCurtain shale member.	
Shale, dark gray to black, poorly shown, contains clay-ironstone concretions, about	65.0
Shale, sandy, hard, poorly shown, about	5.0
Shale, black and dark gray with clay-ironstone concretions, about	55.0
Coal (upper Hartshorne)	0.2
Underclay and shale	1.0
Hartshorne sandstone.	
Sandstone, greenish, contains fossil plant material	2.0
Hartshorne sandstone?	
Shale, very sandy.	

25. SECS. 6 AND 7, T. 12 N., R. 19 E.

McAlester shale.	
Cameron sandstone member.	
Sandstone, platy	3.0
Shale (M_3), covered	25.0
Lequire sandstone member.	
Sandstone, platy	3.0
Shale (M_2).	
Shale, covered	38.0
Sandstone, hard, calcareous, slabby	15.0
Shale, carbonaceous, flaky	2.0
Coal	0.8
Shale and underclay	3.0
Warner sandstone member.	
Sandstone, massive, calcareous, buff	25.0
McCurtain shale member.	

26. EAST HALF SEC. 19, T. 12 N., R 19 E.

Boggy-Savanna formations.	
Bluejacket sandstone member.	
Sandstone, massive, calcareous, blocky	45.0
Covered slope, about	225.0
Keota sandstone member.	
Sandstone, slabby	5.0
Shale.	

27. NW¼ SEC. 19, T. 12 N., R. 19 E.

Boggy formation.	
Bluejacket sandstone member.	
Sandstone, hard, blocky, shows small-scale cross-bedding	20.0
Shale (B_7).	
Shale, gray and buff, arenaceous, more sandy at the top, clayey below	110.0
Shale, dark gray, flaky, probably black where fresh, contains clay-ironstone concretions	55.0
Shale, black, fissile	15.0
Limestone, carbonaceous with *Marginifera muricatina, Spirifer cameratus*	1.0
Coal (lower Boggy)	1.0
Underclay	1.0
Shale (B_6).	
Shale, upper part gray, buff and silty, lower part contains Spiro and Sam Creek, covered	40.0
Shale, silty, gray, calcareous, contains molds of fenestellids and *Marginifera missouriensis*	2.0

28. CENTER SEC. 19, T. 12 N., R. 19 E.

	Feet
Boggy-Savanna formations.	
Bluejacket sandstone member.	
Sandstone, massive, cliff-forming with coal smuts near base, irregular channel contact at base, thins marginally in ⅛ of a mile to fifteen feet, maximum	40.0
Shale (B_7), silty, dark gray, lower part covered, upper part sandy containing some shaly sandstone (upper Savanna section covered)	220.0
Keota sandstone member.	
Sandstone, poorly shown.	

29. WEST LINE SEC. 17, T. 12 N., R. 19 E., VINCINITY OF COAL PITS.

Savanna formation.	
Keota sandstone member.	
Sandstone, poorly shown	4.0
Shale (S_1), covered, about	60.0
Tamaha sandstone member.	
Sandstone, slabby, calcareous, rippled	3.0
McAlester shale.	
Shale (M_4).	
Shale, hard, gray, silty	42.0
Coal (Stigler)	1.5
Underclay	1.0

30. NORTH LINE OF SEC. 20 AND 21, T. 12 N., R. 19 E.

Savanna formation.	
Tamaha sandstone member.	
Sandstone, erosional remnant.	
McAlester shale.	
Shale (M_4), covered, estimated at	50.0
Cameron sandstone member.	
Sandstone, buff, about	4.0
Covered interval.	
Shale, sandstone, covered, estimated at	100.0
Warner sandstone member.	
Sandstone, massive, poorly shown, estimated at	15.0
McCurtain shale member.	
Shale, covered, estimated at	125.0
Hartshorne sandstone.	

31. SOUTH LINE SEC. 8, T. 12 N., R. 20 E.

Atoka formation.	
Georges Fork sandstone member.	
Sandstone, erosional remnant.	
Shale (A_2).	
Shale, olive, argillaceous, with limonite concretions	43.0
Sandstone, irregular	2.0
Sandstone, blocky, gray-buff, very brittle and limy	1.5
Shale, sandy, gray	6.0
Siltstone, olive	0.5
Shale, gray, sandy	5.0
Shale, and green siltstone	1.0
Siltstone, olive, calcareous	3.5
Shale, sandy, with sandstone at base	3.0
Limestone, gray, sandy, with crinoid stems	0.8
Shale, gray, sandy	3.5

	Feet
Sandstone, gray, olive	3.0
Shale, gray, sandy	3.0
Pope Chapel sandstone member.	
Sandstone, buff to gray, irregular, calcareous, pitted with clay blebs	15.0
Shale (A_1).	

32. WEST LINE SEC. 13, NORTH LINE SECS. 14 AND 15, T. 12 N., R 19 E.

	Feet
Hartshorne sandstone.	
Sandstone, blocky, olive-buff	10.0
Atoka formation.	
Shale (A_6), covered, estimated at	75.0
Blackjack sandstone member.	
Sandstone, poorly shown about	10.0
Shale (A_5), covered, computed at	150.0
Webbers Falls sandstone member.	
Siltstone, blocky, green to black, weathers like chert, calcareous at top	10.0
Shale (A_4), gray, with limonite concretions	25.0
Dirty Creek sandstone member.	
Sandstone, olive green, calcareous, filled with borings of the fossil worm *Taonurus*	4.0
Shale (A_3).	
Shale, olive-buff with limonite concretions	50.0
Sandstone, olive-buff, laminated	0.5
Shale, olive, argillaceous with limonite concretions, dark gray at base	50.0
Georges Fork sandstone member.	
Sandstone, greenish to black, fine, calcareous	3.0

33. SOUTH LINE SECS. 23 AND 24, T. 12 N., R. 19 E.

	Feet
Atoka formation.	
Georges Fork sandstone member.	
Sandstone, greenish, poorly shown	3.0
Shale (A_2).	
Shale, dark gray with ironstone concretions, contains a few fossils, *Trepospira* sp., and *Phanerotrema* sp.	15.0
Shale, black, carbonaceous, flaky, estimated at	70.0
Pope Chapel sandstone member.	
Sandstone, massive, cross-bedded, olive-buff, rather coarse, hard	20.0

34. NW COR. SEC. 29, T. 12 N., R. 20 E., RABBIT HILL ALONG HIGHWAY EAST OF WARNER.

	Feet
McAlester shale.	
Warner sandstone member.	
Sandstone, massive	20.0
McCurtain shale member.	
Shale, covered, dark gray, black and buff with red clay-ironstone concretions	160.0
Coal (upper Hartshorne)	1.0
Underclay	2.0
Hartshorne sandstone.	
Sandstone, greenish, platy with trunks of *Lepidodendron* and *Stigmaria*	3.0
Hartshorne sandstone?	
Shale, sandy.	

35. EAST LINE SEC. 35, T. 12 N., R. 20 E., STRIP PITS AT GRITTS.

	Feet
McAlester shale.	
Warner sandstone member.	
Sandstone, massive, makes escarpment	12.0
McCurtain shale member.	
Shale, partly covered, some carbonaceous and some sandy	80.0
Shale, dark gray to black with ironstone concretions	40.0
Ironstone bed, dense, bluish and red, concretionary, contains a few fossils	0.3
Shale, dark gray with limonite and ironstone concretions, more carbonaceous at the base	40.0
Coal (upper Hartshorne)	1.0
Hartshorne sandstone.	
Sandstone and sandy shale	3.0
Shale, hard, silty and sandy, grades upward into sandstone	18.0
Sandstone, irregular	1.5
Atoka formation.	
Shale (A_6), gray with ironstone concretions, lower part covered	3.0

TOWNSHIP 13 NORTH

36. SOUTH CENTRAL PART OF SEC. 1, T. 13 N., R. 18 E.

	Feet
Savanna formation.	
Keota sandstone member.	
Sandstone, slabby, rippled, somewhat blocky, makes escarpment	4.0
Shale (S_1), covered, approximately	90.0
Tamaha sandstone member.	
Sandstone, platy, rippled	3.0
McAlester shale.	
Shale (M_4).	
Shale, mostly covered, upper part with large clay ironstone concretions, estimated at	50.0
Coal (Stigler) in prospect pit, about	1.0
Shale and underclay, about	4.0
Cameron sandstone member.	
Sandstone, shaly, poorly shown	2.0
Shale (M_3 and M_2), sandy at top, lower part penetrated in water well according to log, Warner sandstone was encountered at depth of	74.0

37. CENTER OF SEC. 11, T. 13 N., R. 18 E., RAILROAD CUT AND CREEK EXPOSURES.

	Feet
Savanna formation.	
Spiro sandstone member.	
Sandstone and sandy shale, contains fenestellids, erosional remnant	6.0
Sam Creek limestone member.	
Limestone, brown, shaly, filled with *Marginifera missouriensis*	1.0
Limestone, brown, blocky, filled with *Marginifera*, probably the persistent bed of the Sam Creek	0.8
Shale (S_2).	
Shale, gray, upper 0.5 foot black, carbonaceous, looks like underclay	3.0
Limonite bed, concretionary, filled with molds of *Marginifera missouriensis*	0.3
Shale, gray, silty	2.0
Limonite bed, concretionary, filled with molds of *Marginifera missouriensis*	0.3

	Feet
Shale, gray, exceedingly fossiliferous, contains *Mesolobus striatus, Prismopora serrata, Marginifera missouriensis,* large crinoid stems, fenestellids, etc	2.0
Limonite concretionary bed, fossiliferous	0.2
Shale, covered, contains some clay-ironstone concretions, about	20.0
Sandstone, seen in railroad cut	1.0
Shale, covered	3.0
Spaniard limestone member.	
Limestone, dense, gray, blocky, mottled, contains fusulinids, crinoids, *Campophyllum, Spirifer opimus, Marginifera missouriensis,* etc.	1.0
Shale, fossiliferous, gray, calcareous	2.0
Coal	0.2
Underclay	1.0
Shale, sandy	1.0
Keota sandstone member.	
Shale, sandy and shaly sandstone	4.0
Shale, calcareous, fossiliferous, contains *Spirifer opimus,* and *Composita*	0.6
Clay-ironstone bed	0.2
Shale, hard, silty, dark gray	5.0

38. SECTION LINE BETWEEN SEC. 13, T. 13 N., R. 18 E. AND SEC. 18, T. 13 N., R. 19 E., NEAR FAULT.

Savanna formation.	
Spaniard limestone member.	
Limestone, gray, shaly, filled with *Marginifera* and *Linoproductus*	1.0
Coal	0.2
Shale, sandy, with underclay at top	4.0
Keota sandstone member.	
Sandstone, platy, about	10.0
Shale (S_1).	
Shale, gray, silty and sandy	35.0
Sandstone, shaly	5.0
Shale, gray, silty and sandy, about	65.0
Limestone, red, with a few *Marginifera*	0.3
Coal	0.1
Shale, gray	5.0
Tamaha sandstone member.	
Sandstone, platy	3.0
McAlester shale.	
Shale (M_4).	
Shale, bluish, with ironstone concretions	45.0
Coal (Stigler)	1.0
Underclay.	

39. NORTHWEST COR. OF SEC. 20, T. 13 N., R. 18 E. ESCARPMENT.

Boggy-Savanna formations.	
Bluejacket sandstone member.	
Sandstone, very massive, with obscure cross-bedding	50.0
Shale (B_7).	
Shale, covered, lower part black, about	150.0
Limestone, carbonaceous, fossiliferus, contains *Spirifer cameratus, Marginifera muricatina* and *Composita*	0.5
Coal ("lower Boggy"), poorly shown	0.5
Covered interval, includes Sam Creek limestone and Spiro sandstone, about	40.0

	Feet
Spaniard limestone member.	
Limestone, gray, brittle, contains *Campophyllum, Marginifera missouriensis, Composita,* fusulinids, lower half brown	0.9
Shale, covered, possibly contains coal	4.0
Keota sandstone member.	
Sandstone, heavy, platy	3.5
Shale, covered	12.0
Limestone, carbonaceous, filled with *Marginifera missouriensis*	0.5
Coal	0.3
Shale (S_1), covered, about	70.0
Tamaha sandstone.	
Sandstone, about	3.0
McAlester shale.	

40. WEST SIDE SECS. 4 AND 9, T. 13 N., R. 19 E.

Savanna formation.	
Spaniard limestone member.	
Limestone, gray, poorly shown, crinoidal	0.5
Shale, covered, about	3.0
Keota sandstone member.	
Sandstone, blocky	3.0
Shale, covered, estimated at	8.0
Limestone, ferruginous, weathers to limonite, contains fossil molds	0.2
Coal	0.3
Shale, covered	18.0
Sandstone, platy	3.0
Shale (S_1), dark, silty, upper half light colored, and sandy, contains fossil "mushrooms"	60.0
Tamaha sandstone member.	
Sandstone, rippled, hard, flaggy	4.0
McAlseter shale.	
Shale (M_4).	
Shale, covered	30.0
Shale, carbonaceous	3.0
Coal (Stigler)	0.7
Underclay	1.0
Cameron sandstone member.	
Sandstone, shaly	3.0
Shale (M_3 and M_2).	
Shale, silty	6.0
Ironstone layer, filled with molds of *Composita*	0.2
Shale, covered, about	5.0
Shale, calcareous, filled with specimens of small *Derbya*	0.1
Shale, covered, contains ironstone concretions at top, computed across valley flat at	75.0
Sandstone, hard, slabby	2.0
Sandstone, shaly	11.0
Coal	0.8
Underclay and shale	3.0
Warner sandstone member.	
Sandstone, slabby, filled with *Stigmaria* and other plant fossils	8.0
McCurtain shale member.	

41. NW¼ SEC. 26, T. 13 N., R. 18 E., GULLY NEAR COAL PIT.

McAlester shale.	
Lequire sandstone member.	
Sandstone, blocky	2.0

	Feet
Shale (M_2).	
Shale, covered	15.0
Sandstone, platy	4.0
Shale, carbonaceous	3.0
Coal	1.5
Underclay and shale	2.0
Warner sandstone member.	
Sandstone, massive, estimated at	25.0

42. SE¼ SEC. 22, AND NW¼ SEC. 27, T. 13 N., R. 18 E.

McAlester shale.	
Cameron sandstone member.	
Sandstone, blocky	2.0
Sandstone, shaly, or sandy shale	10.0
Sandstone, calcareous, ferruginous	2.0
Shale (M_3), covered	20.0
Lequire sandstone member.	
Sandstone, platy, ferruginous	3.0
Shale (M_2), covered	20.0
Warner sandstone member.	
Sandstone, massive, filled with coiled and irregularly banded limonite concretions	25.0
McCurtain shale member.	
Shale	5.0
Limonite bed, fossiliferous	0.2
Coal	0.2
Underclay.	

43. SOUTH LINE OF SE¼ OF SEC. 26, T. 13 N., R. 19 E.

Hartshorne sandstone.	
Sandstone, fine, calcareous, olive-buff to buff, blocky with plant fragments	9.0
Atoka formation.	
Shale (A_6), poorly shown, upper part buff and sandy, 0.2 of coal, (lower Hartshorne coal) and underclay at top, estimated at	80.0
Blackjack sandstone member.	

44. NORTH CENTRAL PART OF SEC. 30, AND CENTRAL PART OF SEC. 19, T. 13 N., R. 20 E. SECTION MEASURED ON OUTLIER OF HARTSHORNE SANDSTONE AND IN GORGE TO THE NORTH.

Hartshorne sandstone.	
Sandstone, massive, calcareous, gray, blocky, locally olive colored	12.0
Atoka formation.	
Shale (A_6).	
Shale, covered	50.0
Shale, sandy, hard, gray	10.0
Blackjack sandstone member.	
Sandstone, platy, olive-buff	8.0
Shale, covered	30.0
Sandstone, irregular, olive colored, contains finger-like sandstone concretions	2.0
Shale, sandy, gray	20.0
Sandstone, heavy, with large hairpin shaped worm-borings	3.0
Shale (A_5).	
Shale, covered	90.0
Sandstone, olive colored	3.0
Shale, covered	15.0

	Feet
Webbers Falls sandstone member.	
Siltstone, black, platy, calcareous, with a few layers of black lithographic limestone, weathers to blocky chert-like fragments	15.0
Shale (A_4).	
Shale, dark gray	4.0
Sandstone, calcareous	1.0
Shale, dark gray, with ironstone concretions	9.0
Limestone, ferruginous, red and gray, contains *Lophophyllum, Marginifera, Juresania,* molluscs, etc.	1.5
Shale, dark gray, base covered	5.0

45. CENTER OF THE SOUTH LINE, SEC. 21, T. 13 N., R. 20 E.

Des Moines group.	
Atoka formation.	
Pope Chapel sandstone member.	
Sandstone, massive, erosional remnant.	
Shale (A_1), flaky, black, with limonite concretions, estimated at	50.0
Coody sandstone member.	
Sandstone, massive, gritty and fossiliferous, contains *Spirifer occidentalis*	20.0
Morrow group.	
Shale.	

46. SOUTH PART SEC. 28, W ½ SEC. 33, T. 13 N., R. 20 E., MEASURED ALONG CREEK.

Pennsylvanian series.	
Des Moines group.	
Atoka formation.	
Pope Chapel sandstone member.	
Sandstone, poorly shown, massive, calcareous, purple and buff	5.0
Shale (A_1).	
Shale, covered	35.0
Sandstone, calcareous	2.0
Shale, covered	35.0
Coody sandstone member.	
Sandstone, heavy, blocky, coarse	25.0
Morrow group.	
Bloyd formation.	
Shale, covered	80.0
Kessler? limestone member.	
Limestone, platy, cross-bedded, coquinoid, with dwarf molluscan fauna (*Euomphalus, Nucula*)	7.0
Shale, gray, covered	25.0
Brentwood? limestone member.	
Limestone, shaly, with *Pentremites*	8.0
Limestone, massive, light gray, granular	11.0
Shale, covered	25.0
Limestone, crinoidal	2.0
Shale, gray	5.0
Limestone, granular, gray (base of Brentwood?)	15.0
Hale? formation.	
Shale, gray, with thin sandstone at base	20.0
Hale? or Pitkin?	
Limestone, sandy, platy, cross-bedded, locally oolitic	8.0
Shale, black and interbedded platy limestone or limy siltstone, unfossiliferous (base of Morrow series?	20.0

Feet

Mississippian series.
Chester group.
Pitkin limestone.
Limestone, gray, hard ... 5.0
Shale ... 5.0
Limestone, massive, crinoidal, with interbedded thin layers of lithographic limestone and calcareous shale, lithographic beds especially prominent at base ... 75.0
Fayetteville shale.

TOWNSHIP 14 NORTH

47. SECTION MEASURED FROM CENTER OF THE WEST LINE SEC. 3, TO THE NW COR. SEC. 4, T. 14 N., R. 17 E.

Boggy formation.
Taft sandstone member.
Sandstone, massive, coarse, gritty ... 30.0
Shale (B_{11}).
Shale, covered ... 60.0
Sandstone, makes bench, estimated at ... 5.0
Shale, covered, computed at ... 170.0
Shale, black, fissile, with ironstone layers ... 15.0
Inola limestone member.
Limestone, blocky, dense, gray, contains *Heliospongia* ... 1.0

48. CENTER NORTH LINE SEC. 10, T. 14 N., R. 17 E.

Boggy formation.
Taft sandstone member.
Sandstone, massive, buff ... 30.0
Shale (B_{11}).
Shale, gray, silty, mostly covered, computed at about ... 180.0
Shale, dark, flaky, with ironstone concretions ... 50.0
Inola limestone member.

49. NE¼ OF SEC. 17, T. 14 N., R. 17 E., CREEK BED.

Boggy formation.
Shale (B_{11}).
Shale, gray, leads up to Taft sandstone.
Clay-ironstone concretionary layer ... 0.2
Shale, black, fissile, with limestone septaria (estimated thickness may be too little) ... 15.0
Inola limestone member.
Limestone, even, dense, gray, mottled, contains worm trails, and *Heliospongia* ... 1.0
Shale (B_{10}).
Shale, gray ... 0.3
Coal ... 0.5
Shale, covered, underclay at top, thickness obtained from well logs ... 15.0
Crekola sandstone member.

50. SECTION MEASURED ON CHIMNEY MOUNTAIN, SW PART SEC. 24, T. 14 N., R. 17 E., AND THE SW PART SEC. 19, T. 14 N., R. 18 E.

Boggy formation.
Taft sandstone member.
Sandstone, coarse, cross-bedded ... 10.0
Shale, covered, sandy ... 25.0
Sandstone, slabby, calcareous ... 25.0

Feet

Shale, sandy ... 12.0
Sandstone, slabby, hard ... 5.0
Shale (B_{11} and B_{10}).
Shale, sandy, and massive mudstone ... 35.0
Sandstone, platy ... 1.0
Shale, gray, silty ... 50.0
Shale, black, carbonaceous, with bedded ironstone ... 4.0
Shale, upper half gray, argillaceous, flaky, lower half covered, contains Inola limestone, and black shale, not seen ... 100.0
Crekola sandstone member.

51. NW¼ SEC. 2, T. 14 N., R. 18 E., BANK OF COODY CREEK.

Savanna formation.
Spaniard limestone member.
Limestone, wavy, irregular, buff where weathered, light gray to bluish where fresh, mottled by algal nodules; contains fusulinids, crinoid stems and plates, *Spirifer cameratus*, *Squamularia*, *Composita*, *Marginifera missouriensis* and *Campophyllum* ... 2.0
Shale, gray, poorly shown, sandy ... 4.0
Keota sandstone member.
Sandstone, platy, calcareous, fossiliferous ... 2.5
Shale, gray and buff, silty, contains ironstone concretions, grades upward into sandstone ... 6.5
Limestone, shaly, gray, fossiliferous, somewhat carbonaceous ... 0.8
Coal ... 0.5
Underclay ... 1.0
Shale (S_1).

52. SW COR. OF SEC. 2, T. 14 N., R. 18 E., RAILROAD CUT AND ROAD EXPOSURES.

Savanna formation.
Spiro sandstone member.
Sandstone, shaly.
Sam Creek limestone member.
Limestone, rusty, filled with fossils, weathers into fragments, contains molluscan fauna, *Trachydoma*, *Naticopsis*, *Campophyllum*, *Marginifera missouriensis*, *Mesolobus striatus*, *Schizodus*, *Prismopora serrata* ... 0.3
Shale (S_2), poorly shown, upper part with a few fossils like those in Sam Creek limestone including large Crinoid stems ... 35.0
Spaniard limestone member.
Limestone, dense, bluish-gray, mottled, containing *Campophyllum*, *Marginifera missouriensis*, and fusulinids ... 2.0
Shale.

53. COMPOSITE SECTION MEASURED AT CENTER OF SEC. 20, AND THE CENTER OF SEC. 19, T. 14 N., R. 18 E.

Boggy formation.
Crekola sandstone member.
Sandstone, platy ... 4.0
Shale (B_9).
Shale, platy, sandy ... 5.0
Shale, black, carbonaceous, fossiliferous ... 1.0
Shale (B_8).
Coal (Secor) ... 1.0
Shale, covered, underclay at top ... 20.0
Bluejacket sandstone member.
Sandstone, shaly ... 25.0
Shale (B_7).

54. EAST PART OF SEC. 22, T. 14 N., R. 18 E., GULLIES IN BLUEJACKET ESCARPMENT.

	Feet
Boggy formation.	
Bluejacket sandstone member.	
Sandstone, slabby, shaly	20.0
Shale (B_7 and B_6).	
Shale, grayish, silty, hard	45.0
Shale, black, flaky, carbonaceous, with a few ironstone concretions	70.0
Shale, black fissile at top, lower part covered, including beds down to Keota sandstone	100.0

55. COMPOSITE SECTION IN SECS. 10, 14 AND 15, T. 14 N., R. 18 E., EXPOSURES IN CREEKS AND ALONG ROADS.

	Feet
Boggy formation.	
Shale (B_7).	
Shale, black, fissile, with some large limestone concretions	10.0
Limestone, carbonaceous, loose fragments, not in place, position recorded in water test wells	0.5
Coal, ("lower Boggy"), about	0.5
Shale (B_6), gray, covered, underclay at top	10.0
Savanna formation.	
Spiro sandstone member.	
Sandstone, papery	8.0
Sam Creek limestone member.	
Limestone, brown, silty, concretionary, contains a few fossils	0.4
Shale, gray, and buff, silty	0.8
Limestone, hard, brown, filled with *Marginifera* (base of Sam Creek).	
Shale (S_2).	
Shale, gray, silty, very fossiliferous at base, contains *Mesolobus striatus*, *Spirifer opimus*, *Prismopora serrata*, *Marginifera* sp., large crinoid stems	4.0
Limestone concretions, brown, fossiliferous	0.2
Shale, dark to light gray, silty, hard, contains a few limestone concretions	35.0
Spaniard limestone member.	
Limestone, dense, bluish-gray, mottled, contains *Marginifera missouriensis*, and fusulinids	2.0
Shale, covered, possibly contains coal	4.0
Keota sandstone member.	
Sandstone, shaly, rippled	5.0
Shale, dark gray, contains limestone concretions	8.0
Limestone, carbonaceous, filled with *Marginifera missouriensis*	1.0
Coal	0.4
Shale (S_1).	
Shale, covered, with underclay at top	5.0
Limestone, ferruginous, soft, filled with *Marginifera*	1.0
Shale, dark gray, hard, contains ironstone concretions	35.0
Tamaha sandstone member.	
Sandstone, platy, calcareous	8.0
McAlester shale.	
Shale (M_4).	
Shale, gray, silty, filled with limonite concretions	17.0
Coal (Stigler)	1.5
Underclay	1.0
Cameron sandstone member.	
Sandstone, shaly, and sandy shale	9.0

56. NE¼ SEC. 11, T. 14 N., R. 18 E.

	Feet
Savanna formation.	
Tamaha sandstone member.	
Sandstone, papery, about	4.0
McAlester formation.	
Shale (M_4).	
Shale, sandy, about	10.0
Ironstone concretions, fossiliferous	0.1
Shale	0.5
Coal (Stigler)	0.2
Shale (M_3 and M_2).	
Shale, blue, silty, with ironstone concretions, estimated at	60.0
Sandstone, shaly	20.0
Coal	0.8
Shale and underclay	2.0
Warner sandstone member.	
Sandstone, platy	5.0
McCurtain shale member.	
Shale sandy	15.0

57. NW¼ SEC. 24, T. 14 N., R. 18 E.

	Feet
Savanna formation.	
Tamaha sandstone member.	
Sandstone, flaggy	5.0
McAlester shale.	
Shale (M_4).	
Shale, covered, about	25.0
Coal (Stigler)	1.0
Underclay.	

58. NORTH LINE SEC. 1, T. 14 N., R. 19 E., MEASURED ALONG ROAD.

	Feet
Atoka formation.	
Georges Fork sandstone member.	
Sandstone, massive, reddish and brown, slabby, cross-bedded	15.0
Shale (A_2).	
Shale, gray, lower 1 foot fossiliferous, contains *Lophophyllum*, *Derbya*, *Chonetes*, etc.	4.0
Limestone (A_2a), ferruginous, shaly, contains a species of ammonite as well as other fossils	1.0
Shale, dark gray, argillaceous, contains ironstone concretions, basal part sandy, with fossiliferous concretionary limestone, containing *Spirifer occidentalis*	11.0
Sandstone, calcareous, light buff and gray, carbonaceous at the top	3.0
Shale, covered	45.0
Pope Chapel sandstone member.	
Sandstone, hard, calcareous, contains clams	10.0
Shale (A_1), covered	35.0
Coody sandstone member.	
Sandstone, thin-bedded	25.0
Sandstone, massive	8.0
Sandstone, thin-bedded, contains a few productids	40.0
Shale, sandy	3.0
Sandstone, massive, buff	3.0
Shale, covered	2.0
Sandstone, gray, quartzitic	0.3

	Feet
Limestone, ferruginous, weathered, contains mold of numerous molluscs, brachiopods, and crinoids	1.0
Shale, covered	5.0
Sandstone, very fossiliferous and conglomeratic, with chert pebbles	5.0
Covered section	10.0
Sandstone, poorly shown, platy, calcareous, fine-grained, filled with molds of fossils, base not exposed	10.0

59. NW¼ SEC. 3, T. 14 N., R. 19 E.

	Feet
Atoka formation.	
Webbers Falls sandstone member.	
Siltstone, blocky, calcareous, weathers like light buff chert	4.0
Shale (A_4).	
Shale, argillaceous, olive, contains limonite concretions	30.0
Limestone, buff, ferruginous, unfossiliferous, probably concretionary	0.6
Shale, gray, silty	2.0
Dirty Creek sandstone member.	
Sandstone, carbonaceous and calcareous, shaly	4.0
Sandstone, calcareous, hard, rippled	2.0
Sandstone, covered	2.0
Shale (A_3).	
Shale, covered	4.0
Limestone (A_3a), gray to white, wavy, with a few brachiopods	3.0
Shale, dark gray, lower part covered	45.0
Georges Fork sandstone member.	

60. CENTER SEC. 4, T. 14 N., R 19 E., CREEK BANKS.

	Feet
Atoka formation.	
Shale (A_5).	
Limestone (A_5b), black, carbonaceous, fine-grained, blocky, containing worm trails, *Orbiculoidea, Linoproductus*, weathers to light buff or gray, blocky, cherty fragments like typical Webbers Falls	2.0
Shale, black, flaky, with limonite concretions, and limestone concretions	25.0
Limestone (A_5a), ferruginous, contains *Marginifera, Composita*, etc.	0.3
Shale, black to bluish, flaky, with ironstone concretions	20.0
Siltstone, sandy, carbonaceous, calcareous, black where fresh, gray to buff where weathered, contains *Taonurus* worm trails	12.0
Shale, black to bluish, flaky, with ironstone concretions	20.0
Sandstone, gray, silty, calcareous, slabby, base covered	3.0
(Base of A_5 not reached.)	

61. CENTER OF THE WEST HALF OF SEC. 4, T. 14 N., R. 19 E., BANK OF COODY CREEK.

	Feet
Atoka formation.	
Blackjack sandstone member.	
Sandstone, hard, calcareous, makes scarp, base of Blackjack	2.0
Shale (A_5).	
Shale, gray, covered	84.0
Limestone (top of A_5b), crinoidal, shaly	0.2
Shale, calcareous	2.0
Limestone, bluish, granular, fossiliferous, contains molluscs and brachiopods	3.0
Limestone, shaly (bottom of A_5b), containing *Spirifer occidentalis*	1.0
Shale, dark gray to black, gray, silty, with ironstone concretions	10.0
(Base of A_5 not reached.)	

62. NW COR. SEC. 8, T. 14 N., R. 19 E., ROADCUT.

	Feet
Atoka formation.	
Blackjack sandstone member.	
Sandstone, slabby, thin-bedded, calcareous, weathers in blocky fragments	4.0
Shale, sandy, gray, finger-like concretions at base	7.0
Sandstone, irregular, buff	1.0
Shale, dark gray, silty, contains finger-like concretions	5.0
Sandstone, buff	2.5
Shale, gray, sandy, contains finger-like concretions	5.0

63. SOUTH LINE SECS. 8 AND 9, T. 14 N., R. 19 E.

	Feet
Atoka formation.	
Blackjack sandstone member.	
Sandstone, calcareous	2.0
Shale, covered	8.0
Sandstone, calcareous, filled with *Taonurus*	4.0
Shale, gray, silty, covered	35.0
Sandstone, calcareous, thin-bedded	15.0
Shale, covered	15.0
Sandstone, hard, calcareous, blocky, lower part shaly, makes scarp (basal sandstone of Blackjack)	5.0
Shale (A_5).	
Shale, light gray, silty	10.0
Sandstone, brittle, calcareous, dark gray to olive buff	1.0
Shale, dark gray to black, flaky, with limonite concretions	11.0
Sandstone, whitish	2.0
Shale, sandy and whitish, platy sandstone	8.0
Shale, dark, with poorly exposed, fossiliferous, thin limestone, probably concretionary	5.0
Siltstone, black, calcareous, contains worm trails	3.0
Shale, dark gray, mostly covered, contains limonite concretions	20.0
Sandstone, platy, buff (sandstone 30 feet above Webbers Falls?)	5.0
Shale, gray, argillaceous	10.0

64. CENTRAL NORTHERN PART SEC. 9, T. 14 N., R. 19 E.

	Feet
Atoka formation.	
Blackjack sandstone member.	
Sandstone, calcareous, filled with *Taonurus*	5.0
Shale, dark gray, silty	35.0
Sandstone, platy, mostly covered	8.0
Shale, covered	8.0
Sandstone, very blocky, calcareous	2.0
Shale (A_5).	
Shale, sandy, buff, about	80.0
Limestone (top of A_5b), crinoidal, fossiliferous, blue	0.3
Shale, calcareous, covered	2.0
Limestone (bottom of A_5b), platy, granular, dark gray	2.0
Shale, black, flaky	10.0
Limestone (A_5a), ferruginous, fossiliferous	0.3
Shale, black, flaky, with limonite concretions	8.0
Sandstone, black, upper part shaly, filled with worm trails (about 50 feet above Webbers Falls sandstone)	10.0

65. SEC. 7, T. 14 N., R. 20 E., NEAR MOUTH OF BOUDINOT CREEK ON BRAGGS MOUNTAIN EAST OF ARKANSAS RIVER, ALONG RAILROAD TRACK.

	Feet
Atoka formation.	
Shale (A_5).	
Shale, gray, fossiliferous at the base, with platy crinoidal limestone, upper part eroded	15.0
Limestone, (A_5b), somewhat shaly, blue, crinoidal	3.0
Shale, gray	30.0
Sandstone, gray to black, filled with worm trails, calcareous	20.0
Shale, gray, sandy and ferruginous	30.0
Sandstone, platy, gray, to buff	10.0
Shale, covered	25.0
Webbers Falls sandstone member.	
Limestone, silty, blocky, dove-colored, weathers like chert	10.0
Shale (A_4), covered	20.0
Dirty Creek sandstone member.	
Sandstone, carbonaceous, calcareous, with a few brachiopods, some lenses of granular limestone in the lower part	15.0
Shale (A_3).	
Shale, covered	50.0
Limestone (A_3a?), slabby, granular, blue	0.8
Shale, covered	45.0
Georges Fork sandstone member.	
Sandstone, carbonaceous, gray	15.0

66. CENTER NORTH LINE SEC. 10, T. 14 N., R. 19 E., NEAR SPRING.

Atoka formation.	
Shale (A_5).	
Siltstone, fine, brown, fossiliferous	3.0
Shale, covered	20.0
Webbers Falls sandstone member.	
Siltstone or silty limestone, bluish, siliceous, weathers like fine sandstone or chert, contains a few crinoid stems and brachiopods, carbonaceous in places, lower half less calcareous, containing worm trails	15.0
Shale (A_4), covered	22.0
Dirty Creek sandstone member.	
Sandstone, calcareous, slabby	3.0

67. WESTERN PART OF SEC. 14, T. 14 N., R. 19 E.

Hartshorne sandstone.	
Sandstone, slabby, thin-bedded, light gray and buff, micaceous	12.0
Atoka formation.	
Shale (A_6).	
Shale, sandy	4.0
Coal (lower Hartshorne coal)	0.7
Underclay	1.0
Shale, gray, lower part dark and filled with ironstone concretions	46.0
Blackjack sandstone member.	
Sandstone, shaly	2.0
Shale, olive-gray	25.0
Sandstone, filled with *Taonurus*	2.0
Shale, covered	10.0
Sandstone, platy	4.0
Shale, covered	8.0

	Feet
Sandstone, olive, filled with plant fossils	3.0
Shale, covered	25.0
Sandstone, makes scarp (basal bed of Blackjack)	2.0
Shale (A_5).	
Shale, dark gray	30.0
Sandstone, dark gray, silty	2.0
Shale, covered	10.0
Sandstone, greenish, concretionary, shaly at the middle	6.0
Shale	5.0
Sandstone, shaly	1.0
Shale, gray	5.0
Limestone (top of A_5b), black, blocky, fossiliferous, crinoidal at top	2.0
Shale, black, ranges from 1 foot to	3.0
Limestone (bottom of A_5b), black, platy, silty, contains *Taonurus*	3.0
Shale, black, flaky	5.0
(It is probably some scores of feet down to Webbers Falls.)	

68. CENTER EAST HALF OF SEC. 18, T. 14 N., R. 19 E.

McAlester shale.	
Warner sandstone member.	
Sandstone, slabby, poorly shown	20.0
McCurtain shale member.	
Shale, covered, computed at about	100.0
Hartshorne sandstone.	
Sandstone, hard, blocky, greenish, contains some plant fossils, seen in quarry	10.0

69. CENTRAL PART SEC. 27, T. 14 N., R. 19 E., NORTHEAST POINT OF BRUSHY MOUNTAIN.

McAlester shale.	
Warner sandstone member.	
Sandstone, very massive, cliff-forming	50.0
McCurtain shale member.	
Shale, covered, gray and black	85.0
Hartshorne sandstone.	
Sandstone, irregular, slabby, olive and buff, with plant fossils, somewhat shaly	10.0
Atoka formation.	
Shale (A_6).	
Shale, covered	80.0
Shale, dark gray to black, carbonaceous, flaky, contains red clay ironstone concretions	20.0
Blackjack sandstone member.	
Sandstone, platy, about	20.0
Shale.	

TOWNSHIP 15 NORTH

70. CREEK BED NEAR CENTER OF THE SOUTH SIDE NW¼ SEC. 14, T. 15 N., R 17 E.

Boggy formation.	
Shale (B_{11}), black, fissile, contains ironstone concretions	4.0
Inola limestone member.	
Limestone, blocky, hard, gray, contains *Heliospongia*, and some other fossils	0.9

	Feet
Shale (B_{10}).	
Coal, with a little shale above	0.4
Shale, covered, with underclay at top	7.0
Crekola sandstone member.	
Sandstone, slabby	5.0
Shale (B_9), gray, sandy	10.0
Shale (B_8).	
Coal (Secor)	1.3
Underclay.	

71. NEAR SE COR. SEC. 19, T. 15 N., R. 17 E.

	Feet
Boggy formation.	
Taft sandstone member.	
Sandstone, massive, coarse, brown	20.0
Shale (B_{11}).	
Shale, covered	45.0
Shale, bluish, silty to argillaceous	17.0
Sandstone, fine, slabby	5.5
Shale, gray, silty.	

72. COMPOSITE SECTION IN SECS. 16 AND 21, T. 15 N., R. 17 E.

	Feet
Boggy formation.	
Shale (B_{11} and B_{10}).	
Sandstone, slabby, 50 to 70 feet below Taft sandstone	5.5
Shale, covered, computed at	125.0
Crekola sandstone member.	
Sandstone, slabby	10.0
Shale (B_9), silty, gray, and some sandstone	20.0
Shale (B_8).	
Coal (Secor)	1.3
Shale, sandy, and underclay	3.0
Bluejacket sandstone member.	
Sandstone, slabby, said to be fifty feet in local wells	50.0

73. EAST SIDE OF SEC. 10, T. 15 N., R. 18 E.

	Feet
Savanna formation.	
Keota sandstone member.	
Sandstone, erosional remnant.	
Shale (S_1), covered, estimated at	30.0
Tamaha sandstone member.	
Sandstone, hard, platy, about	4.0
McAlester shale.	
Shale (M_4).	
Shale, argillaceous, and silty, sandy near the top, fossiliferous at base	25.0
Coal	0.4
Underclay and shale	2.0
Warner sandstone member.	
Sandstone, platy, base poorly exposed, about	20.0

74. COMPOSITE SEC. MEASURED IN SECS. 9 AND 10, AND ALONG WEST SIDE SEC. 16, T. 15 N., R. 18 E.

	Feet
Savanna formation.	
Spaniard limestone member.	
Limestone, shaly, fossiliferous, and some hard massive limestone, filled with *Campophyllum*	2.0
Shale, possibly contains coal, covered	4.0

	Feet
Keota sandstone member.	
Sandstone, shaly	3.0
Shale, silty and sandy, contains ironstone concretions, grades upward into sandstone	6.0
Shale, black, fissile	0.3
Limestone, shaly, filled with *Marginifera*	1.0
Coal	0.3
Shale, gray, silty, with 1 foot of underclay at top	3.0
Sandstone, shaly, includes some sandy shale (probably equivalent to the lower bed of the Keota sandstone in township 10 N.)	4.0
Shale (S_1), silty, with ironstone concretions	11.0

75. NORTH PART SEC. 18, T. 15 N., R. 18 E.

	Feet
Boggy formation.	
Bluejacket sandstone member.	
Sandstone, blocky, variable thickness	25.0
Shale (B_7).	
Shale, sandy	40.0
Shale, dark gray, silty, grades up into sandy shale	40.0
Shale, carbonaceous, poorly shown	40.0
Limestone, carbonaceous, soft, crinoidal	0.8
Coal ("lower Boggy")	1.0
Shale (B_6), covered, upper one foot underclay, estimated at	20.0
Savanna formation.	
Spiro sandstone member.	
Sandstone, platy, fossiliferous at base	5.0
Sam Creek limestone member.	
Limestone, pinkish to buff, hard, contains *Spirifer opimus, Prismopora, Marginifera*	1.0
Shale (S_2), covered, estimated at	20.0
Spaniard limestone member.	
Limestone, upper part shaly, lower part hard, contains abundant *Campophyllum*, and some sponges	2.0
Limestone, shaly, fossiliferous	1.0
Coal	0.3
Shale, with underclay at top.	

76. NW PART SEC. 7, T. 15 N., R. 19 E., RIVER BLUFF JUST WEST OF RAILROAD BRIDGE OVER ARKANSAS RIVER.

	Feet
McAlester shale.	
Warner sandstone member.	
Sandstone, massive and slabby	20.0
McCurtain shale member.	
Shale, dark, silty, with ironstone concretions, impressions of fossil clams at base	9.5
Coal	0.4
Underclay	0.3
Shale, silty, with ironstone concretions	10.0

77. SW COR. SEC. 35, T. 15 N., R. 19 E.

	Feet
Atoka formation.	
Georges Fork sandstone member.	
Sandstone, very coarse, gritty, calcareous, many molds of pelecypods, *Spirifer occidentalis*, a few ammonites	10.0
Shale (A_2), covered, lower part only shown, dark gray, argillaceous, with limonite concretions	75.0
Pope Chapel sandstone member.	
Sandstone, fine, olive-buff, carbonaceous, worm trails near middle	9.0
Shale (A_1).	

78. NORTH CENTRAL PART SEC. 35, T. 15 N., R. 19 E., RIVER BLUFF.

	Feet
Des Moines group.	
Atoka formation.	
Pope Chapel? sandstone member.	
Sandstone, poorly shown.	
Shale (A_1), covered	25.0
Coody sandstone member.	
Sandstone, poorly shown, brown to reddish, fossiliferous, gritty	50.0
Morrow group.	
Bloyd? formation.	
Shale, covered, probably includes some limestone	60.0
Brentwood limestone member.	
Limestone, granular, contains *Pentremites*	10.0

79. SEC. 29, T. 15 N., R. 20 E., MEASURED ALONG HIGHWAY 10 OVER BRAGGS MOUNTAIN ESCARPMENT.

Pennsylvanian series.	
Des Moines group.	
Atoka formation.	
Coody sandstone member.	
Sandstone, massive, soft	50.0
Morrow group.	
Bloyd? formation.	
Shale, gray and buff	35.0
Kessler? limestone member.	
Limestone, hard, gray, crinoidal	3.0
Shale, buff, with a few limestone concretions	30.0
Brentwood limestone member.	
Limestone, fine, blue	0.5
Limestone, shaly, coquinoid, contins *Michelinia*	2.0
Limestone, massive, blue, crinoidal	5.0
Limestone, shaly, crinoidal	3.0
Limestone, massive, granular, blue, with *Michelinia*, and *Archimedes*	15.0
Sandstone, platy, calcareous, grades upward into limestone	5.0
Shale, light gray	3.0
Sandstone, limy, greenish-buff	0.3
Limestone, massive, bluish to white, crinoidal, contains *Pentremites*	10.0
Hale? formation.	
Sandstone, buff, calcareous, contains pebbles in limestone matrix at base	6.0
Mississippian series.	
Chester group.	
Pitkin limestone.	
Limestone, massive, fine-grained	3.0
Limestone, crinoidal, blue, shaly zone near middle	13.0
Limestone, shaly	3.0
Limestone, blue, lower part oolitic and cross-bedded, upper part crinoidal, contains *Archimedes*	11.0
Shale, dark gray	0.9
Limestone, gray, silty	0.8
Shale, dark gray, carbonaceous	1.0
Limestone, carbonaceous, silty	0.3
Shale, dark gray	2.0
Limestone, blue, granular and oolitic	6.0
Limestone, blue, lithographic, slabby, irregular, a few fossils near the top	4.0

	Feet
Shale, gray	3.0
Limestone, gray, crinoidal	1.0
Shale, gray	0.5
Limestone, massive, blue, crinoidal	2.0
Limestone, granular, very fossiliferous, contains *Derbya*, *Archimedes*, *Punctospirifer*, etc., locally cross-bedded	5.0
Limestone, shaly, with abundant *Michelinia*, *Chonetes*, *Spirifer*, etc.	1.5
Limestone, gray, irregular	1.0
Limestone, dove-colored, dense, lithographic and interbedded thin beds of gray shale, unfossiliferous	15.0
Fayetteville shale.	
Shale, dark gray.	

TOWNSHIP 17 NORTH

80. SEC. 7, T. 17 N., R. 18 E., BLUEJACKET OUTLIER AND NORTHWESTWARD TO LIMESTONE SHOWN ON STATE MAP AS MORROW (SECTION ESTIMATED NOT MEASURED).

Boggy formation.	
Bluejacket sandstone member.	
Sandstone, caps outlier, erosional remnant.	
Shale (B_7).	
Shale, estimated at	80.0
Limestone, ferruginous	1.0
Shale, covered, estimated at	20.0
Coal ("lower Boggy?"), seen in strip mine, about	1.0
Shale (B_6), and underclay, estimated at	5.0
Savanna formation?	
Spiro? sandstone member.	
Sandstone	5.0
Shale (S_2?).	
Shale, dark gray, silty	50.0
Sandstone, shaly	5.0
Shale	1.0
Spaniard? limestone member.	
Limestone (mapped as Morrow on state map), fine, gray to bluish, filled with *Campophyllum*	2.5
Shale	2.0
Keota? sandstone member.	
Sandstone, platy	5.0

81. SOUTH LINE OF SEC. 1, T. 17 N., R. 18 E., AND SOUTH LINE OF SEC. 6, T. 17 N., R. 19 E. (SECTION ESTIMATED, NOT MEASURED).

Savanna-Atoka.	
Sandstone and shale (S_3?).	
Sandstone, platy	5.0
Shale	1.0
Spaniard? limestone member.	
Limestone, dark gray, fine-grained, contains a few *Campophyllum* (this limestone was traced continuously through Wagoner to outcrops in Sec. 7, T. 17 N., R. 18 E., erroneously mapped as Morrow)	2.0
Coal	0.2
Shale and underclay	2.0
Keota? sandstone member.	
Sandstone, platy	10.0
Shale (S_1-M_2)	50.0

	Feet
Little Cabin (Warner?) sandstone member.	
Sandstone, platy	15.0
(Because of structural features to the south and Arkansas river valley, it is impossible to trace this sandstone into the Muskogee area, but because of the relationship of this sandstone to beds below it is believed to be the Warner sandstone, and certainly no older than the Hartshorne sandstone. The Hartshorne sandstone is thought to drop out before reaching the south bank of Arkansas river, and the view is taken that the Little Cabin sandstone is probably not Hartshorne but Warner.)	
McCurtain—Upper Atoka (A_6) shale.	
Shale	75.0
Blackjack? sandstone member.	
Sandstone, massive, soft, conglomeratic, filled with chert pebbles, evidently unconformable on beds below	8.0
(This sandstone is the basal sandstone of the Pennsylvanian to Vinita and beyond, and was traced toward Arkansas river where it rises high above the underlying sandstone, and loses its conglomeratic character. For reasons stated under Little Cabin sandstone it appears improbable that this is Harthorne, and because of its relative position above undoubted Webbers Falls this sandstone is tentatively assigned to one of the sandstones of the Blackjack succession.)	
Shale (A_5), (thickens to several scores of feet a short distance to the southward)	5.0
Webbers Falls sandstone member.	
Siltstone, black to olive-gray, blocky, cherty	10.0
Shale (A_4).	

TOWNSHIP 25 NORTH

82. SE COR. SEC. 23, T. 25 N., R. 20 E., EAST FACE OF HILL THREE MILES EAST OF VINITA ON HIGHWAY 66, OPPOSITE NIGHT CLUB.

Pennsylvanian series.	
Des Moines group.	
McAlester—Atoka.	
Little Cabin (Warner?) sandstone member.	
Sandstone, shaly	3.0
Shale, whitish, sandy	3.0
Sandstone, shaly, with limonite concretions or pebbles	2.0
Shale, gray, sandy, with ironstone near the top, upper layer of shale whitish	21.0
Limestone, reddish, granular, crinoidal	0.8
Shale, gray, contains ironstone concretions	11.0
Shale, dark gray, silty	5.5
Blackjack? sandstone member.	
Sandstone, greenish, irregular, filled with delicate *Taonurus*	4.0
Shale, sandy	0.8
Coal	0.2
Underclay (base of Pennsylvanian)	3.0
(Unconformity)	
Mississippian series.	
Chester group.	
Shale, greenish-gray	3.0
Limestone, shaly, fossiliferous, with abundant Bryozoa, Productidae, and *Archimedes*	4.0
Shale, base covered, greenish and argillaceous	6.0