Photograph by M. M. Knechtel

Abandoned beehive coke ovens. 1 mile west of McCurtain. Haskell County

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GEOLOGY AND MINERAL RESOURCES OF HASKELL COUNTY, OKLAHOMA

By

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GEOLOGY AND MINERAL RESOURCES OF HASKELL COUNTY, OKLAHOMA

By

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ABSTRACT

The primary purpose of the work herein reported was to study the coal resources of Haskell County. Other purposes were to study the exposed rocks in relation to those of the surrounding areas and in relation to equivalent rocks that occur underground in areas to the west where some of them produce oil and gas, and to locate deposits of other mineral materials.

Haskell County lies in east-central Oklahoma south of the Arkansas and Canadian Rivers and extends southward to 4 miles south of the north line of T. 7 N. It includes Rs. 18 to 23 E., and is separated from the State of Arkansas only by Le Flore County. The area is one of hills and valleys whose pattern is closely related to the structure of the rocks. The hills are the expression of the resistant sandstone layers and the valleys correspond to the less resistant shales.

The outcropping rocks, outside the terrace deposits and alluvium, all belong to the Des Moines series of the Pennsylvanian system and consist predominantly of shale, much of it silty and sandy. Sandstones are a minor but conspicuous element and there are a few impure, discontinuous limestones generally less than 1 foot thick. Coal beds ranging in thickness from less than an inch to several feet occur in all the formations above the Atoka formation, but only the Hartshorne, Stigler (McAlester?), and Secor seams are thick enough to be of economic importance. The rocks exposed in Haskell County lie in the deep McAlester basin, and have a great range of thickness. They are probably about 6,500 feet thick beneath the summit of Sansbois Mountains, less than 2,000 feet thick in northern Haskell County, and are much thinner farther north. All the rocks bear evidence of having been deposited in relatively shallow water and this, in conjunction with the great southward thickening, indicates that deposition filled the basin as fast as subsidence deepened it.

The mapping here reported, together with similar mapping in northern Le Flore County to the east, forms an important link between work already done by the United States Geological Survey, along the south side of the McAlester basin, and work done cooperatively by the United States Geological Survey and the Oklahoma Geological Survey in the Muskogee-Porum district north of the Canadian River and west of the Arkansas River. As a result of all

this work, rocks from the upper part of the Atoka formation to the lower part of the Boggy formation, inclusive, have now been mapped from the south side of the basin to the north side and into the rocks of more marine aspect in northeastern Oklahoma, which have long been correlated with the Cherokee shale of southeastern Kansas.

Among the more salient results are the following: The sandstone and shale normally present between the Lower and Upper Hartshorne coals along the south side of the McAlester basin are not present on the north side of the basin. The two coals appear as one seam, and in order to have a mappable line of demarcation between the Hartshorne sandstone and the McAlester formation, in Haskell County and in northern Le Flore County, the boundary is placed at the top of the combined Lower and Upper Hartshorne coals and thus includes in the Hartshorne sandstone equivalents of both Hartshorne coals. The lowermost sandstone unit of the Savanna formation grades into shale in northern Haskell County, but the Spaniard limestone member of the Savanna formation of Muskogee County occupies approximately the same stratigraphic position as the lower part of this sandstone unit and may well be taken as the base of the Savanna in Muskogee County and northward. The Little Cabin sandstone member of the Cherokee formation of northeastern Oklahoma is continuous with the Warner sandstone member, the lowest and most conspicuous sandstone member of the McAlester formation in Haskell County. The Bluejacket sandstone member of the Cherokee formation of northeastern Oklahoma is continuous with the lowermost conspicuous sandstone member of the Boggy formation in Haskell County.

A number of more or less local anticlinal folds are present in Haskell County, within the larger McAlester basin, and there is some evidence that these folds were formed simultaneously with the basin itself. Some of these folds, notably the Kinta anticline, have produced gas, but to date none has produced oil.

From 1908 to 1943 inclusive about three million short tons of coal was produced in Haskell County, the greater part being from the Hartshorne and Stigler (McAlester?) beds.

There is no limestone of economic value in Haskell County but there is an abundance of sandstone suitable for some building purposes. Clays that would be suitable for making brick and tile could probably be found. There are no good deposits of gravel but some of the ancient stream terraces contain good building sand. Deposits of volcanic ash are located near Stigler, Whitefield, and Brooken.

It is not difficult to secure small local supplies of water from underground sources, but, except possibly in alluvium along the Canadian and Arkansas Rivers, relatively large supplies, on the order of 100,000 gallons or more per day, must come from surface sources. Fortunately, much of the clay soil makes tight storage reservoirs, and the rainfall and stream flow are adequate to fill them.

INTRODUCTION

Scope and purpose. The primary purpose of the work here reported was to study the character, distribution, thickness, and depth of the coal beds in the various parts of Haskell County, and to study the structure of the rocks with reference to its bearing on the production of coal, gas, and possibly oil. The secondary purpose was to study in detail the character, distribution, and thickness of rock formations exposed in the county in order (1) to locate deposits of other mineral materials of economic value; and (2) to obtain such detailed information on the exposed rocks as would advance our knowledge of the geology of Oklahoma, and facilitate more precise correlations of the beds exposed in Haskell County with those in other areas of surface exposure and with corresponding units found underground in drilling for oil and gas in this and other parts of Oklahoma.

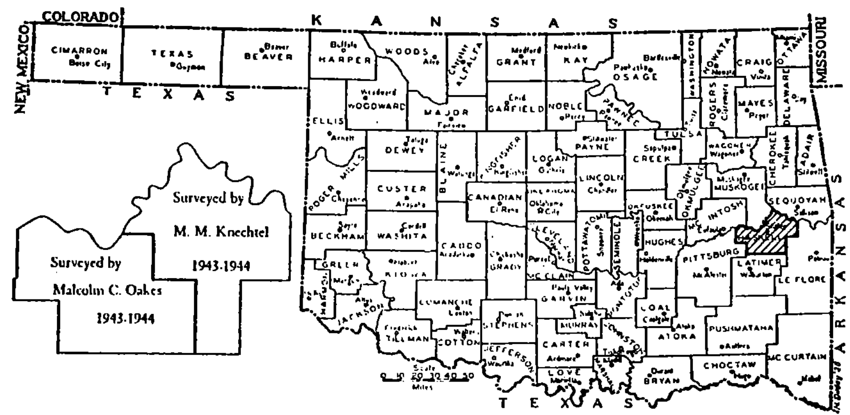

Fig. 1. Index maps showing location of Haskell County, Oklahoma, and parts mapped by Malcolm C. Oakes and M. M. Knechtel.

Location of the area. Haskell County is in eastern Oklahoma. It is irregular in outline and contains approximately 615 square miles. It is 36 miles long in an east-west direction and 26 miles wide in a north-south direction. The eastern boundary is the east line of R. 23 E., about 20 miles from the Arkansas-Oklahoma line, and the western boundary is the west line of R. 18 E. The Canadian and Arkansas Rivers form its northern boundary. On the south it includes approximately the northern one-third of the Sansbois

Mountains. Its extreme southern boundary is four miles south of the north side of T. 7 N., its extreme northern point is near the north side of T. 11 N.

Previous Investigations. The formations that crop out in Haskell County were all first studied in other parts of Oklahoma. Thomas Nuttall[1] in 1818 made several trips across the general region geology. Jules Marcou[2] visited the region in 1852, as geologist for the Pacific Railroad Expedition, and he probably saw parts of Haskell County. What seems to be the earliest published reference to now included in the coal fields of Oklahoma to study its botany and coal in Haskell County, at least among the official documents, is by Whipple:

> . . . . . Bituminous coal is found cropping out, and in many places are mines of it between Fort Smith and the Shawnee villages; especially on the Sans Bois and Coal Creeks. It was used in our blacksmith forges, and found to be of superior quality. There are evidences of an inexhaustible supply for railroad and other purposes.[3]

In 1890, H. M. Chance[4] published his "Geology of the Choctaw Coal Fields". In 1898, N. F. Drake[5] published his thesis "A Geological Reconnaissance of the Coal Fields of the Indian Territory".

In the years from 1897 to 1906, Taff[6] and his associates did their

1. Nuttall, Thomas, "A Journal of Travels into the Arkansas Territory during the year 1819 . . .": Philadelphia, 1821.
2. Marcou, Jules, "Le Terrain Carbonifere dans l'Amerique du Nord": *Archives des Sciences Physiques et Naturelles,* Vol. 29, pp. 95-117, Geneva, June, 1855.
3. Whipple, A.W., "Report of Explorations for a Railway Route, Near the Thirty-Fifth Parallel of Latitude, from the Mississippi River to the Pacific Ocean": p. 15, in *U.S. 33d Cong. 1st Sess. H. Ex. Doc. 129,* V. 18, pt. 2, 1855: Also in *U.S. 33d Cong. 2d Sess. S. Ex. Doc.* 78 and *H. Ex. Doc.* 91, 1856. See also "A Pathfinder in the Southwest," edited and annotated by Grant Foreman: *Univ. of Oklahoma Press,* Norman, 1941.
4. Chance, H. M., "Geology of the Choctaw Coal Fields": *Trans. Amer. Inst. Mining Engineers,* Vol. 18, pp. 653-661, 1890.
5. Drake, N.F., "A Geological Reconnaissance of the Coal Fields of the Indian Territory": *American Philosophical Society Proceedings,* Vol. 36, pp. 326-419, 1897: Also *Contributions to Biology,* Vol. 14, pp. 226-419, *Leland Stanford University,* 1898.
6. Taff, Joseph A., "Geology of the McAlester-Lehigh Coal Field, Indian Territory": *U. S. Geol. Survey, 19th Ann. Rept.* Pt. 3, pp. 423-456, 1899.
Taff, Joseph A. and Adams, George I., "Geology of the Eastern Choctaw Coal Field, Indian Territory": *U. S. Geol. Survey, 21st. Ann. Rept.* Pt. 2, pp. 263-311, 1900.
Taff, Joseph A., "The Southwestern Coal Field": *U. S. Geol. Survey, 22nd. Ann. Rept.* Pt. 3, pp. 373-389, 1902.
Taff, Joseph A., "Geologic Atlas of the United States": *U. S. Geol. Survey, Coalgate Folio* (No. 74), 1901, *Atoka Folio* (No. 79), 1902, *Muscogee Folio* (No. 132), 1906.

memorable work in the Indian Territory and the results appear in several Annual Reports, Bulletins, and in folios of the Geologic Atlas, all published by the United States Geological Survey. They described the rocks and divided them into formations as now named. However, Taff recognized the preliminary nature of his work and said of the Boggy formation that it would have been desirable to map some of the individual sandstone beds separately.[7]

Careful detailed work was delayed for about twenty-five years and in the meantime several publications appeared giving descriptions of the coal with analyses.[8] The United States Geological Survey began more detailed studies in 1930 and the results were published as parts 1 to 4, inclusive, of U. S. Geological Survey Bulletin 874, "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field",[9] covering parts of Pittsburg, Coal, Atoka, Latimer, and central Le Flore Counties, and 18 square miles in western Haskell County. The Muskogee-Porum District, Muskogee and McIntosh Counties, was investigated cooperatively by the United States Geological Survey and the Oklahoma Geological Survey, and preliminary results were published in the Bulletin of the American Association of Petroleum Geologists,[10] and later, with revisions, as

7. Taff, Joseph A., "Geology of the McAlester-Lehigh Coal Field, Indian Territory": *U.S. Geol. Survey, 19th Ann. Rept.* pt. 3, p. 438, 1899.
8. Taff, Joseph A., "Maps of Segregated Coal Lands in the Indian Territory with Descriptions of the Unleased Segregated Coal Lands": *U.S. Department of the Interior, Circulars,* 1904: "McAlester District, Choctaw Nation," *Circular* 1; "Wilburton-Stigler District, Choctaw Nation," *Circular* 2; "Howe-Poteau District, Choctaw Nation," *Circular* 3; "McCurtain-Massey District, Choctaw Nation," *Circular* 4; "Lehigh-Ardmore Districts, Choctaw and Chickasaw Nations," *Circular* 5; "Unleased segregated asphalt lands, Chickasaw Nation," *Circular* 6. Also in *U. S. 61st Cong. 2nd Sess. Senate Doc.* 390, pp. 125-374, 1910.
Shannon, C. W. and others, "Coal in Oklahoma": *Okla. Geol. Survey Bull.* 4, 1926.
Cooper, C. L., Fieldner, A. C., and others, "Analyses of Oklahoma Coals": *U.S. Bureau of Mines Technical Paper* 411, 1928.
Moose, Joe E. and Searle, V. C., "A Chemical Study of Oklahoma Coals": *Okla. Geol. Survey Bull,* 51, 1929.
9. *U. S. Geol. Survey Bull.*: "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field":
Part 1, Hendricks, Thomas A., "The McAlester District": *Bull.* 874-A, 1937.
Part 2, Knechtel, M.M., "The Lehigh District": *Bull.* 874-B, 1937.
Part 3, Dane, C. H., Rothrock, H. E., and Williams, J. S., "The Quinton-Scipio District": *Bull.* 874-C, 1938.
Part 4, Hendricks, Thomas A., "The Howe-Wilburton District": *Bull.* 874-D. 1939.
10. Wilson, Charles W., Jr., "Age and Correlations of Pennsylvanian Surface Formations, and of Oil and Gas Sands of Muskogee County, Oklahoma": *Bull. Amer. Assoc. Petrol. Geol.,* Vol. 19, No. 4, pp. 503-520, 1935.

Bulletin 57[11] of the Oklahoma Geological Survey. An area comprising part of Pittsburg County, all of Haskell County, and the northern part of Le Flore County was studied by W. T. Thom, Jr.[12] map was published.

A cooperative agreement was made in 1942 between the United States Geological Survey and the Oklahoma Geological Survey for the investigation of northern Le Flore County and the field work was done by M. M. Knechtel.[13] In 1943, a similar agreement was made for cooperative work in Haskell County and the results of that investigation are the subject of the present report.

Present investigation. The investigation here reported has been a cooperative project of the United States Geological Survey and the Oklahoma Geological Survey. Approximately the eastern half of the County as shown in Fig. I, was mapped by Maxwell M. Knechtel of the U. S. Geological Survey, and the western half was mapped by Malcolm C. Oakes of the Oklahoma Geological Survey, working essentially independently.

The field work covered a total time of approximately six months, in the autumn of 1943 and the summer of 1944. Aerial photographs obtained from the Agricultural Adjustment Administration served as a base map. They were studied stereoscopically, in the office and in the field, and stratigraphic and structural data were placed upon them directly. The geologic data, drainage, and cultural features were assembled by tracing directly from the photographs onto township plats drawn on transparent cellulose acetate sheets which were used in the final compilation of the geologic map. Haskell County is well suited to this method of mapping, as most of the photographs clearly indicate the land survey lines. The photographs, moreover, are fairly uniform in scale because the topographic relief over most of the county is not so great as to cause serious distortion. Altitude data (elevations) were obtained by means of

11. Wilson, Charles W. and Newell, Norman D., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, 1937.

12. Thom, W. T., Jr., "Coal Map of the Stigler-Poteau District, Pittsburg, Haskell, and Le Flore Counties, Oklahoma": *U. S. Geol. Survey*, preliminary edition, 1935.

for the United States Geological Survey but only a preliminary coal

13. Knechtel, M. M., "Map of Northern Le Flore County, Oklahoma, showing Geologic Structure, Coal Beds, and Natural Gas Fields": *U. S. Geol. Survey*, 1944.
"Geology and Mineral Resources of Northern Le Flore County, Oklahoma": *Okla. Geol. Survey Bull.* (in preparation).

aneroid barometer traverses based on bench marks and corrected for atmospheric pressure changes by means of microbarograph charts. The accuracy of this type of barometric work proved to be adequate for vertical control in structure mapping where rocks dip as steeply as 5° to 15°, as they do in Haskell County, especially when the contour interval is as much as 100 feet.

Acknowledgments. The writers are indebted to the residents of Haskell County for their wholehearted cooperation in gathering the data for this report. All land owners permitted entry on their land, and many of them gave of their time to show us rock exposures that we would not have found otherwise. Much of the information appearing herein could not have been gathered without the assistance of the management and workers in the coal mines. The local newspapers gave the investigation such publicity that its purpose was understood throughout the county. We are especially indebted to Robert H. Dott, Director of the Oklahoma Geological Survey, and to Hugh D. Miser, of the United States Geological Survey for assistance in handling details of the field work and in the preparation of this report, and for advice on the geological problems.

GEOGRAPHY

Topographic features. The topography of Haskell County is of a subdued mountain type; there are several rugged areas in the Sansbois Mountains in the south part, Beaver Mountain and Brooken Mountain in the west part, and Jackson and Beller Mountains in the northeast part. Other parts of the county are occupied by intermontane valleys, broad plains, and minor ridges ranging from hogbacks to cuestas. Buttes are present in some of the synclinal areas. The mountains are now wooded and the term Sansbois Mountains seems a misnomer, because *Sans bois* means "without wood". However Blake, who traversed the area with the Whipple Expedition in 1853 stated; "The SANS BOIS mountains rise to a height of about 2,000 feet, above a heavily-timbered plain; and, as their name indicates, are nearly or quite without trees."[14]

14. Blake, William P., "General Report Upon the Geological Collections" in "Reports of Explorations for a Railway Route, Near the Thirty-Fifth Parallel of North Latitude, from the Mississippi River to the Pacific Ocean": by Lieutenant A. W. Whipple. *U. S. 33rd Congress, 2nd Session, Senate Executive Document* No. 78, *House Executive Document* 91, Vol. 3, Part IV, Chap. 1, p. 14, 1856.

According to topographic maps[15] of the United States Geological Survey, the highest point in Haskell County is in the southeast part, in the Sansbois Mountains where the altitude is nearly 1,600 feet above sea level. The lowest point is less than 450 feet above sea level, on Arkansas River at the east boundary of the county. Valley lands are generally 500 to 600 feet above sea level and the hilltops above 750 feet. Conspicuous named high points are: Tucker Knob, T. 7 N., R. 19 E., about 1,300 feet; Beaver Mountain, T. 8 N., R. 19 E., about 1,250 feet; Brooken Mountain, T. 9 N., R. 18 E., about 1,000 feet; Jackson Mountain, T. 10 N., R. 21 E., about 800 feet; and Beller Mountain, T. 10 N., R. 22 E., about 750 feet.

The topography is the expression of the stratigraphy and structure through erosion. Rocks at the surface are predominantly shale, soft and relatively nonresistant to erosion, but spaced at wide intervals are beds of sandstone, variously thick and resistant. The whole sequence of rocks is faulted and folded into synclines and anticlines and dips are as great as 15 degrees.

Erosion, principally by water, has worn away the thick, soft, nonresistant shales forming low valleys, but has left the thinner but more resistant sandstones standing as long, high ridges which, in some localities, curve round the ends of the synclines and anticlines. The height of these ridges depends primarily upon the thickness of the shales which underlie their sandstone caps, but to some extent upon the dip and the resistance of the sandstone beds. Generally the ridges are asymmetrical, the gentler slopes being in the direction of the dip of the rocks and the steeper, or scarp side, in the opposite direction. Sandstone is generally at the surface far down the gentle or dip slope and shale crops out on the scarp slope but is covered by great quantities of sandstone debris, derived from the sandstone beds by undercutting and slumping. Thus sandstone is conspicuous on the surface out of all proportion to its relative abundance in the stratigraphic section.

Because the structural folds are elongate, with their axes trending in general northeastward, the ridges and valleys also have

15. "Topographic Atlas of the United States": *U. S. Geol. Survey, Sansbois Quadrangle and Sallisaw Quadrangle.*

that trend throughout most of their length. Most of the improved roads cross the ridges and lateral roads lie along their gentler slopes or in the valleys between.

Drainage. The Canadian and Arkansas Rivers form the northern boundary of the county and the Arkansas ultimately receives all of its drainage. The greater part of the county is drained by Sansbois and Little Sansbois Creeks which flow into the Arkansas River in the northeast part of the county. Mountain Fork Creek drains a large part of the Sansbois Mountain area and is a prominent tributary to Sansbois Creek. Brooken and Emachaya Creeks flow northward into Canadian River.

Economic development. Farming and stock raising are the chief industries of Haskell County, but coal mining has received considerable attention. Practically all of the tillable land is under cultivation. Formerly the principal crop was cotton, but with the depletion of the soil and the shrinkage of the market, cotton growing has declined and much of the land has been contour-terraced and turned to grass. Beef and pork are the main livestock products but recently there has been a growing interest in dairying. Feed crops are, of course, important. Cotton growing and ginning are still important. A vegetable cannery was built recently at Stigler. Nursery stock is grown in the vicinity of Stigler and there are several commercial peach and apple orchards.

It is estimated that Haskell County has produced about 3 million short tons of coal in the period 1908 to 1943 inclusive. The greater part of this production came from the strip mines in the Stigler coal, northeast of Stigler, and from the strip mines and slope mines in the Hartshorne coal, in the vicinity of McCurtain. Considerable quantities of slack coal were produced in the course of early-day coal mining and much of the slack at McCurtain was coked in beehive ovens whose ruins are still in evidence west of the town. (frontispiece) It is reported that much of the coke was shipped to Mexico for silver smelting and that it was in considerable demand at artificial gas plants. Excessive expansion of the coal in the coking process prevents its use in modern byproduct ovens, but work of the United States Bureau of Mines in cooperation with Oklahoma Geological Survey has shown that a satisfactory charge for such ovens can be made by blending the low-volatile Hartshorne coal from Haskell County with high-volatile McAlester coal from Pittsburg County.[16] Coal has been supplied from a mine at McCurtain for coke ovens connected with blast furnaces at Daingerfield and Houston, Texas. Similar Hartshorne coal from Le Flore County has been shipped to Provo, Utah, and Los Angeles, California, to be blended with other coal for making coke in byproduct ovens.

Natural gas has been produced from the Kinta anticline, in the vicinity of Kinta, southwestern Haskell County, and Quinton, northeastern Pittsburg County, since 1913, but attempts to develop commercial production in other parts of the county have been disappointing.

SURFACE STRATIGRAPHY

The strata that crop out in Haskell County may be most readily comprehended by taking a wider view of equivalent rocks beyond the borders of the county. These rocks, in their wider aspects, consist of a thick, southern, shallow-water facies, made up mostly of shale, much of it silty to sandy, with minor but conspicuous amounts of sandstone and a little limestone; and a thin northern facies of a more dominantly marine aspect, made up mostly of shale, with minor amounts of limestone, and some sandstone. The facies intergrade and interfinger so there is no exact line of demarcation between them.

Roughly, the shallow-water facies lies in the great structural feature here called the McAlester basin, which occupies part of a large geosyncline. The McAlester basin is situated in east-central Oklahoma and is bounded on the south by the Arbuckle Mountains and the Choctaw fault and on the north by the south flank of the Ozark uplift and a shelf-like western extension of that uplift, which occupies much of northeastern Oklahoma, and over which lies the thin, more marine facies. Similarly the McAlester basin is limited to the west by the great subsurface structural feature, north of the Arbuckle Mountains, known as the central Oklahoma uplift.

16. Davis, J. D., and others, "Carbonizing Properties of Western Region Interior Province Coals and Certain Blends of These Coals": *U. S. Bureau of Mines Technical Paper* 667, 1944.

The sedimentary rocks that fill the McAlester basin are thousands of feet thick in the central part of the basin but they afford no evidence that the water was very deep at any time, and numerous coal seams indicate that marshy conditions were recurrent. The sediments seem to have come from the south or southeast and the amount was sufficient at all times to keep the basin virtually full and to spread out seaward. The most obvious effect of the subsiding basin is the great thickness of all units spread across it. Northward convergences of hundreds of feet within a few miles are common.

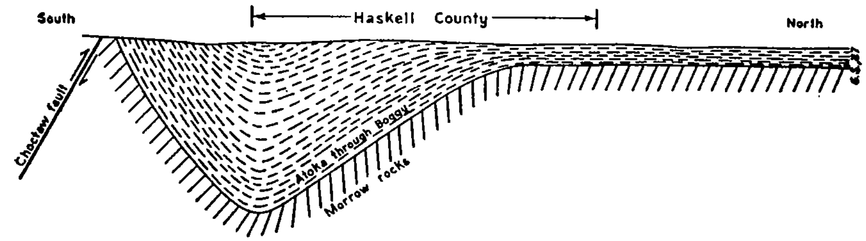

FIG. 2. South—north diagram showing relation of Haskell County to the McAlester basin. Not to scale. Rocks shown are of lower Pennsylvanian age.

The rocks exposed in Haskell County consist of sedimentary strata of Pennsylvanian age and scattered surficial deposits of Pleistocene (?) and Recent age. The rocks of Pennsylvanian age are predominantly shale, but among them are relatively thin and more or less widely spaced units made up of sandstone and siltstone, with minor amounts of shale. Coal beds ranging in thickness from less than an inch to several feet are known to occur in all formations above the Atoka. Thin beds and lenses of clay ironstone and of limestone, commonly containing marine fossils, are present locally in all the exposed bedrock formations.

The oldest rocks exposed are in the uppermost part of the Atoka formation and crop out as inliers at the crests of three anticlines in the eastern part of the county. The youngest rocks are in the Boggy formation and crop out in large areas in the western part of the county and as outliers in synclines in the northeastern and southern parts. The uppermost beds of the Boggy formation crop out beyond the western limits of the county. The strata intervening between the Atoka and Boggy formations are fairly well represented in outcrops, but are largely concealed in many localities by surficial material, such as soil and alluvial deposits.

Correlatives of all the rocks exposed in Haskell County lie beneath the summit of the Sansbois Mountains where the total thickness is probably the greatest, being about 6,500 feet. In that locality the estimated stratigraphic interval between the top of the Atoka formation and the base of the Bluejacket sandstone member of the Boggy formation is approximately 5,000 feet but 20 miles northward, at Jackson Mountain, the same interval is only about 1,200 feet thick. The northward convergence thus shown is typical for the entire county and involves corresponding northward convergence of many key horizons. It seems to be related in part to increasing distance from a southerly source of the sediments of Pennsylvanian age, but in even greater part to differential subsidence coincident with deposition, in which the rate of sinking was most rapid southward and was progressively less northward. Most of the thinning represents a northward decrease in the amount of sediment that was deposited but may be partly due to minor erosional unconformities at the contacts of some of the sandstone units with the subjacent shales.

PENNSYLVANIAN SYSTEM*

Des Moines Series

The rocks exposed in Haskell County all belong to the Des Moines series, one of the major divisions of the Pennsylvanian rocks of the Mid-Continent region. The Des Moines series rests unconformably on the underlying Morrow series of the Pennsylvanian, overlaps the Morrow northward beyond the limits of Haskell County, and rests on eroded rocks of the Mississippian system in northeastern Oklahoma and southeastern Kansas. The base of the Des Moines is not exposed in Haskell County. Uppermost Des Moines rocks crop out west of Haskell County where they are separated from the overlying Missouri series of the Pennsylvanian by an unconformity marked by both erosion and faunal changes that have been observed from southeastern Kansas to the Arbuckle Mountains.

* The Oklahoma Geological Survey ranks the Pennsylvanian and Mississippian rocks as systems, whereas the U. S. Geological Survey ranks them as series of the Carboniferous system. The State Survey also recognizes the Des Moines, Morrow, and other series of the Pennsylvanian system.

TABLE I
SUBDIVISIONS OF THE DES MOINES SERIES IN HASKELL COUNTY, OKLAHOMA

- Des Moines series
  - Boggy formation
    - Strata above the Bluejacket sandstone member
    - Bluejacket sandstone member
    - Lower shale member
  - Savanna formation
  - McAlester formation
    - Unnamed shale member
    - Keota sandstone member
    - Unnamed shale member
    - Tamaha sandstone member
    - Unnamed shale member
    - Cameron sandstone member
    - Unnamed shale member
    - Lequire sandstone member
    - Unnamed shale member
    - Warner sandstone member
    - McCurtain shale member
  - Hartshorne sandstone
  - Atoka formation

ATOKA FORMATION

The term Atoka formation applies to all strata below the Hartshorne sandstone and above the Wapanucka limestone, where the latter is present as a well developed limestone. In the Ouachita Mountains, eastward and southward from the town of Leflore, the term Atoka has been applied to sandstone and shale beds whose basal part is equivalent, in some areas at least, to the Wapanucka. In the area northeast of Haskell County the Atoka rests unconformably on rocks of the Morrow series that are approximately equivalent to the Wapanucka limestone. Still farther north the Atoka overlaps the Morrow rocks and rests unconformably upon rocks of Mississippian age and is in turn overlapped by higher strata, beds of Hartshorne or McAlester age.

First reference. Taff and Adams, 1900.

Nomenclators. Taff and Adams.

Type locality. The formation was named from the town of Atoka, Atoka County, Oklahoma, but there seems to have been no specific type locality. The descriptions given by Taff and Adams are general and apply to several different localities along the outcrop between the Arkansas-Oklahoma line and the vicinity of Atoka.

Original descriptions. Taff and Adams wrote of the Eastern Choctaw Coal Field:

> . . . . . . Near the state line, (Arkansas-Oklahoma line) on the southeastern side of the field, the formation as far as exposed aggregates a thickness of between 6,000 and 7,000 feet. At intervals of from 1,000 to 1,200 feet in these shales there are four groups of sandstone strata, each of which is nearly 100 feet thick.
>
> As the formation is traced westward it is seen that the lower groups of sandstone are cut out by the (Choctaw) fault. The upper sandstone beds may be traced farther west, to near the central part of the field, but beyond that they are not known to occur. It is presumed, therefore, that they are lenticular in form and are limited in their extent from east to west beneath the surface as well as in outcrop. Near the western end of this coal field, in the Boiling Springs anticline, (T. 5 N., Rs. 16 and 17 E.) the formation is exposed to a thickness of nearly 3,000 feet, and in this exposure no rock of consequence except shales was observed. . .
>
> The sandstone beds are brown or light gray and are often thin and slabby, being separated by shaly layers. The shales are very rarely exposed. Where exposed they are seen to be usually bluish clay shales with occasional ferruginous ironstone concretions. Each group of sandstone, where not worn down by active stream erosion, forms a low and nearly level-crested ridge, and the shales are worn down to level valleys and plains. . . [17]

Other descriptions. Newell wrote of the Atoka formation in the Muskogee-Porum district, Muskogee and McIntosh Counties, north of Haskell County:

> 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 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.

17. Taff, Joseph A. and Adams, George I., "Geology of the Eastern Choctaw Coal Field, Indian Territory": *U. S. Geol. Survey, 21st. Ann. Rept.*, Pt. 2, p. 273, 1900.

> 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.[18]

History of usage. Taff and Adams,[19] by implication, fixed the upper limit of the Atoka at the base of the Hartshorne sandstone, which accords with all subsequent usage, but the lower limit was not defined. Later Taff,[20] writing of the Atoka quadrangle, placed the base of the Atoka at the top of the Wapanucka limestone, also by implication. Miser,[21] writing of the area between the Choctaw fault and the Ti Valley fault, said that the Atoka rests upon the Wapanucka limestone where the Wapanucka is present as a limestone, but that eastward and possibly southward from Leflore, in Le Flore County, sandstone and shale beds equivalent to the Wapanucka have been mapped as the basal portion of the Atoka.

Also strata of Morrow age were mapped with the Atoka as mapped by Taff[21a] and later by Knechtel[21b] in Coal County, Oklahoma. Some geologists have recently suggested splitting off the Atoka and undetermined higher strata from the Des Moines series and erecting a new series equivalent to the Lampasas as proposed by Cheney for North Texas.[22] Other geologists, among whom are Spivey and Roberts,[23] propose that the Atoka be elevated to series rank and be called the Atoka series.

Distribution. The Atoka formation crops out in Haskell County only as inliers on anticlines and the base is not exposed. Owing to

18. Wilson, Charles W., Jr., and Newell, Norman D., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, pp. 24-25, 1937.
19. Taff, Joseph A. and Adams, George I., *op. cit.*, p. 273.
20. Taff, Joseph A., "Geologic Atlas of the United States": *U. S. Geol. Survey, Atoka Folio*, No. 79, p. 5, 1902.
21. Miser, Hugh D., "Carboniferous Rocks of the Ouachita Mountains": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 18, No. 8, p. 978, 1934.
21a. *Op. cit.*
21b. Knechtel, M. M., "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field"; Part 2, "The Lehigh District": *U. S. Geol. Survey Bull.* 874-B, p. 99, 1937.
22. Cheney, M. G., "Geology of North-Central Texas": *Bull. Amer. Assoc. of Petrol. Geol.*, Vol. 24, No. 1, p. 81, 1940.
23. Spivey, R. C., and Roberts, T. G., "Lower Pennsylvanian Terminology in Central Texas": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 30, No. 2, pp. 181-186, 1946.

repetition by faulting two exposures occur on the Milton anticline in the vicinity of McCurtain, T. 8 N., R. 22 E. Another exposure occurs on the north flank of the Milton anticline in the southeast corner of T. 9 N., R. 23 E. The Atoka is at the surface on the north or upthrow side of the fault on Round Prairie dome in secs. 33 and 34, T. 10 N., R. 22 E. The largest area of Atoka exposure is on the Lone Star anticline, in the angle between the Canadian and Arkansas Rivers in the northernmost part of the county, mostly in T. 11 N., R. 21 E., where a section 228 feet thick was measured near the N¼ corner of sec. 14.

Thickness. Only the upper part of the Atoka formation is exposed in Haskell County, and its total thickness has been observed directly only in wells. Logs of two wells on the Lone Star anticline in the northernmost part of the county, both of which reached the underlying Wapanucka limestone, show the Atoka to be approximately 1,850 feet thick. Newell[24] gives only 600 feet as the thickness of the Atoka near Muskogee, about 25 miles northwest of the Lone Star anticline; and 21 miles southeast, on the Milton anticline in Le Flore County, the Atoka is 6,500 feet thick, of which 5,000 feet were logged in Red Bank Oil Company's Fee No. 1 well, sec. 35, T. 9 N., R. 24 E., which started below the top of the Atoka. Wilson's[25] studies of convergence of Atoka beds in Muskogee County suggest that the difference in thickness is probably due to thinning of strata within the formation rather than to unconformity at the base of the overlying Hartshorne sandstone.

Character. Probably less than 300 feet of the upper part of the Atoka formation is exposed anywhere in Haskell County and this part consists of a predominant amount of dark clayey to silty shale, and a minor amount of hard, fine-grained, gray to black sandstone in beds a few inches to 20 feet thick. The log of a well drilled in sec. 23, T. 11 N., R. 21 E., indicates that the Atoka in that locality is about 1,850 feet thick and contains conspicuous sandstone beds in the upper 200 feet and in the lower 600 feet. The middle portion is dark shale. No coal is recorded in this log nor has any been observed in the outcrops.

24. Wilson, Charles W., Jr., and Newell, Norman D., *op. cit.*, p. 24.
25. Wilson, Charles W., Jr., "Age and Correlations of Pennsylvanian Surface Formations, and of Oil and Gas Sands of Muskogee County, Oklahoma": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 4, p. 505, 1935.

The beds recorded in the drillers log as limestone are regarded by the authors to be sandstone or possibly limy sandstone.

Stratigraphic relations. In Haskell County the Atoka formation is overlain with apparent conformity by the Hartshorne sandstone. The base is not exposed in the county, but in the area to the northeast, on the flanks of the Ozark Mountains, the Atoka rests unconformably on rocks of the Morrow series.

Correlations: The Atoka formation of Oklahoma is of upper Pottsville age and is the lowest unit of the Des Moines series. The greater part of the Atoka is probably equivalent to part of the upper Dornick Hills formation of the Ardmore basin area, and to the lower part of the Strawn series of north Texas. It is equivalent to undifferentiated sandstone beds formerly mapped as the lower part of the Winslow formation in northeastern Oklahoma. The Atoka formation is overlapped by higher beds in the area south of the Kansas-Oklahoma line and has not been recognized farther north.[26]

Detailed sections. For measured outcrop sections of the Atoka formation see section numbered 46 in the appendix.

HARTSHORNE SANDSTONE (special usage)

The Hartshorne sandstone, 100 to 200 feet thick, overlies the Atoka formation and underlies the McAlester formation. Two coal beds, known as the Upper and Lower Hartshorne coals, are associated with the Hartshorne sandstone, and common usage in Oklahoma has placed the upper boundary of the formation at the top of the first sandstone below the Upper Hartshorne coal. A hitherto unrecognized coalescence of the two coals, in northwestern Le Flore County and in Haskell County, requires a redefinition of the upper boundary of the Hartshorne sandstone, and it is proposed to raise it to the top of the Upper Hartshorne coal, thus including both Hartshorne coals in the Hartshorne sandstone.

In Oklahoma, so far as is known, the Hartshorne sandstone lies at the base of the productive coal measures, and the same is true in Arkansas.[27] The Hartshorne sandstone is generally expressed

26. Wilson, Charles W., Jr. and Newell, Norman D., *op. cit.*, p. 26.
27. Croneis, Carey, "Geology of the Arkansas Paleozoic Area": *Ark. Geol. Survey Bull.* 3, p. 139, 1930.

topographically as a prominent ridge, and is extremely useful as a key horizon in prospecting for the Hartshorne coals throughout the eastern Oklahoma coal district.

First Mention. Taff, 1899.

Nomenclator. Taff.

Type locality. Not mentioned by Taff but presumably the vicinity of the town of Hartshorne, which is partly encircled by the outcrop of the formation.

Original description. Taff wrote of this formation (1899), evidently in the vicinity of Hartshorne:

> This is a brown to light gray sand rock which has an extreme thickness of about 200 feet. Near the top the beds are very thick and some are massive. Upon the surface they occur as roughly rounded masses and thick ledges. Below, and especially in the lower part, many of the beds are thin and slabby and are associated with sandy shales. . . . . The Hartshorne coal lies above this sandstone and is separated from it by a thin but variable bed of shale. The indicative value of this sandstone should be appreciated by the coal prospector, since wherever the sandstone can be traced the coal may be expected to occur.[28]

Taff and Adams (1900) wrote concerning the Hartshorne sandstone, in the area eastward from Hartshorne:

> An aggregation of brown, gray, and usually thin-bedded sandstones which locally become shaly constitutes this formation. The upper beds are in places thick, and even massive, while the lower ones are generally thin and grade into shale toward the base. In places the sandstone beds are thin and shaly throughout; at others—for instance in the railroad cut south of Petros Switch on the Kansas City, Pittsburg and Gulf Railroad—the sandstone is separated into three beds, with shale intervals, each containing a thin coal seam. . . . .
>
> The thickness of this sandstone could not be accurately determined . . . . (but) estimates were made, which varied from 100 feet to a little less than 200 feet. . . .
>
> There are two coals associated with the Hartshorne sandstone, known as the upper and lower Hartshorne coals. The upper bed is above the sandstone and is separated from it by a thin bed of shale, which is variable in thickness. . . . It properly belongs in and at the base of the McAlester shale, which overlies the Hartshorne sandstone. . . . . The lower Hartshorne coal bed is separated from the upper by nearly 50 feet of sandstone and shaly strata. . . . .[29]

28. Taff, Joseph A., "Geology of the McAlester-Lehigh Coal Field, Indian Territory": *U. S. Geol. Survey, 19th Ann. Rept.*, Pt. 3, p. 436, 1899.

History of usage. Taff evidently intended the town of Hartshorne and its immediate environs as the type locality of the formation. His report indicates that coal was being mined at Hartshorne at the time of his investigation, and his description suggests that he recognized only one bed of coal which, in the light of present knowledge, is judged to have been the Lower Hartshorne coal. The following quotation from Hendricks supports this suggestion:

> . . . . .Relatively little mining of this bed (Upper Hartshorne coal), has been done, largely because the dip of the bed is more than 45° at most places and because the Lower Hartshorne bed is thicker and has been mined in preference to it where the dips are low enough to permit mining. However, five mines of considerable size, southwest of Carbon, southwest of Haileyville, and near Blanco, have worked in this bed, and numerous small mines were located on its outcrop.[30]

Hendricks' map[31] shows that most of the mines in the vicinity of Hartshorne are in the Lower Hartshorne bed. It may be assumed then, that Taff's original concept placed the boundary between the Hartshorne sandstone and the McAlester formation at the top of the first continuous sandstone below the Lower Hartshorne coal.

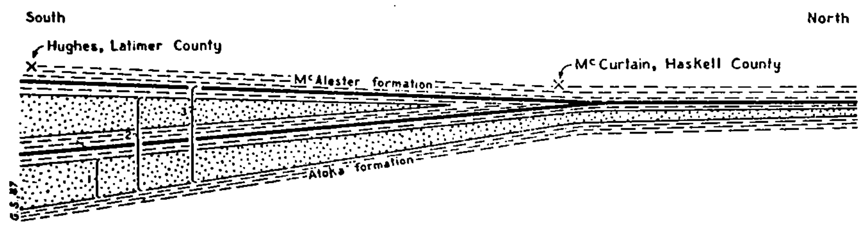

FIG. 3. Diagram showing usage of the term Hartshorne sandstone. Not to scale. Heavy black lines indicate coal.
1. The Hartshorne sandstone of Arkansas usage, which seems to accord with Taff's original concept.
2. The Hartshorne sandstone of Taff and Adams and of later writers in Oklahoma.
3. The Hartshorne sandstone as defined in this report.

29. Taff, Joseph A. and Adams, George I., "Geology of the Eastern Choctaw Coal Field, Indian Territory":*U.S. Geol. Survey, 21st. Ann. Rept.*, Pt. 2, p. 274, 1900.
30. Hendricks, Thomas A., "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field"; Part 1, "McAlester District": *U.S. Geol. Survey Bull.* 874-A, p. 49, 1937.
31. *Idem.* Pl. 7.

In a report on the western part of the Arkansas coal field, Hendricks and Parks[32] summarize the usage and nomenclature of equivalent strata in Arkansas, and state "The Hartshorne sandstone in Arkansas is defined as the first continuous sandstone underlying the lower Hartshorne coal. . . .", and point out that this usage, which seems to agree with Taff's original concept, has always been followed in Arkansas.

Taff and Adams,[33] however, found both the Upper and Lower Hartshorne coals well represented in the eastern Choctaw coal field (Latimer and Le Flore Counties), and sharpened the definition of the Hartshorne sandstone to include specifically the Lower Hartshorne coal and some overlying shale and sandstone. This usage has prevailed in Oklahoma up to the present time.

Redefinition. Knechtel,[34] in the course of mapping northern Le Flore County, discovered a northward and westward convergence of the Upper and Lower Hartshorne coals from the mines on the south limb of the Backbone anticline to the mines on the Milton anticline in the vicinity of Bokoshe and McCurtain, where the two coals coalesce or are separated by only a few inches to a few feet of bony coal or coaly shale. In northwestern Le Flore County and in Haskell County, therefore, the two coals cannot be mapped separately, and the established usage, following Taff and Adams, of drawing the boundary between the Hartshorne sandstone and the McAlester formation at the top of the first sandstone below the Upper Hartshorne coal is not applicable. Some readjustment and redefinition is therefore necessary in this report and in the northern Le Flore County report, and two alternatives suggest themselves:

1. Revert to Taff's original usage and that followed by Arkansas geologists, by lowering the top of the Hartshorne sandstone to the top of the first sandstone below the Lower Hartshorne coal, thus placing both coals in the McAlester formation.

2. Raise the top of the Hartshorne sandstone to the top of the Upper Hartshorne coal, thus including both coals in the Hartshorne.

32. Hendricks, T. A. and Parks, Bryan, "Geology and Mineral Resources of the Western Part of the Arkansas Coal Field": *U.S. Geol. Survey Bull.* 847-E, p. 198, 1937.
33. Taff, Joseph A. and Adams, George I., *op. cit.*, pp. 274-275.
34. Knechtel, M. M., "Geology and Mineral Resources of Northern Le Flore County, Oklahoma": *Okla. Geol. Survey Bull.* (in preparation.)

The first appears the more logical, both on the grounds of stratigraphic history and the precedent of usage; but the latter is considered the more desirable from a utilitarian standpoint, because of the association of the name Hartshorne, and because it probably will cause least confusion among Oklahoma geologists. The top of the Upper Hartshorne coal is therefore taken to mark the boundary between the Hartshorne sandstone and the McAlester formation, in Haskell County and in northern Le Flore County.

Distribution. The Hartshorne sandstone crops out in Haskell County only on the crests and flanks of anticlines. Because of repetition by faulting several outcrops occur on the Milton anticline in the vicinity of McCurtain, T. 8 N., R. 22 E. Another outcrop lies on the north flank of the Milton anticline in the southeast corner of T. 9 N., R. 23 E. It crops out in two areas, one on either side of the fault which crosses Round Prairie dome, in secs. 33 and 34, T. 10 N., R. 22 E. An exposure is present in secs. 30 and 31, T. 9 N., R. 21 E., on Pruit anticline south of Stigler. The longest single outcrop of the Hartshorne sandstone is on the southeast flank of Lone Star anticline in T. 11 N., Rs. 21 and 22 E.

Thickness and character. The Hartshorne sandstone in Haskell County consists of a lower sandstone zone which is generally less than 50 feet thick, but is locally thicker, and an upper zone 50 feet thick, maximum, which is composed mostly of shale and contains the Hartshorne coal at the top. Along its southernmost, and most extensive, outcrop, in Pittsburg, Latimer, and Le Flore Counties, there are two seams of Hartshorne coal, an upper and a lower, 40 feet or more apart. The interval between them is filled mostly by sandstone, but in Haskell County there is only a parting a few inches thick and this parting is absent locally. The coal is discussed in detail in another section of this report.

Stratigraphic relations. The few exposures of the contact in Haskell County indicate that the Hartshorne sandstone lies conformably on the Atoka formation. Hendricks and Parks[35] report a minor unconformity at this contact in Arkansas, and Newell[36]

35. Hendricks, T. A. and Parks, Bryan, *op. cit.*, p. 198.
36. Wilson, Charles W., Jr., and Newell, Norman D., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, p. 26, 1937.

suggests that in the northeast part of Oklahoma, a short distance south of the Kansas-Oklahoma line, sandy strata possibly equivalent to some part of the formation rest unconformably on rocks of Mississippian age. The Hartshorne is overlain conformably by the McAlester formation in all areas of outcrop.

Age and correlation. Read[37] considers from a study of the fossil plants, that the Hartshorne sandstone as well as the overlying McAlester formation, the Savanna formation, and at least the lower part of the Boggy formation are of the same age as the Clarion coal of Pennsylvania. The Clarion coal was formerly classified as in the lower part of the Allegheny series in the Appalachian area, but recently[38] Ashley proposed that the Pottsville-Allegheny boundary be raised, thus shifting the Clarion to the upper part of the Pottsville series.

The Hartshorne sandstone is equivalent in large part to the sandstone and coals of the same name in Arkansas, to some part of the upper Dornick Hills (Big Branch)[39] formation of the Ardmore basin, and to the upper Lampasas series or lower Strawn series of north Texas. The Hartshorne has not been positively identified north of Muskogee, but Newell[40] suggests the possibility that beds of the same age as the Hartshorne may be present in the area north of Wagoner.

Detailed sections. For measured outcrop sections of the Hartshorne sandstone see section numbered 44 in the appendix.

MC ALESTER FORMATION (special usage), GENERAL

In Haskell County the McAlester formation, originally designated the McAlester shale, consists for the most part of shale, much of it silty, but at widely spaced intervals there are several sandstone units which are conspicuously resistant to erosion and stand out as prominent ridges. Only one of the shale units, the McCurtain shale member at the base, has been named. The sandstone units

37. Hendricks, T. A. and Read, C. B., "Correlations of Pennsylvanian Strata in Arkansas and Oklahoma Coal Fields": *Bull. Amer. Assoc. Petrol. Geol.,* Vol. 18, No. 8, footnote pp. 1055-56, 1934.
38. Ashley, George H., "The Pittsburg-Pottsville Boundary": *Journal of Geology,* Vol. 53, No. 6, pp. 374-89, 1945.
39. Floyd, F. W., and Nufer, D. C., "Stratigraphy of the Ardmore Area": *Tulsa Geol. Society Digest,* pp. 10-11, 1934.
40. Wilson, Charles W. Jr. and Newell, Norman D., *op. cit.,* p. 36.

are, from the McCurtain shale member upward, the Warner sandstone member, the Lequire sandstone member, the Cameron sandstone member, the Tamaha sandstone member, and the Keota sandstone member. Of these the Warner and the Lequire are conspicuous, persistent sandstones. The Tamaha is thick and massive locally, but is generally absent in the south part of the county. The Cameron is erratic in thickness. It is absent in some localities, and in others it cannot be differentiated from the Lequire. The Keota is a persistent zone of sandstone lenses separated by sandy, silty shale. The well known Stigler (McAlester?) coal lies a few feet above the horizon of the Cameron sandstone member.

As originally defined by Taff, the McAlester formation included the Upper Hartshorne coal near the base, but in this report the base is redefined as the top of the Upper Hartshorne coal, to conform with the redefinition of the Hartshorne sandstone. The McAlester-Savanna contact in Haskell County and northern Le Flore County is here defined as the top of the first shale unit above the Keota sandstone member, and over most of these two counties it is equivalent to the contact as mapped by Taff[41] in the vicinity of Savanna, Pittsburg County, and extended by Taff and Adams,[42] and later by Hendricks[43] to the vicinity of Poteau, Le Flore County.

In Muskogee County, the Tamaha sandstone member and overlying shale, and the Keota sandstone member and overlying shale were tentatively included in the Savanna formation by Wilson,[44] in an attempt to correlate them with the Savanna rocks exposed in the vicinity of Savanna, Pittsburg County. At that time, detailed geologic mapping of the intervening territory, including the area described in this report, was incomplete.

41. Taff, Joseph A., "Geology of the McAlester-Lehigh Coal Field, Indian Territory": *U.S. Geol. Survey, 19th Ann. Rept.,* Pt. 3, p. 437, and pl. 64, 1899.
42. Taff, Joseph A. and Adams, George I., "Geology of the Eastern Choctaw Coal Field, Indian Territory": *U.S. Geol. Survey, 21st Ann. Rept.,* Pt. 2, pp. 275-277, 1900.
43. Hendricks, Thomas A., "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field": Part 4, "the Howe-Wilburton District. . .": *U.S. Geol. Survey Bull.* 874-D, Map. pl. 27, 1939.
44. Wilson, Charles W., Jr., "Age and Correlation of Pennsylvanian Surface Formations, and of Oil and Gas Sands of Muskogee County, Oklahoma": *Bull. Amer. Assoc. Petrol. Geol.,* Vol. 19, No. 4, pp. 503-520, 1935.
Wilson, Charles W., Jr., and Newell, Norman D., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, 1937.

The McAlester formation is only a few hundred feet thick o the north flank of the Arbuckle Mountains, about 2,000 feet in th McAlester district, about 2,800 feet southeast of Red Oak in Latime County, and only about 1,200 feet on the south side of Poteau Mour tain in Le Flore County. Northward from Red Oak the McAleste formation is about 2,000 feet thick in the Sansbois Mountains i southern Haskell County, about 700 feet in northern Haskell County about 500 feet in southern Muskogee County, about 200 feet in th latitude of Muskogee, and thinner northward, probably to th Kansas-Oklahoma line.

First reference. Taff, J. A., 1899.

Nomenclator. Taff, J. A.

Type locality. Taff did not formally designate a type localit but the name was probably first applied to outcrops of the forma tion in the vicinity of McAlester.

Original description. Writing of the McAlester district Taf said:

> This formation (McAlester formation), for convenience of discussion, may be divided into a series of three parts. The lowest is composed almost entirely of shale, with thin sandstone and coal, in all 800 feet thick. Locally sandstone occurs with thin coal beds near the center of this shale. The Hartshorne or Grady coal occurs at the base of this shale. The middle division of the McAlester shale is composed of three to four beds of sandstone separated by shale 100 to 200 feet thick. Together these beds of sandstone and shale are about 500 feet thick. The lowest of these sandstone beds caps the mesa of Belle Star Mountain and the ridge northwest of Hartshorne. Here it is nearly 200 feet thick. Over most of its surface area, however, the sandstone is not well exposed. The upper division is almost entirely of shale, nearly 700 feet thick and the Mc-Alester coal is about 50 feet above its base. Several thin seams of coal occur in this shale also, but none have been found thick enough to be workable. The shale is blue, gray, or black, with the gray color predominating.[45]

History of usage. Common usage in Oklahoma has applied the term McAlester formation, or McAlester shale, to the strata between the top of the Hartshorne sandstone, below, and the base

45. Taff, Joseph A., "Geology of the McAlester-Lehigh Coal Field, Indian Territory": *U.S. Geol. Survey 19th Ann. Rept.*, Pt. 3, p. 437, 1899.

of the Savanna sandstone or Savanna formation, above. It has included the Upper Hartshorne coal but not the Lower Hartshorne coal, the latter being included in the Hartshorne sandstone. However, as already mentioned under Hartshorne sandstone, usage in Arkansas extended application of the term McAlester formation downward to include the Lower Hartshorne coal and its underlying shale.

In 1927, W. T. Thom[46] made a preliminary investigation of most of Haskell County and of northern Le Flore County. In the course of the work he applied names to most of the sandstone units and to the basal shale unit.

Wilson[47] working under Thom's direction, carried these names northward into Muskogee County, and made first published application of them. He included in the McAlester all strata between the base of the McCurtain shale member and the base of the Tamaha sandstone member. Recent work by Oakes and Knechtel in Haskell County has disclosed previous errors in interpretation of local structure and stratigraphy in the vicinities of Lequire and Tamaha. Thus the adoption of new type localities for members bearing these names is necessary.

Furthermore, Knechtel's work in northern Le Flore County, and that of Knechtel and Oakes in Haskell County, connecting the mapping of the Muskogee-Porum district[48] with the mapping in southern Le Flore County[49] disclosed that the Keota and Tamaha sandstone units belong below the upper boundary of the McAlester formation, as traced eastward from the type locality by Hendricks, rather than above, as shown by Wilson.

Knechtel ascertained that in the vicinity of Poteau, northern Le Flore County, the base of the overlying Savanna formation, as mapped by Hendricks, is at the base of an unnamed sandstone

46. Thom, W. T. Jr., "Coal Map of the Stigler-Poteau District, Pittsburg, Haskell, and Le Flore Counties, Oklahoma": *U.S. Geol. Survey*, preliminary edition, 1935.
47. Wilson, Charles W. and Newell, Norman D., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, pp. 11-12, 1937.
48. *Idem.*
49. Hendricks, Thomas A., "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field"; Pt. 4, "The Howe-Wilburton District . . .": *U.S. Geol. Survey Bull.* 874-D, map, pl. 27, 1939.

which is the same as that which forms the first conspicuous ridge of the Sansbois Mountains south of Lequire, southern Haskell County. However, over part of northern Haskell County this sandstone is not present and therefore the McAlester-Savanna contact in Haskell County and northern Le Flore County is here defined as the top of the first shale unit above the Keota sandstone member, and is described more fully in the discussion of the Savanna formation.

Distribution. Outcrops of the McAlester formation are more continuous and widely distributed than those of any other formation in Haskell County, occupying more than three-fourths of the total area of the county.[50]

Thickness and character. The McAlester, like other Pennsylvanian formations in this part of Oklahoma, is markedly thinner northward. It is about 2,000 feet thick in the Sansbois Mountains, in southern Haskell County, but is only about 700 feet thick along the Arkansas and Canadian Rivers, on the north side of the county. All members seem to be thinner northward and probably little or none of the difference in thickness is due to unconformities.

The McAlester formation consists mostly of shale, but it includes sandstone units, coal beds, and beds and lenses of limestone and clay ironstone. The shales are commonly very dark, where freshly exposed, but they weather to yellow, sticky clay and their outcrops are generally covered. The sandstones range from moderately fine grained to silty and from laminated to massive, in thin and thick beds. They are generally gray in fresh exposures, but weather to various shades of yellow, brown, and red.

Stratigraphic relations. So far as could be determined, the McAlester formation rests conformably on the Hartshorne sandstone at all exposures in Haskell County, and probably throughout the McAlester basin. There is no evidence in Haskell County to suggest more than local, minor unconformity and channeling between the McAlester formation and the overlying Savanna formation. Hendricks,[51] however, believes that there is an unconformity at this

50. See Plate I.

51. Hendricks, Thomas A., "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field"; Part I, "McAlester District": *U. S. Geol. Survey Bull.* 874-A, pp. 15-17, 1937.

contact in the McAlester district because of marked channeling at the base of the Savanna, variable thickness of the upper part of the McAlester, and uncommonly great thickness of the Savanna in the southwest part of the district where the upper part of the McAlester appears to be abnormally thin. Hendricks also reported truncation of shale in the upper part of the McAlester formation on Sugarloaf Mountain in the Howe-Wilburton district.

Correlation. The McAlester formation is equivalent to undifferentiated sandstone and shale beds in the lower part of the Deese formation or the upper part of the upper Dornick Hills (Big Branch) formation of the Ardmore basin, and to part of the Strawn series of North Texas.

SUBDIVISIONS OF THE MC ALESTER

MC CURTAIN SHALE MEMBER

The term McCurtain shale member was first used in print by Wilson.[52] The unit takes its name from McCurtain, Haskell County, and crops out extensively in that locality. Newell published the earliest detailed description of the McCurtain shale:

> This unit consists almost entirely of shale, unbroken by resistant 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.[53]

According to both Wilson and Newell the McCurtain shale unit of Muskogee County includes the Upper Hartshorne coal. But according to the classification used in this report the coal is excluded and the McCurtain shale member includes the strata above the top of the Hartshorne coal and below the base of the Warner sandstone member.

Outcrops of the McCurtain shale member are confined to the east and north parts of the county, occurring on the flanks of the Milton anticline, the northeast and southeast flanks of the Whitefield uplift, and the southeast flank of the Lone Star anticline.

52. Wilson, Charles W., Jr., "Age and Correlation of Pennsylvanian Surface Formations, and of Oil and Gas Sands of Muskogee County, Oklahoma": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 4, p. 508, 1935.

53. Wilson, Charles W., Jr. and Newell, Norman D., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, p. 37, 1937.

The McCurtain shale member is about 500 feet thick in T. 8 N., R. 22 E., on the south side of the county, but is thinner northward, being only about 200 feet thick in T. 11 N., R. 22 E., on the north side of the county. It consists predominantly of shale but in the SE¼ sec. 34, and the SW¼ sec. 35, T. 9 N., R. 23 E. it contains a thick succession of sandstone beds, many of which are massive in character, and there are many shale pellets in some layers of the sandstone. This sandstone zone here forms prominent cliffs, but farther west, in the vicinity of McCurtain, it is less than 10 feet thick, is made up mostly of thin, flaggy beds that are well ripple-marked locally, and crops out in relatively inconspicuous, low ridges. A calcareous, fossiliferous layer in this sandstone zone is exposed in the road-cut at the center of sec. 15, T. 8 N., R. 22 E., a mile and a half north of McCurtain, and on the south side of the artificial lake in the SE¼ sec. 11, T. 8 N., R. 22 E. Layers of sandstone and fossiliferous limestone occur in the McCurtain shale farther northwestward, notably in the south part of T. 9 N., Rs. 20 and 21 E., but are so poorly exposed at most places that it is not practicable to map them. Locally, a thin coal bed occurs in the McCurtain shale a few inches below the overlying Warner sandstone member.

The McCurtain shale, the lowest member of the McAlester formation, is underlain by the Hartshorne coal at the top of the Hartshorne sandstone and is overlain by the Warner sandstone member of the McAlester, both contacts being comformable.

The McCurtain shale of Haskell County is directly equivalent to the McCurtain shale of northern Le Flore County and equivalent to that part of the McCurtain shale unit of southern Muskogee County which lies above the Hartshorne coal, and may well be equivalent to the lower shale in the McAlester district described by Taff as being 800 feet thick.[54]

WARNER SANDSTONE MEMBER

The term Warner sandstone was first published by Wilson.[55] The name is derived from the town of Warner, Muskogee County, and the type locality is about one-fourth of a mile east of the northwest corner of sec. 21, T. 12 N., R. 19 E., 1 mile north of Warner. Newell published the earliest detailed description:

> 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 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. 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.[56]

In his description Newell modified Wilson's original definition of the Warner by excluding thin-bedded sandstone, shale, and coal that overlie the main sandstone:

> The two sandstones and the intervening shale and coal were all included by Wilson in the Warner division to facilitate mapping. However, the upper sandstone is relatively local and is so nonresistant that it is never seen in the Warner escarpment, having been weathered far back in the direction of dip. Furthermore, the thin shale and fairly persistent coal bed between the two sandstones indicate that more than a single depositional unit is involved. Therefore, the term Warner is here restricted to the scarp-forming, massive, lower sandstone.[57]

Similarly, a coal with associated shale and overlying sandstone occurs locally in Haskell County and the view expressed by Newell applies equally well there, but a formation or a member is fundamentally a mappable unit, born of expediency, convenience, or necessity, and on this basis we have here followed the precedent set by Wilson and included the coal, its associated shale, and the overlying sandstone in the Warner member.

Outcrops of the Warner sandstone member in Haskell County are confined almost exclusively to the eastern part and occupy the flanks and tops of anticlines.

54. Taff, Joseph A., "Geology of the McAlester-Lehigh Coal Field, Indian Territory"; *U.S. Geol. Survey, 19th Ann. Rept.* Pt. 3, p. 437, 1899.
55. Wilson, Charles W., Jr., "Age and Correlation of Pennsylvanian Surface Formations, and of Oil and Gas Sands of Muskogee County, Oklahoma": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 4, p. 508, 1935.

56. Wilson, Charles W., Jr., and Newell, Norman D., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, pp. 37 and 38, 1937.
57. *Idem.*, p. 38.

The thickness of the Warner sandstone member is irregular but its order of magnitude is about 50 feet in the south part of the county and somewhat less northward, where it may have suffered post-Warner, pre-Lequire erosion.

The Warner sandstone member of the McAlester, except in the southeast corner of T. 9 N., R. 23 E., where a prominent sandstone occurs in the McCurtain shale, is the first conspicuous sandstone above the base of the formation and, with the underlying thick McCurtain shale member, produces one of the most prominent escarpments in the county; in this respect it is comparable here, as in Muskogee County, to the Bluejacket sandstone member of the Boggy formation. The Warner consists largely of sandstone and in most localities is made up mostly of irregular beds of fine-grained sandstone with some layers of slabby to platy sandstone, siltstone, and shale. A thin coal bed is exposed from place to place in the upper part of the Warner sandstone member and at some places is associated with a shale bed which is locally as much as 5 feet thick. Generally the coal and shale are overlain by some 10 feet of thin-bedded, soft sandstone. This is probably the same sandstone, coal, and shale that were excluded from the Warner member in Muskogee County by Newell.

So far as is indicated by the few exposures of the contact, the Warner sandstone member in Haskell County is underlain conformably by the McCurtain shale member. In southern and western Haskell County and in southern Muskogee County it is overlain conformably by an unnamed shale member which is 250 to 300 feet thick in southern Haskell County but thinner northward over the south and west flanks of the Ozark uplift. It is only 50 feet thick in southern Muskogee County. This shale is absent altogether in most of the area north and east of Stigler, including the eastern end of the Whitefield uplift, the Stigler syncline, and the Lone Star anticline. Where the shale is not present there is but one sandstone to represent both the Warner and the Lequire, and it is not apparent whether this sandstone is the Warner, the Lequire, or the two in contact, and it is therefore mapped as the Lequire-Warner sandstone unit. The historical implications of these observed relations are discussed under structure.

The Warner sandstone member in Haskell County is equivalent to the Warner sandstone member in northern Le Flore County, is approximately equivalent to the Warner of Muskogee County, and is correlated with the Little Cabin sandstone member of the Cherokee formation in northeast Oklahoma. Newell says:

> 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 Pennsylvanian on Mississippian, until it rests directly on the Mississippian in southeastern Kansas.[58]

UNNAMED SHALE MEMBER

The unnamed shale member above the Warner sandstone member was first mentioned by Wilson.[59] Newell published the earliest detailed description of it:

> 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.[60]

The shale above the Warner sandstone crops out as an inlier in the Kinta anticline, in Tps. 7 and 8 N., Rs. 19 and 20 E., where the base is not exposed; on both north and south flanks of the Milton anticline; around the southwest end of the Shropshire Valley anticline and along the north side of the Cowlington syncline as far northeastward as sec. 20, T. 9 N., R. 22 E.; on the Whitefield uplift southwest, south, east and northeast of Stigler as far as sec. 13, T. 9 N., R. 21 E. and sec. 19, T. 10 N., R. 22 E. where the underlying Warner and overlying Lequire sandstones are in contact.

This shale member is notable for its differences in thickness. Logs of wells on the Kinta anticline, in Tps. 7 and 8 N., Rs. 19 and 20 E., indicate that it is about 250 feet thick at the center of SE¼SE¼ sec. 33, T. 8 N., R. 19 E., and less than 200 feet thick at the center

58. Wilson, C. W., Jr., and Newell, Norman D., *op. cit.*, p. 39.
59. Wilson, Charles W. Jr., "Age and Correlation of Pennsylvanian Surface Formations, and of Oil and Gas Sands of Muskogee County, Oklahoma": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 4, p. 508, 1935.
60. Wilson, Charles W., Jr., and Newell, Norman D., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, p. 39, 1937.

W½W½NW¼ sec. 26, T. 8 N., R. 20 E., some 300 feet higher on the structure. The thickness computed from surface data is about 180 feet at the center of sec. 1, T. 8 N., R. 20 E., on the southwest flank of the Shropshire Valley anticline, 300 feet in secs. 5 and 8, T. 8 N., R. 21 E., 320 feet in secs. 4 and 9, T. 8 N., R. 21 E., about 200 feet across secs. 19, 20, 21, 22, 23, and 24, T. 9 N., R. 20 E., and about 210 feet in the SE¼ sec. 17, T. 8 N., R. 22 E., on the southeast side of the Cowlington syncline. In sec. 13, T. 9 N., R. 21 E. and in sec. 19, T. 10 N., R. 22 E. the overlying Lequire sandstone rests on the Warner sandstone, and the shale here discussed is not present in most of the area north and east and northeast of Stigler.

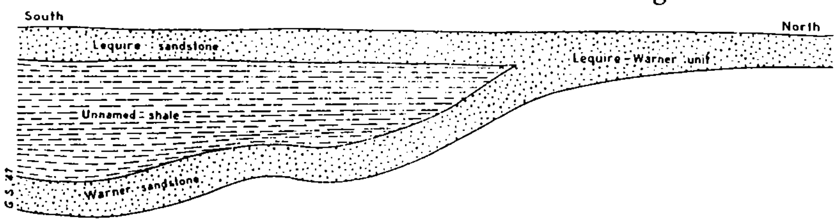

FIG. 4. Diagram showing the Warner sandstone, the Lequire sandstone, and the intervening shale member of the McAlester formation in eastern Haskell County. Not to scale.

The shale member is not present in the area east and north of Stigler and it is not known whether the single sandstone, here referred to as the Lequire-Warner unit, represents the Lequire, the Warner, or the Lequire and Warner combined.

This unnamed shale unit is not well exposed at many places, and it is not possible to describe a complete section in any one locality. Such exposures as were found indicate only that it is composed of shale of various shades of gray. It is underlain conformably by the Warner sandstone member and is overlain, for the most part conformably, by the Lequire sandstone member. As just indicated it is overlapped by the Lequire east of Stigler.

This unit in Haskell County is equivalent to the shale above the Warner sandstone member in Le Flore County, to the east, and to the shale above the Warner sandstone member as mapped by Wilson[61] in southern Muskogee County to the north. As described by Newell[62] in Muskogee County this unit contains some coal, shale

61. Wilson, Charles W., Jr., "Age and Correlation of Pennsylvanian Formations, and of Oil and Gas Sands of Muskogee County, Oklahoma": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 4, p. 508.
62. Wilson, Charles W., Jr., and Newell, Norman D., *op. cit.*, p. 39.

and sandstone at the base which is here included in the Warner sandstone member.

LEQUIRE SANDSTONE MEMBER

Wilson[63] was the first to mention the Lequire sandstone member. It takes its name from the town of Lequire, Haskell County. Owing to errors in the original unpublished mapping in Haskell County, the type locality mentioned by Wilson is inapplicable, and is in reality occupied by outcrops of the Warner sandstone member. Sec. 31, T. 8 N., R. 21 E., 1½ miles northwest of Lequire, is here designated as the type locality. Newell published the earliest detailed description of the Lequire sandstone member:

> The Lequire sandstone member is a single buff sandstone unit ranging from 8 to 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.[64]

The term Lequire sandstone member was used by both Wilson and Newell in the same sense as it is used here.

The Lequire sandstone member, like the Warner sandstone member, crops out widely over the eastern part of the county. In the western part it crops out as a conspicuous rimrock around the higher part of the Kinta anticline in Tps. 7 and 8 N., Rs. 19 and 20 E. It is present on the southwest flank of the Shropshire Valley anticline, in the southwest part of T. 9 N., R. 20 E., and in secs. 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, and 24 of the same township and range. It rests on the Warner sandstone member in sec. 13, T. 9 N., R. 21 E. and in sec. 19, T. 10 N., R. 22 E. In most of the area north and east of Stigler, including the east end of the Whitefield uplift, the Stigler syncline, and the Lone Star anticline, both the Stigler and the Warner are represented by a single sandstone which may be either the Warner, the Lequire, or the two in contact and is therefore mapped as the Lequire-Warner sandstone unit. However, the Lequire and Warner sandstone members crop out, together with the intervening unnamed shale member, to the southeast in sec. 28, T. 9, N., R. 23 E.

63. Wilson, Charles W., Jr., *op. cit.*, p. 508.
64. Wilson, Charles W., Jr., and Newell, Norman D., *op. cit.*, p. 41.

The Lequire sandstone member ranges greatly in both thickness and character from place to place in Haskell County. It is made up largely of thin, slabby beds of fine-grained sandstone, commonly showing ripple marks, and at most places it is a prominent scarp-maker. In the designated type locality, 1½ miles northwest of Lequire, Haskell County, where the exposures are characteristically poor, the total computed thickness is about 150 feet. Along the road on the east side of sec. 31, T. 8 N., R. 21 E. the lower 15 to 20 feet is exposed in a road-cut immediately below the top of a south-facing escarpment and consists of alternating beds of flaggy, silty sandstone and silty shale, which weather buff to reddish-brown. The remainder of the member crops out farther north, on the dip slope, and is exposed in the road from place to place. Such exposures as there are indicate a succession of silty sandstone beds with silty shale partings. The debris indicates massive beds, possibly as much as 2 feet thick, in the upper part of the member. Eastward in sec. 26, of the same township and range, the Lequire consists of a few inconspicuous, silty, shaly beds, but in sec. 25 it is a prominent scarpmaker.

The Lequire sandstone member is thin-bedded, silty, shaly, and probably not over 10 feet thick in the vicinity of the S¼ cor. sec. 34, T. 8 N., R. 19 E. From west to east across the middle of T. 9 N., R. 20 E., the interval from the base of the Lequire practically up to the Stigler coal is occupied by silty shale and silty sandstone lenses mapped as the Lequire. Immediately east and southeast of Stigler the Lequire contains notably thick massive beds.

Except in most of the area north, east and northeast of Stigler the Lequire rests with apparent conformity on the unnamed shale above the Warner sandstone member. However, great differences in thickness of the shale from place to place suggest that the contact may be unconformable, or at least that there may have been tectonic movement during the deposition of the shale. The relations of the Lequire to underlying strata are not known in most of the area north, and east and northeast of Stigler nor, indeed, is it certainly known that the Lequire is present. Throughout Haskell County the Lequire sandstone is overlain conformably by shale and sandstone beds here discussed as beds between the Lequire and Keota sandstone members.

The Lequire of Haskell County is equivalent to the Lequire sandstone member of northern Le Flore County to the east and of southern Muskogee County to the north.

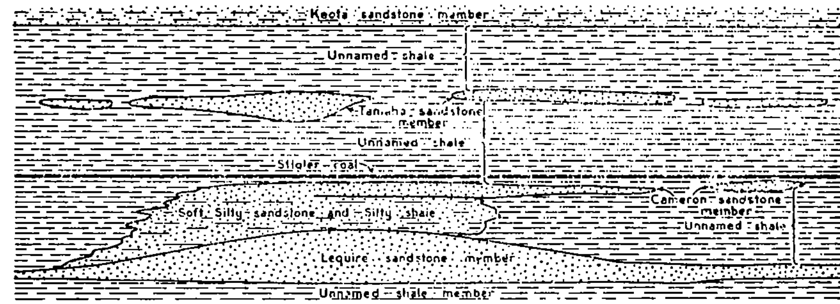

FIG. 5. Diagram indicating the character and stratigraphic relations of units in the McAlester formation occurring between the base of the Lequire sandstone member and the base of the Keota sandstone member, including the Cameron and Tamaha sandstone members and three unnamed shale members. Not to scale. Not oriented.

The Stigler coal lies only a few feet above the horizon of the Cameron sandstone member. Locally sandstone and sandy shale beds extend from the base of the Lequire up to within a few feet of the Stigler coal and the Cameron cannot be differentiated.

BEDS BETWEEN LEQUIRE AND KEOTA SANDSTONE MEMBERS

In Muskogee County, to the north, Wilson[65] and later Newell[66] described equivalents of these strata as the shale overlying the Lequire sandstone, "the Cameron sandstone and overlying shale", and "The Tamaha sandstone and overlying shale"; but neither the Cameron nor the Tamaha is present over all of Haskell County, and in some areas both are absent from the section. As a result there are no mappable lines of demarcation for long distances along the outcrops to separate the various shale units, and it is thought best to describe the shales and sandstones together.

The total thickness of these strata is considerably different in the several parts of the area. It seems to be about 900 feet in the Russellville syncline in T. 8 N., R. 20 E., and about 600 feet in the Sansbois syncline. It decreases northward from the Russellville syncline, and is only about 200 feet in the area between Stigler and

65. Wilson, Charles W., Jr., *op. cit.*, pp. 507-508.
66. Wilson, Charles W., Jr. and Newell, Norman D., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, pp. 41-44, 1937.

Whitefield and northward to Canadian River. However, it is about 350 feet in the north part of T. 10 N., R. 22 E.

The shales are covered for the greater part and there is little detailed knowledge about their character. In general they are dark to gray, and clayey to silty. The sandstones exhibit shades of gray where fresh, but weather to tan, yellow, brown, and reddish brown. They range from massive and fine-grained to thin-bedded and silty, and are commonly ripple-marked.

The type locality of the Cameron sandstone member is in the vicinity of the town of Cameron, northern Le Flore County,[67] and Thom designated the sandstone at Tamaha, northeastern Haskell County, as the type locality of the Tamaha sandstone member.[68] However, mistakes in mapping were made in carrying the work into southern Muskogee County, and in fact the town of Tamaha is on the outcrop of the combined Lequire-Warner sandstone unit. Consequently a new type locality of the Tamaha is here designated as sec. 30, T. 11 N., R. 22 E., some 2 miles west of Tamaha. The base of the member makes a prominent escarpment in the SW¼ of that section.

The Cameron sandstone member, where present in eastern Haskell County, is made up chiefly of thin beds, commonly ripple-marked, of fine-grained sandstone with some interbedded shale. In T. 9 N., R. 20 E., between Whitefield and Stigler, the entire interval from the base of the Lequire sandstone member to within a few feet of the Stigler coal is occupied by fine-grained sandstone lenses and sandy, silty shale, all of which is mapped as Lequire for convenience, though it is reasonable to suppose that the upper few feet is equivalent to the Cameron sandstone unit of other areas. Farther south, across secs. 29, 33, and 34, T. 9 N., R. 20 E., the Cameron is well developed and separated from the Lequire by shale, and the Stigler coal lies a few feet above the Cameron. Thence southeastward, across the northeast part of T. 8 N., R. 20 E., the Cameron is less well developed and the shale between it and the Lequire is thinner and more and more sandy. In secs. 7, 8, 9, 16, 17,

67. Wilson, Charles W., Jr., "Age and Correlation of Pennsylvanian Surface Formations, and of Oil and Gas Sands of Muskogee County, Oklahoma": *Bull. Amer. Assoc Petrol. Geol.*, Vol. 19, No. 4, p. 507, 1935.
68. Wilson, Charles W., Jr., *op. cit.*, p. 509.

and 18, T. 8 N., R. 21 E. the Cameron is merely a resistant sandstone separated from the Lequire by a few feet of softer, more silty sandstone. Southwestward from this locality, on the north flank of the Kinta anticline, the Cameron is either absent or more probably is represented by sandstone beds not distinguishable from the Lequire. On the south flank of the Kinta anticline, in the vicinity of the N¼ cor. sec. 12, T. 7 N., R. 19 E., there is a resistant sandstone a few feet thick, separated from the Lequire by soft, sandy beds, and above the resistant sandstone is a coal. The coal is questionably mapped as Stigler, and the sandstone may be Cameron.

Another exposure of sandstone in the NW¼ sec. 26, T. 8 N., R. 22 E. is similarly mapped as the Cameron sandstone member. Other than these two exposures, no outcrop of distinguishable Cameron sandstone is known along the south side of Haskell County, south of the Kinta and Milton anticlines. In much of this part of the county the Lequire sandstone member is uncommonly thick and it is thought that its upper beds are equivalent to the Cameron sandstone of other areas.

The Stigler coal lies a few feet above the Cameron sandstone member wherever the Cameron is present in Haskell County. In areas where the Lequire sandstone member is thickest and may include in its upper few feet beds equivalent to the Cameron, the Stigler coal lies only a few feet above. In other localities, where the Lequire is unusually thin, and the Cameron is missing as in the abandoned strip pit in the SW¼ sec. 34, T. 8 N., R. 19 E., the Stigler coal lies in shale as much as 80 feet above the Lequire. As the coal is generally only a few feet above the Cameron its outcrop may be taken as indicating approximately the horizon of the Cameron. In much of eastern Haskell County a thin but persistent coal bed occurs in the shale above the Stigler coal and below the Tamaha sandstone member. This bed is exposed at a prospect pit along State Highway No. 26, in the NW¼SW¼ sec. 35, T. 9 N., R. 22 E., where it is 3 inches thick and 44 feet above the Stigler coal. This bed is also present everywhere along the belt of strip mines between Stigler and Tamaha, where it is from 2 to 6 inches thick, is underlain by a foot or more of underclay, and is separated from the Stigler coal by about 25 feet of shale. This bed is known to the miners as the "rider vein".

Outcrops of the Tamaha sandstone member were not found across the south part of the county, south of Kinta and Milton anticlines, except in secs. 2, 3, 4, and 5, T. 7 N., R. 20 E., nor were any found in a local area on the north flank of the Kinta anticline, in the south part of T. 8 N., R. 19 E. Elsewhere the Tamaha seems to be present, but its thickness and other characters are different from place to place. It is more than 20 feet thick and massive in the vicinity of the N¼ corner sec. 20, T. 8 N., R. 21 E., but at the E¼ corner of the same section it is so shaly and nonresistant that it hardly makes a mappable outcrop. It crops out in massive ledges on Beller Mountain, T. 10 N., R. 22 E. In several other areas, as north of the highway from Whitefield to Stigler, the outcrop of the Tamaha can scarcely be found.

The shale below the Cameron rests conformably on or locally grades into the Lequire sandstone member. Where there is such intergradation, neither the Cameron nor the shale below the Cameron can be differentiated. The shale above the Tamaha is conformably overlain by the Keota sandstone member.

KEOTA SANDSTONE MEMBER

The Keota sandstone member was first mentioned by Wilson,[69] following Thom, who named it from the town of Keota, Haskell County, the type locality comprising the town and the area immediately adjacent to the northwest. Newell published the earliest detailed description:

> . . . . . A persistent coal and overlying limestone occur in the midst of the Keota division, ... in the southern part of the area. Traced northward the lower sandstone of the section becomes sporadic, and at many localities is absent. . . . .
>
> 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. . . . .[70]

Both Wilson and Newell used the term in substantially the same sense in which it is used here, but classified the Keota as a member of the Savanna formation, whereas it is now known to be in the McAlester formation.

69. Wilson, Charles W., Jr., *op. cit.*, p. 509.
70. Wilson, Charles W., Jr., and Newell, Norman D., *op. cit.*, p. 44.

Notwithstanding its variable thickness and heterogeneous nature the Keota sandstone member has great lateral extent and continuity. Outcrops of the member are present entirely across the south side of the county, in the Sansbois and Panther Mountain synclines; in the Cowlington and Stigler synclines; and in the Russellville syncline. Outcrops are also present on the Whitefield uplift west of Whitefield, in the conspicuous hills between Whitefield and Stigler, and northwest of Stigler.

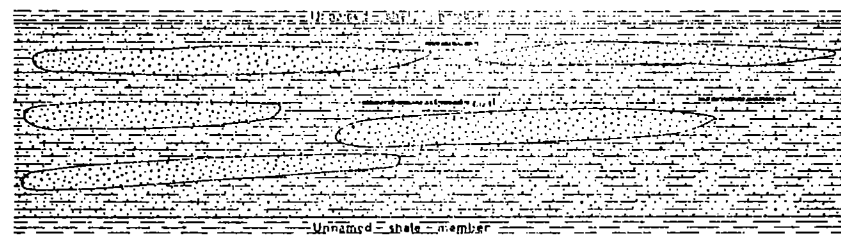

FIG. 6. Diagram indicating the character of the Keota sandstone member of the McAlester formation. Not to scale. Not oriented.
The Keota consists of sandstone lenses separated by sandy to silty shale which contains local coal beds too thin to be of commercial importance. The shale in the Keota is noticeably more sandy and silty than the adjacent shale members.

The Keota sandstone member is erratic in thickness and in the number and character of its beds. Locally this poses a problem as to what it should include, especially in its basal part.

Within the town limits of Keota there are two sandstone units, each comparable to that described as the Keota sandstone member in Muskogee County. These two units and the intervening shale are considered here as constituting the Keota sandstone member within the Cowlington syncline in eastern Haskell County. In the Sansbois and Stigler synclines only one sandstone unit seems to be present at this horizon.

The Keota is in reality a sequence of lenticular sandstone and arenaceous shale beds, locally including one or more coal seams of no economic value. The Keota is separated from other sandstone members of the McAlester and Savanna formations, below and above, by shale members notably thicker and less silty than shales within the Keota. A more adequate conception of its character may be had from a study of the map and measured sections.

In Haskell County the Keota sandstone member is underlain conformably by unnamed shale that lies above the Tamaha sandstone or above the horizon of the Tamaha where the Tamaha is not present. It is overlain conformably by unnamed shale in the upper part of the McAlester formation.

The Keota sandstone member in Haskell County is directly equivalent to the Keota sandstone in northern Le Flore County, to the east, and in Muskogee County, to the north.

UNNAMED SHALE ABOVE THE KEOTA SANDSTONE MEMBER

The uppermost shale member of the McAlester formation in Haskell County is the unnamed shale unit above the Keota, and its upper limit is discussed at length in the following discussion of the Savanna formation. The member is about 500 feet thick in the southern part of Haskell County, but only 75 to 200 feet thick in the northern part. It is covered at most places in the county but is well exposed along State Highway No. 2, north of Tucker Knob, where it consists, from the base upward, of 205 feet of shale, a coal seam about 1 inch thick, and 35 feet of shale.

Detailed sections. For measured outcrop sections of the McAlester formation see sections numbered 2, 3, 5, 6, 7, 8, 10, 12, 13, 16, 18, 19, 20, 21, 22, 23, 24, 26, 27, 29, 29, 30, 31, 32, 33, 34, 35, 37, 38, 41, 42, 43 and 44 in the appendix.

SAVANNA FORMATION

The Savanna formation, or Savanna sandstone as originally called, is a succession of sandstone and shale beds in which shale predominates but sandstone is most conspicuous in outcrops. It contains a minor amount of limestone in thin lenses and beds, and fossils of both marine animals and land plants are present locally. It rests with but slight local erosional unconformity on the McAlester formation and is overlain with general conformity by the Boggy formation. It has been differentiated from the Arbuckle Mountains to Muskogee and beyond, and undifferentiated representatives are probably present in the Cherokee formation of northeastern Oklahoma and southeastern Kansas. It laps onto the east flank of the Arbuckle Mountains, with local unconformity between

it and the underlying McAlester formation, and is itself overlapped by the Boggy formation. In that area it contains limestone conglomerates, part of the Franks conglomerate of earlier authors.[71] In the vicinity of McAlester it is 1,000 to 1,300 feet thick, 1,700 feet in the vicinity of Poteau, 500 to 1,150 feet in southern Haskell County, 80 feet in southern Muskogee County, but only about 25 feet in the latitude of Muskogee.

First reference. Taff, J. A., 1899.

Nomenclator. Taff, J. A., 1899.

Type locality. The type locality is not specifically stated but presumably it is in the vicinity of Savanna, where the formation is exposed.

Original descriptions. Writing of the McAlester district Taff said:

> Next above the McAlester shale there is a series of sandstones and shales about 1,150 feet thick. The shaly beds combined are probably thicker than the sandstones, but since the sandstones are better exposed and their presence is so strongly impressed upon the observer in the prominent ridges which they make, sandstone seems the more appropriate term. There are five principal sandstone beds, which have different thicknesses, from nearly 50 to 200 feet, the one at the top and the one at the base being generally thicker than the intermediate ones. The sandstones may be distinguished only by their position in the section or their thickness of bedding. They are brown or grayish-brown, fine-grained and compact. Except in the uppermost beds, upon which the town of McAlester is built, the beds are generally thin and in part shaly. The uppermost sandstone occurs in two members, 75 to 100 feet thick, separated by variable blue clay shales. The uppermost beds of this sandstone are found in many places to be massive, and those in contact with the shale are often beautifully ripple-marked. No coal of any value has been found associated with these beds of sandstone in the McAlester district, though a thin bed has been reported to occur in the upper part of the series.[72]

Writing of the area eastward from the vicinity of Hartshorne to the Arkansas-Oklahoma line, Taff and Adams said:

71. Morgan, George D., "Geology of the Stonewall Quadrangle, Oklahoma": *Bureau of Geology, Bull.* 2, p. 74, 1924.
72. Taff, Joseph A., "Geology of the McAlester-Lehigh Coal Field, Indian Territory": *U.S. Geol. Survey 19th Ann. Rept.*, Pt. 3, pp. 437-438, 1899.

> The Savanna formation contains three prominent divisions or collections of sandstone beds, having thicknesses of from 100 to 200 feet each and separated by masses of shale and thin sandstone, with two known workable coal beds. The upper division of this series of sandstones is the thickest, being nearly 200 feet thick; its upper strata are locally massive. . . . . The medial bed is the next in importance and thickness and is also a prominent ridge maker. . . . . The lowest sandstone, while neither so thick in section nor so prominent as a ridge-forming rock, is not less important, from the fact that it is associated with a prominent coal bed.
>
> The shales of the Savanna formation are separated into two divisions by the medial sandstone bed. The upper of these varies in thickness from 450 to 530 feet, while the lower division ranges from 300 to 450 feet.
>
> The shales of this formation are as a whole more sandy than shales of the formation below, though they are friable and disintegrate readily, forming valleys and level stretches of country. Estimates of the thickness of this formation vary from 1,200 to 1,500 feet. It appears to grow thicker from west toward the east. The lowest estimate was made near the west end, in Sansbois Mountain, and the highest near the east end in Poteau Mountain. . . . There are two coal beds occurring within the limits of the Savanna formation, one (Cavanal?) in the lower part, almost immediately below the medial sandstone division, and the other very near the top of the upper sandstone division and practically at the top of the formation.[73]

Writing of the Savanna in Latimer and southern Le Flore counties, Hendricks said:

> The Savanna sandstone consists of alternating sandstone and shale. The Cavanal coal and several thin local coal beds are present in the shale of the formation. The sandstone is highly variable in character, both from bed to bed and from place to place in a single bed. . . . . Some of the thicker sandstones grade laterally into sandy shale. The shale in the formation is mostly gray sandy shale, although there are thin beds of black carbonaceous shale present. Most of the black shales contain well preserved plant fossils, and locally marine invertebrates are present in the shales.[74]

History of usage. So far as is known subsequent usage of the term Savanna sandstone or Savanna formation has been in the

73. Taff, Joseph A. and Adams, George I., "Geology of the Eastern Choctaw Coal Field, Indian Territory": *U.S. Geol. Survey 21st Ann. Rept.*, Pt. 2, pp. 277-278, 1900.
74. Hendricks, Thomas A., "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field"; Part 4, "The Howe-Wilburton District. . . ": *U.S. Geol. Survey Bull.* 874-D, p. 272, 1939.

original sense of Taff. However, because of the variable nature of its individual beds, difficulties of precise correlation, and lack of detailed mapping, various writers on various areas may have included somewhat more or less than the equivalents of the original Savanna of Taff, both above and below. Specifically, the upper part of the McAlester formation and the lower part of the Boggy formation were tentatively included in the Savanna formation by Wilson[75] in an attempt to correlate them with the Savanna rocks in the vicinity of Savanna, Pittsburg County. At that time detailed geologic mapping of the intervening territory, including the area described in this report, was incomplete.

Taff said:

> South of Sansbois Mountain the Savanna is approximately 1,000 feet thick. Its thickness becomes gradually less toward the north, until the sandstone beds contained in it are lost to view near the southern boundary of the Muscogee Quadrangle. This formation not being distinguishable, the top of the Winslow formation, being stratigraphically the same as the upper boundary of the McAlester seems to be in contact with the overlying Boggy formation.[76]

Wilson[77] recognized equivalents of the Savanna formation as far north as Arkansas River, northern Muskogee County, thus proving Taff in error, but he placed the top of the formation at the top of the Bluejacket sandstone member of the Boggy formation and the base at the base of the Tamaha sandstone member of the McAlester formation. Work by Dane and Hendricks[78] in 1936 disclosed that the Bluejacket sandstone is the lowermost sandstone member of the Boggy formation, and Newell[79] placed the top of the Savanna formation at the top of the "Spiro" sandstone, leaving the base as drawn by Wilson at the base of the Tamaha sandstone

75. Wilson, Charles W., Jr., "Age and Correlation of Pennsylvanian Surface Formations, and of Oil and Gas Sands of Muskogee County, Oklahoma": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 4, p. 509, 1935.
76. Taff, Joseph A., "Geologic Atlas of the United States": *U.S. Geol. Survey Muscogee Folio* (No. 132), p. 4, 1906.
77. Wilson, Charles W., Jr., *op. cit.* pp. 508-509.
78. Dane, C. H. and Hendricks, T. A., "Correlation of Bluejacket Sandstone, Oklahoma": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 3, pp. 312-314, 1936.
79. Wilson, Charles W., Jr., and Newell, Norman D., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, p. 50, 1937.

member. Mapping by Knechtel[80] in northern Le Flore County and by Knechtel and Oakes in Haskell County has shown that the upper boundary of the Savanna formation, as mapped by Taff and Adams[81] and by Hendricks,[82] in the vicinity of Poteau and by Taff and Adams on the Brazil Creek anticline is substantially the same as the top of the "Spiro" sandstone of Wilson and Newell.

Knechtel found the base of the Savanna as mapped by Taff and Adams and by Hendricks, in the vicinity of Poteau, northern Le Flore County, is at the base of an unnamed sandstone which is the same as that which forms the first conspicuous ridge of the Sansbois Mountains south of Lequire, southern Haskell County. However, this sandstone is not present over all of northern Haskell County, and the McAlester-Savanna contact in Haskell County and northern Le Flore County is here defined as the top of the first shale unit above the Keota sandstone member of the McAlester formation. Throughout most of these two counties it is equivalent to the actual McAlester-Savanna contact as originally mapped by Taff in the vicinity of McAlester, Pittsburg County and extended by Taff and Adams and later by Hendricks to the vicinity of Poteau. However, along the main outcrop northward from sec. 18, T. 9 N., R. 19 E., northwestern Haskell County, the actual McAlester-Savanna contact is not recognizable because the basal sandstone of the Savanna is not present, and the same obtains on outliers in the Stigler syncline and 3 miles west of Stigler. In these areas the actual contact, equivalent to that in the vicinity of Savanna, is shown approximately on the accompanying geologic map by a dotted line drawn below and essentially parallel to the base of a sandstone unit which is unquestionably in the Savanna and is probably equivalent to the "Spiro" sandstone mapped by Wilson[83] in Muskogee County. Such evidence as we have seems to indicate that the actual contact so indicated falls approximately at the stratigraphic position of the base of the Spaniard limestone member of the Savanna, also mapped by Wilson in Muskogee County. In-

80. Knechtel, M. M., "Geology and Coal and Natural Gas Resources of Northern Le Flore County, Oklahoma": *Okla. Geol. Survey Bull.* (in preparation.)
81. Taff, Joseph A. and Adams, George I., *op. cit.*
82. Hendricks, Thomas A., "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field"; Pt. 4, "The Howe-Wilburton District. . . ": *U.S. Geol. Survey Bull.* 874-D, map, pl. 27, 1939.
83. Wilson, Charles W., Jr., *op. cit.* p. 509.

formation now at hand indicates that the Spaniard limestone extends northward at least into Mayes County. A fossiliferous calcareous zone crops out along the road ¼ mile north of the SW cor. sec. 18, T. 10 N., R. 21 E., 1¼ miles north of Perry, and the base of this limy outcrop is provisionally regarded as marking the actual McAlester-Savanna contact, which is indicated on the accompanying geologic map by the dotted line mentioned above.

Distribution. The Savanna formation is present along the south side of the county, in the Sansbois and Panther Mountain synclines; in the eastern end of the Cowlington syncline, eastern part of the county; in the Stigler syncline, north of Stigler; in the southeastern and northeastern parts of the Russellville syncline; on the Whitefield uplift, west of Whitefield; and thence northward to Canadian River west of Hoyt.

Thickness. All the sandstones and shales of the Savanna formation are markedly and progressively thinner northward across the county, and many of the sandstone beds disappear from the section, probably because of gradation into shale. There is less limestone than farther north in Muskogee County. The Savanna is 450 to 1,400 feet thick on the south side of the county and 100 to 200 feet thick on the north side. Hendricks[84] reports 1,120 to 1,325 feet as the thickness of the Savanna in the McAlester district and 1,750 feet near Wister, Le Flore County.

Character. The Savanna formation in southern Haskell County consists of two sandstone zones, upper and lower, which contain some silty shale, and an intervening shale zone which contains a few thin sandstones. The upper and lower sandstone zones crop out as the first and second conspicuous ridges of the Sansbois Mountains south of Lequire, southern Haskell County. The sandstone beds in both zones are fine-grained, thin-bedded to massive, and weather brown. Many are ripple-marked and some bear abundant fossil worm-borings. Fossil plants are present locally and there are a few fossil marine invertebrates. A thin coal of no economic importance crops out in the upper sandstone zone about

84. Hendricks, Thomas A., "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field"; Part 1, "McAlester District. . . ": *U.S. Geol. Survey Bull.* 874-A, p. 19, 1937; and Part 4, "the Howe-Wilburton District. . . ": *Bull.* 874-D, p. 272, 1939.

¼ mile east of the NW cor. sec. 17, T. 7 N., R. 21 E.; and at about the same stratigraphic position in the Panther Mountain syncline there is impure, fossiliferous limestone less than 1 foot thick. Both the upper and lower sandstone zones are present in Panther Mountain syncline, east and north of Tucker Knob, and the upper zone, or part of it at least, crops out northward to Canadian River northwest of Hoyt.

The lower zone is 200 to 300 feet thick in Sansbois Mountain and about 150 feet thick along State Highway No. 2, north of Tucker Knob. Across Tps. 8 and 9 N., Rs. 19 and 20 E. it consists generally of a single massive bed, only a few feet thick, which disappears near the north side of sec. 18, T. 9 N., R. 19 E., where it probably grades into shale.

The middle shale zone is 400 to 700 feet thick in Sansbois Mountain, 130 feet thick on State Highway No. 2, north of Tucker Knob. It cannot be differentiated north of sec. 18, T. 9 N., R. 19 E. because the underlying sandstone is not present.

The upper sandstone zone of the Savanna is 150 to 300 feet thick in the Sansbois Mountains. Along State Highway No. 2, north of Tucker Knob, it is about 200 feet thick and contains a shale near the middle which is about 50 feet thick. This upper sandstone zone of the Savanna has this tripartite character northward to Canadian River, northwest of Hoyt, where it is about 50 feet thick. This locality is immediately across Canadian River from the locality from which Newell reported his thickest measurement of the "Spiro" sandstone member in Muskogee County:

> Except in the extreme southern part of the Muskogee-Porum district, along Canadian River, the Spiro sandstone is thin and non-resistant, resting directly upon 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 feet thick and is reduced to about 2 feet of soft sandstone in sec. 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-resistant and shaly. . . . [85]

85. Wilson, Charles W. Jr., and Newell, Norman D., "Geology of Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, p. 50, 1937.

The correlation of Newell's 20 feet of "Spiro" sandstone in the extreme southern part of the Muskogee-Porum district with the 20 feet of massive, fine-grained, resistant sandstone in the lower part of the upper sandstone zone of the Savanna which caps the south bluff of the Canadian River northwest of Hoyt is based upon the facts: (1) that each occupies about the same stratigraphic position below the Bluejacket sandstone member of the Boggy formation, (2) that each, in its own area, is the first such bed below the Bluejacket, and (3) that the Bluejacket can be traced across Canadian

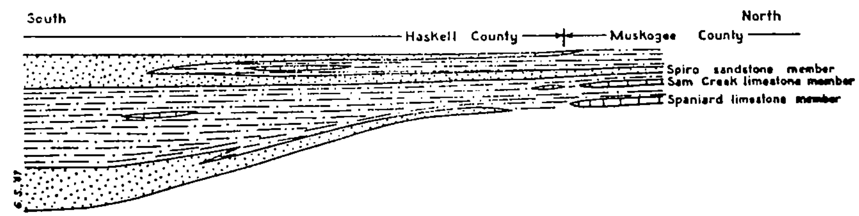

FIG. 7. Diagram indicating the character of the Savanna formation in Haskell County and its relation to representatives in Muskogee County. Not to scale.

The term "Spiro" sandstone member, used in Muskogee County, is not applicable in Haskell County.

River. It is true that Newell mentioned only one division, or bed, of his "Spiro" sandstone, but Oakes saw topographic evidence of a higher bed somewhat farther up the hill in sec. 33, T. 10 N., R. 19 E., and thinks it probable that this is the upper sandstone of the upper sandy zone of the Savanna in southern Haskell County, and that this upper bed is not noticeable farther north because of combined thinning and gradation into shale. Because the "Spiro" sandstone member of the Savanna in Muskogee County thus probably represents but a small and indeterminable part of the upper sandstone zone in southern Haskell County, it seems that there would be little utility in perpetuating the term "Spiro sandstone" in this report.

The Sam Creek limestone member in Muskogee County occupies about the same stratigraphic position below the 20 feet of massive "Spiro" sandstone as does limestone float seen by Oakes below the massive sandstone forming the lower part of the upper sandstone zone of the Savanna northwest of Hoyt. The Spaniard limestone member in Muskogee County seems to occupy about the same stratigraphic position as the base of the Savanna in southern

Haskell County, and though we do not presume to say that it is continuous with the lowest sandstone of the Savanna, the Spaniard may well serve to mark the base of the Savanna in Muskogee County and northward.

Only the upper sandy zone of the Savanna can be differentiated on the outliers three miles west and northwest of Stigler where it has about the same character as along the main outcrop west of Hoyt.

Stratigraphic relations. The McAlester-Savanna contact has been suggested by several authors as marking a stratigraphic break of sufficient magnitude and stratigraphic importance to be used as a series boundary. Moore[86] placed the Des Moines-Lampasas boundary at the base of the Tamaha sandstone unit following Wilson and Newell in considering the Tamaha as the basal member of the Savanna in Muskogee County, and Cheney[87] considered the base of the Savanna, especially in the McAlester district, as one of the more likely planes for drawing the boundary between the Pottsville and Allegheny, as well as between the proposed Lampasas series and the Des Moines series. No evidence was seen in Haskell County to indicate unconformity of more than minor, local importance either above or below the Savanna formation. Hendricks[88] believes there is an unconformity of considerable magnitude between the McAlester and Savanna formations in the McAlester district because of channeling at the base of the Savanna, variable thickness of the upper part of the McAlester, and the uncommonly great thickness of the Savanna in the southwestern part of the district where the upper part of the McAlester appears to be thin. In the report on the Howe-Wilburton area, he states:

> Sections of the McAlester shale (pl. 30) show that the variation in thickness of the formation is for the most part due to variation in thickness of the individual units rather than to variable erosion prior to the deposition of the Savanna sandstone.[89]

86. Moore, R. C. and others, "Correlation of Pennsylvanian Formations of North America": *Bull. Geol. Soc. Amer.*, Vol. 55, No. 6, pp. 657-706, chart, 1944.
87. Cheney, M. G. and others, "Classification of Mississippian and Pennsylvanian Rocks of North America": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 29, No. 2, pp. 147-156, 1945.
88. Hendricks, Thomas A., "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field"; Part 1, "McAlester District . . .": *U. S. Geol. Survey Bull.* 874-A, pp. 16-17, 1937.

Writing on the western part of the Arkansas coal field, Hendricks and Parks state:

> The Savanna sandstone rests with a somewhat irregular contact on the McAlester shale. Near the Arkansas State line, on the part of Sugarloaf Mountain that extends into Oklahoma, the basal sandstone of the Savanna cuts downward across beds in the upper part of the McAlester shale at an angle of several degrees. These features indicate that at least a minor unconformity is present at the base of the Savanna sandstone.[90]

Hendricks, Dane, and Knechtel, after discussing evidence of structural movements within the Arkansas-Oklahoma coal basin, wrote:

> From the foregoing evidence, it is apparent that minor structural movements occurred at many places in the Arkansas-Oklahoma coal basin throughout the period of deposition of the strata now found there, but it is unlikely that any single structural movement affected the entire coal basin, and it is even doubtful that the unconformities at the base of the Hartshorne and Savanna sandstones extended over the entire area where these formations are present.[91]

In the Stonewall quadrangle, Morgan[92] found the Savanna to be involved in a major, progressive overlap that encompasses most of the Pennsylvanian rocks above the Wapanucka limestone, around the flanks of the Arbuckle Mountains.

Local unconformities, some of considerable apparent magnitude, are common in the Pennsylvanian section of Oklahoma, especially in the McAlester basin. Overlap against the Arbuckle Mountains is considered to be a local feature incident to the geologic history of that uplift, and not significant in a regional sense. Hence there is no clearcut physical evidence for postulating a regional

89. Hendricks, Thomas A., "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field"; Part 4, "The Howe-Wilburton District . . .": *U. S. Geol. Survey Bull.* 874-D, p. 270, 1939.
90. Hendricks, T. A. and Parks, Bryan, "Geology and Mineral Resources of the Western Part of the Arkansas Coal Field": *U. S. Geol. Survey Bull.* 847-E, p. 199, 1937.
91. Hendricks, T. A., Dane, C. H., and Knechtel, M. M., "Stratigraphy of the Arkansas-Oklahoma Coal Basin": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 10, p. 1356, 1936.
92. Morgan, George D., "Geology of the Stonewall Quadrangle": *Bureau of Geology Bull.* 2, p. 75, 1924.

break at the McAlester-Savanna boundary. This conclusion is substantiated by evidence of fossil plants as reported by Read:

> . . . . .The flora of the McAlester coal is related closely to that of the Savanna and lower Boggy as well as to the Hartshorne. The obvious conclusion concerning these strata is that whatever may be their age it is undesirable to draw a major boundary line within the sequence if this can be avoided.[93]

For these reasons the Oklahoma Geological Survey has not adopted the term Lampasas, and continues to refer to the Des Moines series all rocks from the base of the Atoka formation to the base of the Seminole formation.

Correlation. The Savanna formation is correlated with the formation of the same name in Arkansas, with the lower part of the Deese formation of the Ardmore basin, and with some part of the Strawn series of north Texas. As discussed under "character", the Savanna is represented approximately in Muskogee County by strata from the base of the Spaniard limestone member to the top of the "Spiro" sandstone member including the Sam Creek limestone. The Sam Creek and Spaniard limestone members have been traced northward to the latitude of Choteau, Mayes County, Oklahoma, and are reported farther north, indicating that the Savanna is represented in the middle part of the Cherokee shale.

Detailed sections. For measured outcrop sections of the Savanna formations see sections numbered 1, 2, 3, 5, 6, 7, 8, 10, 11, 13, 15, 16, 17, 18, 26, 27, 28, 29, 30, 31, 36 and 40 in the appendix.

BOGGY FORMATION, GENERAL

The Boggy formation, originally designated the Boggy shale, extends from the Arbuckle Mountains to the vicinity of Muskogee. There are, in addition, extensive outcrops eastward in the McAlester basin as far as the Arkansas-Oklahoma line. Undifferentiated equivalents of the Boggy extend north of the latitude of Muskogee and constitute a large part of the Cherokee shale of southeastern Kansas.

93. Hendricks, T. A. and Read, C. B., "Correlation of Pennsylvanian Strata in Arkansas and Oklahoma Coal Fields": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 18, No. 8, pp. 1055-56, footnote, 1934.

The thickness of the Boggy formation ranges from a thin edge in the Arbuckle Mountain area to a maximum of more than 4,000 feet in Cavanal Mountain, eastern Le Flore County, where the top is eroded. Equivalent beds are only hundreds of feet thick at the Kansas-Oklahoma line. The Boggy consists predominantly of dark shale, much of it silty and sandy, but there are several conspicuous sandstone zones. It rests with general conformity on the Savanna formation, except on the east flank of the Arbuckle Mountains, where it rests on beds as old as Ordovician.

First reference. Taff, 1899.

Nomenclator. Taff, 1899.

Type locality. Taff did not state the type locality formally, but the formation was probably named from extensive outcrops in the valleys of Clear and Muddy Boggy Creeks in Pontotoc, Coal, and Pittsburg Counties.

Original description. Taff wrote of the Boggy in the McAlester district:

> There is a mass of shale and sandstone above the Savanna sandstone nearly 3,000 feet thick. Throughout a part of this field it is possible, and would be desirable, to separate these beds and map them as two or more series of beds from both stratigraphical and structural points of view. In other parts of the field, however, it is not possible to trace or map beds of sandstone or shale in separate collections of strata. . . . . In the Boggy shale there are probably not less than sixteen beds of sandstone, ranging in thickness from 20 to 150 feet, separated by shale from 100 to 600 feet thick. One coal bed, about 2 feet 6 inches thick, has been located and worked to a small extent, though now abandoned. This coal bed is about 400 feet above the base of the Boggy shale. . . . .
>
> The shales of this series are exposed to a very slight extent. In the few hill slopes and stream cuttings where observed the shales are bluish fissile clay containing ironstone concretions, thin wavy sandstone plates, and shaly sandstone strata. The sandstones . . . . . vary but little in minor detail of texture. They are generally brownish or gray and some beds are quite ferruginous. . . . . All the sandstones are fine-grained and were without doubt deposited under very similar conditions.[94]

94. Taff, Joseph A., "Geology of the McAlester-Lehigh Coal Field, Indian Territory": *U. S. Geol. Survey*, 19th *Ann. Rept.*, Pt. 3, pp. 438-39, 1899.

Of the Boggy in the area eastward from the McAlester district Taff and Adams wrote:

> . . . . . In spite of the apparent prominence of the sandstone, it makes relatively a small part of the formation when compared to the shale. . . . .
>
> One coal bed (Secor coal) is known in the Boggy shale. This occurs about 200 feet above its base. It is mined at the east end and upon the north side of Cavanal Mountain and varies between 3 and 4 feet in thickness. . . . .[95]

Hendricks describes the Boggy in the Howe-Wilburton area as follows:

> Only the lower 1,200 feet of the Boggy shale is present in this district, although 4,000 feet of beds in the Boggy shale occur on Cavanal Mountain, just north of the district, in T. 7 N., R. 24 E., where the top of the formation is not present. . . . . The part of the formation present consists of dark shale in which are several sandstone beds and two beds of coal. . . . .[96]

History of usage. Subsequent usage of the term Boggy shale or Boggy formation has followed generally the precedent set by Taff.

Distribution. In Haskell County, outcrops of the Boggy formation are found in the Sansbois and Panther Mountain synclines, in the south part; in the eastern end of the Cowlington syncline, in the east part; in the Stigler syncline, in the north part; and across the western part, including the Russellville and Brooken Creek synclines and the western end of the Whitefield uplift.

Thickness and character. The upper beds of the Boggy formation are not exposed anywhere in Haskell County, but more than 2,000 feet is exposed in the Sansbois syncline, in the south part. About 1,100 feet of Boggy is present in Tucker Knob, secs. 16, 17, 20, and 21, T. 7 N., R. 19 E., on the axis of the Panther Mountain syncline, and about 1,200 feet of Boggy crops out in the Russellville syncline, in the western part of the county.

95. Taff, Joseph A. and Adams, George I., "Geology of the Eastern Choctaw Coal Field": *U. S. Geol. Survey 21st Ann. Rept.*, Pt. 2, P. 278, 1900.
96. Hendricks, Thomas A., "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field"; Part 4, "The Howe-Wilburton District": *U. S. Geol. Survey Bull.* 874-D, p. 272, 1939.

The Boggy formation in Haskell County consists of alternating dark, generally silty shale and sandstone zones. The shale zones are covered by residual debris except locally, so that it is not feasible to describe them in detail. Local variations are black blocky shale, black fissile shale, clay shale, and thin lenticular, silty sandstone beds. The sandstone zones are not clear-cut with definite, continuously traceable tops and bases. Typically they are made up of lenses of thin-bedded to massive, silty to moderately coarse sandstone intercalated with silty to sandy shale. The base of the sandstone cap of an escarpment may actually range 10 to 30 feet up or down in the section within a mile.

Dane and others[97] in the course of their work on the Boggy in the Quinton-Scipio District, which includes the north half of T. 8 N., R. 18 E., in Haskell County, numbered the sandstone zones in ascending order and later Dane and Hendricks[98] demonstrated that their lowest zone, No. 1, is identical with the Bluejacket sandstone of northeastern Oklahoma. In addition to the Bluejacket, their zones Nos. 2, 3A, and 4 crop out in western Haskell County.

Stratigraphic relations. The Boggy formation rests on the Savanna formation, probably with general conformity. However, locally, there is some evidence that lower Boggy strata are overlapped by higher Boggy strata northward.

Newell[99] found that his units B_1 to B_5 inclusive, making up 160 feet of heterogeneous lower Boggy strata in T. 10 N., are not present in T. 12 N., but inasmuch as they are eroded across T. 11 N., he could not say with certainty whether they were lost by overlap or by convergence and gradation into shale.

Outcrops are so poor in Haskell County that the strata below the Bluejacket sandstone member have not been differentiated into units comparable to those of Newell. Newell found these strata about 400 feet thick in T. 10 N.; and they appear to be about 360 feet thick in secs. 5 and 6, T. 9 N., R. 19 E.; 485 feet in the east

97. Dane, C. H. and others, "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field"; Part 3, "Quinton-Scipio District": *U. S. Geol. Survey Bull.* 874-C, pp. 160-65, 1938.
98. Dane, C. H. and Hendricks, Thomas A., "Correlation of the Bluejacket Sandstone, Oklahoma": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 3, pp. 312-314, 1936.
99. Wilson, Charles W., Jr., and Newell, Norman D., *op. cit.*, pp. 51-52.

central part of T. 9 N., R. 18 E.; about 340 feet in the southwest part of T. 8 N., R. 19 E.; and about 275 feet in the vicinity of Tucker Knob, T. 7 N., R. 19 E. But here as in Muskogee County it is not possible to say with certainty whether this variation in thickness is due to variation in thickness of individual beds or to unconformity.

The Boggy formation is overlain by the Thurman sandstone, probably unconformably, but the contact is not present in Haskell County.

Correlation. The Boggy formation is equivalent to a large part of the Cherokee shale of southeastern Kansas. Southward it is equivalent to a part of the Deese formation of the Ardmore basin and to a part of the Strawn series of north Texas.[100]

For purposes of discussion the Boggy formation in Haskell County is separated into three parts which are in ascending order, the lower shale member, the Bluejacket sandstone member, and the strata above the Bluejacket.

SUBDIVISIONS OF THE BOGGY

LOWER SHALE MEMBER

Outcrops of the lower shale member of the Boggy in Haskell County are generally covered. The best exposures are along State Highway 2 in sec. 7, T. 8 N., R. 20 E., where 280 feet of a total of 473 feet is covered. Judging from these and other exposures, most of it consists of dark-colored siltstone and silty shale, all of which generally weathers to some shade of gray, brown, or reddish brown. This lower shale member is about 275 feet thick along State Highway 2, north of Tucker Knob in T. 7 N., R. 19 E.; 340 feet thick across the southwest part of T. 8 N., R. 19 E., 360 feet thick in the northwest part of T. 9 N., R. 19 E.; and about 300 feet thick in Jackson Mountain, T. 10 N., R. 21 E. In T. 10 N., Muskogee County, Newell[101] was able to subdivide this shale member into

100. Dott, Robert H., "Regional Stratigraphy of the Mid-Continent": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 25, No. 9, p. 1659, 1941.
101. Wilson, Charles W., Jr., and Newell, Norman D., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, p. 52-54, 1937.

seven units having a total thickness of about 400 feet which he numbered in ascending order B_1 to B_7 inclusive. A coal which may be Newell's "Lower Boggy" coal is present in the shale below the Bluejacket sandstone member southwest of Jackson Mountain.

BLUEJACKET SANDSTONE MEMBER

Without naming it Taff described the Bluejacket as follows:

> In the Muscogee Quadrangle only the lowest sandstone and its inclosing shale members are exposed. The basal deposit is a comparatively soft shale, approximately 200 feet thick. The overlying sandstone is a gray to yellowish-brown rock, and occurs for the most part in thick or massive and moderately hard beds. The lower sandstone beds are usually exposed in cliffs and bluffs at the crests of escarpments which they produce. The upper layers make flat and gently rolling tracts of sandy loam which slope westward from the escarpment of the Rattlesnake Mountains. Toward the northwest this sandstone gradually grows thinner, more shaly, and softer, the decrease in thickness and the change in character being emphasized by the topographic expression of the rock. Near the southern boundary of the quadrangle the sandstone is marked by the strong escarpment and timbered table-land of the Rattlesnake Mountains. . . . . The lowest shaly strata, lying above the sandstone, occur in the southwest corner of the quadrangle. A bed of bituminous coal (Secor coal), 2 feet 6 inches thick, occurs in this shale near the base. It should be found to crop out across the southwest corner of the quadrangle.[102]

The Bluejacket was named by D. W. Ohern in an unpublished manuscript, from the hills west of the town of Bluejacket, Craig County. He described it as follows:

> In many places its total thickness of 50 to 60 feet is a solid mass of sandstone, but usually it is broken up into several beds by intervening shales. This sandstone is well exposed on the west bank of Neosho River a mile south of the Kansas line, where more than 30 feet is seen above the river surface. It forms an escarpment in the eastern part of T. 28 N., R. 21 E., and is widespread east of Welch. It extends southward past Bluejacket and its typical development is found in the hills west of the town from which it is proposed to name it the Bluejacket sandstone member.

102. Taff, Joseph A., "Geologic Atlas of the United States": *U. S. Geol. Survey, Muscogee Folio* (No. 132), p. 4, 1906.

Owing to miscorrelation across faults McCoy[103] applied the name, by inference, to the Warner sandstone member of the McAlester formation in the vicinity of Warner. Later Wilson, by tracing and by correlation across faults, mapped the Bluejacket sandstone member as far south as the south part of T. 10 N., R. 19 E., finding it equivalent to the beds on Rattlesnake Mountain, described by Taff as the lowest sandstone unit of the Boggy formation. However Wilson[104] considered the Bluejacket to be the uppermost sandstone of the Savanna formation. Dane and Hendricks[105] completed the tracing of the Bluejacket into the Quinton-Scipio district and found it to be the same as the lowest sandstone unit (No. 1) of the Boggy formation as previously mapped by Dane and others.[106] Hence the Bluejacket is recognized as a member of the Boggy formation.

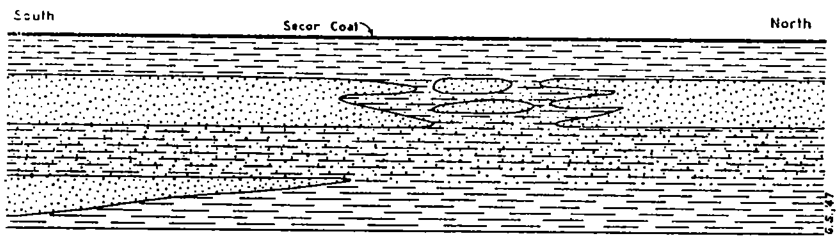

FIG. 8. Diagram indicating the general character of the Bluejacket sandstone member of the Boggy formation. Not to scale.
Generally in the south part of the county the Bluejacket consists of upper and lower massive sandstone beds and intervening soft, silty to shaly beds. In the north part of the county only one set of massive beds, probably the upper, is present. The position of the Secor coal above the Bluejacket is indicated by the heavy black line.

In Haskell County the Bluejacket crops out in the western and southern parts and in local areas in the Cowlington and Stigler synclines. Generally the lower part forms cliffs capping escarpments and the indistinctly expressed upper limit lies at a considerable distance down the dip slope. Consequently estimates of thickness are subject to qualification. Across the south side of the county and as far north as the north side of T. 8 N., the Bluejacket consists at most places of two massive sandstone units separated by thin-bedded, silty sandstone and silty to sandy shale, but locally the intervening material is merely softer sandstone. Its total thickness in this part of the area is 100 to 150 feet. The lower massive unit grades into shale in the northeast part of T. 8 N., R. 18 E.; and farther southwest, in the same township and range, the upper unit is so shaly that its upper and lower limits are mapped with difficulty. North of T. 8 N., the total thickness is some 50 to 75 feet and generally only one unit, probably the upper, is present. The massive parts of the Bluejacket weather into large exfoliated blocks which are prominent in the talus material.

103. McCoy, Alex W., "A Short Sketch of the Paleogeography and Historical Geology of the Mid-continent Oil District and its Importance to Petroleum Geology": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 5, No. 5, p. 548, 1921.
104. Wilson, Charles W., Jr., "Age and Correlation of Pennsylvanian Surface Formations, and of Oil and Gas Sands of Muskogee County, Oklahoma": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 4, pp. 508-509, 1935.
105. Dane, C. H. and Hendricks, Thomas A., *op. cit.*
106. Dane, C. H. and others, "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field"; Part 3, "The Quinton-Scipio District": *U. S. Geol. Survey Bull.*, 874-C, Map pl. 12, 1938.

STRATA ABOVE THE BLUEJACKET SANDSTONE MEMBER

Strata of the Boggy formation higher than the Bluejacket sandstone member crop out in the western part of Haskell County along the south side, in the Panther Mountain and Sansbois synclines; and in the east part, in the Cowlington syncline. In western Haskell County the Secor coal bed lies about 100 feet above the top of the Bluejacket sandstone, in the shale between the Bluejacket and sandstone unit No. 2 of Dane and others.[107] This shale is about 200 feet thick, is composed for the greater part of dark clay shale and contains near the top, at least locally, another coal bed only a few inches thick and of no economic importance.

The sandstone unit corresponding to No. 2 of Dane and others is thin and patchy in western Haskell County and was not traced north of sec. 8, T. 9 N., R. 18 E. Unit 3A of Dane and others is about 20 feet thick in the south part of T. 9 N., R. 18 E., but was not confidently identified as far north as Canadian River. Unit 4 of Dane and others covers about 8 square miles in the western part of T. 9 N., R. 18 E., where it consists of several lenticular sandstone beds separated by silty, sandy shale. It caps a prominent escarpment about 300 feet high known as Brooken Mountain, but the rim of the escarpment is formed by various sandstone lenses of local development ranging through several tens of feet in the section. The total thickness of the part of the Boggy exposed above

107. Dane, C. H. and others, *op. cit.*

the Bluejacket sandstone member in western Haskell County is about 700 feet.

About 700 feet of sandstones and shales lie above the Bluejacket sandstone member in Tucker Knob, in the Panther Mountain syncline. The 50-foot sandstone capping the knob is the coarsest sandstone found in Haskell County. These strata are so poorly exposed, for the greater part, that no further description of them will be given here, and the reader is referred to section No. 4, in the appendix. Also, because of the poor exposures, no attempt is made to correlate the Tucker Knob section with the section above the Bluejacket anywhere else in the county.

The total thickness of that part of the Boggy formation exposed above the Bluejacket sandstone member in the Sansbois syncline of southern Haskell County is about 1,800 feet. These strata consist of several thick, mappable sandstone units and thick intervening shale units. The sandstone units are generally composed of thin-bedded to massive, fine-grained, brown-weathering sandstone and sandy to silty shale. The intervening shale units are so poorly exposed that little can be said about their character. A coal, considered to be the Secor, is exposed at a landslide near the W¼ cor. sec. 15, T. 7 N., R. 21 E., where it lies about 100 feet above the top of the Bluejacket sandstone member. However, a sandstone which lies about 10 feet above the coal at this place can be traced over most of the Sansbois Mountain area and was found to lie in some localities as much as 250 feet above the Bluejacket. The higher of these Boggy beds are probably younger than any Boggy beds exposed elsewhere in the county, but it is not thought safe to extend the numbered sandstone units of Dane and others into the Sansbois syncline as they were extended into western Haskell County, because of the discontinuity of the outcrops and the dissimilarity of the sections in the Sansbois syncline and in western Haskell County.

A little shale is present above the Bluejacket sandstone member in the Cowlington syncline and the Secor coal has been uncovered there in a small prospect in the SW¼ sec. 21, T. 10 N., R. 23 E., where it is only 1 foot thick.

Detailed sections. For measured outcrop sections of the Boggy formation see sections numbered 2, 4, 5, 7, 8, 9, 11, 14, 25, 26, 39, and 45 in the appendix.

QUATERNARY (?) SYSTEM

Gerty Sand (Pleistocene?)

A deposit of sand, silt, and clay, probably nowhere more than 100 feet thick, forms a dissected terrace well above the Canadian River floodplain, in the vicinity of Stigler and about Whitefield. It is similar and considered equivalent to the Gerty sand of Pleistocene (?) age which was first named and described by Taff[108] from its type locality near Gerty, Coal County, where it contains pebbles different from any of the bedrock in Oklahoma. This terrace material probably originated from outcrops hundreds of miles to the west and formed the floodplains of streams much older than the present rivers. In Haskell County these terrace deposits contain also pebbles and clay of local origin. At some places it is not possible to tell with certainty where the Gerty sand ends and entirely residual deposits begin.

Locally the terrace deposits contain beds of volcanic ash a few feet thick which is generally impure. The most notable ash deposits of Haskell County lie northeast of Stigler, in the vicinity of Whitefield, and north of Brooken, and are discussed under economic geology. The terrace material about Brooken is so thin and dissected that it is not shown on the areal geology map but the area in which volcanic ash has been found is indicated. Sand and gravel suitable for building have been obtained from the terrace north of Stigler in amount sufficient for the limited local demand. Lack of suitable transportation facilities has precluded more extensive development.

An area in the vicinity of Lequire and westward, T. 7 N., Rs. 20 and 21 E., is covered by sand and silt and is mapped as a terrace deposit, but it contains little, if anything, except material of local origin.

QUATERNARY SYSTEM

Recent Alluvium

The stream valleys in all parts of Haskell County are filled by deposits of recent alluvium, probably nowhere more than 100 feet

108. Taff, Joseph A., "Geologic Atlas of the United States": *U. S. Geol. Survey*, Coalgate Folio (No. 74), pp. 4-5, 1901;
Taff, Joseph A., "Geology of the McAlester-Lehigh Coal Field, Indian Territory": *U. S. Geol. Survey*, 19th *Ann. Rept.*, Pt. 3, p. 439, 1899.

thick, composed mainly of silt and sand. Such deposits underlie tracts of bottom land of considerable size adjacent to Arkansas and Canadian Rivers and along Sansbois Creek.

SUBSURFACE STRATIGRAPHY

Several holes that have been drilled for oil or gas in eastern Haskell County have penetrated rocks older than any of those exposed at the surface. The oldest rocks drilled belong to the Arbuckle limestone which was reached in I. T. I. O. Company's Blake No. 1 well in SW¼NW¼ sec. 3, T. 10 N., R. 21 E. This well was started not far below the top of the Atoka formation and was drilled to a total depth of 3,007 feet. According to the company geologist's log, the Wapanucka limestone (Pennsylvanian) was entered at 1,800 feet; the Pitkin limestone (Mississippian) at 2,015 feet; the Woodford chert (Mississippian)* at 2,160 feet; the Hunton limestone (Silurian and Devonian) at 2,186 feet; the Sylvan shale (Upper Ordovician) at 2,410 feet; the Viola limestone (Middle and Upper Ordovician) at 2,448 feet; the Simpson group (Lower and Middle Ordovician) at 2,504 feet; and the Arbuckle limestone (Cambrian and Ordovician) at 2,880 feet.

STRUCTURE

Haskell County lies within a belt of moderately intense folding that skirts the northern margin of the Ouachita Mountains from Arkansas southwestward to the Arbuckle Mountains. This belt is characterized by synclinal and anticlinal flexures whose axes trend chiefly in easterly and northeasterly directions. The county lies also in the southern part of a system of subparallel faults,[109] trending in general east-northeastward, through several Oklahoma counties on the southern and western flanks of the Ozark dome.

The folds lie roughly en echelon and only one of them extends entirely across the county. Eastern Haskell County is crossed by six major folds. From south to north they are: Sansbois syncline, Milton anticline, Cowlington syncline, Whitefield uplift, Stigler syncline, and Lone Star anticline. The folds in western Haskell County are from south to north as follows: Panther Mountain syncline, Kinta anticline, Russellville syncline, Enterprise anticline, (western part of the Whitefield uplift), Brooken Creek syncline, and an unnamed ill-defined westward plunging anticlinal feature immediately south of Canadian River in the vicinity of Brooken.

* U. S. Geol. Survey age assignment of Woodford chert is "Devonian?".

109. Miser, Hugh D., "Geologic Map of Oklahoma": *U. S. Geol. Survey*, 1926.

Within most of the large anticlinal structures and in the Stigler and Cowlington synclines there are a number of large faults and many subordinate flexures and faults. These are especially numerous on the complex feature here called the Whitefield uplift. The Sansbois and Panther Mountain synclines, on the other hand, are relatively simple in structure; the only faults found are too small for representation on the map. The faults, in general, trend nearly parallel with the axes of the major folds, but the Mudlark fault lies diagonally across the Stigler syncline and the Whitefield uplift.

Sansbois syncline. The Sansbois syncline is a broad basin-like feature centering in Sansbois Mountain, south of McCurtain and Lequire. Strata in the upper part of the Boggy formation form high, mesa-like outliers along its axis across T. 7 N., Rs. 21 and 22 E. Along the northern and southern limbs long hogbacks and valleys are formed by outcropping sandstones and shales of the Boggy and Savanna formations, which dip at moderately steep angles inward toward the axis.

Milton anticline. The Milton anticline extends into Haskell County from northwestern Le Flore County. Its northern flank occupies part of T. 9 N., R. 23 E. and the axis enters Haskell County across the SE¼ sec. 13, T. 8 N., R. 22 E., plunging southwestward to a saddle in sec. 29 about 2 miles southwestward from McCurtain. Thence it rises southwestward to a dome in secs. 29 and 31, T. 8 N., R. 22 E. and continues westward to the vicinity of Lequire and beyond. The Lequire sandstone member of the McAlester formation occupies the saddle southwest of McCurtain and older strata crop out along the axis both westward and eastward. The upper part of the Atoka formation is exposed at the Le Flore-Haskell County line.

In the vicinity of the southwest corner of sec. 1, T. 7 N., R. 20 E., 3 to 4 miles westward from Lequire, the axis of the Milton anticline is lost in an area of relatively low southward dips on the south flank of the Kinta anticline. However, the area of relatively steep dips characteristic of the south flank of the Milton anticline and the north limb of the Sansbois syncline extends southwestward beyond the Haskell-Latimer County line.

The Milton anticline is somewhat complicated by faulting, especially near its crest. Only the larger faults are shown on the map but many others are present, some with displacements of 20 feet or more. Such small faults cut the Hartshorne coal in all the mines near McCurtain, and cause much trouble in mining the coal. Both normal and reverse faults are present. The normal faults, among which are the largest on the anticline, seem to be steeply inclined, whereas the reverse faults have relatively small vertical displacements and are inclined at low angles. A large normal fault, downthrown to the south, seems to originate in sec. 11, T. 7 N., R. 20 E. on the south flank of the anticline, crosses the crest in sec. 34, T. 8 N., R. 21 E., reaches a displacement of about 500 feet at the west line of sec. 30, T. 8 N., R. 22 E., and is believed to die out in the area immediately north of McCurtain. A relatively large normal fault, downthrown to the south, crosses the crest of the Milton anticline in the SE¼ sec. 31 T. 8 N., R. 21 E., extends along the north flank, and appears to terminate in the NW¼ sec. 30, T. 8 N., R. 22 E. Another normal fault, downthrown to the south, crosses the Le Flore-Haskell County line about the center of the east side of sec. 13, T. 8 N., R. 22 E., where it has a displacement of about 500 feet, reaches a maximum displacement of about 600 feet at Bald Knob, a mile north of McCurtain, and appears to die out in sec. 20, T. 8 N., R. 22 E. From this fault a small normal fault, downthrown to the south, branches westward in sec. 13 and dies out near the center of sec. 14, T. 8 N., R. 22 E. Two small faults in sec. 28, T. 8 N., R. 22 E. trending westward and upthrown to the south, are believed to be reverse faults.

Panther Mountain syncline. The Panther Mountain syncline is nearly in alinement with the Cowlington syncline but is separated from it by an area several miles wide in which the southward dip, though relatively low, is continuous from the south limb of the Kinta anticline across the south part of T. 8 N., R. 20 E., and north part of T. 7 N., R. 20 E., to the north limb of the Sansbois syncline,

where the southward dip is much greater. Only the northeast end of the Panther Mountain syncline lies in Haskell County; the syncline extends about 13 miles southwestward into Pittsburg County. Tucker Knob, in Haskell County, and Panther Mountain, in Pittsburg County, are typical synclinal hills lying along the axis. Strata from the upper part of the McAlester formation through the Savanna formation to the top of the Bluejacket sandstone member of the Boggy formation are exposed in the north limb of the syncline along State Highway 2; and Tucker Knob, immediately east of the highway, contains beds probably as high as No. 4 zone of Dane and others[110] in the Boggy formation. The Secor coal should crop out around the lower part of Tucker Knob but was not found. Both the Stigler and Hartshorne coals should be present in the subsurface. The Hartshorne coal lies about 1,800 feet below sea level in the lowest part of the syncline in Haskell County and deeper to the west in Pittsburg County.

Cowlington syncline. The Cowlington syncline, broad and shallow, and asymetrical, enters Haskell County at the northeast corner; there it crosses Arkansas River, and extends southwestward into the central part of T. 8 N., R. 21 E., north of Lequire. It is deepest northwest of Star, in the south part of T. 10 N., R. 23 E., where shale above the Bluejacket sandstone member of the Boggy formation is present as an outlier. From that locality the axis rises southwestward, and older strata are at the surface. The Savanna formation crosses the axis 1½ miles west of Keota and the Keota sandstone member of the McAlester formation forms high, mesa-like outliers southwestward into T. 8 N., R. 21 E. The steepest dips observed are near Arkansas River, on the northwest limb of the syncline, which is bounded there and farther southwestward by a faulted belt related to the Whitefield uplift. In general, the strata on the broad southeast limb of the syncline dip gently northwestward away from the Milton anticline. Between Keota and the Le Flore-Haskell County line, however, the structure of this part of the syncline is slightly modified by faulting and gentle subsidiary folding. A fault, downthrown to the south, crosses State Highway 9 near the Le Flore-Haskell County line, at the northeast corner sec. 13, T. 9 N.,

110. Dane, C. H. and others, "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field;" Part 3, "Quinton-Scipio District": *U. S. Geol. Survey Bull.*, 874-C, Map, Pl. 12, 1938.

R. 23 E. and bifurcates farther westward. One branch dies out east and the other northeast of Keota. There is a gentle structural undulation on the southeast limb of the Cowlington syncline in the southeast part of T. 10 N., R. 23 E. which is expressed in outcrops of the Savanna formation as a small, shallow subsidiary syncline trending northeastward, with a low anticline between it and the main synclinal axis to the north.

Kinta anticline. The Kinta anticline trends slightly north of east and is about 24 miles long. Its eastern half lies in Haskell County, the western half in Pittsburg County, and the axis passes through the town of Kinta, Haskell County. In both counties there are few sections of land along the axis that have not produced gas. The highest part of the anticline is near its eastern end, in Haskell County, where the Hartshorne coal lies about 200 feet below sea level; and from that locality it plunges westward till the Hartshorne coal lies about 2,000 feet below sea level in sec. 23, T. 7 N., R. 16 E. in Pittsburg County.

In its highest part, near Kinta, in Haskell County, the Kinta anticline is marked by a broad level prairie rimmed by bold outcrops of the Lequire sandstone member of the McAlester formation. These outcrops cross the axis in sec. 5, T. 7 N., R. 19 E. and in secs. 24 and 26, T. 8 N., R. 20 E. Farther west, in Pittsburg County, outcrops of the Savanna formation and the lower members of the Boggy formation are successively present. The Kinta anticline does not seem to be cut by faults at the surface, but Colton[111] thought he found evidence of two faults cutting the gas-producing horizon, the Hartshorne sandstone, north of the axis.

Russellville syncline. The Russellville syncline lies immediately north of the Kinta anticline. The axis of the syncline is markedly sinuous. In general it plunges westward, but in the northeast part of T. 8 N., R. 18 E. there is a closed synclinal depression with about 100 feet of structural relief on the Hartshorne coal. At the eastern end of the Russellville syncline, on the east side of T. 8 N., R. 20 E., Haskell County, the Hartshorne coal lies about 500 feet below sea level. At the deepest part in western Haskell County the Hartshorne

111. Colton, Earl G., "Natural Gas in Arkansas Basin of Eastern Oklahoma" in "Geology of Natural Gas", edited by Ley, Henry A.: *Amer. Assoc. Petrol. Geol.*, pp. 520-524, 1935.

coal is about 1,700 feet below sea level and at the western end of the syncline in T. 8 N., R. 17 E., Pittsburg County, it is estimated to be no more than 1,900 feet below sea level. The Stigler coal crops out along the south side, around the east end, and along the northeast side of the syncline.

At the surface the extreme eastern end of the syncline is occupied by upper beds of the McAlester formation and by the Savanna formation but the major part of the syncline is occupied by strata in the lower part of the Boggy formation. The Bluejacket sandstone member of the Boggy formation forms a conspicuous escarpment within the syncline facing up dip toward the southeast, east, and northeast. The central part of the syncline contains outcrops of the Secor coal and higher units of the Boggy formation.

At its eastern end the Russellville syncline is separated from the Cowlington syncline by a structurally flat area or saddle. The north flanks of the Russellville and Cowlington synclines are continuous and relatively steep, and mark the south side of a structurally high area which is here called the Whitefield uplift.

Whitefield uplift. The Whitefield uplift occupies a wide belt lying between the Russellville and Cowlington synclines on the south and the Brooken Creek and Stigler synclines on the north. The north side of the Whitefield uplift is structurally less steep than the south side and less well defined, because the Brooken Creek syncline seems to terminate about the middle of the east side in T. 9 N., R. 18 E. and the Stigler syncline seems to terminate in the northwest part of T. 9 N., R. 20 E., and the area between is largely covered by Quaternary (?) terrace deposits and Recent alluvium. The Whitefield uplift extends entirely across Haskell County in a general northeasterly direction.

The Whitefield uplift, though broadly anticlinal, includes several smaller folds and some faults. Named subsidiary features include: Enterprise anticline, Pruit Valley anticline, Shropshire Valley anticline, Comco syncline, Kanima syncline, Round Prairie dome, Beller Mountain graben, Antioch anticline, Quinine Flats anticline, Red Hill syncline, Garland fault, Saylor Bottom syncline, Chickasaw Flats anticline, and Tamaha anticline. The oldest strata exposed belong to the Atoka formation which crops out at

Round Prairie in secs. 33 and 34, T. 10 N., R. 22 E. The combined upper and lower Hartshorne coal beds also crop out in secs. 30 and 31, T. 9 N., R. 21 E. On the west side of Haskell County, in sec. 18, T. 8 N., R. 18 E., the Hartshorne coal lies about 1,200 feet below sea level on the highest part of the uplift in that area. The outcrop of the Savanna formation crosses the uplift in the southwest part of T. 9 N., R. 20 E. and the central part of T. 9 N., R. 19 E., and farther west beds of the Boggy formation are at the surface on the uplift. The rocks most extensively exposed on the uplift, however, belong to the McAlester formation. The Warner and Lequire sandstone members of the McAlester formation crop out over many square miles from southwest of Stigler to the east side of T. 10 N., R. 22 E. but give place in prominence farther northeastward to the Tamaha sandstone member.

Enterprise anticline. The Enterprise anticline occupies the western end of the Whitefield uplift. The axis extends from sec. 18, T. 8 N., R. 18 E. to sec. 19, T. 9 N., R. 19 E. At the surface the Savanna formation crosses the eastern end of the anticline but the major part of the anticline is occupied by strata in the lower part of the Boggy formation, below the Bluejacket sandstone member.

Both the Stigler coal and the Hartshorne coal should be present beneath the surface on this anticline, the latter at depths ranging from 500 feet below sea level to 1,200 feet below sea level.

Complications of faulting, sharp change in strike of the rocks, and a cover of Pleistocene (?) sand and gravel in the area southwest of Hoyt, conspire to obscure the northeast end of the Enterprise anticline, so that it cannot be delineated beyond sec. 19, T. 9 N., R. 19 E.

Features near Whitefield. A large part of the area of the Whitefield uplift in T. 9 N., R. 19 E. is covered by Quaternary (?) terrace deposits and by Recent alluvium. Such outcrops as are present, however, indicate the general structure to be substantially as shown by the broken contours on the structure map.

The structure of the Whitefield uplift is complicated in the south part of T. 9 N., R. 20 E. by a set of at least three step faults; the downthrow side of each is to the south. The most southerly of these faults cuts and repeats the Warner sandstone member of the McAlester formation and extends along the northwest flank of the Pruit Valley anticline.

From the vicinity of Stigler northeastward the Whitefield uplift is more complex and contains a number of minor anticlines and synclines as well as several faults.

Pruit Valley anticline. The faulted Pruit Valley anticline lies south of Stigler along Pruit Valley in the southwest part of T. 9 N., R. 21 E. and extends westward across the southeast part of T. 9 N., R. 20 E. The north limb of this structure forms a broad dip slope in the Warner sandstone member of the McAlester formation both eastward and westward from the vicinity of the Stigler reservoir, sec. 20, T. 9 N., R. 21 E., and is cut by the fault mentioned above; but the south limb is largely replaced by a fault downthrown on its south side which passes across secs. 29 and 31, T. 9 N., R. 21 E.

The Hartshorne sandstone crops out in secs. 30 and 31, adjacent to this fault.

Shropshire Valley anticline. The Shropshire Valley anticline is faulted but so far as is known its axis extends from the southeast part of sec. 31, T. 9 N., R. 21 E. in a northeasterly direction to sec. 25, T. 9 N., R. 21 E. where the anticline terminates in a small dome that has its apex in an elongate inlier of the McCurtain shale member of the McAlester formation.

Comco syncline. The Comco syncline is a gentle synclinal flexure within the broad extent of the combined Lequire-Warner sandstone unit of the McAlester formation, east of Stigler. It plunges both eastward and westward from the vicinity of Comco siding, near the W¼ corner sec. 14, T. 9 N., R. 21 E. This syncline is marked by three long, low, mesa-like outliers of the Lequire sandstone member, in the easternmost of which the Lequire rests on and coalesces with the Warner sandstone member, the shale that normally lies between them being absent.

The Lequire member likewise rests upon the Warner member across the SE¼ of sec. 19, T. 10 N., R. 22 E., and it thus seems that the sandstone at the surface east of a line connecting these points should be called the combined Lequire and Warner sandstone unit.

The absence of the shale between the Warner and Lequire sandstone members indicates that between Warner and Lequire time this portion of the Whitefield uplift was near or above sea level, so that this shale either was not deposited, or was removed by erosion prior to deposition of the Lequire sandstone. In the course of subsurface studies along the Kinta anticline the same shale member was found to be notably thin over the highest part of the anticline.

Kanima syncline. The Kanima syncline is a basin-like structural depression centered in an area of Tamaha sandstone in secs. 7 and 8, T. 9 N., R. 22 E., and is reflected in a belt of outcrop of the Lequire-Warner sandstone unit that forms a wide arc in secs. 4, 5, and 6, T. 9 N., R. 22 E. and in secs. 12 and 13, T. 9 N., R. 21 E.

Round Prairie dome. The Round Prairie dome is a faulted anticline in the south part of T. 10 N., R. 22 E. Its axis crosses the SE¼ sec. 33 and extends northeastward to the fault in the north part of sec. 34, where it is offset a short distance westward, and thence continues to another fault slightly west of the N¼ corner of sec. 26. The apex of the dome lies in the little valley known as Round Prairie, and the Lequire-Warner sandstone unit of the McAlester formation crops out in prominent ridges around the margins. Poorly exposed beds at the top of the Atoka formation come to the surface in the central part, in a small area along the north side of the fault. The Hartshorne sandstone forms a low hogback north of this Atoka outcrop and also crops out south of the fault as an inlier, elongate in a northwesterly direction. The Hartshorne coal has been mined to a limited extent at several places. The dips on the northwest side of the dome are relatively low, but on the southeast side the Lequire-Warner sandstone unit dips as high as 9 degrees.

Beller Mountain graben. The Beller Mountain graben is a shallow synclinal graben well indicated by outcrops of Tamaha sandstone which forms Beller Mountain. The axis extends northeastward across secs. 28 and 22, T. 10 N., R. 22 E. The north fault passes eastward through the north part of sec. 22 and northeastward across secs. 14 and 13 toward Arkansas River. The south fault passes northeastward across secs. 28, 27, 23, and 24, T. 10 N., R. 22 E. The Stigler coal crops out around the west end and along part of the south side of the syncline, and the Hartshorne coal should be found at sea level to 300 feet above sea level.

Antioch anticline. The axis of the Antioch anticline extends from near the W¼ corner sec. 15, T. 9 N., R. 21 E. northeastward past Antioch school house, 3 miles east of Stigler on State Highway 9, and terminates at a fault near the northeast corner of the same township. It is well expressed in outcrops of the Lequire and Warner sandstone members of the McAlester formation along State Highway 9 and along a graveled road leading northward from Comco siding, on the Midland Valley Railroad, toward the strip pits at Garland. The strata dip at relatively low angles in all parts of the anticline. Its northwest limb is practically continuous with the northwest limb of the Quinine Flats anticline. The fault which is here considered to terminate the Antioch anticline northward is downthrown on the south side and crosses the north part of secs. 1 and 2, T. 9 N., R. 21 E. It extends northward and eastward across secs. 31, 32, 33, and 34, T. 10 N., R. 22 E., being the same fault mentioned above as intersecting the axis of Round Prairie dome.

Quinine Flats anticline. The Quinine Flats anticline is, in a sense, a continuation of the Antioch anticline, their north flanks being continuous. Its axis probably follows a sinuous course from the fault near the S¼ corner of sec. 30, to the southwest part of sec. 11, T. 10 N., R. 22 E. The anticline is low and plunges northeastward toward the Saylor Bottom alluvial plain. It is well expressed in outcrops of the Tamaha sandstone member of the McAlester formation on the north and south sides of an area of bottom land on Little Sansbois Creek known as Quinine Flats. Southwestward from Quinine Flats the anticline is believed to pass into a broad expanse of the Lequire-Warner sandstone unit within which, in the W½ of sec. 21, T. 10 N., R. 22 E., an inlier of the McCurtain shale member is brought to the surface. The anticline is believed to terminate against the fault already described in the south part of sec. 30, T. 10 N., R. 22 E. Near this fault, at the west line of sec. 36, T. 10 N., R. 21 E., the Lequire sandstone member dips 27° northwestward but elsewhere on the anticline the strata dip, generally, at low angles.

Red Hill syncline. The Red Hill syncline lies between the Quinine Flats anticline on the north and the Beller Mountain synclinal graben on the south. Its axis passes southwestward from Saylor Bottom through secs. 14 and 15, T. 10 N., R. 22 E., to the neighborhood of Red Hill store. It is well expressed in outcrops of the Tamaha sandstone member of the McAlester formation which generally dips at low angles. However, a dip of 10° was observed at one place on the southeast limb, at the west line of sec. 14.

Garland fault. The Garland fault trends northeastward across the north part of sec. 27, T. 10 N., R. 21 E., southwest of Garland. It cuts outcrops of the Tamaha, Keota, and Cameron sandstone members of the McAlester formation, offsetting them eastward on its north or downthrow side. It lies within a low, westward plunging anticlinal flexure, to the south of which lies a shallow syncline.

Saylor Bottom syncline. The Saylor Bottom syncline lies immediately north of Little Sansbois Creek. Its axis extends in a northeasterly direction from sec. 7, T. 10 N., R. 22 E. to the alluvial plain, known as Saylor Bottom, which borders the Arkansas River, The axis is gently undulatory with the highest points at the line between secs. 7 and 8, and near the center of sec. 9. Between these two localities a slightly depressed segment of the axis is marked by a group of mesa-like outliers of the Tamaha sandstone member of the McAlester formation and another such depression of the axis extends in a northeasterly direction from sec. 9, to Saylor Bottom.

Chickasaw Flats anticline. The Chickasaw Flats anticline occupies the nearly level tract of land known as Chickasaw Flats, south of Tamaha. Its axis extends in a northeasterly direction from the north part of sec. 7, T. 10 N., R. 22 E. to the Mudlark fault in the SE¼ sec. 33, T. 11 N., R. 22 E. It is a low anticline and the observed dips are also low.

Tamaha anticline. The Tamaha anticline is low and is expressed in outcrops of the Lequire-Warner sandstone unit of the McAlester formation just south of Tamaha. The axis extends from the Mudlark fault in the SE¼ sec. 32, northeastward to Arkansas River in the SW¼ sec. 27, T. 11 N., R. 22 E. Dips are low everywhere on the anticline except in the vicinity of the Mudlark fault, which cuts off the anticline on its south side, where southward dips of 8° were observed in one locality. The Chickasaw Flats and Tamaha anticlines have the appearance of a single anticline, with the axis offset about a mile along the Mudlark fault.

Brooken Creek syncline. The Brooken Creek syncline is a broad structural feature in western Haskell County. Its axis extends from west to east approximately through the middle of T. 9 N., R. 18 E. Along the south flank, well down toward the axis, is a narrow zone along which the beds are disturbed and show erratic dips, suggesting faulting, but except in sec. 24, the beds are not noticeably offset anywhere in T. 9 N., R. 18 E. This is thought to be the westward extension of the northern one of two faults that cut and offset beds in the Savanna formation in sec. 18, T. 9 N., R. 19 E. Because of this faulting and the cover of Quaternary (?) terrace material and Recent alluvium, the Brooken Creek syncline is not delineated farther east than the east line of T. 9 N., R. 18 E. It appears to be roughly in alinement with the Stigler syncline to the northeast and their south flanks seem to be continuous.

Stigler syncline. The axis of the Stigler syncline is known to extend in a northeasterly direction from sec. 4, T. 9 N., R. 20 E., northwest of Stigler, to sec. 30, T. 11 N., R. 22 E., near Arkansas River. It appears to be roughly in alinement with the axis of the Brooken Creek syncline, farther west. The intervening outcrops are covered by Quaternary (?) terrace material and Recent alluvium.

This long structural trough is asymmetrical, with steep dips on the northwest limb and with a broad southeast limb formed of strata dipping gently northwestward. The deepest part of the trough lies southeast of Jackson Creek, near Mudlark schoolhouse, and is marked by Jackson Mountain, a long, high, mesa-like outlier of the Bluejacket sandstone member of the Boggy formation. Toward this outlier the syncline plunges from areas underlain by older strata in both directions along its axis. The axis crosses the Boggy-Savanna contact in sec. 25, T. 10 N., R. 20 E., southwest of Perry, and in sec. 11, T. 10 N., R. 21 E., southwest of Mt. Olive schoolhouse.

The Mudlark fault, long and sinuous, passes in an easterly direction across the syncline roughly along the line between Tps. 10 and 11 N., in Rs. 21 and 22 E. From it another fault branches off in sec. 3, T. 10 N., R. 21 E., crosses the axis of the Stigler syncline, in sec. 2, and dies out to the southeast. The area between these two faults is a graben in which the axis of the syncline plunges northeastward and is offset about a third of a mile westward. Exposed beds are offset in the same direction. Beyond the graben the axis of the syncline continues northeastward along Briar Creek, where the exposed bedrock is shale of the McAlester formation. The axis bifurcates in sec. 30, T. 11 N., R. 22 E., giving the northeast end of the Stigler syncline a blunt, square-cornered appearance, and strata of the McAlester, Hartshorne, and Atoka formations are brought to the surface along the south side of the Arkansas River. At the north line of sec. 19, T. 11 N., R. 22 E., a fault striking eastward and dipping 55° S., with its downthrow on the south side, is well exposed in outcrops of the Atoka formation on the south bank of the Arkansas River. The Atoka beds immediately north of this fault dip gently southward, but are essentially horizontal a few hundred feet farther north.

Lone Star anticline. The Lone Star anticline extends in a northeasterly direction along the southeast side of the Canadian River. Its axis emerges from the alluvium of Canadian River in sec. 27, T. 10 N., R. 20 E., extends northeastward to a fault in sec. 3, T. 10 N., R. 21 E., where it is offset about a mile to the west, whence it resumes a northeasterly course to the alluvium of the Arkansas River in sec. 12, T. 11 N., R. 21 E.

The anticline is asymmetrical in cross-section, with its steeper limb on the southeast side, adjacent to the Stigler syncline. The northwest limb, which is largely concealed by alluvial deposits of the Canadian River, merges with the broad southeast limb of the Porum syncline, northwest of the Canadian River, beyond the limits of Haskell County. North of the Mudlark fault, which cuts across the anticline in the north part of T. 10 N., R. 21 E., the Atoka formation crops out in a broad belt within the anticline and is upthrown along the fault into contact with the McAlester formation, which is the oldest formation exposed in the anticline south of the fault.

Branching northward from the Mudlark fault in the NE¼ sec. 3, T. 10 N., R. 21 E., another fault, having a smaller displacement and with the strata downthrown on its east side, parallels the anticlinal axis of the Lone Star anticline in the area of outcrop of the Atoka formation for a distance of about 1½ miles, and dies out in sec. 26, T. 11 N., R. 21 E. A fault which may be an offshoot of this branch is exposed in the ditch north of the road in the SE¼SW¼ sec. 26, with strike N. 35° E. and dip 50° E. The presence of strata adjacent to the fault plane that dip steeply eastward on its east side probably indicates drag upon the fault and suggests that the downthrow is on that side. The amount of displacement is not known but is probably small. The meager data obtainable from the poor exposures along the fault in sec. 24, T. 11 N., R. 21 E. suggest that the downthrow is on the east side.

The Lone Star anticline probably extends westward into the Muskogee-Porum district, beyond the limits of Haskell County, and may be represented there by the anticline mapped by Wilson in sec. 29, T. 10 N., R. 20 E.

Mudlark fault. The Mudlark fault is an important structural feature of Haskell County. It takes its name from Mudlark schoolhouse in sec. 9, T. 10 N., R. 21 E. The fault is sinuous in its course but extends in general northeastward from Mudlark schoolhouse across several structural features to the alluvium of the Arkansas River in sec. 34, T. 11 N., R. 22 E. Southwestward it passes beneath the alluvium of Canadian River in sec. 12, T. 10 N., R. 20 E. Comparison of the structure and stratigraphy south of the Canadian River in Haskell County with that north of the river in Muskogee County leads to the conclusion that a fault of considerable magnitude separates the two areas, and strongly suggests that the Mudlark fault may pass beneath the alluvium of the Canadian River and Quaternary (?) terrace deposits west of Whitefield and connect with a fault which is likewise downthrown on the south in the NE¼ sec. 15, T. 9 N., R. 19 E., Haskell County. This fault probably dies out in sec. 30, T. 9 N., R. 19 E.

ECONOMIC GEOLOGY

Coal

Haskell County lies within the Arkansas-Oklahoma coal field where valuable coal beds occur in formations of Pennsylvanian age, as described in several publications of the United States and the Oklahoma Geological Surveys.[112] Several beds, all irregular in thickness, crop out in the county. Of these beds the Hartshorne, Stigler, and Secor are the only ones of commercial importance. The Cavanal coal in the Savanna formation, the coal in the lower shale member of the Boggy formation, and several other unnamed beds are less than 14 inches thick at all of their exposures that have been examined, and so are of small value.

The production of coal in Haskell County from 1908 to 1943, inclusive, was approximately 3 million short tons and most of this production came from the east half of the county. At most places where coal beds should crop out, the coal is concealed by soil or alluvium and is rarely seen in natural exposures. Sections of the coal beds in numerous drill holes, mines, and prospects are given in the following tables.

112. 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, pp. 257-311, 1900.
Taff, J. A., "Geologic Atlas of the United States": *U. S. Geol. Survey, Coalgate Folio* (No. 74), 1901.
Wilson, C. W., Jr., and Newell, Norman D., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, 1937.
Taff, Joseph A., "Maps of Segregated Coal Lands in the Indian Territory with Descriptions of the Unleased Segregated Coal Lands": *U. S. Department of the Interior, Circulars*, 1904: "McAlester District, Choctaw Nation," *Circular* 1; "Wilburton-Stigler District, Choctaw Nation," *Circular* 2; "Howe-Poteau District, Choctaw Nation," *Circular* 3; "McCurtain-Massey District, Choctaw Nation," *Circular* 4; "Lehigh-Ardmore Districts, Choctaw and Chickasaw Nations," *Circular* 5; "Unleased Segregated Asphalt Lands, Chickasaw Nation," *Circular* 6. Also in *U. S. 61st Cong. 2nd Sess. Senate Doc.* 390, pp. 125-374, 1910.
Shannon, C. W. and others, "Coal in Oklahoma": *Okla. Geol. Survey Bull.* 4, 1926.
Cooper, C. L., Fieldner, A. C., and others, "Analyses of Oklahoma Coals": *U. S. Bureau of Mines Technical Paper* 411, 1928.
Moose, Joe E. and Searle, V. C., "A Chemical Study of Oklahoma Coals": *Okla. Geol. Survey Bull.* 51, 1929.
Hendricks, T. A., Knechtel, M. M., Dane, C. H., Rothrock, H. E. and Williams, J. S., "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field": *U. S. Geol. Survey Bull. 874-A, 874-B, 874-C, 874-D*, 1937-1939.

Much of the most easily mined coal in the county is beneath segregated land of the Choctaw and Chickasaw Nations (Pl. II, in pocket) and mining rights may be leased or bought through the Office of Indian Affairs, U. S. Department of the Interior, at Muskogee, Oklahoma.

HARTSHORNE COAL

Character. Coal of the Hartshorne bed as sampled near McCurtain and in a small stripping in sec. 30, T. 9 N., R. 21 E., is medium-volatile bituminous coal with low percentages of ash and sulfur.

Carbonization tests by the Bureau of Mines, United States Department of the Interior, in cooperation with Oklahoma Geological Survey,[113] show that the low- and medium-volatile bituminous coal of the Hartshorne beds, in Haskell and Le Flore Counties, if blended with high-volatile coal of the McAlester bed in Pittsburg County, is suitable for use in manufacturing metallurgical coke. When coked alone in beehive ovens as was done 40 or 50 years ago at McCurtain (Frontispiece) the Hartshorne coal yields coke of good mechanical strength, but it expands to such extent that it would rupture modern byproduct ovens. On the other hand much of the high-volatile bituminous coal of areas farther west in Oklahoma contracts in coking and yields coke low in mechanical strength and unfit for blast-furnace use. The carbonization tests demonstrate that correct blends of coal from the two sources can be coked satisfactorily in byproduct ovens to yield satisfactory blast-furnace coke. Medium-volatile bituminous coal of the Hartshorne bed mined in sec. 20, T. 8 N., R. 22 E., near McCurtain, and high-volatile coal from the McAlester bed at Carbon, Pittsburg County, have been supplied to the coke oven of the Lone Star Steel Corporation at Daingerfield, Texas, and to the coke oven of the Sheffield Steel Company's plant at Houston, Texas.

At many places the Hartshorne coal bed consists of two benches of coal separated by a shale parting a few inches thick. These benches represent the Upper and Lower Hartshorne coal beds,

113. Davis, J. D. and others, "Carbonizing Properties of Western Region Interior Province Coals and Certain Blends of These Coals": *U. S. Bureau of Mines Technical Paper* 667, 1944.

which in some other parts of the McAlester basin are separated by as much as 60 feet, or more, of shale and sandstone.

Mining. There have been a few strip-mining operations on the Hartshorne bed at Round Prairie, Pruit Valley, and in sec. 20, T. 11 N., R. 22 E., but the major operations have been in the vicinity of McCurtain, where there have been both strip and slope mines on a westward plunging part of the Milton anticline. Here the coal at most places is 3 to 5 feet thick.

Extent. The Hartshorne coal bed is probably present beneath all of Haskell County except a few relatively small areas where it has been removed by erosion. The largest of these areas are on the Milton anticline, east of McCurtain, and on the Lone Star anticline in Tps. 10 and 11 N., Rs. 21 and 22 E. Smaller ones are in sec. 36, T. 9 N., R. 23 E., southeast of Cartersville; on the Pruit Valley anticline in secs. 30 and 31, T. 9 N., R. 21 E.; and on the Round Prairie dome in secs. 33 and 34, T. 10 N., R. 22 E.

Two large faults are present on the Milton anticline in the vicinity of McCurtain and divide the outcrop of the Hartshorne bed into three parts, which were formerly supposed to represent three separate beds. The miners refer to these parts as the outcrops of "Nos. 1, 2 and 3 veins", as they are entered respectively by Sans-bois Coal Company's Nos. 1, 2, and 3 mines, and it is therefore convenient to refer to them as "outcrops" 1, 2 and 3.

Outcrop 1, which crosses State Highway 31, about 1 mile west of McCurtain, is marked by a hook-shaped belt of small abandoned strip mines in sec. 21, T. 8 N., R. 22 E., lying across the crest of the Milton anticline on the north or upthrow side of the large fault that extends southwestward past Lequire into the northeast part of T. 7 N., R. 20 E.

Outcrop 2 extends westward from the Le Flore-Haskell County line, closely following the railroad on the steeply dipping south limb of the Milton anticline. At McCurtain this outcrop swings across the crest of the anticline and continues in a northeasterly direction to a fault in sec. 13, T. 8 N., R. 22 E.

Outcrop 3 lies on the north limb of the anticline extending from the NE¼ of sec. 21, T. 8 N., R. 22 E. northeastward to the

Le Flore-Haskell County line, but is interrupted locally by a fault on the north side of Bald Knob, in the vicinity of the SW cor. sec. 15.

The Hartshorne coal is exposed in Pruit Valley, sec. 31, T. 9 N., R. 21 E., on the west side of the road leading south from Stigler, where it has a gentle northward dip. Years ago it was prospected with a hand-operated earth auger and the outcrop was found to extend several hundred feet southeastward. Westward from the strip pit the outcrop was found to bend slightly toward the north.

In sec. 36, T. 9 N., R. 23 E., about 1½ miles southeast of Cartersville, the Hartshorne coal bed crops out on the northeast limb of the Milton anticline. A drill hole immediately east of the Le Flore-Haskell County line showed 2 feet 4 inches of coal and a prospect a few hundred feet south of sec. 35, T. 9 N., R. 23 E. showed 3 feet 3 inches of coal with a thin shale parting 11 inches above the base. However, the coal is reported to have been only 1 foot thick in a diamond-drill hole near the east line of sec. 35.

The Hartshorne coal crops out on Round Prairie dome, where it is 1 foot 7 inches thick in a small strip pit in the south part of sec. 33, T. 10 N., R. 22 E. In a prospect a little farther north, in the same section, the coal is 1 foot 5 inches thick with a half-inch shale parting.

The Hartshorne coal is only 11 inches thick in a small prospect in sec. 20, T. 11 N., R. 22 E., just south of the Arkansas River.

STIGLER COAL

Character. Coal of the Stigler bed as sampled in the northeastern part of Haskell County, is classed as medium low-volatile bituminous. The percentages of sulfur and ash are low from the vicinity of Stigler northeastward to sec. 7, T. 10 N., R. 22 E., but farther northeastward these impurities are present in considerable amount. Though pits have been opened in other parts of the county they have generally produced coal for local use only; most of them are no longer operated, and analyses of the coal are not available. However, inasmuch as most reports agree that the Stigler coal is generally good for forge coal, it is presumed that the percentage of sulfur is low at most places.

Mining. The strip mining operations of the Garland Coal Company between Stigler and Tamaha have produced the greater part of the coal that has been mined from the Stigler bed in Haskell County. A large steam shovel has been used for removing the overburden and a smaller shovel for loading the coal. Formerly it was loaded on railroad cars in the pits and hauled over a company-owned spur to the main line of the Midland Valley Railroad at Stigler. The spur has been abandoned for several years and coal is now hauled about 3½ miles by truck to the main line at Comco siding, near the W¼ cor. sec. 14, T. 9 N., R. 21 E. It is doubtful that the present operation will be continued much longer.

The shovel that has been used could remove economically about 40 feet of overburden. The width of coal stripped along the outcrop varied considerably, depending on the pitch of the coal and the topography.

Possibly as much as a million tons of coal could still be produced by strip mining in the eastern part of Haskell county. Among the more promising areas for further strip mining are those along the outcrops of the Stigler coal in T. 10 N., R. 22 E. However, it is possible that thick deposits of silt, sand, and clay north of Little Sansbois Creek would interfere locally. Strip mining could possibly be done along the belt of outcrop west of Tamaha, secs. 29 and 31, T. 11 N., R. 22 E., and along the outcrop on the southeast limb of the Cowlington syncline, from the vicinity of Keota southwestward. Some of these sites have attracted considerable attention recently on account of the demand for readily minable supplies of railroad steam coal. The geologic and structure maps show areas from which coal had been stripped prior to August 1, 1948.

In western Haskell County the dip along most of the outcrop of the Stigler coal bed is so steep and the topography so rugged as to preclude strip mining except in a relatively narrow band. Also most of the outcrop is so far from transportation facilities as to render strip mining unattractive at the present time. A limited amount of strip mining has been done with horse-drawn equipment from place to place along most of the outcrop, as shown on Plates

I and II. These operations depended for the greater part on the local domestic demand and practically all the pits are now abandoned. In spite of the steep pitch it would no doubt be possible to strip-mine many times the amount of coal that has been so mined to date, if power equipment were used.

Apparently the most promising area for strip mining in western Haskell County is in the S½ of secs. 15 and 16, T. 9 N., R. 20 E., along the road from Stigler to Whitefield. In this area the coal has a relatively low pitch and underlies a dip slope developed on a thin, silty sandstone about 10 feet above the coal, so that the overburden is unusually thin. The coal is exposed in a ravine about ¼ of a mile north of the S¼ corner of sec. 15 and prospecting by hand auger is feasible over most of the area. There is an abandoned strip pit ¼ mile west of the E¼ corner of sec. 15, but little could be learned about the thickness and quality of the coal.

The reserves of Stigler coal for underground mining in Haskell County are much greater than those for strip mining. Natural exposures and prospecting already done, indicate that they deserve to be more thoroughly and systematically explored. At many places in eastern Haskell County the character of the roof and floor as well as the thickness and pitch of the Stigler bed appear to be favorable for economical longwall mining similar to that being done in the Cavanal coal of like thickness near Poteau, Le Flore County. When the need arises it is probable that the Stigler bed can be mined successfully in all parts of the county where it is present, except perhaps in a small area in the deepest part of the Sansbois syncline.

Extent. The Stigler coal bed underlies two broad belts trending east-northeasterly across eastern Haskell County and coinciding roughly in extent with the Stigler and Cowlington synclines. It also underlies certain local synclinal areas on the Whitefield uplift, mostly in T. 10 N., R. 22 E. It underlies a broad area stretching entirely across the south side of the county in the Sansbois and Panther Mountain synclines but the outcrop is covered for the most part by the alluvium of Owl, Turkey, and Sansbois Creeks. The coal was at one time uncovered in prospects at the N¼ cor. sec. 33, T. 8 N., R. 22 E.; on Turkey Creek at the middle of the W½ sec. 5,

T. 7 N., R. 21 E.; in Mountain Fork Creek in the east part of sec. 1, T. 7 N., R. 20 E.; in the NW¼ sec. 4 and the NE¼ sec. 5, and the SE¼ sec. 6, T. 7 N., R. 20 E.; and near the N¼ cor. sec. 12, T. 7 N., R. 19 E. At none of these places could the coal be seen by the writers but it is reported to be 14 to 22 inches thick.

On the southeast limb of the Cowlington syncline the Stigler coal crops out continuously from secs. 20 and 29, T. 8 N., R. 21 E. to the N¼ cor. sec. 17, T. 9 N., R. 23 E., on the south side of State Highway 9, about 1½ miles east of Keota, where it is cut off by a fault. Much of this belt of outcrop has been thoroughly explored by hand auger and power drilling. Drilling has also been done farther east in secs. 9, 10, and 11, T. 9 N., R. 23 E., where the Stigler bed was not found because it had been removed by erosion. The Stigler bed also crops out from a fault west of the center of sec. 12, T. 9 N., R. 23 E. to the Le Flore-Haskell County line.

On the northwest limb of the Cowlington syncline, State Highway 9 crosses a belt of abandoned strip mines in the Stigler coal near the N¼ cor. sec. 18, T. 9 N., R. 22 E. The coal outcrop extends northward nearly a mile and thence northeastward to the alluvium of Sansbois Creek in the NE¼ sec. 3, T. 9 N., R. 22 E. South of State Highway 9 the outcrop turns eastward and extends as far as a fault in sec. 17, T. 9 N., R. 22 E. The position of the outcrop is uncertain in the graben lying between this fault and another to the southeast, but farther south it is marked by a small abandoned strip mine lying athwart the line between secs. 17 and 20, T. 9 N., R. 22 E. Southwestward from this pit the coal is covered by alluvium.

The Stigler coal bed crops out on the northwest limb of the Stigler syncline from sec. 27, T. 10 N., R. 20 E. northeastward across two faults near the north line of that township and to sec. 19, T. 11 N., R. 22 E.; thence the outcrop turns eastward across the syncline and back southwestward along its southeast limb to the Mudlark fault in sec. 31, T. 11 N., R. 22 E., whence it is offset eastward to the SE¼ sec. 32, T. 11 N., R. 22 E. From that point southwestward to the environs of Stigler the outcrop is marked by the abandoned strip mines of the Garland Coal Company.

An area underlain by Stigler coal extends eastward from the Garland Company's working along the axis of the Saylor Bottom syncline to the center of sec. 9, T. 10 N., R. 22 E. The coal pitches gently toward the axis of the syncline. On the south limb, in the flats north of Little Sansbois Creek, the coal is partly buried under a thick deposit of sand and clay, which contains fragmentary coal from the Stigler bed. One streak of this material was so thick locally that it was once mistaken for the Stigler bed and when it was found to pinch out laterally prospecting was abandoned on both limbs of the Saylor Bottom syncline. Consequently the Stigler coal is still available for stripping. Another outcrop of Stigler coal extends along the north limb of the Saylor Bottom syncline northeastward from slightly east of the center of sec. 9, T. 10 N., R. 22 E. The coal pitches toward the axis of the syncline somewhat more steeply than in the eastern area just mentioned. Parts of secs. 14 and 15, T. 10 N., R. 22 E., in the Red Hill syncline, are underlain by the Stigler coal, as are parts of secs. 13, 21, 22, 23, 27, and 28 in the Beller Mountain syncline.

The greater part of western Haskell County is underlain by the Stigler coal bed. The outcrop extends from the western environs of Stigler westward along the north flank of the Whitefield uplift to the vicinity of Whitefield. Thence it swings southward and then southeastward beneath terrace deposits and recent alluvium over the crest of the Whitefield uplift to a faulted area in the SW¼ sec. 24, T. 9 N., R. 19 E. South of this faulted area it extends from near the E¼ cor. sec. 30, T. 9 N., R. 20 E. southeastward into the west part of T. 8 N., R. 21 E., where it swings round the end of the Russellville syncline, and thence extends southwestward to sec. 5, T. 7 N., R. 19 E. where it crosses the Kinta anticline into the Panther Mountain syncline, in the southern part of the County. Along this extensive outcrop there are numerous abandoned strip mines and several abandoned slope mines. A fault through secs. 15, 16, and 17, T. 9 N., R. 19 E. brings the Stigler coal to the surface and it has been found beneath the terrace deposits and Recent alluvium in secs. 9 and 10 in several abandoned strip mines and in drill holes.

SECOR COAL

Character. Dane and others[114] described the Secor coal in T. 8 N., R. 18 E. as being generally 1 foot 6 inches to 2 feet thick and containing, generally, a shale parting 1 to 6 inches thick. Only two strip mines were working in the Secor coal in western Haskell County during the present investigation, and they supplied only a restricted local demand for domestic heating, consequently little was learned about its character. The coal in these two pits is bituminous, relatively hard, seems to contain considerable amounts of calcite and sulfur, and ranges in thickness from 1 foot 7 inches to 1 foot 10 inches, including a 1-inch shale parting 2 inches from the bottom. Residents who have mined the coal for local use report that it may range in thickness from 1 foot 6 inches to 1 foot 10 inches in a single small pit. The Secor is said to burn well; probably its principal use will be as steam coal.

As the result of a diligent search only one exposure of Secor coal was found in southern Haskell County, at a landslide in the Sansbois Mountains near the W¼ cor. sec. 15, T. 7 N., R. 21 E. At this exposure the Secor coal consists of 11 inches of clean coal overlain by 10 inches of shaly coal, the total thickness about 1 foot, 9 inches. It is said that the Secor was formerly exposed in sec. 8, T. 7 N., R. 22 E., and in the course of his work in northern Le Flore County, Knechtel found an outcrop of Secor coal a short distance east of the Le Flore-Haskell County line, where it is 2 feet, 1 inch thick.

The Secor coal has been uncovered in a small prospect in the SW¼ sec. 21, T. 10 N., R. 23 E., where it is only 1 foot thick.

Mining. Coal has been mined from the Secor bed in Haskell County from at least one slope mine and several small strip mines. Some of it was formerly shipped to market over the Fort Smith and Western Railway, now abandoned, and a small amount of "dead" or weathered coal was sold to the zinc smelter formerly operating at Quinton, Pittsburg County. The coal is said to have been used as fuel by the railway. However, no great amount was ever mined and at present it is used only locally as domestic fuel. The most favorable

114. Dane, C. H. and others, "Geology and Fuel Resources of the Southern Part of the Oklahoma Coal Field"; Part 3, "Quinton-Scipio District": *U. S. Geol. Survey Bull.* 874-C, pp. 196-201, 1938.

areas for strip mining are in secs. 9, 16, 15, 14, and 23, T. 9 N., R. 18 E., where the pitch is relatively low and the surface relatively level along the outcrop of the coal.

Extent. The Secor coal underlies six relatively small areas in Haskell County as follows: (1) In the western part of T. 9 N., R. 18 E.; (2) in the northeastern part of T. 8 N., R. 18 E. and the northwestern part of T. 8 N., R. 19 E.; (3) in sec. 33, T. 9 N., R. 19 E.; (4) beneath Tucker Knob, secs. 20 and 21, T. 7 N., R. 19 E. where no exposure was found; (5) in the Sansbois syncline in the south part of the County, T. 7 N., Rs. 20, 21, and 22 E.; (6) in the east end of the Cowlington syncline, secs. 20, 21, 28, and 29, T. 10 N., R. 23 E.

BUILDING STONE

Sandstone is the only available building stone in Haskell County, but there is plenty of it. Dimension stone can be quarried at some places and an abundance of stone suitable for ordinary purposes can be secured in most localities with a minimum of effort. Common uses for such stone are culverts, bridges, barns, foundations, veneer, and spillways for ponds and terraces.

The former abundance of wood in Haskell County and elsewhere and the ease of working it have not fostered the familiarity with stone which was possessed by our forebears from Europe, but the various relief agencies operating throughout the country a few years ago made a start toward reviving the almost forgotten art of working with common stone.

The finer sorts of stone work are rightly classed as skilled trades, but so is carpentry. Farmers and others not classed as specialists have long done the rougher sorts of building in wood, and they can do it likewise in stone. With the passing of the virgin forests wood is no longer cheap, and will be more dear with the passing years. Where stone is close at hand and the work can be done when other tasks are not pressing, the cash outlay may be no more than for the less durable wood. The dampness so often associated with stone buildings can be remedied by waterproofing the work with stucco or even with cement wash applied with a brush. Sandstone commonly has impervious laminae parallel with the bedding and water absorption can be greatly reduced by laying at least the outer course with the bedding vertical.

TABLE II
CHEMICAL ANALYSES OF MINE SAMPLES OF COAL FROM HASKELL COUNTY

LOCALITY, BED, MINE, ETC.	Sample			Proximate				Ultimate					Air-drying loss	Calorific Value		Softening temperature[4]	Bulletin No.[5]
	Laboratory No.[1]	Kind[2]	Condition[3]	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen		Calories	B.t.u.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
ANALYZED BY THE U. S. BUREAU OF MINES																	
McCurtain, 1 mile west of; Sans Bois No. 2 mine, Hartshorne bed (face of 10 south entry, 2,700 feet from mine mouth)	10057	A	1	2.4	19.3	69.5	8.8	1.0	4.6	79.4	1.6	4.6	1.9	7,698	13,840	1,990	22
			2	......	19.7	71.3	9.0	1.1	4.4	81.3	1.6	2.6	......	7,878	14,180	......	
			3	......	21.7	78.3	......	1.2	4.9	89.4	1.8	2.7	......	8,661	15,590	......	
Same (face of 13 south entry, 5,000 feet west of slope mouth).	13688	A	1	2.4	20.8	69.8	7.0	1.2	......	......	......	......	1.7	......	......	2,050	85
Same (face of 3 room, 13 north entry, top side, 5,000 feet west of slope mouth)	13689	A	1	2.6	20.3	71.2	5.9	.8	......	......	......	......	1.8	......	......	2,100	85
Same (face of 11 south entry, 50 feet from slope, 5,000 feet west of slope mouth.)	13690	A	1	3.2	21.8	68.8	6.2	.6	......	......	......	......	2.2	......	......	2,220	85
Same (face of 12 south entry, top side, 5,000 feet west of slope mouth.)	13691	A	1	2.8	20.8	70.6	5.8	.6	......	......	......	......	2.0	......	......	2,180	
Same (neck of 6 room, 12 north entry, top side, 5,300 feet west of slope mouth.)	13692	A	1	2.9	21.4	68.9	6.8	.8	......	......	......	......	2.0	......	......	2,130	85
Same (composite of samples 13688 to 13692, inclusive).	13693	A	1	2.7	21.1	69.8	6.4	.8	4.5	81.3	1.7	5.3	1.9	7,833	14,100	......	85
			2	......	21.7	71.8	6.5	.8	4.3	83.6	1.7	3.1	......	8,050	14,490	......	
			3	......	23.2	76.8	......	.9	4.6	89.4	1.8	3.3	......	8,611	15,500	......	
1 mile northwest of; Blue Ridge No. 3 mine, Hartshorne bed (face of 7 west entry, main slope entry).	W69353	A	1	3.0	22.7	67.0	7.3	.8	......	......	......	......	......	7,661	13,790	......	193
			2	......	23.4	69.1	7.5	.8	......	......	......	......	......	7,900	14,220	......	
Same (face of 6 west entry, main slope entry .	W69354	A	1	3.2	22.4	67.7	6.7	.7	......	......	......	......	......	7,756	13,960	......	193
			2	......	23.1	70.0	6.9	.7	......	......	......	......	......	8,011	14,420	......	
Same (face of 7 east entry, main slope entry).	W69355	A	1	2.4	22.6	67.5	7.5	.8	......	......	......	......	......	7,761	13,970	......	193
			2	......	23.1	69.2	7.7	.8	......	......	......	......	......	7,956	14,320	......	
Same (face of 6 east entry, main slope entry).	W69356	A	1	2.9	22.6	67.1	7.4	.8	......	......	......	......	......	7,750	13,950	......	193
			2	......	23.3	69.1	7.6	.9	......	......	......	......	......	7,978	14,360	......	
1 mile west of; Blue Ridge No. 5 mine, Hartshorne bed (face of 2 west entry, main slope entry).	29839	A	1	3.6	22.5	66.0	7.9	.7	......	......	......	......	3.1	7,650	13,770	2,140	193

TABLE II (Continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Same (face of 3 room, 2 east entry, main slope entry).	29842	A	1	3.4	21.4	68.6	6.6	1.0	......	......	......	......	3.0	7,800	14,040	2,100	193
Same (composite of samples 29839 and 29842)	29844	A	1	3.6	21.8	67.3	7.3	.9	4.8	79.5	1.7	5.8	3.0	7,705	13,870	......	193
			2	......	22.6	69.8	7.6	.9	4.5	82.5	1.7	2.8	......	7,996	14,390	......	
			3	......	24.5	75.5	......	1.0	4.9	89.3	1.9	2.9	......	8,650	15,570	......	
1¼ miles west of; Blue Ridge No. 4 mine, Hartshorne bed (left north rib, 40 feet from face of main slope.)	29840	A	1	2.3	22.8	68.0	6.9	.9	......	......	......	......	1.7	7,800	14,040	2,130	193
Same (face of 4 west entry, main slope entry)	29841	A	1	3.7	22.6	68.7	5.0	1.0	......	......	......	......	3.2	7,906	14,230	......	193
Same (composite of samples 29840 and 29841)	29843	A	1	3.0	22.8	68.2	6.0	1.0	4.8	80.9	1.8	5.5	2.5	7,861	14,150	......	193
			2	......	23.5	70.3	6.2	1.0	4.6	83.4	1.9	2.9	......	8,106	14,590	......	
			3	......	25.0	75.0	......	1.1	4.9	88.9	2.0	3.1	......	8,639	15,550	......	
Same (face of 5 east entry, main slope entry).	W69349	A	1	2.5	23.5	66.5	7.5	.7	......	......	......	......	......	7,728	13,910	......	193
			2	......	24.1	68.2	7.7	.8	......	......	......	......	......	7,928	14,270	......	
Same (face of 4 west entry, main slope entry).	W69350	A	1	3.2	22.7	66.2	7.9	.9	......	......	......	......	......	7,672	13,810	......	193
			2	......	23.4	68.4	8.2	1.0	......	......	......	......	......	7,928	14,270	......	
Same (face of 5 room, 4 east entry, main slope entry).	W69351	A	1	2.6	23.6	67.4	6.4	.8	......	......	......	......	......	7,822	14,080	......	193
			2	......	24.2	69.2	6.6	.8	......	......	......	......	......	8,028	14,450	......	
Same (face of 5 west entry, main slope entry).	W69352	A	1	2.9	22.9	67.8	6.4	.8	......	......	......	......	......	7,778	14,000	......	193
			2	......	23.6	69.8	6.6	.9	......	......	......	......	......	8,011	14,420	......	
1 mile north of; Sans Bois No. 14 mine, Upper and Lower Hartshorne beds (4th west room off old No. 14 main slope, 550 feet west, 50 feet south of NE corner of SE¼ sec. 15, T. 8 N., R. 22 E.)	B88027	A	1	3.6	22.3	69.0	5.1	1.3	5.0	80.5	1.8	6.3	3.1	......	14,200	2,080	U
			2	.5	23.0	71.2	5.3	1.4	4.8	83.2	1.9	3.4	......	......	14,660	......	
			3	......	24.4	75.6	......	1.5	5.0	88.2	2.0	3.3	......	......	15,550	......	
Same (6th east room off east diagonal slope; 25 feet north, 350 feet west of NE corner of SE¼ sec. 15, T. 8 N., R. 22 E.)	B88028	A	1	4.4	22.1	69.1	4.4	1.5	......	......	......	......	3.9	......	14,240	2,110	U
			2	.5	23.0	71.9	4.6	1.5	......	......	......	......	......	......	14,830	......	
			3	......	24.2	75.8	......	1.6	......	......	......	......	......	......	15,610	......	
Same (old pillar of 2nd west room below 1st west entry; 250 feet north, 775 feet west of northeast corner of SE¼ sec. 15, T. 8 N., R. 22 E).	B88029	A	1	3.6	21.8	68.9	5.7	1.2	......	......	......	......	3.1	......	14,090	2,090	U
			2	.5	22.5	71.1	5.9	1.2	......	......	......	......	......	......	14,540	......	
			3	......	24.1	75.9	......	1.3	......	......	......	......	......	......	15,530	......	
Same (Composite of samples B88027 to B88029, inclusive).	B88030	A	1	3.9	22.2	68.9	5.0	1.3	5.0	80.6	1.8	6.3	3.4	......	14,170	......	U
			2	.5	23.0	71.3	5.2	1.4	4.8	83.4	1.9	3.3	......	......	14,670	......	
			3	......	24.4	75.6	......	1.5	5.0	88.5	2.0	3.0	......	......	15,550	......	
1 mile north of; Sans Bois No. 11 mine, Upper and Lower Hartshorne beds (top rib, 4th west panel, 350 feet from slope; 2,400 feet from slope opening).	B23750	A	1	3.4	21.6	66.6	8.4	1.0	......	......	......	......	2.5	......	13,610	......	U
			2	.9	22.2	68.2	8.7	1.0	......	......	......	......	......	......	13,950	......	
			3	......	24.5	75.5	......	1.1	......	......	......	......	......	......	15,420	......	
Same (No. 2 room, lower rib 4, east panel, 350 feet from slope, 2,300 feet from opening).	B23751	A	1	3.4	21.5	68.0	7.1	1.0	......	......	......	......	2.4	......	13,840	2,370	U
			2	1.0	22.1	69.7	7.2	1.1	......	......	......	......	......	......	14,180	......	
			3	......	24.0	76.0	......	1.2	......	......	......	......	......	......	15,450	......	

TABLE II (Continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Same (Composite of samples B23750 and B23751).	B23752	A	1	3.4	21.5	67.5	7.6	1.0	4.8	78.8	1.7	6.1	2.4	......	13,720	......	U
			2	1.0	22.1	69.1	7.8	1.0	4.6	80.8	1.8	4.0	......	......	14,060	......	
			3	......	24.2	75.8	......	1.1	4.9	88.6	2.0	3.4	......	......	15,410	......	
Stigler, 1 mile northeast of; Turner Bros. strip pit, Stigler (McAlester) bed.	17646	A	1	1.5	27.6	67.0	3.9	0.6	......	......	......	......	0.3	8,172	14,710	1,940	123
			2	......	28.0	68.0	4.0	.6	......	......	......	......	......	8,294	14,930	......	
2 miles south of; H. A. Turner strip pit, Hartshorne bed (north end of pit).	26323	B	1	3.8	27.1	66.6	2.5	.6	5.2	83.1	1.9	6.7	3.1	8,133	14,640	2,090	193
			2	......	28.2	69.2	2.6	.7	5.0	86.4	2.0	3.3	......	8,450	15,210	......	
			3	......	29.0	71.0	......	.7	5.1	88.7	2.0	3.5	......	8,678	15,620	......	
3 miles northwest of; sec. 5, T. 9 N., R. 21 E.; strip pit, Stigler bed (face of workings).	30344	A	1	3.1	26.1	66.2	4.6	.7	......	......	......	......	2.1	7,972	14,350	2,050	193
			2	......	26.9	68.4	4.7	.7	......	......	......	......	......	8,228	14,810	......	
3 miles east of; Acme strip pit, Stigler bed (face of coal in pit).	A3085	B	1	3.6	26.9	66.2	3.3	.7	......	......	......	......	2.8	8,056	14,500	2,010	411
			2	......	27.9	68.9	3.4	.8	......	......	......	......	......	8,350	15,030	......	
7 miles northeast of; Garland strip pit, Stigler bed (850 feet north, 350 feet east of SW corner of sec. 26, T. 10 N., R. 21 E.)	B88502	A	1	2.4	25.7	67.0	4.9	.5	......	......	......	......	1.8	......	14,360	2,140	U
			2	.6	26.2	68.2	5.0	.5	......	......	......	......	......	......	14,620	......	
			3	......	27.7	72.3	......	.5	......	......	......	......	......	......	15,490	......	
Same (150 feet north, 25 feet west of SE corner of NW¼, SW¼ sec. 26, T. 10 N., R. 21 E.)	B88503	A	1	2.5	25.8	68.3	3.4	.6	......	......	......	......	1.8	......	14,680	2,150	U
			2	.7	26.3	69.5	3.5	.6	......	......	......	......	......	......	14,950	......	
			3	......	27.5	72.5	......	.6	......	......	......	......	......	......	15,600	......	
Same (125 feet south, 1,020 feet west of SE corner of NW¼ sec. 26, T. 10 N., R. 21 E.)	B88504	A	1	2.8	25.6	67.9	3.7	.7	......	......	......	......	2.2	......	14,640	2,080	U
			2	.6	26.1	69.5	3.8	.7	......	......	......	......	......	......	14,970	......	
			3	......	27.3	72.7	......	.8	......	......	......	......	......	......	15,660	......	
Same (175 feet north, 390 feet east of SW corner of NW¼ sec. 26, T. 10 N., R. 21 E.)	B88505	A	1	2.0	24.9	66.9	6.2	.4	5.0	81.2	1.8	5.4	1.2	......	14,260	2,100	
			2	.8	25.2	67.7	6.3	.5	4.9	82.2	1.8	4.3	......	......	14,440	......	
			3	......	27.1	72.9	......	.5	5.2	88.4	1.9	4.0	......	......	15,540	......	
Same (160 feet north, 1,186 feet west of SE corner of NE¼ sec. 27, T. 10 N., R. 21 E.)	B88506	A	1	2.5	25.1	68.9	3.5	1.0	......	......	......	......	1.8	......	14,690	2,080	U
			2	.8	25.6	70.1	3.5	1.1	......	......	......	......	......	......	14,950	......	
			3	......	26.7	73.3	......	1.1	......	......	......	......	......	......	15,630	......	
Same (Composite of samples B88502 to B88506, inclusive).	B88507	A	1	2.5	25.3	67.9	4.3	.7	5.2	82.4	1.8	5.6	1.8	......	14,530	......	U
			2	.8	25.8	69.0	4.4	.7	5.1	83.9	1.9	4.0	......	......	14,790	......	
			3	......	27.2	72.8	......	.7	5.2	88.5	2.0	3.6	......	......	15,600	......	
Tamaha, 3½ miles from; Floyd Nunnally strip pit, NE¼ sec. 9, T. 10 N., R. 22 E., Stigler bed (at face of pit).	26324	B	1	3.0	21.3	69.6	6.1	3.8	......	......	......	......	2.7	7,933	14,280	2,250	193
			2	......	22.0	71.7	6.3	4.0	......	......	......	......	......	8,184	14,730	......	
SW¼ of sec. 19, T. 11 N., R. 22 E., abandoned Old Slope mine, Stigler bed (near mouth of slope).	30706	A	1	5.5	22.7	64.2	7.6	3.4	......	......	......	......	3.6	7,406	13,330	1,920	193
			2	......	24.0	67.9	8.1	3.6	......	......	......	......	......	7,833	14,100	......	
Whitefield, 1½ miles southwest of; sec. 24, T. 9 N., R. 19 E., Ligon strip pit, Stigler bed (face of workings).	26325	B	1	3.9	29.7	63.9	2.5	1.4	......	......	......	......	2.9	8,072	14,530	2,000	193
			2	......	30.9	66.5	2.6	1.4	......	......	......	......	......	8,400	15,120	......	

TABLE II (Continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
FROM OKLAHOMA GEOLOGICAL SURVEY BULL. 51[6]																	
McCurtain, ¼ mile north of; Stum and Barkley No. 1 mine, Hartshorne bed: Face of 4th east entry, 300 feet from mouth of slope.	168	....	1	4.4	20.6	70.2	4.8	1.3	......	......	......	......	3.1	7,910	14,230	......	
Stigler, 12 miles northeast of; Garland Coal and Mining Co. strip pit, Stigler bed, composite of: Face 300 yards from west end of pit. Face 450 yards from west end of pit.	169	....	1	2.3	24.2	68.5	5.0	0.8	......	......	......	......	1.5	8,000	14,400	......	
Kanima ½ mile east of; Kanima Consolidated No. 1 mine, Stigler bed: Face of main entry, 850 feet from mouth of slope.	170	....	1	2.6	24.9	68.0	4.5	0.6	......	......	......	......	1.9	8,130	14,630	......	

[1] Laboratory numbers with a prefix "W" represent samples analyzed in the Washington laboratory of the bureau; all other Bureau of Mines samples were analyzed at the Pittsburgh laboratory.
[2] A. mine sample collected by an engineer of the Bureau of Mines; B. mine sample collected by a geologist of the U. S. Geological Survey.
[3] 1. Sample as received; 2. dried at 105° C.; 3. moisture and ash free.
[4] Figures in this column represent the temperature at which the cone of coal ash fused to a spherical lump when heated in the furnace in a slightly reducing atmosphere.
[5] Figures in column 18 represent the Bureau of Mines Bulletins (or Technical Paper 411) in which may be found the description of the section of the bed from which the sample was taken. U, indicates an unpublished analysis by the bureau.
[6] Samples were collected by J. E. Moose and W. R. Rutherford, July 3 to 11, 1928. The analytical work was done in the laboratory of the Department of Chemistry, University of Oklahoma.

TABLE III

Measurements of Coal Beds

Column headed Symbol No. refers to numbered symbols for mines, prospects and drill holes on Plate II. * indicates that the measurements were made by field men of the State Mineral Survey, WPA project 65-65-538, sponsored and directed by the Oklahoma Geological Survey, 1936. At that time these workings were open but at the time of the present investigation they were inactive and the coal covered by caving overburden.

Township and Range	Sec.	Symbol No.	Description	Ft.	In.
T. 7 N., R. 19 E.	12	1	Overburden	4	0*
			Coal (Stigler)	1	0
T. 7 N., R. 20 E.	1	1	Overburden	15	0*
			Coal (Stigler)	1	10
T. 7 N., R. 21 E.	15	1	Overburden	20	0
			Coal (Secor, shaly)	0	10
			Coal (Secor, clean)	0	11
T. 8 N., R. 18 E.	1	1	Overburden	8	0*
			Coal (Secor)	2	6
	11	2	Overburden	9	0*
			Coal (Secor)	2	6
	15	3	Overburden	7	0*
			Coal (Secor)	2	8
T. 8 N., R. 19 E.	35	1	Overburden	13	6
			Coal (Stigler)	1	10
		2	Overburden	12	8
			Coal (Stigler)	2	1
	36	3	Overburden	22	7
			Coal (Stigler)	1	6
		4	Overburden	31	6
			Coal (Stigler)	1	4
T. 8 N., R. 20 E.	12	1	Overburden	14	0*
			Coal (Stigler)	1	6
	13	2	Overburden	44	6
			Coal (Stigler)	1	6
		3	Overburden	49	8
			Coal (Stigler)	1	4
	21	4	Overburden	71	6
			Coal (Stigler)	1	5
	22	5	Overburden	55	0
			Coal (Stigler)	1	4
		6	Overburden	29	6
			Coal (Stigler)	1	0
		7	Overburden	65	6
			Coal (Stigler)	1	1
	23	8	Overburden	31	6
			Coal (Stigler)	1	4
		9	Overburden	59	0
			Coal (Stigler)	1	6
		10	Overburden	56	0
			Coal (Stigler)	1	4
	24	11	Overburden	61	9
			Coal (Stigler)	1	2
	28	12	Overburden	6	0
			Coal (Stigler)	1	5
		13	Overburden	7	2
			Coal (Stigler)	1	0
	29	14	Overburden	44	6
			Coal (Stigler)	1	6
		15	Overburden	75	6
			Coal (Stigler)	1	5
		16	Overburden	57	0
			Coal (Stigler)	1	8

Township and Range	Sec.	Symbol No.	Description	Ft.	In.
T. 8 N., R. 20 E.	30	17	Overburden	46	0
			Coal (Stigler)	1	5
		18	Overburden	39	6
			Coal (Stigler)	1	2
T. 8 N., R. 21 E.	18	1	Overburden	46	0
			Coal (Stigler)	1	6
		2	Overburden	32	6
			Coal (Stigler)	1	6
		3	Overburden	22	0
			Coal (Stigler)	1	4
	20	4	Overburden	20	0*
			Coal (Stigler)	1	2
	28	5	Overburden	36	0
			Coal (Stigler)	1	7
		6	Overburden	24	0
			Coal (Stigler)	1	6
		7	Overburden	30	0
			Coal (Stigler)	1	6
	29	8	Overburden	13	0
			Coal (Stigler)	1	8
		9	Overburden	40	6
			Coal (Stigler)	1	6
		10	Overburden	50	0
			Coal (Stigler)	1	6
T. 8 N., R. 22 E.	2	1	Soil	4	
			Shale, gray	9	6
			Shale, blue	16	3
			Coal (Stigler)	1	4½
		2	Soil	4	
			Shale, gray	8	
			Shale, blue	15	
			Coal (Stigler)	1	6
		3	Soil	6	
			Shale, gray	9	
			Shale, blue	21	
			Coal (Stigler)	1	6
	3	4	Soil	6	
			Shale, gray	9	
			Shale, blue	21	6
			Coal (Stigler)	1	5
		5	Soil and clay	8	
			Shale, gray	5	
			Coal		3
			Clay		3
			Shale, blue	40	
			Coal (Stigler)	1	6
			Clay		6
	8	6	Cover	163	1
			Coal, shaly (Stigler)	2	3
	9	7	Soil and clay	4	
			Shale, gray	3	
			Coal		3
			Clay		3
			Shale, blue	42	6
			Coal (Stigler)	1	4
			Clay		8
		8	Soil and clay	6	
			Shale, gray	6	
			Shale, blue	40	
			Coal (Stigler)	1	8
			Clay		4

Township and Range	Sec.	Symbol No.	Description	Ft.	in.
		9	Soil and clay	5	
			Shale, gray	5	
			Shale, blue	30	
			Coal (Stigler)	1	6
			Clay		6
	10	10	Soil and clay	6	
			Shale, gray	5	
			Shale, blue	5	
			Coal		2
			Clay		4
			Shale, blue	43	6
			Coal (Stigler)	1	8
			Clay		4
	11	11	Cover	354	5
			Coal (Upper Hartshorne)	1	11½
			Shale, slaty		1¼
			Coal (Lower Hartshorne)	1	9¼
	12	12	Soil, clay and gravel	8	
			Shale, gray	5	
			Shale, slaty, blue	62	
			Coal (Hartshorne)	3	5
			Clay		7
		13	Soil and clay	8	
			Shale, gray	6	
			Shale, blue	20	6
			Coal (Upper Hartshorne)	1	4
			Shale		2
			Coal (Lower Hartshorne)	1	10
			Clay		8
	13	14	Soil and clay	8	
			Shale, gray	6	
			Shale, slaty, blue	10	6
			Coal (Hartshorne)	3	5
			Clay		7
		15	Soil and clay	3	
			Gravel	4	
			Shale, gray	6	
			Shale, slaty, blue	39	
			Coal (Hartshorne)	4	
			Clay		6
	14	16	Soil and clay	8	
			Shale, gray	6	
			Shale, slaty, blue	42	
			Coal (Hartshorne)	4	2
			Clay		4
		17	Soil and clay	5	
			Shale, gray	6	
			Shale, slaty, blue	22	6
			Coal (Upper Hartshorne)	2	
			Shale		2
			Coal (Lower Hartshorne)	1	7
			Clay		2
		18	Soil and clay	4	
			Gravel	1	
			Shale, gray	5	
			Shale, slaty, blue	22	6
			Coal (Upper Hartshorne)	2	2
			Shale		3
			Coal	1	4
			Clay		3
		19	Soil and clay	3	
			Gravel	1	
			Shale, gray	5	
			Shale, blue	37	
			Coal (Upper Hartshorne)	2	
			Shale		2
			Coal (Lower Hartshorne)	1	7
			Clay		3
		20	Soil and clay	4	
			Shale, gray	4	
			Shale, blue	44	6
			Coal (Hartshorne)	4	3
			Clay		3

Township and Range	Sec.	Symbol No.	Description	Ft.	in.
T. 8 N., R. 22 E.		21	Cover	137	3
			Coal (Hartshorne)	3	8
		22	Cover	141	5
			Coal (Hartshorne)	3	7
	15	23	Cover	498	6
			Coal (Hartshorne)	3	9
		24	Cover	366	7
			Coal (Upper Hartshorne)	2	0½
			Shale, slaty		2
			Coal (Lower Hartshorne)	1	6½
		25	Cover	373	9
			Coal (Upper Hartshorne)	2	1
			Shale, slaty		1
			Coal (Lower Hartshorne)	1	7
		26	Cover	373	10
			Coal (Upper Hartshorne)	2	
			Shale, slaty		2
			Coal (Lower Hartshorne)	1	6
		27	Cover	140	9
			Coal (Hartshorne)	3	9
		28	Cover	207	2
			Coal (Hartshorne)	3	8
		29	Cover	207	6
			Coal (Hartshorne)	3	8
		30	Cover	247	
			Coal (Hartshorne)	3	7
		31	Shale, gray, with siderite concretions	6+	
			Coal (Upper & Lower Hartshorne)	4	6
			Clay		3+
	16	32	Cover	19	
			Coal (Hartshorne)	4	
		33	Cover	280	
			Coal (Hartshorne)	4	
		34	Cover	367	2
			Coal (Upper Hartshorne)	1	10
			Shale, slaty		2
			Coal (Lower Hartshorne)	1	11
		35	Cover	341	10
			Coal (Upper Hartshorne)	1	3
			Shale, slaty		2
			Coal (Lower Hartshorne)	2	2
		36	Cover	543	11
			Coal (Upper Hartshorne)	2	
			Shale, slaty		2
			Coal (Lower Hartshorne)	1	6
		37	Cover	544	
			Coal (Upper Hartshorne)	2	
			Shale		2
			Coal (Lower Hartshorne)	1	4
		38	Cover	563	
			Coal (Upper Hartshorne)	1	4
			Shale, slaty	1	0¼
			Coal (Lower Hartshorne)	1	6
	17	39	Shale, gray	3+	
			Coal (Stigler)	1	5
			Clay		1+
			Shale and sandstone	869	
			Coal (Upper Hartshorne)	1	7½
			Shale		2½
			Coal (Lower Hartshorne)	1	10
	18	40	Cover	883	2
			Coal (Hartshorne)	4	3
	19	41	Cover	620	
			Coal (Hartshorne)	4	6
		42	Cover	850	
			Coal (Upper Hartshorne)	2	6
			Shale		3½
			Coal (Lower Hartshorne)	2	8

Township and Range	Sec.	Symbol No.	Description	Ft.	In.
	20	43	Cover	602	8
			Coal (Upper Hartshorne)	2	1
			Shale		2
			Coal (Lower Hartshorne)	1	11
		44	Cover	244	10
			Coal (Upper Hartshorne)	2	1
			Shale, slaty		2
			Coal (Lower Hartshorne)	3	5
		45	Cover	116	8
			Coal (Upper Hartshorne)	1	11
			Shale, slaty		2
			Coal (Lower Hartshorne)	2	1
		46	Cover	90	2
			Coal (Upper Hartshorne)	1	10
			Shale, slaty		6
			Coal (Lower Hartshorne)	2	1
		47	Cover	98	11
			Coal (Upper Hartshorne)	2	
			Shale, slaty		3
			Coal (Lower Hartshorne)	2	2
		48	Cover	165	7
			Coal (Upper Hartshorne)	2	1
			Shale, slaty		2
			Coal (Lower Hartshorne)	2	6
		49	Cover	293	9
			Coal (Upper Hartshorne)	1	9
			Shale, slaty		1
			Coal (Lower Hartshorne)	2	6
		50	Cover	218	4
			Coal (Upper Hartshorne)	1	6
			Shale, slaty		1
			Coal (Lower Hartshorne)	4	
		51	Cover	228	
			Coal (Upper Hartshorne)	1	10
			Shale		6
			Coal (Lower Hartshorne)	2	6
	21	52	Cover	348	4
			Coal (Upper Hartshorne)	1	3
			Shale, slaty		1
			Coal (Lower Hartshorne)	2	7
		53	Cover	182	
			Coal (Upper Hartshorne)	2	
			Shale, slaty		1
			Coal (Hartshorne)	2	2
		54	Shale, slaty (no coal)	870	
		55	Cover	212	9
			Shale with thin coal streak	1	3
			Coal		5
		56	Cover	373	8
			Coal (Upper Hartshorne)	3	2
			Shale, slaty		2
			Coal (Lower Hartshorne)		9
		57	Cover	194	6
			Coal (Hartshorne)	5	5
		58	Cover	61	4
			Coal (Hartshorne)	4	11
		59	Cover	17	
			Coal (Hartshorne)	4	3
		60	Cover	125	
			Coal (Upper Hartshorne)	1	11
			Shale, slaty		2
			Coal (Lower Hartshorne)	2	2
		61	Cover	154	1
			Coal (Upper Hartshorne)	2	
			Shale, slaty, black		2
			Coal (Lower Hartshorne)	3	10
		62	Cover	223	9
			Coal (Upper Hartshorne)	2	8
			Shale, slaty		2
			Coal (Lower Hartshorne)	3	6
		63	Cover	341	4
			Coal		8
			Shale, slaty } Upper Hartshorne		9
			Coal		11
			Shale, slaty		2
			Coal (Lower Hartshorne)	5	4

MEASUREMENTS OF COAL BEDS

Township and Range	Sec.	Symbol No.	Description	Ft.	In.
		64	Cover	235	7
			Coal, shaly		3
			Coal (Upper Hartshorne)	2	5
			Shale, slaty	1	3
			Coal (Lower Hartshorne)	4	3
		65	Cover	156	6
			Coal (Upper Hartshorne)	2	3
			Shale	1	11
			Coal	1	9
			Shale } (Lower Hartshorne)		4
			Coal		5
	22	66	Cover	26	
			Coal (Hartshorne)	5	4
		67	Cover	189	6
			Coal (Upper Hartshorne)	1	10
			Coal and shale, slaty		8
			Shale, slaty with thin coal bed	3	6
			Coal (Lower Hartshorne)	3	4
		68	Cover	217	5
			Coal (Hartshorne)	7	5
		69	Cover	364	4
			Coal (Upper Hartshorne)	3	
			Shale, slaty		4
			Coal (Lower Hartshorne)	6	
		70	Shale roof		
			Coal (Upper Hartshorne)	2	10
			Shale parting	1	2
			Coal (Lower Hartshorne)	3	8
			Clay floor		
		71	Cover	190	
			Coal (Hartshorne)	7	0
	23	72	Cover	204	4
			Coal (Hartshorne)	6	6
		73	Cover	455	3
			Coal (Upper Hartshorne)	2	
			Shale		2
			Coal (Lower Hartshorne)	1	1
		74	Cover	291	2
			Coal (Upper Hartshorne)		8
			Shale		5
			Coal (Lower Hartshorne)	2	
		75	Cover	313	3
			Coal (Hartshorne)	5	
		76	Cover	50	
			Coal	1	3
			Barren rock	402	8
			Coal	1	6
			Barren rock	395	10
			Coal (Upper Hartshorne)	3	4
			Shale	6	8
			Coal (Lower Hartshorne)	4	11
	24	77	Cover	105	
			Coal (Upper Hartshorne)		10
			Shale and coal	16	10
			Coal (Lower Hartshorne)	2	4
		78	Cover	194	
			Coal, shaly (Upper Hartshorne)	4	
			Shale, slaty	7	
			Coal (Lower Hartshorne)	2	
		79	Cover	164	
			Coal (Upper Hartshorne)	3	
			Shale	15	
			Coal (Lower Hartshorne)	3	10
	28	80	Cover	406	
			Coal (Upper Hartshorne)	2	5
			Shale, slaty	4	7
			Coal (Lower Hartshorne)	3	7
	30	81	Cover	492	
			Coal (Hartshorne)	3	6
	31	82	Cover	709	
			Coal (Hartshorne)	4	

Township and Range	Sec.	Symbol No.	Description	Ft.	In.
T. 9 N., R. 18 E.	5	1	Overburden	7	0*
			Coal, stray, about 100 ft. above Secor	1	0
	14	2	Overburden in bank of pit	4	0
			Coal (Secor)	1	3
			Shale parting	0	2
			Coal (Secor)	0	2
	15	3	Overburden in pit	8	0
			Coal (Secor)	1	6
			Shale parting	0	2
			Coal (Secor)	0	2
T. 9 N., R. 19 E.	10	1	Overburden	18	0*
			Coal (Stigler)	1	6
	24	2	Overburden	22	0*
			Coal (Stigler)	1	6
	33	3	Overburden	18	0*
			Coal (Secor)	2	0
T. 9 N., R. 20 E.	17	1	Overburden	Mine	*
			Coal (Stigler)	1	10
T. 9 N., R. 21 E.	4	1	Cover	22	
			Coal (Stigler)	1	10
		2	Shale, gray		
			Coal (Stigler)	1	6
			Clay, light gray		
		3	Cover	36	
			Coal (Stigler)	2	
		4	Cover	39	
			Coal (Stigler)	2	
		5	Cover	49	
			Coal (Stigler)	2	
		6	Cover	36	
			Coal (Stigler)	1	11
	5	7	Cover	1	11
			Coal (Stigler)	1	10
		8	Cover	29	
			Coal (Stigler)	2	
	8	9	Cover	46	
			Coal (Stigler)	2	
		10	Cover	39	
			Coal (Stigler)	2	
		11	Cover	15	
			Coal (Stigler)	1	10
	30	12	Soil	9	
			Shale	3	9
			Bone		1
			Coal (Hartshorne)	2	2
		13	Soil	8	5
			Shale	4	
			Coal (Upper Hartshorne)	1	8
			Shale		1
			Coal (Lower Hartshorne)		4
T. 9 N., R. 22 E.	3	1	Coal (Stigler)	1	5
	4	2	Shale, gray, fissile	6+	
			Coal (Stigler)	2	1
			Clay, light gray		2+
	7	3	Coal (Stigler)	2	0
	8	4	Shale roof		
			Coal (Stigler)	2	0
			Clay floor		
	17	5	Shale	2+	
			Coal (Stigler)	1	8
	24	6	Soil		5
			Shale	7	10
			Coal '(Stigler)	2	2
		7	Soil	9	
			Shale, blue	22	6
			Coal (Stigler)	2	5

Township and Range	Sec.	Symbol No.	Description	Ft.	In.
		8	Soil	6	4
			Shale	25	
			Coal (Stigler)	1	10
	26	9	Soil	7	
			Shale, gray	7	
			Shale, blue	18	6
			Coal (Stigler)	2	4
		10	Soil	7	
			Shale, gray	11	
			Shale, blue	18	
			Coal (Stigler)	1	1
	34	11	Soil	5	
			Shale, gray	9	
			Shale, blue	11	3
			Coal (Stigler)	1	5¼
		12	Soil	4	
			Shale, gray	13	
			Shale, blue	4	
			Coal	1	6
	35	13	Soil	3	
			Shale, gray	10	6
			Shale, blue	18	3
			Coal (Stigler)	1	10
		14	Soil	2	6
			Shale, gray	9	
			Shale, blue	16	10
			Bone		6
			Coal (Stigler)	1	0½
		15	Shale, gray with thin siderite layers	10+	
			Coal (Stigler)	1	5
			Clay floor		2+
T. 9 N., R. 23 E.	5	1	Shale with thin siderite layers	6+	
			Coal (Unnamed)		10
	6	2	Coal (Cavanal?)		10
	17	3	Coal (Stigler)	1	3+?
		4	Shale, gray, with thin siderite layers	6+	
			Shale, carbonaceous with coal streaks		0-5
			Coal with a little pyrite (Stigler)	1	5
			Clay floor		
	18	5	Soil	8	6
			Shale	4	4
			Coal (Stigler)	1	1
		6	Soil	6	6
			Shale	4	6
			Coal (Stigler)	1	7½
	35	7	Clay and gravel	14	
			Shale, dark, firm	94	
			Coal (Hartshorne)	1	0
			Shale, dark	10	
			Shale, dark, sandy with occasional sandstone beds	74	
			Shale, dark	164	
T. 10 N., R. 20 E.	13	1	Soil		
			Coal (In Warner sandstone)	1+	
			Shale, dark gray, carbonaceous		10
			Clay		8+
		2	Shale, gray	8+	
			Coal (Stigler)	2	3
			Clay, light gray		2+
	24	3	Shale		
			Coal (Stigler)	2	2
			Clay		1+
	26	4	Shale, gray, fissile	15+	
			Coal	1	11
			Clay		8
			Shale, gray fissile	8+	

Township and Range	Sec.	Symbol No.	Description	Ft.	In.
T. 10 N., R. 21 E.	13	1	Surficial material	6	
			Shale	6	
			Shale, slaty	37	
			Coal (Stigler)	2	7
		2	Surficial material	12	
			Shale	6	
			Shale, slaty	39	
			Coal (Stigler)	2	6
		3	Soil, clay and sand	9	
			Shale, slaty	29	
			Coal (Stigler)	2	3
		4	Surficial material	8	
			Shale	10	
			Shale, slaty	24	
			Coal (Stigler)	2	7
		5	Surficial material	6	6
			Shale	10	
			Shale, slaty	21	
			Coal (Stigler)	2	4
		6	Surficial material	8	
			Shale	8	
			Shale, slaty	37	7
			Coal (Stigler)	2	4
		7	Surficial material	9	
			Shale	10	
			Shale, slaty	37	
			Coal (Stigler)	2	4
	19	8	Shale, dark gray, carbonaceous	1+	
			Coal (Lower Boggy)		11
			Clay, light gray		8+
	22	9	Shale, gray, fissile	10+	
			Coal	2	0
			Clay, light gray		3+
	23	10	Surficial material	8	
			Shale	5	
			Shale, slaty	26	6
			Coal (Stigler)	2	6
		11	Surficial material	8	
			Shale	8	
			Shale, slaty	26	
			Coal (Stigler)	2	7
		12	Surficial material	7	
			Shale	9	
			Shale, slaty	27	6
			Coal (Stigler)	2	7
	26	13	Shale with siderite concretions		
			Coal (Stigler)	1	11
			Clay		
		14	Shale with siderite concretions		
			Coal (Stigler)	1	11
			Clay		
	27	15	Shale, gray, fissile	20+	
			Shale, black, carbonaceous		4
			Coal		2
			Shale, gray fissile		3/4
			Coal	1	9
			Clay, gray		
		16	Surficial material	8	
			Shale	6	
			Shale, slaty	16	
			Coal (Stigler)	2	3
		17	Surficial material	8	
			Shale	6	
			Shale, slaty	24	
			Coal (Stigler)	2	0
		18	Surficial material	13	
			Shale, slaty	24	
			Coal (Stigler)	2	4
		19	Clay	6	
			Shale, slaty	33	
			Coal (Stigler)	2	6

Township and Range	Sec.	Symbol No.	Description	Ft.	In.
		20	Surficial material	8	
			Shale, slaty	32	
			Coal (Stigler)	2	3
	33	21	Cover	26	
			Coal (Stigler)	2	
	34	22	Shale with siderite concretions		
			Coal (Stigler)	2	1
			Clay		1+
T. 10 N., R. 22 E.	5	1	Surficial material	6	
			Shale	10	
			Shale, slaty	20	5
			Coal (Stigler)	2	4
		2	Surficial material	6	
			Shale	9	
			Shale, slaty	25	
			Coal (Stigler)	2	6
		3	Surficial material	6	
			Shale	10	
			Shale, slaty	20	
			Coal (Stigler)	2	6
		4	Surficial material	8	
			Shale	9	
			Shale, slaty	23	
			Coal (Stigler)	2	6
	6	5	Surficial material	9	6
			Shale	14	
			Shale, slaty	36	6
			Coal (Stigler)	2	5
		6	Surficial material	8	
			Shale	11	
			Shale, slaty	44	
			Coal (Stigler)	2	5
		7	Surficial material	6	
			Shale	8	6
			Shale, slaty	47	6
			Coal (Stigler)	2	4
	7	8	Surficial material	7	
			Shale	13	
			Shale, slaty	27	
			Coal (Stigler)	2	5
		9	Surficial material	6	
			Shale	13	
			Shale, slaty	8	6
			Coal (Stigler)	2	8
		10	Surficial material	18	
			Coal (Stigler)	2	4
		11	Surficial material	6	
			Shale	12	
			Shale, slaty	20	
			Coal (Stigler)	2	6
		12	Surficial material	12	
			Shale	9	
			Shale, slaty	15	
			Coal (Stigler)	2	4
	9	13	Shale	6+	
			Coal (Stigler)	2	1
			Clay		1+
		14	Shale	8+	
			Coal (Stigler)	2	2
			Clay		1+
	13	15	Shale		
			Coal (Stigler)	1	7
			Clay		
	14	16	Shale, gray	3+	
			Coal (Stigler)	1	8
			Clay, light gray		1+
	15	17	Shale	10+	
			Coal (Stigler)	2	0
			Clay		

Township and Range	Sec.	Symbol No.	Description	Ft.	In.
	16	18	Shale, gray	12+	
			Coal (Stigler)	1	7
			Shale, dark gray		2+
	17	19	Shale		
			Coal (Stigler)	2	0
	18	20	Cover	39	
			Coal (Stigler)	2	7
		21	Surficial material	6	5
			Shale	10	
			Shale, slaty	7	
			Coal (Stigler)	2	6
		22	Surficial material	5½	
			Shale	11	
			Shale, slaty	9	
			Coal (Stigler)	2	7
		23	Surficial material	12	
			Shale	6	
			Shale, slaty	23	
			Coal (Stigler)	2	7
	33	24	Shale, weathered		10+
			Coal (Upper Hartshorne)	1	0
			Shale		½
			Coal (Lower Hartshorne)		5
			Shale, gray		6
			Clay, light gray		8+
		25	Shale, gray, fissile with numerous thin concretionary siderite layers	3+	
			Coal (Hartshorne)	1	7
			Clay, light gray		
T. 10 N., R. 23 E.	18	1	Shale, gray		
			Coal (Stigler)	1	10
			Clay and shale	3	
			Sandstone		6
	21	2	Shale, dark gray	1+	
			Shale, black, carbonaceous		3
			Coal (Secor)		8-12
			Clay, light gray		2+
T. 11 N., R. 21 E.	36	1	Shale, gray		2
			Coal (Stigler)	2	2
			Clay	1+	
T. 11 N., R. 22 E.	19	1	Shale	1+	
			Coal (Stigler)	2	1
			Clay		2+
	30	2	Cover	25	
			Coal (Stigler)	2	1
			To bottom of well	33	
	31	3	Cover	30	
			Coal (Stigler)	2	5
	32	4	Surficial material	8	
			Shale	18	
			Shale, slaty	18	
			Coal (Stigler)	2	4
		5	Surficial material	14	
			Shale	4	
			Coal (Stigler)	2	3
		6	Surficial material	16	
			Shale	6	4
			Coal (Stigler)	2	3
		7	Surficial material	8	
			Shale	4	
			Coal (in Warner sandstone)	1	0
	34	8	Shale	10+	
			Coal	2	5
			Clay		

OIL AND GAS

To date, excepting a small reported "show", no oil has been found in Haskell County, and it is possible that regional metamorphism has progressed so far in this area that only gas will be produced. On the other hand, the absence of wet gas and oil in the areas so far tested may be due to the nature of the source materials.

Considerable gas has been produced from the Kinta anticline, the eastern half of which extends into southwestern Haskell County. In fact there are few sections of land along the axis that have not produced gas. All of it has come from the Hartshorne sandstone but to date the Atoka and deeper formations have not been adequately explored. There is no considerable commercial production from other structures in western Haskell County though shows have been reported. However, the drilling done to date has not by any means exhausted possibilities.

The results of the small amount of drilling so far done in eastern Haskell County have not been encouraging, but there is still a possibility of discovering natural gas in commercial quantities. The Cartersville gas field, which produces gas at a depth of about 5,000 feet from the basal beds of the Atoka Formation on the Milton anticline, has so far been developed only in T. 9 N., R. 24 E., in Le Flore County, and the limits of the reservoir have not yet been determined on the northwest side of the anticline. Possibly the reservoir extends into the broad monoclinal area in the S½ of T. 9 N., R. 23 E., in Haskell County. Some of the other anticlinal structures described in preceding pages and shown on the structure map might yield gas from sands in the Atoka formation or from the Hartshorne sandstone, which are the principal producing formations in adjacent areas. Most of these structures, however, show small areas of closure and are associated with considerable faulting and are therefore considered to be less promising than the area in T. 9 N., R. 23 E., referred to above.

LIMESTONE

Only impure, local limestones rarely more than 1 foot thick crop out in Haskell County and probably they never will have any economic value.

TABLE IV
SAND AND GRAVEL IN HASKELL COUNTY

LOCATION	Thickness (feet)	Overburden (feet)	Estimated cubic yards	Approximate Screen Analysis of Washed Sample[1] Percent Retained on Screen 1½"	1"	¾"	½"	¼"	20	50	100	200	Wash[2] Loss	REMARKS
NW¼ SE¼ 13, T. 9 N., R. 19 E.	8.0-13.0	1.0	10,000						3.6	59.8	32.0	4.6	5.0	Used for concrete. Abandoned pit ⅛ mi. S. Removal of sand uncovered coal.
NE¼ NE¼ 15, T. 9 N., R. 19 E.	5.0	7.0	10,000						3.7	66.7	25.4	4.2		About 10-acre exposure in pit.
S½ NW¼ NW¼ 24, T. 9 N., R. 19 E.	5.0	3.0-8.0	1,000	4.8	5.8	2.6	4.5	7.7	46.3	28.2		0.1		More firmly cemented than deposit in sec. 13. Overburden is impure volcanic ash.
NE¼ sec. 1, T. 9 N., R. 20 E.	4.0	3.0						20.6	29.4	35.6	9.2	5.2	6.5	Building sand, some flint gravel. 4 test holes. Samples from NE¼ SW¼ NE¼ Abandoned pit.
SW¼ sec. 1, T. 9 N., R. 20 E.	4.0	3.0						3.7	38.2	47.9	7.6	2.6	2.5	Building sand, less gravel. 7 test holes. Abandoned pit. Sample from SE¼ NE¼ SW¼.

TABLE IV (Continued)
SAND AND GRAVEL IN HASKELL COUNTY

LOCATION	Thickness (feet)	Overburden (feet)	Estimated cubic yards	Approximate Screen Analysis of Washed Sample[1] Percent Retained on Screen 1½"	1"	¾"	½"	¼"	20	50	100	200	Wash[2] Loss	REMARKS
Section 6, T. 9 N., R. 21 E.	15.0	1.0-2.0							4.3	65.8	27.3	2.6	1.5	Pit in SW¼ NW¼. Sand underlies about half of sec.
NW¼ NW¼ NW¼ 28, T. 10 N., R. 18 E.			Unlimited						1.0	88.6	7.4	3.0	3.0	Bed of Canadian River. Similar deposits can probably be found up and down river.
NW¼ NW¼ SE¼ 29, T. 10 N., R. 18 E.	15.0		"							5.7	80.3	14.0	2.0	
SW¼ SE¼ SE¼ 36, T. 10 N., R. 20 E.	5.0	5.0	10,000 (for the three sec. 36 entries)					2.0	6.3	47.3	27.6	16.8	10.5	Some gravel.
SW¼ SE¼ SE¼ 36, T. 10 N., R. 20 E.	2.0	2.0		3.3	6.8	3.5	8.5	6.7	45.8	23.4	2.0		4.5	"
SW¼ SW¼ SE¼ 36, T. 10 N., R. 20 E.	5.0	5.0						9.1	47.4	34.1	6.3	3.1	3.5	"
[3]Section 12, T. 10 N., R. 22 E.														Concrete sand and gravel. Bars along Arkansas River.
[3]Secs. 20 & 21, T. 11 N., R. 22 E.														

[1] Screen analysis by Leslie Snow, Testing Engineer on Mineral Survey
[2] Independently determined
[3] FERA Report

SAND AND GRAVEL

No good deposits of gravel are known in Haskell County. However, the Quaternary (?) terrace deposits are said to afford good building sand locally, particularly in the area north of Stigler. Eleven deposits were reported by crews of the State Mineral Survey,[115] and the data, including screen analyses, are summarized in the accompanying table which includes also data from two deposits listed by Rimmer.[116]

PHOSPHATE

Local limy ferruginous shale lenses 1 or 2 feet thick in the Savanna formation contain as much as 4 percent P_2O_5. Such lean material, especially in such small amount, probably will never be economically useful.

CLAY

There is no clay-products industry in Haskell County, but this situation is probably due to factors other than a dearth of suitable local materials. No special attention was paid to clays and shales in the course of this investigation and no samples were collected for laboratory tests. However, both clay and shale were noted at several places and from our cursory examination some seemed to be suitable for making brick and tile. The clay immediately beneath the Stigler coal from several places in Muskogee and McIntosh Counties is known to be buff-burning, and the upper 10 inches of about 4 feet of underclay from beneath the Secor coal of McIntosh County burned buff when tested in the laboratory of the Oklahoma Geological Survey.

In 1929-30 four samples of shale from Haskell County were collected by John S. Redfield, of the Oklahoma Geological Survey, in the course of a statewide survey of the clays and shales of Oklahoma, and were tested at the Engineering Experiment Station, Oklahoma A. and M. College, Stillwater, under the direction of Leonard F. Sheerar. The following is quoted from the report of

115. *Works Progress Administration Project* No. 65-65-538, sponsored and directed by the Oklahoma Geological Survey, 1936-37.
116. Rimmer, Harry L., "Sand and Gravel of Oklahoma": *Federal Emergency Recovery Administration Report on Construction Materials in Oklahoma.* Project S-F2-89, Charles N. Gould, Director. 1934.

this work,[117] with minor corrections of stratigraphic nomenclature in conformity with the present report:

SAMPLE NO. 113

At Keota, a black carbonaceous and fossiliferous shale in the Keota sandstone member of the McAlester formation is exposed for 35 feet with base not showing. Some iron concretions are present and the formation is badly iron-stained.
NW¼ Sec. 18, T. 9 N., R. 23 E. County: Haskell.
Geologic formation: McAlester formation.
Working properties: Fair plasticity, easy to mold.
Tempering water: 28.3%.
Drying linear shrinkage: 8.3%.
Drying volume shrinkage: 26.9%.
Average transverse strength: 393 lbs. per sq. in.

Burning Temperature in Cones	Per Cent Linear Shrinkage	Per Cent Volume Shrinkage	Per Cent Porosity	Hardness	Color
010	1.1	3.2	35.7	<steel	11''b
08	3.3	9.6	31.6	steel	11''b
06	5.4	15.3	25.6	>steel	9''b
04	7.8	21.8	17.9	>steel	11''
02	8.5	23.5	14.7	>steel	7''i
1	9.7	26.4	11.3	>steel	7''i

Overburning temperature: Above Cone 1 (2102°F-1150°C).
Best burning range: Cone 06 to Cone 01 (1886°F-1030°C to 2066°F-1130°C).
Total linear shrinkage: 32.% at Cone 1 (2102°F-1150°C).
Possibilities: Common brick, sewer pipe, face brick.

SAMPLE NO. 114

One and one-half miles from Stigler in Sec. 17, T. 9 N., R. 21 E., eight feet of shale is exposed with two feet of overburden resembling volcanic ash. East of the branch railroad the clay is eight feet thick which thins to two feet a short distance west of the track. This probably is part of the shale overlying the Lequire sandstone member of the McAlester formation.
NW sec. 17, T. 9 N., R. 21 E. County: Haskell.
Geologic formation: McAlester formation.
Working properties: Very plastic and sticky, difficult to mold.
Tempering water: 37.9%.
Drying linear shrinkage: 15.8%.
Drying volume shrinkage: 56.9%.
Average transverse strength: 849 lbs. per sq. in.
All test pieces shattered in firing.
Remarks: This shale has an extremely high drying shrinkage and has no practical use.

SAMPLE NO. 182

A dark, gray shale outcrops along the road. The section shows a cap of 6-inch sandstone and 60 feet of shale. The areal extent of the outcrops is extensive in this vicinity. This shale overlies the Lequire sandstone member of the McAlester formation.

117. Sheerar, Leonard F. and Redfield, John S., "The Clays and Shales of Oklahoma": *Okla. Agri. and Mech. College, Division of Engineering Publication,* Vol. 3, No. 5, pp. 141-42, September, 1932.

NE NE NW Sec. 3, T. 7 N., R. 19 E. County: Haskell.
Geologic formation: McAlester formation.
Working properties: Medium plasticity, easy to mold.
Tempering water: 25.6%.
Drying linear shrinkage: 6.9%.
Drying volume shrinkage: 22.1%.
Average transverse strength: 613 lbs. per sq. in.

Burning Temperature in Cones	Per Cent Linear Shrinkage	Per Cent Volume Shrinkage	Per Cent Porosity	Hardness	Color
06	2.4	7.1	28.6	>steel	11''b
04	5.7	16.1	19.6	>steel	9''b
02	6.7	18.9	17.7	>steel	7''
1					
3	9.7	26.3	4.6	>steel	7''k
5	9.0	24.7	0.0	>steel	7''k

Overburning temperature: Cone 5 (2246°F-1230°C).
Best burning range: Cone 06 to Cone 3 (1886°F-1030°C to 2174°F-1190°C).
Total linear shrinkage: 15.5% at Cone 3 (2174°F-1190°C).
Possibilities: Common and face brick, sewer pipe, paving brick.

SAMPLE NO. 183

A shale very similar to No. 182 outcrops northwest of Kinta where six to ten feet of sandstone overlies 50 feet of shale. This shale, like No. 182, overlies the Lequire sandstone member of the McAlester formation.
SE NE Sec. 36, T. 8 N., R. 19 E. County: Haskell.
Geologic formation: McAlester formation.
Working properties: Medium plasticity, easy to mold.
Tempering water: 28.4%.
Drying linear shrinkage: 7.8%.
Drying volume shrinkage: 23.5%.
Average transverse strength: 649 lbs. per sq. in.

Burning Temperature in Cones	Per Cent Linear Shrinkage	Per Cent Volume Shrinkage	Per Cent Porosity	Hardness	Color
06	2.9	8.4	32.5	>steel	11'd
04	5.8	16.3	23.1	>steel	11'b
02	7.7	21.4	15.6	>steel	11''b
1	8.3	22.8	10.0	>steel	7''
3	8.7	24.0	6.9	>steel	7''1
5	9.2	25.1	3.7	>steel	7''k

Overburning temperature: 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: 14.9% at Cone 3 (2174°F-1190°C).
Possibilities: Common brick.

VOLCANIC ASH

Volcanic ash or pumicite, has been known in Haskell County for many years.[118] In 1936 the State Mineral Survey made an extensive investigation of Haskell County which included a rather detailed study of the volcanic ash deposits near Stigler and Brooken, and the results are set forth in Table V, and on Plate I. It was found that the deposits are thinner and more impure than earlier investigators had supposed. The thickness of ash reported from all test holes is of the order of 3½ to 4 feet including a large quantity of impurities in the form of beds of sand and clay.

It appears from the field data that the volcanic ash occurs in limited pockets and that it is generally mixed with sand and clay, although locally there are beds of ash 3 to 5 feet thick which are relatively free from impurities. Mineralogical and chemical studies in the laboratory of the Oklahoma Geological Survey indicate that the ash is little altered; however, it does contain a few stringers of bentonite (altered ash).

Unaltered volcanic ash is used in cleaning and scouring compounds, soaps, and floor sweeps. Several years ago ash from the Stigler deposit was packaged and sold for scouring powder. Altered ash or ash containing clay has been used as a binder in topping for dirt or gravel roads.

In 1945, A. L. Burwell, industrial chemist of the Oklahoma Geological Survey, began experiments on the bloating or expanding properties of Oklahoma volcanic ash to produce a light-weight building material which the Survey calls pumicell. Since that time, as circumstances have permitted, more work has been done on bloating so that now it is definitely known that volcanic ash from all the major deposits in Oklahoma including those of Haskell County, can be bloated to yield pumicell. Experiments have been made to determine the temperature range within which bloating takes place and the influence of the length of time the material is held at bloating temperature, but practical methods for commercial

118. Buttram, Frank, "Volcanic Dust in Oklahoma": *Okla. Geol. Survey Bull.* 13, pp. 42-43, 1914.
Beckstrom, R. C., "Volcanic Ash or Pumicite in Oklahoma", *Federal Emergency Recovery Administration Report on Construction Materials of Oklahoma*, Project S-F2-89, Charles N. Gould, Director, 1934.

TABLE V.
DATA ON TEST HOLES FOR VOLCANIC ASH, HASKELL COUNTY, OKLAHOMA*

Test Hole No.	Over-burden Feet	Volcanic Ash Feet	REMARKS
STIGLER DEPOSIT, T. 9 N., R. 21 E.			
SEC. 7			
1	2	5.3	
2	3.4	5.9	2-inch layer of bentonite in ash.
3	14.0	0.0	
4	14.0	0.0	
5	14.0	0.0	
6	1.7	2.7	
7	5.3	1.8	Overburden consisted of 0.5 foot of top soil and 4.8 feet of mixed ash and red clay. Ash contained a layer of bentonite 0.1 foot thick.
8	3.5	1.0	
9	1.0	0.3	
10	8.0	0.2	
11	4.0	5.0	Layer of pink bentonite in ash 0.2 foot thick.
12	14.0	1.0	Ash and bentonite. Laboratory test shows sample of bentonitic material, swells 47 percent.
13	5.5	3.5	Sample of upper 1.5 feet of bentonitic ash tested in laboratory swelled 47 percent.
14	4.1	0.5	Clay and volcanic ash; tested in laboratory swelled 29 percent.
15	4.0	1.0	
16	13.0	0.0	
17	8.0	0.0	
18	9.0	0.0	
19	10.0	0.3	
20	2.0	2.3	Several thin layers of bentonite in ash totaling 9 inches.
21	2.3	7.8	
22	9.0	0.0	Abandoned hole.
23	16.0	......	No mention of ash.
SEC. 8			
1	5.5	2	The ash consists of bentonite and sand. Tested in laboratory, swelled 45 percent.
2	12.5	0.0	Hole abandoned, account of hard drilling.
3	3.7	1.3	Impure bentonitic ash. Tested in laboratory, swelled 31 percent.
SEC. 8			
1	9.0	5.0	
2	13.0	0.0	The greater part of the material drilled through in this hole is described as mixed clay and may contain considerable ash.
3	14.0	0.0	
4	14.0	0.0	
5	12.5	0.0	
SEC. 8			
1	14.0	0.0	
2	14.0	0.0	
3	1.0	4.0	
4	1.0	0.5	Ash is described as mixed.
5	7.0	7.0	
6	14.0	0.0	
7	10.0	4.0	Ash is described as mixed clay and ash.

TABLE V (Continued).
DATA ON TEST HOLES FOR VOLCANIC ASH, HASKELL COUNTY, OKLAHOMA*

Test Hole No.	Over-burden Feet	Volcanic Ash Feet	REMARKS
SEC. 17			
1	1.5	8.5	There is a bed of sand 1 foot thick, 2 feet from the base of the ash.
2	6.0	2.7	1.2 feet near top of ash is mixed with clay.
3	7.0	5.5	Lower 2 feet of ash mixed with clay.
4	3.0	0.5	Ash mixed with sand.
5	1.3	8.7	Ash is described as mixed clay.
6	0.8	11.3	Ash is mixed with clay except 2 feet 8 inches below top and lower 2 feet.
7	6.5	7.5	Ash is mixed with clay.
8	2.0	3.2	The ash contains sand in seams and lenses. This test was a pit 3.0 feet wide and 4.5 feet long.
9	10.5	3.5	Ash is mixed with clay in upper 2.5 feet
BROOKEN DEPOSIT, Secs. 3, 4, T. 9 N., R. 18 E. and 34, T. 10 N., R. 18 E.			
1	0.5	1.5	
2	2.5	2.0	
3	....	......	A pit was dug 7.5 feet deep; ash was found irregularly distributed in pockets.
4	1.5	1.5	The greater part of the material in the Brooken deposit is impure, containing clay, sand and a small amount of bentonite.
5	1.5	1.5	

* Compiled from records of the State Mineral Survey, Works Progress Administration project No. 65-65-538, sponsored and directed by the Oklahoma Geological Survey, 1936-37.

manufacture are yet to be devised. In a truly cellular material like pumicell, the cells or "bubbles" are not connected one with another, as are the pores of a sponge or a sandstone, and consequently the material does not absorb moisture any more than does glass. It is possible to obtain a product weighing as little as 55 pounds per cubic foot with sufficient mechanical strength to be useful as a building material and with great promise as sound and heat insulation.

Water Resources

SURFACE WATER

It is not difficult to secure relatively small supplies of water from underground sources but relatively large supplies of the magnitude of 100,000 gallons or more per day, must come from surface sources. Fortunately the clay soil of the county seems to be sufficiently impervious to make large earthen reservoirs feasible, and rainfall and stream flow are adequate to fill them. For any large supplies that may be needed such reservoirs seem to be the best solution.

UNDERGROUND WATER

No systematic study of the underground water resources was undertaken in connection with the present investigation. Data on rural water wells and springs were obtained by crews of the State Mineral Survey,[119] who filled 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, for they were assembled by untrained relief workers who depended on the memory and opinions of 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, also information on the effects of drought should be fairly reliable inasmuch as the investigation was made during a protracted drought. These data are in the files of the Oklahoma Geological Survey and may be consulted by anyone interested.

MUNICIPAL WATER SUPPLIES

Stigler is the only town in the county having a municipal water supply; it depends on impounding surface water in a reservoir 1 mile southeast of the town.

119. *Works Progress Administration Project* No. 65-65-538, sponsored and directed by the Oklahoma Geological Survey, 1936-37.

APPENDIX

MEASURED STRATIGRAPHIC SECTIONS IN HASKELL COUNTY

TOWNSHIP 7 NORTH

SEC. 1, T. 7 N., R. 18 E., (PITTSBURG COUNTY). MEASURED NORTH ALONG WEST LINE FROM A POINT 1,950 FEET SOUTH OF NW COR.

Savanna formation

	Feet
Sandstone: fine to silty; massive beds up to 1½ feet thick; weathers reddish brown; top of Savanna, at least	20.0
Covered: appears to be shale; weathers red	74.0
Sandstone: reddish brown, fine-grained to silty	5.0
Shale: gray-green, contains clay ironstone streaks; silty in upper part	57.0
Sandstone: fine-grained to silty; beds up to 2 feet thick; weathers reddish brown	38.0
Shale: gray-green	5.0
Sandstone	1.0
Shale: weathers gray-green	9.0
Sandstone: gray, silty	5.0
Shale: weathers gray-green	13.0
Shale: dark	0.2
Siltstone	1.0
Shale: weathers gray-green to yellow	2.0
Shale: black, fissile	2.0
Siltstone: red, limy, fossiliferous	1.0
Covered	187.0
Sandstone: (at forks of old and new roads) about	3.0
Covered	48.0
Sandstone: (70 paces south of forks of old and new roads) about	5.0

SECS. 7, 8, 17, AND 20, T. 7 N., R. 19 E. SECTION EXTENDS FROM THE FOOT OF THE MOUNTAIN IN SEC. 7 ALONG STATE HIGHWAY NO. 2 TO THE TOP OF THE MOUNTAIN AND DOWN THE DIP SLOPE WEST OF TUCKER KNOB IN SEC. 20.

Boggy formation	
Bluejacket sandstone member	
Sandstone and silty shale: greater part covered; top corresponds approximately with a tree line which crosses the road about 400 feet north of the S¼ cor. sec. 17. The base makes a distinct ridge which crosses small lake near the center of sec. 17	100.0
Unnamed shale member	
Silty shale and sandstone: greater part covered	285.0
Savanna formation	
Sandstone: gray, fine-grained, massive; crops out in roadside park at top of mountain; about	15.0
Covered: shale	15.0

	Feet
Sandstone: greenish gray, fine-grained; massive beds 1 foot thick	6.7
Covered: shale	10.0
Sandstone: greenish gray; massive, fine-grained, dense; weathers brown	6.7
Covered: shale	10.0
Sandstone: gray, massive, fine-grained; weathers brown	1.7
Covered: shale	10.0
Sandstone: massive, fine-grained; weathers brown	2.2
Shale and a few thin beds of sandstone: covered in part	44.0
Limestone: brown, deeply weathered; fossiliferous	0.5
Sandstone: gray, rough, massive, fine-grained; weathers brown	10.0
Shale	2.5
Sandstone: gray, a single massive bed, fine-grained; weathers brown	3.4
Covered: shale	6.7
Sandstone: massive, fine-grained; weathers brown	6.7
Covered in part: shale	25.0
Covered in part: shale containing thin sandstone beds	10.0
Covered by clay and sandstone rubble	50.0
Shale: dark	29.0
Covered by clay and sandstone rubble: shale	57.0
Sandstone: massive; weathers brown; a shale pit lies on the south side of the road at the top of this bed from which a draw runs southwest	1.7
Covered: shale; about	2.5
Sandstone: gray, massive; weathers brown	2.5
Covered: probably shale	10.0
Sandstone: massive, fine-grained; weathers brown	0.8
Shale: dark; weathers green	6.7
Sandstone: greenish-drab color, massive; about	1.7
Covered: shale, about	5.0
Sandstone: greenish-drab color, massive, fine-grained	2.2
Covered: shale	8.5
Sandstone: gray, massive, fine-grained	2.5
Sandstone: silty, thin-bedded	20.0
Shale: dark; weathers olive-green to brown	10.0
Shale: dark, fissile	0.8
Limestone: fossiliferous, shaly, ferruginous	2.5
Shale: weathers green	1.7
Sandstone: green, rough but fine-grained; weathers brown	1.7
Shale; dark; weathers green; contains a few ferruginous lenses	3.4
Sandstone: olive green; thin-bedded, fine-grained; weathers gray to brown; shale partings up to 0.5 foot thick	3.4
Shale	3.4
Sandstone: olive green, thin-bedded, fine-grained; weathers gray to brown; shale partings up to 0.5 foot thick	12.0
Shale: dark; weathers olive-green; contains abundant ferruginous beds and lenses, 0.1 to 0.5 foot thick	12.0
Sandstone: olive green, rough, massive, fine-grained; weathers brown to red	3.4
Shale: dark; weathers olive green; contains ferruginous lenses	4.2
Sandstone: gray to brown, fine-grained; one massive bed	5.9
Sandstone and sandy shale: brown, lenticular	14.0

	Feet
McAlester formation	
Unnamed shale member	
Shale: green and brown; contains a few ferruginous concretions	35.0
Coal streak	0.1
Shale: dark green	59.0
Shale: dark	59.0
Covered: shale	57.0
Shale: olive-drab, silty	30.0
Keota sandstone member	
Sandstone: light brown, thin-bedded, fine-grained	17.0
Covered: not measured.	

3. SECS. 12, 23, AND 24, T. 7 N., R. 19 E. ONLY THE LAST TWO ENTRIES WERE MEASURED IN SEC 12. ALL OTHERS ARE FROM THE NE¼ SEC. 23 AND THE NW¼ SEC 24. COMPUTED AND COMPILED FROM ELEVATIONS DETERMINED BY BAROMETER, DIPS MEASURED BY BRUNTON, HAND-LEVEL DATA, AND HORIZONTAL ANGLES AND DISTANCES MEASURED ON AERIAL PHOTOGRAPHS.

	Feet
Savanna formation	
Sandstone: top of Savanna	20.0
Covered: shale	40.0
Siltstone: represented by a topographic bench	10.0
Covered: shale	89.0
Limestone	1.0
Covered: shale	35.0
Sandstone	5.0
Covered: shale	330.0
Sandstone	5.0
Covered: shale	90.0
Sandstone	20.0
Covered: shale	30.0
Sandstone	20.0
McAlester formation	
Unnamed shale member	
Covered: shale; measured near E¼ cor. sec. 12	285.0
Keota sandstone member	
Sandstone: fine-grained, thin wavy bedding; weathers buff to brown; at least	4.0

4. SECS. 20 AND 21, T. 7 N., R. 19 E. MEASURED BY BAROMETER TRAVERSE UP THE SOUTH SIDE OF TUCKER KNOB, FROM THE GATE BY A HOUSE 800 FEET NORTH OF THE SW CORNER SEC. 21 ALONG SECTION LINE TO THE TOP. BASE OF THE SECTION IS ABOUT 75 FEET ABOVE THE TOP OF THE BLUEJACKET SANDSTONE MEMBER OF THE BOGGY FORMATION.

	Feet
Bogry formation	
Unnamed units	
Sandstone: massive, coarse quartz grains, no chert; weathers white, brown or red; caps knob	50.0
Covered	10.0
Sandstone: massive, fine-grained; weathers brown	4.0
Covered	100.0
Topographic bench, probably represents siltstone, about	10.0
Covered	50.0

	Feet
Steep slope covered by loose sandstone, probably represents thin-bedded sandstone	10.0
Sandstone: gray to brown, massive, relatively coarse-grained, in comparison with sandstones lower in the section	4.0
Covered	27.0

	Feet
Topographic bench probably sandstone, about	5.0
Covered: rubbly slope	115.0
Sandstone: gray, fine-grained; thick laminated bed	32.0
Covered for the greater part: shale with a few thin beds of sandstone	74.0
Sandstone: gray to brown, fine-grained to silty; laminated beds 1 to 3 feet thick	10.0
Covered: probably silty shale and thin beds of silty sandstone	40.0
Sandstone: gray to brown, fine-grained, thin-bedded, silty	17.0
Covered	60.0

5. SECS. 12, 13, AND 24, T. 7 N., R. 20 E. CROPS OUT IN ASCENDING ORDER ALONG THE WEST SIDE OF SECS. 12 AND 13 TO JUNCTION OF CAMP AND MOUNTAIN FORK CREEKS, THENCE UP CAMP CREEK TO THE VICINITY OF THE SE CORNER SEC. 24. COMPUTED AND COMPILED FROM HAND-LEVEL MEASUREMENTS, ELEVATIONS DETERMINED BY BAROMETER, DIPS MEASURED BY BRUNTON, AND HORIZONTAL ANGLES AND DISTANCES MEASURED ON AERIAL PHOTOGRAPHS.

Boggy formation	
Unnamed units	
Sandstone: massive beds; crops out southward from SE corner sec. 24	40.0
Covered: shale; crops out from SE cor. sec. 24 along Camp Creek to vicinity of house	330.0
Sandstone: crops out in creek south of house	10.0
Covered: shale	245.0
Sandstone: massive, fine-grained, weathers brown	5.0
Covered: probably silty shale	65.0
Sandstone; massive, fine-grained; weathers brown	5.0
Covered: shale	295.0
Bluejacket sandstone member	
Sandstone: not well exposed; at many places consists of upper and lower massive resistant members and intervening silty shale to soft nonresistant sandstone	120.0
Unnamed shale member	
Covered: shale, forms the valley of Mountain Fork Creek	690.0
Savanna formation	
Sandstone: massive; top crops out in Camp Creek a short distance above its junction with Mountain Fork Creek	35.0
Covered: probably silty shale or soft sandstone	20.0
Sandstone: massive, resistant, fine-grained	5.0
Covered: probably silty shale or soft nonresistant sandstone	45.0
Sandstone: top crops out in Mountain Fork Creek; poorly exposed; weathers brown to reddish brown; massive beds several feet thick	10.0
Covered: probably silty to sandy shale or soft nonresistant sandstone	60.0
Sandstone: massive, resistant, fine-grained; weathers brown	5.0
Covered: probably silty shale to soft nonresistant sandstone	45.0

	Feet
Sandstone: massive, resistant, fine-grained; weathers brown	5.0
Covered: probably silty shale or soft non-resistant sandstone	40.0
Sandstone: massive, resistant, fine-grained; weathers brown	10.0
Covered: probably silty shale to soft nonresistant sandstone	35.0
Sandstone: massive, resistant, fine-grained; weathers brown to reddish brown	10.0

	Feet
Covered: shale; forms talus slope of second conspicuous escarpment south of State Highway No. 31	730.0
Sandstone: top exposed in creek bed about 1/5 mile south of the NW cor. sec. 13	5.0
Covered: probably silty shale to soft nonresistant sandstone	105.0
Sandstone: massive, resistant, fine-grained; weathers brown	10.0
Covered; probably silty shale and soft nonresistant sandstone	45.0
Sandstone: massive, fine-grained, resistant; weathers brown	5.0
Covered: probably silty shale and soft nonresistant sandstone	70.0
Sandstone: massive, resistant, fine-grained; weathers brown	10.0
Covered: probably silty shale and soft sandstone	45.0
Sandstone: massive, resistant, fine-grained	5.0
Covered: probably shale or soft sandstone	20.0
Sandstone: poorly exposed; caps first conspicuous escarpment south of State Highway No. 31	15.0
McAlester formation	
Covered: shale, not measured.	

6. SEC. 1, T. 7 N., R. 21 E. CROPS OUT FROM A POINT 1/8 MILE NORTH OF THE NE COR. TO A POINT 1/8 MILE NORTH OF THE SE COR. SEC. 1. COMPUTED AND COMPILED FROM ESTIMATED DIFFERENCES IN ELEVATION, DIPS MEASURED BY BRUNTON, HORIZONTAL ANGLES, AND DISTANCES MEASURED ON AERIAL PHOTOGRAPHS.

Savanna formation	
An aggregation of sandstone and sandy silty shale making up the first conspicuous ridge south of Lequire	275.0
McAlester formation	
Unnamed shale member	
Covered: shale	410.0
Keota sandstone member	
Sandstone: crops out indistinctly; estimated	25.0
Unnamed shale member	
Covered: shale; at most places in the county this zone contains the Tamaha sandstone member which seems to be absent here. It contains the Stigler coal near the base	630.0
Lequire-Cameron sandstone unit	
Sandstone: medium to fine-grained, thin-bedded to massive. The interval between the Lequire and the Cameron sandstone members is filled with shale in many localities in Haskell County as well as in northern Le Flore County to the east and in Muskogee County to the north, but in this and some other localities it is filled with sandstone and the Lequire and the Cameron cannot be differentiated	50.0

7. SECS. 2, 11, 14, AND 23, T. 7 N., R. 21 E. CROPS OUT FROM A POINT 1/8 MILE SOUTH OF THE E¼ COR. SEC. 2 SOUTHWARD TO A POINT NEAR THE CENTER OF SEC. 23. COMPUTED AND COMPILED FROM ELEVATIONS DETERMINED BY BAROMETER, DIPS MEASURED BY BRUNTON, HAND-LEVEL DATA, HORIZONTAL ANGLES

AND DISTANCES MEASURED ON AERIAL PHOTOGRAPHS.

	Feet
Boggy formation	
Unnamed units	
Sandstone: massive beds 2 to 5 feet thick; coarser than usual; poorly exposed; caps hill; weathers gray to reddish brown; top eroded	10.0
Covered: shale, probably silty	435.0
Sandstone: poorly exposed; debris indicates massive beds, 2 to 5 feet thick	20.0
Covered: shale	385.0
Sandstone: massive beds 3 to 5 feet thick, coarser than common; weathers gray to reddish brown	20.0
Covered: shale	160.0
Sandstone	5.0
Covered: shale	175.0
Sandstone: massive, fine-grained; weathers brown	45.0
Covered: shale	165.0
Sandstone: poorly exposed, massive to thin-bedded; weathers brown	25.0
Covered: shale	250.0
Bluejacket sandstone member	
Sandstone	3.0
Covered	7.0
Sandstone	10.0
Covered: shale	95.0
Sandstone: massive, fine-grained	20.0
Unnamed shale member	
Covered: shale	85.0
Sandstone: thin-bedded, fine-grained	40.0
Covered: probably shale	885.0
Savanna formation	
Sandstone: massive	10.0
Covered: shale	45.0
Sandstone: massive	5.0
Poorly exposed: probably silty shale with some thin sandstone beds	85.0
Sandstone: fine-grained, gray to brown; massive	5.0
(The foregoing upper Savanna beds form the second conspicuous ridge south of Lequire.)	
Covered: shale	225.0
Sandstone: massive, beds 0.5 to 1.5 feet thick; fine-grained; weathers gray to brown	5.0
Covered: shale	190.0
An aggregation of massive to thin sandstone beds and sandy to silty shale making up the first conspicuous sandstone ridge south of Lequire	275.0
McAlester formation	
Unnamed shale member	
Covered: shale	415.0
Keota sandstone member	
Sandstone: an inconspicuous outcrop near a house about 1/8 mile south of the E¼ corner of sec. 2; estimated	20.0

8. SECS. 5, 8, 17, AND 20, T. 7 N., R. 21 E. CROPS OUT WESTWARD FROM LEQUIRE ACROSS SW¼ SEC. 5, THE WEST SIDE OF SEC. 8, SOUTHEASTWARD ACROSS SEC. 17 AND ALONG THE EAST SIDE OF SEC. 20. COMPUTED AND COMPILED FROM BAROMETRIC ELEVATIONS, DIPS MEASURED BY BRUNTON, HAND-LEVEL DATA, HORIZONTAL ANGLES AND DISTANCES MEASURED ON AERIAL PHOTOGRAPHS, AND FIELD NOTES AS TO CHARACTER.

	Feet
Boggy formation	
Unnamed units	
Sandstone: near the top of the mountain in the vicinity of the southeast corner of sec. 20; poorly exposed and may extend lower in the section	10.0
Covered: probably silty shale and siltstone	335.0
Sandstone: represented by a topographic bench	15.0
Covered: probably silty shale and sandstone	70.0
Sandstone: represented by a topographic bench	15.0
Covered: shale	305.0
Sandstone: massive	15.0
Covered: shale	405.0
Sandstone: fine-grained; beds 3 to 4 feet thick; weathers gray to brown	20.0
Covered: shale	55.0
Sandstone	10.0
Covered: shale	115.0
Sandstone: represented by topographic bench covered by large sandstone fragments and blocks	10.0
Covered: shale	170.0
Sandstone: massive, fine-grained; weathers gray to brown; poorly exposed	10.0
Covered: shale	245.0
Bluejacket sandstone member	
Sandstone: composed of upper and lower massive zones with intervening soft silty beds	160.0
Lower shale member	
Covered: shale	795.0
Savanna formation	
Sandstone	10.0
Covered: shale	55.0
Sandstone	10.0
Covered: shale	100.0
Coal seam	0.1
Covered: shale	30.0
Sandstone	10.0
Covered: shale	20.0
Sandstone	15.0
Covered: shale	40.0
Sandstone	5.0
(The preceding 295 feet of beds constitute the second conspicuous ridge south of Lequire.)	
Covered: shale	655.0
Sandstone and silty shale: forms the first conspicuous ridge south of Lequire	195.0
McAlester formation	
Unnamed shale member	
Covered: shale	470.0
Keota sandstone member	
Sandstone: constitutes the low ridge in the south part of Lequire; at least	10.0

TOWNSHIP 8 NORTH

9. SECS. 7, 8, 17, 18, 19, 20, 29, and 30, T. 8 N., R. 19 E. COMPILED FROM ELEVATIONS DETERMINED BY BAROMETER, STRUCTURE CONTOURS ON LOCAL BEDS, HAND-LEVEL MEASUREMENTS, AND FIELD NOTES AS TO CHARACTER.

	Feet
Boggy formation	
Unnamed units	
Sandstone: massive to thin-bedded, fine-grained; weathers brown; top eroded; caps hill in sec. 7. (3A of Dane and others)	20.0
Covered: silty shale	250.0
Alternating beds of sandstone and sandy shale: sandstone thin-bedded, fine-grained; weathers brown	50.0
Covered: shale	20.0
Sandstone	10.0
Shale: silty to sandy, a few thin beds of sandstone	90.0
Sandstone and silty shale	60.0
Covered: shale	120.0
Silty shale and silty sandstone	8.0
Coal: Secor	2.0
Covered: shale	60.0
Bluejacket sandstone member	
Sandstone: massive to thin-bedded, fine-grained; weathers brown	40.0
Shale: sandy to silty; in some areas consists of soft nonresistant sandstone	30.0
Sandstone: massive to thin-bedded, fine-grained; weathers brown	50.0
Unnamed shale member	
Covered: shale	100.0
(Section from base to Secor coal measured in vicinity of abandoned coal mine near W¼ cor. sec. 30.)	

10. SECS. 27 AND 34, T. 8 N., R. 19 E. CROPS OUT ALONG THE WEST SIDE OF SECS. 27 AND 34. COMPUTED AND COMPILED FROM BAROMETER ELEVATIONS, HAND-LEVEL MEASUREMENTS, DIPS MEASURED BY BRUNTON, HORIZONTAL ANGLES AND DISTANCES TAKEN FROM AERIAL PHOTOGRAPHS, AND FIELD NOTES AS TO CHARACTER.

	Feet
Savanna formation	
Sandstone: massive; upper sandstone of the Savanna	20.0
Covered: shale	100.0
Sandstone	5.0
Covered: shale	110.0
Sandstone	5.0
McAlester formation	
Unnamed shale member	
Covered: shale	45.0
Sandstone: thin-bedded, fine-grained, silty; weathers brown	2.0
Covered: shale	138.0
Keota sandstone member	
Sandstone: poor exposure	5.0
Covered: shale	5.0
Sandstone: loose blocks indicate beds less than 1 foot thick; wavy bedding, fine-grained to silty; weathers reddish brown	10.0
Covered: shale	20.0

	Feet
Limestone: fossiliferous; less than	1.0
Covered: shale	9.0
Sandstone: about	5.0
Covered: shale	25.0
Sandstone: thin-bedded to massive, cross-bedded and wavy, fine-grained; weathers gray to reddish-brown	25.0
Unnamed shale member	
Covered: shale	45.0
Silty shale zone	10.0
Covered: shale	225.0
Tamaha sandstone member	
Covered: sandstone, a low ridge with a few loose slabs of sandstone	5.0
Unnamed shale member	
Covered: shale	55.0
Coal: Stigler; has been mined in strip pit in SW¼ sec. 34	1.5
Covered: shale	75.0
Lequire sandstone member	
Sandstone: thin-bedded, platy, fine-grained to silty	10.0

11. SEC. 31, T. 8 N., R. 19 E. MEASURED IN THE CUT OF THE ABANDONED FORT SMITH AND WESTERN RAILROAD, NEAR CENTER OF SEC. 31, BASE OF SECTION AT THE STREAM SOUTH OF CUT.

	Feet
Boggy formation	
Unnamed shale member	
Shale not measured.	
Savanna formation	
Sandstone: rough massive beds 0.5 to 2.5 feet thick, with silty shale between; fine-grained; weathers brown; upper sandstone of the Savanna	25.0
Shale: contains thin bands and nodules of ferruginous material	8.0
Shale: greenish gray	6.0
Shale: gray; contains ferruginous fossiliferous concretions	2.5
Covered: shale; computed thickness from Brunton dips and paced distance	140.0
Sandstone: appears to be a single massive bed	2.5

12. SEC. 31, T. 8 N., R. 19 E. MEASURED IN THE SE¼, IN THE CUT OF THE ABANDONED FORT SMITH AND WESTERN RAILROAD BENEATH OVERPASS ON STATE HIGHWAY NO. 2.

	Feet
McAlester formation	
Keota sandstone member	
Covered: shale; not measured.	
Shale: clay shale, greenish gray	45.0
Sandstone: gray, thin-bedded to massive (beds 0.2 to 2 feet thick), fine-grained; weathers brown; shale partings	6.0
Shale: greenish gray clay shale; ferruginous concretions	17.0
Sandstone: thin-bedded with shale partings, fine-grained	1.0
Shale: clay shale	1.0
Sandstone: silty	0.4
Shale: clay shale	1.0
Sandstone: thin-bedded, fine-grained to silty	3.3
Shale: greenish gray, silty	10.0
Shale: greenish gray clay shale; contains a few bands of ferruginous concretions	18.0
Shale: black, fissile; no concretions, no coal	0.4

	Feet
Limestone: fossiliferous, ferruginous, in beds 0.1 to 1.4 feet thick alternating with calcareous shale in beds 0.1 to 1.0 foot thick	3.5
Shale: greenish gray clay shale, with ferruginous concretions	5.0
Sandstone: fine-grained in rough massive contorted beds, 1.0 to 2.0 feet thick alternating with gray silty shale beds 0.2 to 2.0 feet thick	18.0
Shale: greenish gray clay shale	8.0
Band of ferruginous concretions	0.5
Shale: greenish gray clay shale	5.0
Covered: shale; not measured.	

13. SECS. 32 AND 33, T. 8 N., R. 19 E. CROPS OUT ALONG THE OLD ROAD BETWEEN SECS. 32 AND 33 FROM THE FIRST STREAM NORTH OF THE ABANDONED GRADE OF THE FORT SMITH AND WESTERN RAILROAD NORTH TO THE TOP OF THE HILL IMMEDIATELY SOUTH OF STATE HIGHWAY NO. 31, 1/8 MILE SOUTH OF NW COR. SEC. 33.

Savanna formation	
Sandstone: gray, fine-grained; rough massive beds about 1 foot thick; weathers brown; impressions of plant stems, some of them at right angles to the bedding; top not well exposed	5.0
McAlester formation	
Unnamed shale member	
Shale: dark; several bands of plant fossils	20.0
Sandstone: fine-grained, thin wavy bedding	1.0
Shale: dark, clay shale, with bands of clay ironstone 0.2 foot thick and 3 to 5 feet apart	20.0
Siltstone: limy, many almost microscopic fossils; weathers yellow	0.5
Shale: black, fissile; contains invertebrate and plant fossils	0.3
Shale: dark; certain bands contain leaf and stem impressions	15.0
Bench covered by debris; probably silty shale	5.0
Poorly exposed: seems to be shale; stream with a concrete slab instead of a bridge lies at the base	140.0
Keota sandstone member	
Sandstone: cross-bedded, fine-grained, micaceous; weathers rough and brown	5.0
Covered: sandy shale	3.0
Sandstone: cross-bedded, fine-grained, micaceous; weathers rough and brown	4.0
Covered: shale	20.0
Sandstone: poorly exposed, fine-grained; weathers brown; probably includes much shale as partings	6.0
Covered: shale; not measured.	

14. SEC. 7, T. 8 N., R. 20 E. MEASURED NORTHWARD ALONG STATE HIGHWAY NO. 2 UP THE HILL FROM THE TOP OF THE SAVANNA FORMATION NEAR THE CENTER OF THE SE¼ TO THE BASE OF THE BLUEJACKET SANDSTONE AT THE TOP OF THE HILL NEAR THE CENTER OF THE NW¼.

Boggy formation

Bluejacket sandstone member

Sandstone: not measured; massive, medium-grained (much coarser than sandstones lower in this measured section);

	Feet
weathers brown; rests on underlying laminated shale with apparent unconformity which may indicate only bottom scouring; clay flakes, plant impressions and carbonized wood abundant at least locally in lower few inches; weathering by exfoliation common wherever sandstone is massive.	
Unnamed shale member	
Shale: silty; contains resistant sandy beds a few inches apart; weathers brown	40.0
Sandstone: fine-grained; thin-bedded to massive	3.0
Alternating thin beds of extremely fine-grained to silty sandstone and silty shale; weathers brown	6.0
Shale: silty; weathers brown	8.0
Alternating thin beds of extremely fine-grained to silty sandstone and silty shale; weathers brown	30.0
Shale; silty to sandy; weathers brown; local cross-bedding resembles truncation	15.0
Shale: silty, contains silty sandstone beds less than 1 foot thick	12.0
Covered: probably silty shale	30.0
Shale: silty; weathers brown; about	30.0
Sandstone: silty, extremely fine-grained	1.0
Shale: silty; weathers brown	2.0
Sandstone: silty to extremely fine-grained	1.0
Shale: dark, silty; weathers brown	15.0
Covered: probably shale, (extends northward to lowest exposure in hillside cut of road); about	280.0
Savanna formation	
Sandstone: not measured.	

15. SECS. 9 AND 16, T. 8 N., R. 20 E. CROPS OUT FROM THE ESCARPMENT ABOUT 1/8 MILE WEST OF THE N¼ CORNER SEC. 16 NORTH TO THE TRAIL IMMEDIATELY NORTH OF THE SOUTH LINE OF SEC. 9.

Savanna formation	
Basal part of a massive wooded sandstone; estimated	20.0
Covered: shale	45.0
Sandstone: thin-bedded to massive, fine-grained; weathers brown	5.0
Covered: shale	30.0
Sandstone: seems to be a single bed; weathers brown	1.0
Covered: shale	30.0
Sandstone: massive and gnarly, fine-grained; weathers brown	5.0
Covered: shale	30.0
Sandstone: thin-bedded to massive, fine-grained; weathers brown	3.0
Covered: shale; weathers red	20.0
Sandstone: massive and gnarly, fine-grained	5.0
Shale: covered; not measured.	

16. SEC. 16, T. 8 N., R. 20 E. SECTION CROPS OUT FROM A POINT 1/8 MILE SOUTH OF NE COR. SEC. 16, ALONG STRIKE TO TOP OF HILL, CENTER OF NE¼ SEC. 16, THENCE NORTHWEST TO ESCARPMENT ABOUT ⅛ MILE EAST OF N¼ CORNER SEC. 16.

Savanna formation	
Shale: not measured.	
Sandstone: about	10.0
McAlester formation	
Unnamed shale member	
Covered: shale	250.0

	Feet
Keota sandstone member	
Sandstone: thin-bedded to massive, fine-grained; weathers brown	5.0
Covered: shale	25.0
Sandstone: thin-bedded to massive, fine-grained; weathers brown	5.0
Covered: shale	20.0
Sandstone: thin-bedded to massive, fine-grained; weathers brown	5.0
Covered: shale	30.0
Sandstone: thin-bedded to massive, fine-grained: weathers brown	5.0
Shale: not measured.	

17. SEC. 17, T. 8 N., R. 20 E. MEASURED NEAR THE CENTER OF SEC. 17.

Savanna formation, lower part	
Shale not measured	
Sandstone: indicated by a change of slope and by material along a pipeline ditch; about	3.0
Covered: shale; about	50.0
Sandstone: massive to thin-bedded, fine-grained; weathers brown; about	3.0
Covered: shale; about	30.0
Sandstone: fine-grained; about	2.0
McAlester formation	
Covered: shale, dark; forms talus slope of high escarpment immediately south of the center of sec. 17; not measured.	

18. * SECS. 19 & 30, T. 8 N., R. 20 E. CROPS OUT NORTHWARD AND WESTWARD FROM THE VICINITY OF THE SE CORNER SEC. 30 TO THE HILL TOP IN THE NW¼ SEC. 19. COMPUTED AND COMPILED FROM ELEVATIONS DETERMINED BY BAROMETER, DIPS MEASURED BY BRUNTON, HORIZONTAL ANGLES AND DISTANCES FROM AERIAL PHOTOGRAPHS, HAND-LEVEL MEASUREMENTS, AND FIELD NOTES AS TO CHARACTER.

Savanna formation	
Sandstone: fine-grained but somewhat less so than is common in Haskell County; massive to thin-bedded; weathers brown; top eroded; upper sandstone of the Savanna formation	20.0
Covered: shale	90.0
Sandstone: fine-grained to massive, thin-bedded; weathers brown	10.0
Covered: shale	72.0
Sandstone: a single massive bed; exposed in road ⅛ mile south of north line of sec. 19; fine-grained; weathers brown	3.0
McAlester formation	
Unnamed shale member	
Covered, probably shale	300.0
Keota sandstone member	
Sandstone: fine-grained; weathers brown	5.0
Covered: shale	15.0

* This section lies in the Russellville syncline and all units are thicker than anywhere else in the same latitude in Haskell County, suggesting that the syncline was developing during deposition as was the McAlester basin as a whole.

	Feet
Sandstone: fine-grained, thin-bedded; weathers brown	5.0
Covered: shale	35.0
Sandstone; thin-bedded to massive, fine-grained; weathers brown	5.0
Covered: shale	15.0
Sandstone: thin-bedded to massive, fine-grained; weathers brown	5.0
Unnamed shale member	
Covered: shale	282.0
Sandstone: thin-bedded to massive, fine-grained; weathers brown	8.0
Covered: shale	215.0
Tamaha sandstone member	
Sandstone: makes a low ridge ½ mile south of the NE corner sec. 30; generally thin-bedded to massive, fine-grained; weathers brown	5.0
Unnamed shale member	
Covered: shale; contains the Stigler coal a few feet above the base	420.0
Lequire-Cameron sandstone unit	
Sandstone: thin-bedded to massive, locally platy; weathers brown; probably consists of Lequire and Cameron sandstone members with intervening interval filled with sandstone; crops out across the road near the SE cor. sec. 30 and rims the Kinta anticline	40.0

19. T. 8 N., R. 21 E. COMPILED FROM VARIOUS DATA AND REPRESENTS ONLY MEAN INTERVALS FOR THE TOWNSHIP, ALL ELEVATIONS MEASURED BY BAROMETER, DIPS BY BRUNTON, HORIZONTAL ANGLES AND DISTANCES FROM AERIAL PHOTOGRAPHS. INTERVALS IN THE KEOTA MEMBER TAKEN FROM A MAP CONTOURED ON LOCAL BEDS.

McAlester formation	
Keota sandstone member, upper part eroded	
Sandstone: upper part eroded; fine-grained, thin-bedded; weathers brown	10.0
Shale: contains a thin coal of no economic importance near the top	40.0
Sandstone: thin-bedded, fine-grained; weathers brown	10.0
Shale: dark	90.0
Sandstone: fine-grained, thin-bedded; weathers brown	10.0
Unnamed shale member	
Shale: dark	340.0
Tamaha sandstone member	
Sandstone: fine-grained, thin-bedded; weathers brown	10.0
Unnamed shale member	
Shale: dark	70.0
Coal: Stigler vein	1.5
Shale: dark	15.0
Lequire-Cameron sandstone unit	
Sandstone: lower part locally massive and resistant; about the upper 10 feet is generally resistant and can be differentiated as the Cameron sandstone member; intervening portion consists of silty to sandy shale and soft nonresistant sandstone. The Lequire-Cameron may be as much as 200 feet thick in the south part of the township	110.0
Unnamed shale member	
Covered: dark shale	300.0

	Feet
Warner sandstone member	
Sandstone: massive to thin-bedded, fine-grained; weathers brown	75.0

20. NW¼NW¼ SEC. 8, T. 8 N., R. 22 E., HILLSIDE NORTHEAST OF SHILOH SCHOOLHOUSE.

McAlester formation	
Keota sandstone member	
Sandstone: hard, fine-grained, blocky; superjacent bedrock not exposed	12.0
Shale: largely covered	38.0
Limestone: impure, containing marine invertebrate fossils	0.7
Shale and siltstone: gray, interbedded	29.0
Shale: gray; subjacent bedrock not exposed	64.0

21. SEC. 11, T. 8 N., R. 22 E., ROAD-CUT ON HIGHWAY NO. 26, 2 MILES NORTH OF McCURTAIN.

McAlester formation	
Lequire sandstone member	
Sandstone: hard, fine-grained, thin-bedded, light gray to buff; superjacent rock not exposed	11.0
Sandstone: greenish gray, hard, fine-grained; thin-bedded, with a few thin layers of ferruginous clay; contains marine invertebrate fossils	3.0
Shale: light gray to buff	8.0
Shale: dark to medium gray; subjacent rock not exposed	11.0

22. NW¼NE¼ SEC. 15, T. 8 N., R. 22 E., ROAD-CUT A MILE AND A HALF NORTH OF McCURTAIN.

McAlester formation	
Warner sandstone member	
Sandstone: hard, fine-grained, massive, lumpy; superjacent bedrock not exposed	3.0
Sandstone: hard, fine-grained; thin-bedded, ripple-marked	18.0
McCurtain shale member	
Shale: gray	9.0
Siltstone: greenish gray, hard, platy	17.0
Shale: gray	22.0
Covered: probably shale	60.0
Shale: light gray; a few layers of clay ironstone	14.0
Shale: light-gray, subjacent rock not exposed	37.0

23. SE¼ SEC. 17, T. 8 N., R. 22 E., ROAD-CUT 2 MILES NORTHWEST OF McCURTAIN.

McAlester shale	
Lequire sandstone member	
Sandstone: hard, fine-grained, slabby at base, more blocky in upper part; superjacent bedrock not exposed	30.0
Unnamed shale member	
Shale: gray	62.0
Covered: probably shale	11.0
Shale: dark gray	27.0
Shale; partly covered	30.0
Covered; probably shale	52.0
Warner sandstone member	
Sandstone: hard, fine-grained, blocky	

24. NW¼NW¼ SEC. 17, T. 8 N., R. 22 E., 1 MILE SOUTH OF SHILOH SCHOOLHOUSE.

	Feet
McAlester formation	
Tamaha sandstone member	
Sandstone: hard, fine-grained, blocky; superjacent bedrock not exposed	8.0
Siltstone and shale: light-gray	12.0
Shale: gray	43.0
Sandstone: hard, fine-grained	1.0
Siltstone: gray; subjacent rock not exposed	4.0

TOWNSHIP 9 NORTH

25. T. 9 N., R. 18 E. COMPILED FROM A STRUCTURE MAP CONTOURED ON SEVERAL LOCAL SANDSTONE UNITS, COMPUTED INTERVALS, HAND-LEVEL MEASUREMENTS, AND FIELD NOTES AS TO CHARACTER. ELEVATIONS DETERMINED BY BAROMETER, DIPS BY BRUNTON, HORIZONTAL DISTANCES AND ANGLES FROM AERIAL PHOTOGRAPHS.

Boggy formation	
Unnamed units	
Sandstone and silty shale: occupies the high western part of the township. The sandstone is generally fine-grained, thin-bedded to massive, and occurs as lenses. Sandstone lenses of this unit form the cap above the escarpment but owing to their lenticularity the base of the cap ranges through several tens of feet of section. These sandstone and silty shale beds are continuous with sandstone unit No. 4 of Dane and others in the Boggy formation of Pittsburg County	100.0
Covered: dark shale	180.0
Sandstone: thin-bedded to massive; weathers brown; continuous with sandstone unit No. 3A of Dane and others	40.0
Covered: shale	190.0
Sandstone: thin-bedded, fine-grained; weathers brown; crops out locally in secs. 27 and 28; sandstone unit No. 2 of Dane and others	10.0
Shale: dark	5.0
Limestone: fossiliferous	0.1
Shale: dark	4.8
Coal	0.1
Covered: probably dark shale	90.0
Coal: Secor	2.0
Covered: probably dark shale	98.0
Bluejacket sandstone member	
Sandstone: generally this member includes one or more basal sandstone beds each of which is several feet thick, fine- to medium-grained, massive, and weathers by exfoliation to form conspicuously large rounded boulders. These massive basal beds are separated and succeeded by softer, less resistant beds of sandstone and sandy shale whose debris occupies the dip slope making it difficult to map the top of the member exactly	100.0

26. SECS. 5 AND 6, T. 9 N., R. 19 E. COMPUTED AND COMPILED FROM ELEVATIONS DETERMINED BY BAROMETER, DIPS FROM STRUCTURE CONTOURS OF LOCAL BEDS, HAND-LEVEL MEASUREMENTS, AND FIELD NOTES AS TO CHARACTER.

	Feet
Boggy formation	
Bluejacket sandstone member	
Sandstone: massive, fine-grained; weathers brown; top eroded	50.0
Unnamed shale member	
Covered: probably shale	120.0
Sandstone: massive, and fine-grained to thin-bedded and silty	40.0
Covered: probably shale	200.0
Savanna formation	
Sandstone: thin-bedded, fine-grained; weathers brown	15.0
Covered: shale	25.0
Sandstone: massive, fine-grained; weathers brown	20.0
Savanna and McAlester formations	
Covered: shale	80.0
McAlester formation	
Keota sandstone member	
Sandstone: thin-bedded, fine-grained to silty	10.0

27. SECS. 21, 22, 27, AND 28, T. 9 N., R. 19 E. COMPUTED AND COMPILED FROM ELEVATIONS DETERMINED BY BAROMETER, DIPS MEASURED BY BRUNTON, HORIZONTAL ANGLES AND DISTANCES MEASURED ON AERIAL PHOTOGRAPHS, HAND-LEVEL MEASUREMENTS, AND FIELD NOTES AS TO CHARACTER.

	Feet
Savanna formation	
Sandstone: thin-bedded; weathers brown	10.0
Covered: dark shale	35.0
Sandstone: thin-bedded, fine-grained; weathers brown	10.0
Covered: dark shale	145.0
Sandstone: thin-bedded, fine-grained; weathers brown	5.0
McAlester formation	
Unnamed shale member	
Covered: dark shale	90.0
Keota sandstone member	
Sandstone: thin-bedded, fine-grained; weathers brown	10.0
Covered: shale	100.0
Sandstone: thin-bedded to massive, fine-grained; weathers brown	20.0

28. SECS. 4, 5, 8, AND 9, T. 9 N., R. 20 E. COMPILED FROM ELEVATIONS DETERMINED BY BAROMETER, DIPS DETERMINED FROM STRUCTURE CONTOURS ON LOCAL BEDS, HAND-LEVEL MEASUREMENTS, AND FIELD NOTES AS TO CHARACTER.

	Feet
Savanna formation	
Sandstone: caps hill in SW¼ sec. 4; top eroded	15.0
Covered: shale	20.0
Sandstone: base crops out in NE¼ sec. 8	20.0
Shale: dark	8.0
Limestone: gray; fossiliferous	0.5
Savanna and McAlester formations	
Shale: dark	90.0
McAlester formation	
Keota sandstone member	
Sandstone: poorly exposed above the alluvium near the center of sec. 8	10.0
Shale: dark, silty; poorly exposed	30.0
Sandstone: basal member of Keota	10.0

29. SECS. 21 AND 22, T. 9 N., R. 20 E. CROPS OUT IN THE HILLS IN SECS. 21 AND 22. COMPUTED AND COMPILED FROM ELEVATIONS DETERMINED BY BAROMETER, DIPS DETERMINED FROM STRUCTURE CONTOURS ON LOCAL BEDS, HAND-LEVEL MEASUREMENTS, AND FIELD NOTES AS TO CHARACTER.

	Feet
Savanna formation	
Sandstone: caps hill in sec. 21; top eroded	10.0
Covered in part: dark shale	20.0
Sandstone	10.0
Covered in part: dark shale	29.5
Limestone: fossiliferous, silty	0.5
Savanna and McAlester formations	
Covered in part: dark shale	95.0
McAlester formation	
Keota sandstone member	
Sandstone: well exposed in east end of hill near N¼ corner sec. 22	5.0
Unnamed shale member	
Shale: dark	15.0
Tamaha sandstone member	
Shale: silty to sandy; probably represents Tamaha which is not mapped in this area	2.0
Unnamed shale member	
Shale: dark	60.0
Coal: Stigler	2.0
Shale: dark	5.0
Lequire sandstone member, probably includes Cameron member in the upper few feet	
Sandstone and sandy to silty shale: poorly exposed; probably represents the interval from the base of the Lequire sandstone member to the top of the Cameron sandstone member	50.0

30. SECS. 28 AND 33, T. 9 N., R. 20 E. COMPUTED AND COMPILED FROM BAROMETER ELEVATIONS, BRUNTON DIP MEASUREMENTS, HORIZONTAL ANGLES AND DISTANCES FROM AERIAL PHOTOGRAPHS, AND FIELD NOTES AS TO CHARACTER. SECTION CROPS OUT FROM A POINT ¼ MILE SOUTH OF THE W¼ CORNER SEC. 28 TO THE SW CORNER SEC. 33.

Savanna formation	
Shale: not measured.	
Sandstone: estimated	20.0
Covered: shale	150.0
Sandstone	5.0
McAlester formation	
Unnamed shale member	
Covered: shale	163.0
Keota sandstone member	
Sandstone	5.0
Covered: shale	57.0
Sandstone	10.0
Shale	60.0
Sandstone	5.0
Covered: shale	108.0
Sandstone	10.0
Unnamed shale member	
Shale: covered for the greater part; thin coal near the top	181.0

	Feet
Tamaha sandstone member	
Sandstone	5.0
Unnamed shale member	
Shale: greater part covered; contains Stigler coal a few feet above the base	103.0
Cameron sandstone member	
Sandstone	5.0
Unnamed shale member	
Covered: shale	70.0
Lequire sandstone member	
Sandstone	35.0

31. SEC. 30, T. 9 N., R. 20 E. COMPUTED AND COMPILED FROM BAROMETER ELEVATIONS, BRUNTON DIP MEASUREMENTS, DISTANCES AND HORIZONTAL ANGLES FROM AERIAL PHOTOGRAPHS, AND FIELD NOTES AS TO CHARACTER. SECTION CROPS OUT ALONG THE WEST SIDE OF THE SW¼.

Savanna formation, middle and lower part	
Sandstone	10.0
Covered: silty shale	214.0
Sandstone	5.0
McAlester formation	
Unnamed shale member	
Covered: silty shale	110.0
Keota sandstone member	
Sandstone	5.0
Covered: silty shale	160.0
Sandstone	5.0

32. SECS. 30 AND 31, T. 9, R. 20 E. COMPUTED AND COMPILED FROM BAROMETER ELEVATIONS, BRUNTON DIP MEASUREMENTS, DISTANCES AND HORIZONTAL ANGLES MEASURED ON AERIAL PHOTOGRAPHS, AND FIELD NOTES AS TO CHARACTER. SECTION CROPS OUT FROM THE TOP OF THE CONSPICUOUS HILL AT THE E¼ CORNER SEC. 30, SOUTH TO THE RIDGE 3/8 MILE SOUTH OF THE NE CORNER SEC. 31.

McAlester formation	
Keota sandstone member	
Sandstone	5.0
Covered: shale, silty	120.0
Sandstone	5.0
Covered: silty shale	95.0
Sandstone	5.0
Unnamed shale member	
Covered: silty shale	205.0
Tamaha sandstone member	
Sandstone	5.0
Unnamed shale member	
Covered: shale; contains the Stigler coal a few feet above the base	85.0
Cameron sandstone member	
Sandstone	5.0
Unnamed shale member	
Covered: shale; about	60.0
Lequire sandstone member	
Sandstone: lower part cut out by a fault	20.0

33. SEC. 15, T. 9 N., R. 21 E. ALONG THE NORTH LINE OF NW¼ (From barometer and odometer readings)

	Feet
McAlester formation	
Lequire sandstone member	
Basal portion sandstone: not measured	
Unnamed shale member	
Shale: covered in part	50.0
Warner sandstone member, upper part	
Sandstone: not measured	

34. NW¼SW¼ SEC. 32, T. 9 N., R. 21 E., ROAD-CUT ON NORTH SIDE OF SHROPSHIRE VALLEY.

McAlester formation	
Warner sandstone member	
Sandstone: gray, hard, fine-grained, ripple-marked; beds platy in lower part, thicker toward top; superjacent bedrock not exposed	20.0
McCurtain shale member	
Shale: light-gray, partly weathered pink	8.0
Covered: probably shale	32.0
Shale: gray	11.0
Sandstone: gray, hard, fine-grained, ripple-marked	2.0
Limestone: contains abundant marine invertebrate fossils	2.0
Shale: gray	12.0
Limestone: marine invertebrate fossils abundant	0.5
Shale: gray	72.0
Covered: probably shale	8.0
Shale: dark gray; a few thin layers of clay ironstone	18.0
Shale: dark gray	9.0
Sandstone: tan, hard, fine-grained	1.5
Siltstone: gray	5.0
Shale: gray, silty	18.0
Covered: probably shale	11.0
Shale: gray; subjacent bedrock not exposed	12.0

35. NE¼NE¼ SEC. 13, T. 9 N., R. 22 E. SHALE PIT AT KEOTA.

McAlester formation	
Keota sandstone member	
Sandstone: hard, fine-grained, slabby; superjacent bedrock not exposed	2.5
Shale: gray, partly silty	8.0
Shale: dark gray, a few clay ironstone concretions; subjacent bedrock not exposed	45.0

36. NW¼NW¼, SEC. 14, T. 9 N., R. 22 E., ROAD-CUT NORTH OF JUNCTION, STATE HIGHWAYS 9 AND 26.

Savanna formation	
Siltstone: light gray; superjacent bedrock not exposed	6.0
Sandstone: gray, hard, fine-grained	10.0
Shale: gray; and siltstone, gray, platy	5.0
Shale: gray-buff	28.0
Limestone: ferruginous, contains marine invertebrate fossils	0.2
Shale: buff; ostracods, crinoidal remains, and bryozoa	0.2
Shale: gray; abundant ostracods	0.3
Shale: dark gray	2.5
Paper shale: dark and light gray, with thin layers nearly white; shale containing abundant ostracods	2.0

	Feet
Limestone: gray, marly; thin beds intercalated with shale, fissile	3.0
Shale: dark gray	1.5
Coal	0.3
Underclay: light gray	0.1
Shale: gray	0.7
Sandstone: light greenish gray, hard, fine-grained	4.0
Shale: gray, silty	5.0
Shale: gray	12.0
Shale: gray, silty; subjacent bedrock not exposed	3.0

37. NE¼SE¼ SEC. 22, T. 9 N., R. 22 E., ROAD-CUT ON HIGHWAY 26.

McAlester formation
Keota sandstone member

Sandstone: gray, hard, fine-grained, slabby to massive; superjacent bedrock not exposed	11.0
Shale: light gray, silty	5.0
Shale: gray	19.0
Limestone: impure, ferruginous, containing marine fossils	1.0
Shale: gray, fissile; subjacent bedrock not exposed	25.0

38. NW¼SW¼ SEC. 35, T. 9 N., R. 22 E., ON WEST SIDE OF SMALL STRIP MINE NEAR HIGHWAY NO. 26.

McAlester formation
Tamaha sandstone member and underlying shale

Sandstone: hard, fine-grained, thin-bedded, ripple-marked; overlying rock not exposed	7.0
Shale: gray; a few thin layers of clay ironstone, mostly within 6 feet of base	38.0
Coal	0.3
Shale: gray; a few thin layers of clay ironstone	44.0
Coal: (Stigler bed)	1.5
Underclay: light gray; only top exposed	0.2

TOWNSHIP 10 NORTH

39. SEC. 36, T. 10 N., R. 18 E. FROM WATER'S EDGE IN CANADIAN RIVER UP ESCARPMENT TO SOUTHEAST IN VICINITY OF SE. CORNER SEC. 36. HAND LEVEL AND BAROMETER MEASUREMENTS.

Boggy formation
Bluejacket sandstone member

Covered slope: massive, fine-grained, exfoliated sandstone boulders; lower and upper massive benches separated by intervening silty sandstone	15.0
Sandstone: massive, fine-grained, blocky: weathers brown	10.0
Sandstone: brown in upper part, fine-grained, grades into siltstone in lower part; forms over-hanging cliff	40.0

Unnamed shale member

Covered: talus slope, no fragments of limestone or coal found	285.0
Siltstone: extends down to water in Canadian River	20.0

40. SW¼SW¼ SEC. 18, T. 10 N., R. 21 E., ROAD-CUT 1¼ MILE NORTH OF PERRY.

Savanna formation

	Feet
Sandstone: gray, hard, fine-grained; interbedded with shale, mostly covered; superjacent bedrock not exposed	27.0
Shale: gray, silty near top	46.0
Paper shale: contains ostracods and *Lingula*-like impressions	1.3
Shale: light-gray, calcareous	3.0
Limestone: marly, thin beds alternating with layers of shale, fissile, black	2.0
Shale: largely carbonaceous (horizon of Cavanal coal)	2.5
Underclay	1.5
Siltstone: gray, thin-bedded	1.0
Shale: gray, silty	3.0
Shale: gray; subjacent bedrock not exposed	5.0

41. NW¼NE¼ SEC. 27, T. 10 N., R. 22 E., NORTH OF ROCK FORD SCHOOLHOUSE.

McAlester formation
Tamaha sandstone member

Sandstone: hard, fine-grained, blocky to thin-bedded; superjacent bedrock not exposed	8.0

Unnamed shale member

Shale: gray	33.0
Coal	0.1
Underclay: light gray	0.2
Sandstone: greenish gray, hard, fine-grained, micaceous	0.5
Shale: gray; subjacent bedrock not exposed	71.0

42. SE¼NE¼ SEC. 27, T. 10 N., R. 22 E., NORTH OF ROCK FORD SCHOOLHOUSE.

McAlester formation
Lequire-Warner sandstone unit

Sandstone: hard, fine-grained, blocky; superjacent bedrock not exposed	12.0

McCurtain shale member

Covered: probably shale	35.0
Clay ironstone	0.5
Shale: light gray	3.0
Covered: probably shale	14.0
Shale: gray; subjacent rock not exposed	43.0

43. SE¼NE¼ SEC. 27, T. 10 N., R. 22 E. NORTH OF ROCK FORD SCHOOLHOUSE.

McAlester formation
McCurtain shale member

Sandstone: hard, fine-grained, slabby; superjacent bedrock not exposed	2.0
Shale: gray; subjacent bedrock not exposed	40.0

44. VICINITY OF SE COR. SEC. 33, T. 10 N., R. 22 E., ON SOUTH SIDE OF ROUND PRAIRIE.

McAlester formation
Lequire-Warner sandstone unit

Shale: gray; superjacent rock not exposed	1.0
Coal	0.5
Shale: gray	3.0
Covered: probably shale	5.0
Sandstone: hard, fine-grained	12.0

	Feet
McCurtain shale member	
Shale: gray	37.0
Limestone: containing marine invertebrate fossils	0.3
Siltstone: light gray, calcareous, some fossils	4.0
Limestone: marine invertebrates	0.5
Shale: gray	0.3
Limestone: fossiliferous	0.2
Siltstone: gray	2.0
Shale: gray	8.0
Covered: probably shale	23.0
Shale: gray	11.0
Covered: probably shale	39.0
Shale: light gray	17.0
Covered: probably shale	49.0
Shale: gray, clay ironstone concretions	6.0
Hartshorne sandstone	
Coal	1.7
Underclay: light gray; subjacent rock not exposed	0.2

45. SE¼ SEC. 36, T. 10 N., R. 22 E., 2 MILES NORTH OF KEOTA.

	Feet
Boggy formation	
Bluejacket sandstone member	
Sandstone: coarse-grained, thick-bedded, weathering to large exfoliated blocks; superjacent rock not exposed	25.0
Sandstone: medium-grained, thin-bedded; abundant stems of plants	3.0
Conglomerate: containing pellets of siltstone, shale and sandstone, and many plant fragments	1.0
Sandstone: hard, fine-grained, thin-bedded; interbedded in siltstone, gray, fissile	8.0
Unnamed shale member	
Siltstone: gray, fissile; subjacent rock not exposed	12.0

TOWNSHIP 11 NORTH

46. NW¼NE¼ SEC. 14, T. 11 N., R. 21 E., IN SMALL STREAM ON SOUTH SIDE OF HISAW BOTTOM.

	Feet
Atoka formation	
Blackjack School sandstone member (?)	
Shale: dark gray, soft, flaky; overlain by sandstone; hard, fine-grained, gray to buff; mostly covered	110.0
Sandstone: gray, hard, fine-grained, forming massive bed	7.0
Shale: medium to light gray, silty to sandy, micaceous, grading upward near top into sandstone, fine-grained, thin-bedded, ripple-marked	62.0
Sandstone: medium gray, hard, fine-grained, fairly massive beds	11.0
Shale: dark gray, micaceous, silty; base not exposed	40.0

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Photograph by M. M. Knechtel

Strip mining in Stigler coal bed, near Garland, Haskell County