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# GEOLOGY AND MINERAL RESOURCES OF WASHINGTON COUNTY, OKLAHOMA

by

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Norman

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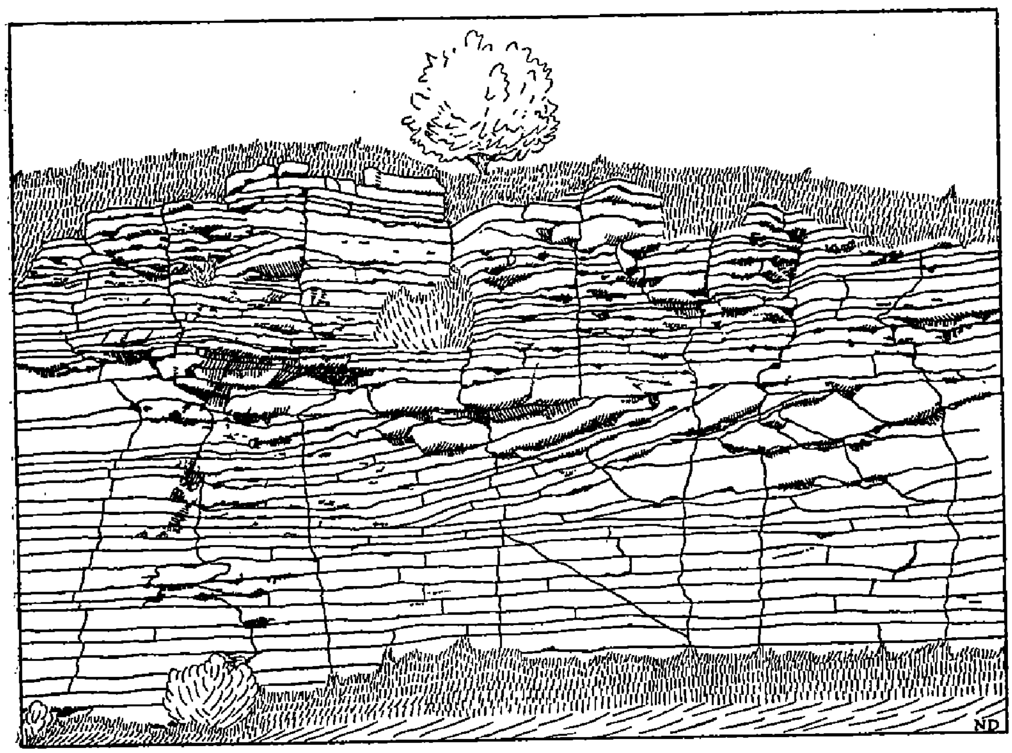


EXPOSURE OF TORPEDO SANDSTONE SHOWING CROSS-BEDDING AND JOINTING. ROAD CUT JUST SOUTH OF COTTON CREEK, 2 MILES NORTH OF COPAN ALONG U. S. HIGHWAY 75, DRAWN FROM A PHOTOGRAPH.

## FOREWORD

A few minerals such as petroleum, coal, lead, and zinc have captured public imagination and interest. These conspicuous resources are important, but there are many more mineral resources that are fundamentally of equal or greater importance. Among these are building stone, gravel, sand, brick and potter's clay, cement-making materials, gypsum, limestone, phosphate and water resources. New uses are being found constantly for materials, as the new industrial use of impure limestone for making rock wool insulation exemplifies.

The Geological Survey, as a service organization, should be in a position to recommend the best available supplies of mineral raw materials, including underground water. It is only when accurate, detailed information about our out-cropping formations, and their probable underground extension is available, that this function can be performed satisfactorily.

In addition to supplying information that is useful to industry and agriculture, a detailed study of surface outcrops reveals many characteristics which are helpful in subsurface studies, so important to geologists engaged in the search for new oil fields.

Robert H. Dott
Director

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# GEOLOGY AND MINERAL RESOURCES OF WASHINGTON COUNTY, OKLAHOMA

by

MALCOLM C. OAKES

## ABSTRACT

Washington County, in northeast Oklahoma, lies immediately south of the Kansas-Oklahoma line and east of the 96th meridian. The area consists, for the most part, of extensive plains overlooked by long, high, eastward-facing ridges called escarpments.

Rocks cropping out in the area comprise most of the Missouri subseries of the Pennsylvanian series and are divided into the Skiatook and Ochelata groups. Other workers have extended the name Seminole formation into northeastern Oklahoma and restricted the Coffeyville formation to strata between the Checkerboard limestone and the Hogshooter formation. The term Hogshooter has been expanded somewhat and retained as a formation name. The Dewey limestone is correlated with the Drum limestone of Kansas, although it is absent immediately south of the Kansas-Oklahoma line, owing to pre-Chanute erosion.

The Chanute and Iola formations of Kansas are mapped entirely across the area. The term Wann formation was previously restricted and redefined by the writer. The Torpedo sandstone and overlying shale were found to constitute a large erosion remnant preserved in a pre-Birch Creek syncline and to be overlain unconformably by the Birch Creek limestone.

The extent, thickness, and character of formations not exposed in Washington County but encountered in drilling for oil and gas are given briefly. Pre-Cambrian granite has been encountered at depths ranging from 1,775 to 2,548 feet and probably underlies all of the county. The granite is overlain by Ordovician limestone ranging from about 100 to more than 700 feet thick. Succeeding Carboniferous rocks continue upward to outcropping beds.

The most important oil and gas producing sands are in the Cherokee shale, the lowest unit of the Pennsylvanian series in the area. The Burgess (Hogshooter) sand, lenticular and patchy in occurrence, rests on the "Mississippi lime" and has been the greatest gas producing sand of the county. The Bartlesville sand,

in the middle of the Cherokee, is the most important oil producer. The Squirrel sand, at the top of the Cherokee, is also an important oil sand. Other oil producing horizons are: The "Oswego" (Ft. Scott) limestone, Peru sand in the Labette shale, and Wayside sand in the Nowata shale.

Oil and gas development began in Washington County in 1894 and production reached its peak in 1906 although exploration maintained its pace to 1915. Production is now in the "stripper" stage but further decline is slow and recent pipeline runs show that the county produces well over a million barrels a year. Both vacuum and repressuring with gas and air have been used to increase recovery but water flooding is now attracting the greatest interest. Eventually the sands may be mined for the residual oil as is done in France. Correlation and description of the oil and gas sands is given and each pool is discussed as to location, surface stratigraphy, structure, depth to sands, development, and production.

Washington County is well supplied with limestone suitable for agricultural use and for many industrial purposes. The main sources are the Winterset limestone member of the Hogshooter formation and the Dewey limestone. The uses of limestone and its direct products, burned lime and carbon dioxide, are discussed and tables are included showing graphic sections with chemical analyses of limestones from seven localities.

Four phosphate horizons were found in the county, one of which, the basal bed of the Winterset limestone member of the Hogshooter formation, may prove to be of local importance. It is about 1 foot thick, contains phosphatic nodules, and may be unusually valuable as agricultural limestone if the contained phosphate proves to be available to growing crops. There seem to be no quarry sites where first class dimension stone could be secured, but the county is abundantly supplied with stone suitable for other purposes. There is no clay-products industry in the county, but the same shale stratum used for making brick at Coffeyville, Kansas, extends across the southeast part of the county and tests of shales from the Nellie Bly and Wann indicate that material from these formations is suitable for making brick and tile. Several thin coal seams cross Washington County but are of little practical value. Large quantities of oil field brines are available, and twelve analyses are given.

Portland cement has been made at Dewey for many years. Zinc is smelted at Bartlesville where sulfuric acid is made as a by-product. It is technically possible to make a number of chemical products from raw materials available in Washington and adjacent counties. Costs and markets would be the determining factors.

The Noxie sandstone, underlying most of T. 29 N., is an unusually good aquifer and it might prove feasible to develop sufficiently large water supplies from this source to serve the small towns in the north part of the area. In other parts of the county, supplies, such as those for farms and ranches, can usually be secured from underground sources but in many instances must come from cisterns and ponds. Any really large supply of water must come from surface storage and fortunately the clay soils seem to be sufficiently impervious to make storage reservoirs feasible.

## INTRODUCTION

*Scope and purpose.* The primary purpose of this investigation was to study in detail the character, distribution, and thickness of the rock formations exposed in Washington County, in order (1) to locate deposits of mineral materials of economic value, especially phospate and limestone that might be suitable for agricultural purposes, and to collect samples for analysis in the chemical laboratory of the Geological Survey; 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 Washington County with those in other areas of surface exposures and with corresponding units found by drilling for oil and gas in areas to the west.

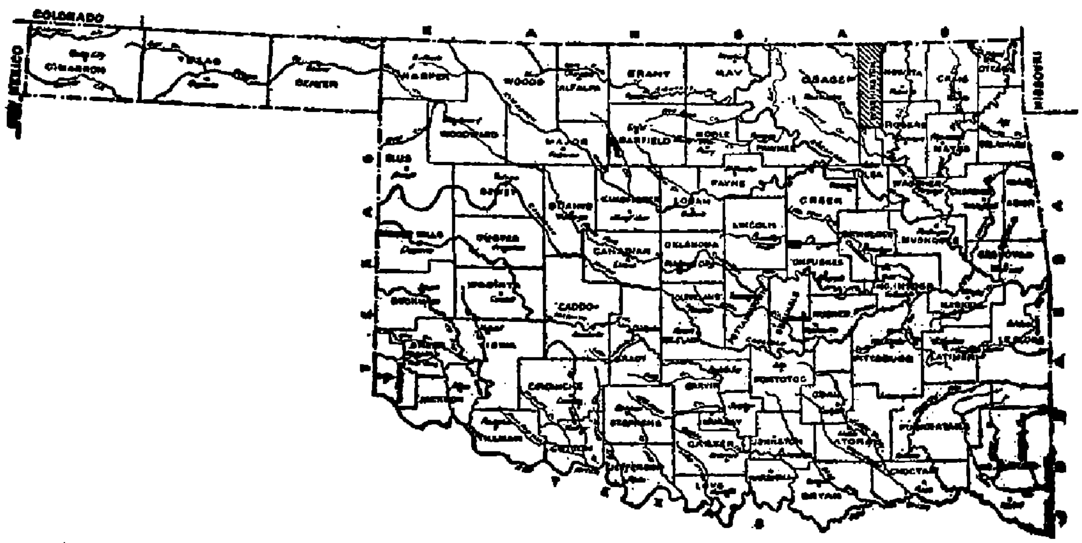

FIG. 1. Index map of Oklahoma showing location of Washington County.

*Location of the area.* Washington County is in northeastern Oklahoma, east of the 96th meridian, and south of the Kansas-Oklahoma line, which coincides with the 37th parallel. It includes Townships 23-29 North, and the east half of Range 12, Range 13, and the west half of Range 14 East, and contains about 425 square miles.

While this report is concerned primarily with Washington County, it was necessary, in order to embrace a workable geologic unit, to map in equal detail, 125 square miles in Nowata County and 18 square miles in Rogers County, to the east; and 30 square miles in Osage County, to the west. It was also necessary to check and correlate in the field, work previously done in Osage County by various geologists of the United States Geological Survey.[1]

*Previous investigations.* The earliest noteworthy geological report on the area is that by Adams[2] which was made in connection with a study of the oil and gas fields of the Indian Territory in 1901. Gould, Ohern, and Hutchison[3] and Ohern[4] contributed to the knowledge of the geology of Washington County in publications of the University of Oklahoma in 1910. Further contributions were made by Ohern in his unpublished manuscript, "The Geology of Nowata and Vinita Quadrangles," 1914, now in the files of the Oklahoma Geological Survey. Shannon and Trout[5] gave a brief description of the Pennsylvanian of northeast Oklahoma, including Washington County. Carpenter gave a summary description of the geology of the county.[6]

*Present investigation.* The present investigation was begun in August, 1937, as a study of phosphate and limestone deposits in relation to their suitability for agricultural use. The investigation was continued during the summer of 1938 and finally completed in the spring of 1939. The earlier mapping in the area was thoroughly rechecked and a number of units not previously mapped were traced across the county.

The mapping was on a scale of 1 inch to the mile, using a base prepared from the reports of the State Mineral Survey.[7] This map showed the drainage, roads, schools, railroads, and other

1. White, David, and others, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma": *U. S. Geol. Survey Bull.* 686, 1922.
2. Adams, George I., "Oil and Gas Fields of the Western Interior and Northern Texas Coal Measures and of the Upper Cretaceous and Tertiary of the Western Gulf Coast": *U. S. Geol. Survey Bull.* 184, 1901.
3. Gould, Chas. N., Ohern, D. W., and Hutchison, L. L., "Proposed Groups of Pennsylvanian Rocks of Eastern Oklahoma": *The State Univ. of Okla., Research Bull.* 3, 1910.
4. Ohern, D. W., "The Stratigraphy of the Older Pennsylvanian Rocks of Northeastern Oklahoma": *The State Univ. of Okla. Research Bull.* 4, 1910.
5. Shannon, C. W., and Trout, L. E., "Petroleum and Natural Gas in Oklahoma": *Okla. Geol. Survey Bull.* 19, pt. 1, 1915.
6. Carpenter, Everett, "Oil and Gas in Oklahoma, Geology of Washington County": *Okla. Geol. Survey Bull.* 40, Vol. III, 1928.
7. Works Progress Administration project No. 65-65-538, sponsored and directed by the Oklahoma Geological Survey, 1936-37.

cultural features. Outcrops were mapped on this base by automobile traverse and by pacing. In some areas aerial photographs were utilized. So far as possible, formations were mapped by actual tracing in the field, reducing the distances between known outcrops to the minimum.

Sections were measured, where possible, by hand level at exposures where no corrections for dips were necessary. In situations where such corrections were necessary, the component of dip in the direction of measurement was determined from aneroid observations over one or more courses in the immediate vicinity. In a few local areas structure contour maps were made, using altimeter elevations, in order that the necessary corrections for dip might be determined.

In no instance was it possible to measure a completely continuous section across all the strata mapped. Instead, sections were compiled from measured sections having overlapping portions that could be correlated by tracing along the outcrop.

Each sample for chemical analysis was so taken as to include proportional amounts of material from all parts of the deposit represented by that sample. Samples taken in the field weighed 30 to 50 pounds. Each sample was taken between definite stratigraphic limits which, together with the geographic location, were carefully described, in order that later workers may identify the locality and bed sampled, in the field. If stratigraphic differences in lithology or other characteristics within a single exposure suggested differences in chemical composition a separate sample from each phase was taken.

*Acknowledgements.* Thanks are due to Norman D. Newell, who gave two days of his time for a field conference, and to Joseph L. Borden, for field assistance, for two measured sections, and for the location of several outcrops not hitherto reported. Robert H. Dott has lent his assistance and encouragement throughout. During the summer of 1938, John R. Davis, then a graduate student of the University of Oklahoma, checked, under the supervision of the writer, previous mapping of the Checkerboard limestone from Tulsa to the Kansas-Oklahoma line. He found many previously unmapped exposures, especially north of Township 26

North. The results of his work are embodied in his thesis for the Master of Science degree, now in the library of the University of Oklahoma.

## GEOGRAPHY

*Topographic Features.* The maximum regional relief of Washington County is about 350 feet. Elevations along Caney River range from about 650 feet to about 700 feet above sea level while elevations on the north line of the county and on Blue Mound are 1,000 feet above sea level. Elevations along the escarpment west of Caney River are 900 to 950 feet above sea level.

The present topography of Washington County is the result of erosion on beds of unequal hardness. The rocks at the surface over most of the county are predominantly shale, which is relatively non-resistant to erosion, interspersed, at comparatively large intervals, with much thinner, but hard and more resistant beds of sandstone and limestone. All these beds, though originally deposited in a horizontal position, have been tilted, and now dip, or slope generally in a direction a little north of west (N. 67° W.), at an average rate of about 30 feet per mile.

Erosion, principally by water, has worn away the soft shales over much of the county, producing extensive plains, and causing the eroded edges of the harder beds to stand up in long, high, eastward-facing ridges, overlooking these plains. Such ridges are called escarpments or cuestas. Such an escarpment is to be seen to the westward, across Caney River, from U. S. Highway No. 75.

The escarpments are characterized by steep faces, opposed by gentle back slopes that descend to the level of the plains. The height of the escarpment is dependent on the thickness of the underlying, non-resistant shale, and the depth of erosion. The back slopes usually descend with the dip of the rocks, and are called dip-slopes. While the harder beds are eroded somewhat by the processes of weathering, their principal removal is accomplished by undercutting of the underlying, softer shale, and slumping or caving of blocks of the harder bed. As this process continues, the front of the escarpment "migrates" westward, in the direction of dip.

The line of the escarpment is frequently modified by locally greater erosion by streams, which either head in, or cross it. This produces a sinuous trace, characterized by promontories and re-entrants, or the escarpment may be severed by streams heading west of it. Headward cutting by tributary streams may completely sever a promontory from the rest of the escarpment, producing an isolated hill or butte. These hills are locally known as "mounds" and are conspicuous in several parts of Washington County, rising above the plains as prominent and picturesque features of the landscape, located many miles from the escarpments of which they were once a part. They are conspicuous in the northeast part of the county.

*Drainage.* The major drainage is by Caney River and its largest tributary, Caney Creek. The latter enters the county from Kansas and flows along the west side of R. 13 E. to the north side of T. 27 N., where it joins the river. Caney River enters the county in SW¼ sec. 26, T. 28 N., R. 12 E., and continues southward to the north side of T. 25 N. where it is deflected southeast along a prominent syncline. At the southeast corner of T. 25 N., R. 13 E. it resumes its southward course along the east side of the county, and leaves near the southeast corner.

With the exception of Double Creek, in the southwest part of the county, the larger tributaries enter the river from the east and have a southward to southwestward course across dip slopes developed on the harder layers of rock. These tributaries are, from north to south: Cotton Creek, Brush Creek, Post Oak Creek, Coon Creek, Hogshooter Creek, Curl Creek, and Buck Creek. There are numerous swamps and lakes along the course of Caney River.

*Economic Development.* Production of oil and gas forms the chief industry of the county. Aggressive development occurred in the early 1900's. Lack of early production records makes it difficult to estimate how much oil has been produced in Washington County. Weirich[8] estimates that the Washington-Nowata County district has produced possibly in excess of 300,000,000 barrels. Production is now in the "stripper" stage, that is the gas

8. Weirich, T. E., "Petroleum Geology of Nowata and Washington Counties, Oklahoma": *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society*, p. 86, 1937.

pressure is practically exhausted and operators are engaged in recovering what oil will drain to the wells by gravity. Many properties have been at some time under vacuum to bolster up the declining gas pressure by relieving the back pressure of the atmosphere at the wells. Repressuring by water-flooding is in an experimental stage and offers considerable promise of increased recovery. According to Weirich, analyses of cores taken recently indicate that from 70% to 90% of the original oil content of the sands still remains. Such a large reserve of oil will continue to challenge ingenious operators, especially in periods when oil commands a relatively high price, and no doubt Washington County will produce oil for many years to come.

The zinc smelter at Bartlesville was established because of an abundant, local supply of cheap gas for fuel. It operates six blocks of retorts. The sulphur dioxide from the roasters is recovered and utilized in the manufacture of sulphuric acid. Cadmium is a by-product.

The cement plant at Dewey was originally established because of the availability of cheap gas, but with the decline of gas production coal has been substituted. The plant has a daily capacity of 5,000 barrels, each barrel equivalent to four 94 pound sacks of cement.

Oil well specialties as well as the simpler sorts of plumbing and heating supplies are manufactured in Bartlesville. Possibilities of manufacturing have hardly been scratched. For instance, it is possible that the oil field brines of the area might contribute raw materials for a chemical industry. It is technically possible to make hydrochloric acid from the sodium chloride of the brine, using sulphuric acid from the smelter. The magnesium chloride could be converted into the metal and various magnesium salts.

Before the development of oil and gas, farming and ranching were the chief occupations and continue to be important. Shales generally weather to good soils but in Washington County they usually crop out in scarp slopes too steep for cultivation. The sandstone dip slopes are usually poor and rocky. Large dip slope areas are covered by limestone which weathers to good soil. Though such areas are generally too rocky for tillage, the grass is abundant and of superior quality, supporting large herds. Most of the upland is devoted to meadows and pastures, but considerable feed and some wheat are grown where the land is tillable. The alluvial soil along the larger streams is good for farming where it is not subject to overflow.

## SURFACE STRATIGRAPHY[9]

Rocks belonging to the Missouri subseries, of middle Pennsylvanian age, are exposed in Washington County, and form a part of the sequence of upper Carboniferous rocks that is so well developed in the northern Mid-Continent area. In common with other parts of the northeast Oklahoma section, many individual beds continue with unbroken outcrops across the state line, from Kansas. Other Kansas units undergo complete changes of facies before reaching the state line, and consequently are unrecognizable in Oklahoma. A sufficient number of the Kansas units are present in northern Oklahoma to establish definite correlations, and to permit a broad classification that corresponds in general with the classification used in Kansas.

Because the outcrops cross the county obliquely it has been necessary to do considerable work in adjoining Osage and Nowata Counties, in order to embrace a satisfactory geologic unit. The rocks which crop out in Washington County are shales, sandstones, and limestones in the order of their importance. In the northern part of the county they rest on the flank of the structural ridge or shelf known as the Chautauqua arch which seems to have been consistently higher throughout Pennsylvanian time than the region to the south.

9. Substantially as set forth more briefly by the writer in "Results of Recent Field Studies in Osage, Washington, and Nowata Counties, Oklahoma": *Bull. Amer. Assoc. Petro. Geol.*, Vol. 24, pp. 716-730, 1940.

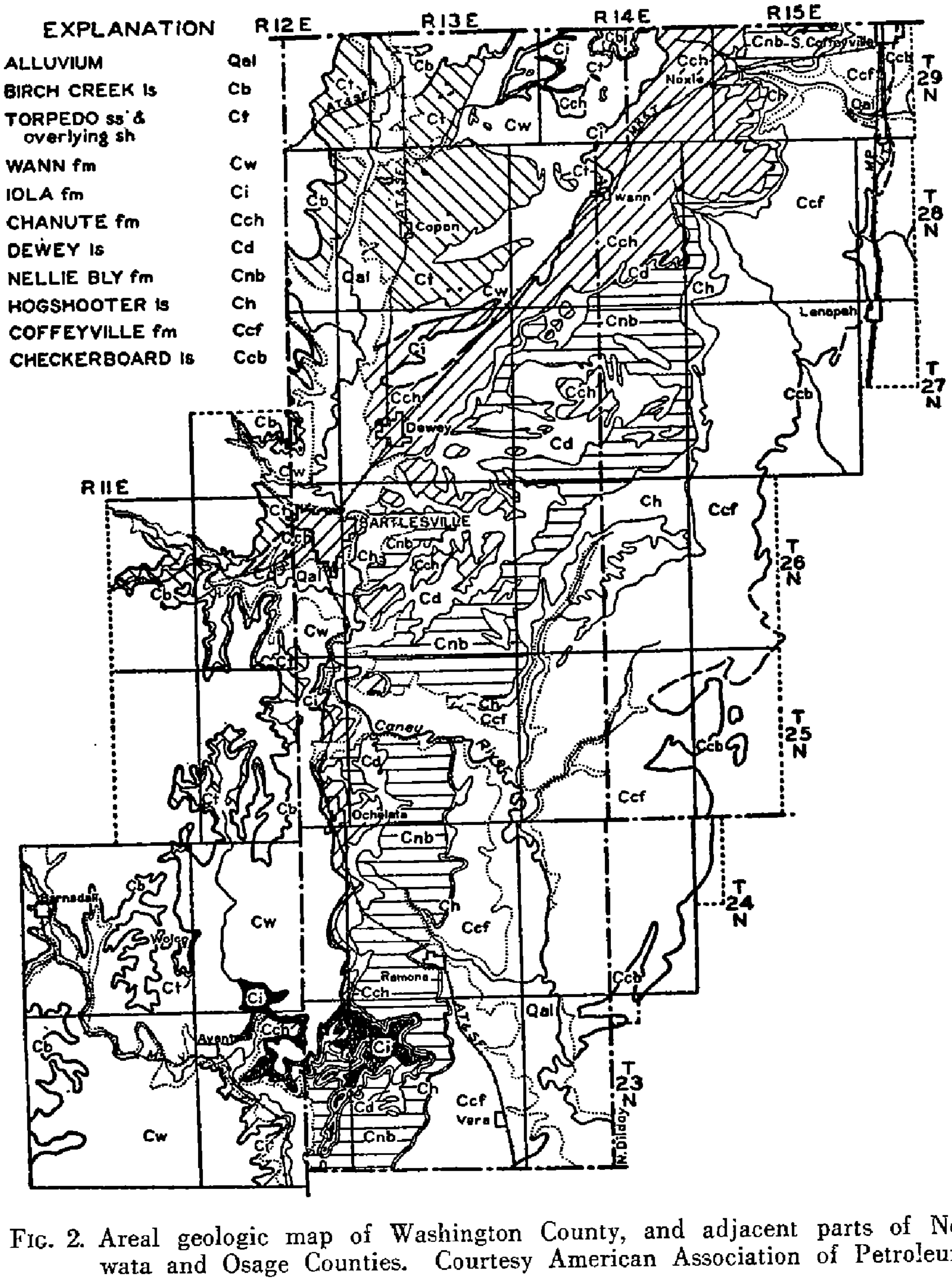


FIG. 2. Areal geologic map of Washington County, and adjacent parts of Nowata and Osage Counties. Courtesy American Association of Petroleum Geologists.

# CARBONIFEROUS SYSTEM

## PENNSYLVANIAN SERIES

### *Missouri Subseries*

The Missouri subseries is one of four major divisions of the Pennsylvanian rocks of Oklahoma, and includes rocks of the same age that are similarly referred to the Missouri subseries in Kansas. It is set off from the underlying Des Moines subseries by an unconformity and faunal change, that has been observed from the Kansas-Oklahoma line to the area of the Arbuckle Mountains; and further work will doubtless demonstrate that it is separated from the overlying Virgil subseries by a large unconformity which is marked by changes in lithology and large scale truncation of beds. Neither the basal nor uppermost units of the Missouri subseries are exposed in Washington County, so the upper and lower boundaries were not investigated in detail during the present work, and our knowledge of their relationships is based largely on the results of previous studies by other workers.[10]

Moore, Newell, Dott, and Borden[11] suggested a division of the Missouri rocks of northern Oklahoma and southern Kansas into two groups: Skiatook and Ochelata. The logic of this division as applied to rocks exposed in Washington County has been fully demonstrated by the present work, and the definitions of the groups that appeared in the Guidebook, are quoted in full:

#### SKIATOOK GROUP

> Ohern[12] introduced the term Skiatook to apply to beds between the Lenapah and Dewey limestones; it was used only in the southern part of the area mapped by him and, as shown by his mapping, he here mistook the Checkerboard limestone for Lenapah. Consequently, original application

10. Moore, Raymond, C., and Newell, Norman D., "The Missouri-Virgil Boundary in Southern Kansas and Northern Oklahoma": *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society*, p. 37, 1937.
11. Moore, Raymond C., Newell, Norman D., Dott, Robert H., and Borden, Joseph L., "Definition and Classification of the Missouri Subseries of the Pennsylvanian Series in Northeastern Oklahoma": *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society*, p. 39, 1937.
12. Ohern, D. W., "The Stratigraphy of the Older Pennsylvanian Rocks of Northeastern Oklahoma": *The State Univ. of Okla. Research Bull.* 4, p. 34, 1910.

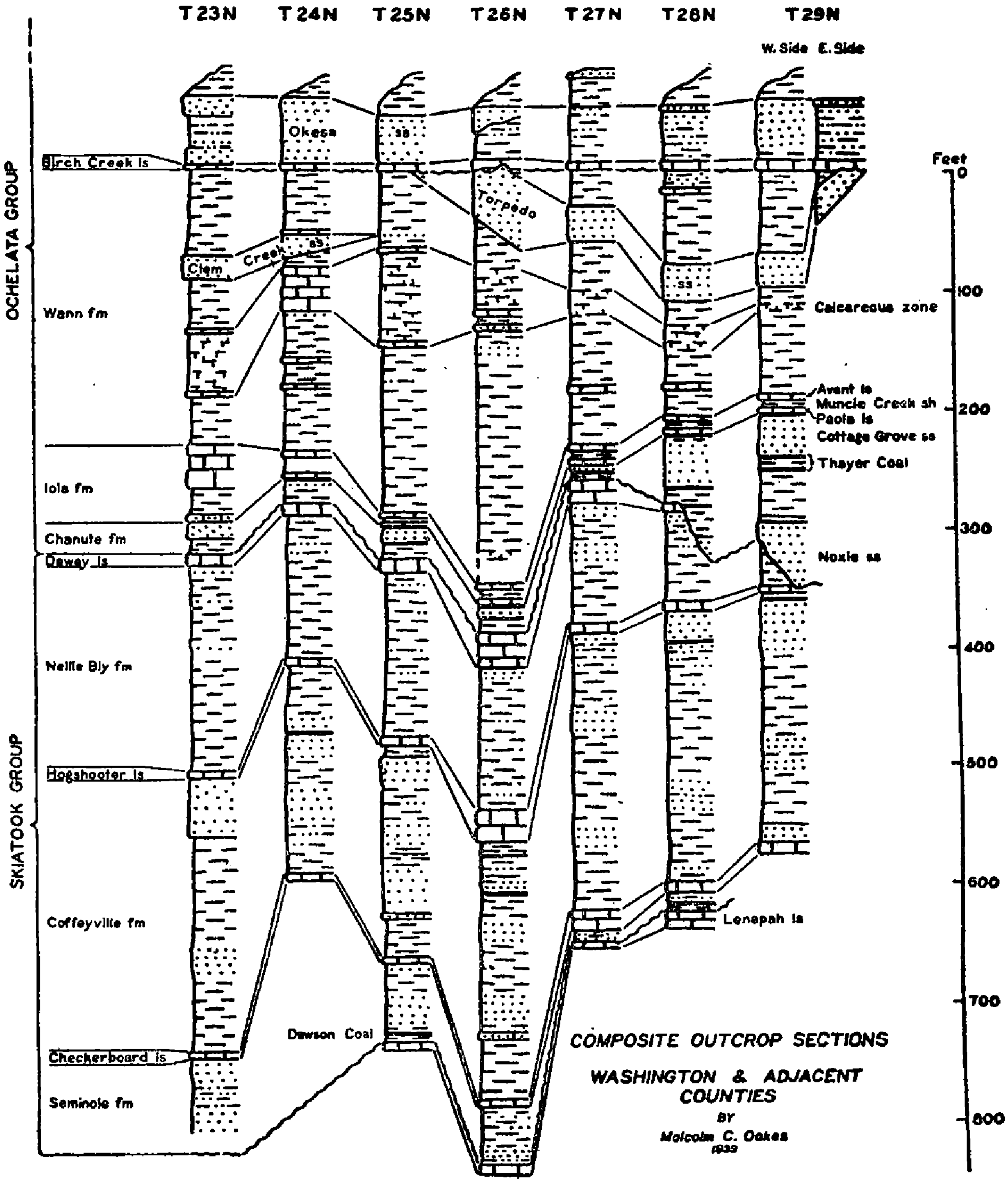


FIG. 3. Measured outcrop sections of Pennsylvanian rocks exposed in Washington and adjacent parts of Nowata and Osage Counties. Courtesy American Association of Petroleum Geologists.

of Skiatook was really to the strata between Checkerboard and Dewey.

It appears desirable in Oklahoma and in southern Kansas to divide the Missouri sub-series into two parts, using the disconformity at the base of the Chanute shale, discovered in work by N. D. Newell, as the boundary line. This is the most significant line of division within the Missouri deposits of this region and appears to be mainly responsible for the cutting out of the Drum (equivalent to Dewey) limestone in various places, especially near the state line. The prominent limestones that furnish the chief basis for differentiation of groups in east-central and northeastern Kansas sections of the Missouri subseries are lacking in southern Kansas and in Oklahoma; therefore, if any groups are to be defined in the southern area, they must be different from those in the north. The Ochelata beds are a group, equivalent to several Kansas formations, and introduction of a correlative group term to include the lower Missouri deposits is useful. For example, this classification brings out rather more clearly than otherwise the significance of the Missouri-Virgil unconformity in southern Oklahoma where practically all of the Missouri beds belong to the Skiatook group, the Ochelata being mostly absent.

In bringing Skiatook back from the limbo of unused stratigraphic names, application is changed so that its lower boundary coincides with the disconformity that marks the base of the Missouri subseries, and its upper boundary is placed at the top of the Drum limestone (or where this limestone is absent, at the base of sandstone in the lowermost Chanute shale).[13]

TABLE I

SUBDIVISIONS OF THE SKIATOOK GROUP IN WASHINGTON AND ADJACENT COUNTIES

Missouri subseries
    *Unconformity*
    Skiatook group
        Dewey limestone
        Nellie Bly formation
        Hogshooter formation
            Winterset limestone member
            Stark shale member (local) } Lost City limestone member (local)
            Canville limestone member (local) }

13. Moore, Newell, Dott, and Borden, *Op. cit.*, p. 40.

Coffeyville formation
Shale, containing coal near top, locally.
Dodds Creek sandstone member, contains Cedar Bluff coal near base.
Shale, with local sandstone ledges
Checkerboard limestone
Seminole formation
Sandstone and shale
Shale, contains Dawson coal
Sandstone and Shale (in south part of area)
*Unconformity*
Des Moines subseries
Break, filled by Memorial shale farther south
Lenapah limestone

SEMINOLE FORMATION

Use of the name Seminole formation has been extended into northeast Oklahoma and applied to the shale and sandstone unit lying above the unconformity at the base of the Missouri subseries, and below the base of the Checkerboard limestone. Across Tps. 29, 28, and 27 N., Rs. 15 and 16 E., Nowata County, the Seminole consists of 10 to 20 feet of sandy shale and sandstone with the Dawson coal 1 to 2 feet above the base. South of T. 27 N. the formation thickens rapidly to 240 feet in the vicinity of Collinsville.

*First reference.* Taff, 1901. Called Seminole conglomerate.

*Nomenclator,* Taff.

*Type locality.* Southeast part of Seminole nation, now County (probably T. 6 N., Rs. 7 and 8 E.)

*Original description*:

> About 50 feet of the lower part of the Seminole conglomerate is exposed in a small area in the northwestern corner of the Coalgate quadrangle. * * * Forty to 50 feet from the base the conglomerate grades into brown sandstone which continues upward about 100 feet to the top of the formation. The Seminole formation crops out in rugged hilly country northwestward in the Seminole Nation, making rough timbered lands.[14]

*History of usage.* Taff defined the lower limit of the Seminole formation as the base of the conglomerate above the Holdenville shale, but left the upper limit undefined except to imply that it is about 150 feet above the base of the conglomerate. Morgan[15]

14. Taff, J. A., *U. S. Geol. Survey Geol. Atlas, Coalgate Folio,* (No. 74) p. 4, 1901.
15. Morgan, Geo. D., "Geology of the Stonewall Quadrangle, Oklahoma": *Bureau of Geology Bull.* 2, pp. 109-112, 1924.

definitely fixed the upper limit of the formation at the base of the DeNay limestone. In the northwestern part of the Coalgate quadrangle, the DeNay is about 150 feet above the base of the conglomerate.

Application of the term Seminole to certain beds in northeast Oklahoma was first proposed informally by Dott at the Tulsa meeting of the American Association of Petroleum Geologists, in 1936; and was formally proposed by Ware and Dott,[16] in 1937, and in the same year by Moore, Newell, Dott, and Borden, who are quoted in the following summary:

> Recent studies, especially by Dott, have indicated equivalence of sandy beds, formerly included in the lower part of the Coffeyville formation of northeastern Oklahoma, with at least part of the Seminole sandstone of southeastern Oklahoma. It is desirable in simplification of stratigraphic classification to extend application of Seminole into northern Oklahoma, its boundaries here being defined as the basal Missouri disconformity, below, and the base of the Checkerboard limestone, above. It is not now established that the Checkerboard is the precise equivalent of the DeNay limestone, which in southern Oklahoma immediately overlies the Seminole, but the equivalence is sufficiently close to indicate that little violence will be done in defining the upper limit of the northern Seminole as has been indicated.[17]

*Distribution.* Only a little of the upper part of the Seminole formation, exposed in the southeast corner of Washington County, was mapped in connection with the present investigation. The portion of its outcrop herein discussed extends in a band, averaging about 4 miles wide, from the vicinity of Tulsa to the Kansas-Oklahoma line in the vicinity of South Coffeyville, crossing parts of Tulsa, Washington, Rogers, and Nowata Counties.

*Thickness and character.* The Seminole formation is only 10 to 20 feet thick across Tps. 29, 28, and 27 N., Rs. 15 and 16 E. At the base is 1 to 2 feet of shale, succeeded by the Dawson coal

16. Ware, John M., and Dott, Robert H., in a contribution to "A New Pennsylvanian Cephalopod Fauna from Oklahoma": by A. K. Miller and John Britts Owen, *Jour. Paleontology*, Vol. 11, No. 5, pp. 403-404, 1937.
17. Moore, Newell, Dott, and Borden, *Op. cit.*, p. 41.

which is less than 1 foot thick. Beds above the Dawson are usually sandy shale in this part of the area, but sandstone beds occur locally, especially near the top. Across T. 26 N., and farther south beds above the Dawson coal thicken remarkably. The shale below the coal is only 2.5 feet thick as far south as sec. 27, T. 25 N., R. 15 E. but is thicker farther south and overlies the northernmost exposures of the lower Seminole sandstone in the vicinity of Talala. From the latitude of Talala to that of Tulsa the Seminole formation consists of three members: lower sandstone, middle shale containing the Dawson coal, and upper sandstone with some shale. Owing to the southward thickening of upper Seminole beds and to the presence of beds lower than any in the northern part of the area, the Dawson coal lies 60 feet or more below the top of the formation and at least 180 feet above the base, in the vicinity of Collinsville.

*Stratigraphic relations.* The Seminole formation is underlain by the uppermost beds of the Des Moines subseries. North of Talala the uppermost Des Moines bed is the Lenapah limestone, in the vicinity of Oologah it is the Nowata shale, and in the vicinity of Tulsa it is the Memorial shale,[18] which lies above the Eleventh Street limestone, thought to be equivalent to the Lenapah. The Seminole is overlain by the Checkerboard limestone, which is provisionally correlated with the DeNay limestone of Pontotoc and Seminole Counties.

*Correlation.* The Seminole formation of northeastern Oklahoma is considered the northward extension of the Seminole formation of the area immediately north of the Arbuckle Mountains. It is equivalent to that part of the original Coffeyville formation below the Checkerboard limestone in the area north of Nowata but also includes the upper part of the Nowata shale as shown on the Geologic Map of Oklahoma in Rogers and Tulsa Counties. Owing to uncertainty as to the equivalent of the Checkerboard limestone in Kansas, definite correlation cannot be made. If the Checkerboard limestone is equivalent to the Hertha limestone of Kansas, the Seminole is exactly equivalent to the Bourbon formation of Kansas. If, on the other hand, the Checkerboard is below

18. Dott, Robert H., Referred to by Raymond C. Moore, "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas": *Kansas Geol. Survey Bull.* 22, p. 67, 1935.

the Hertha, as seems probable, the Bourbon includes beds in its upper part which are above the highest beds in the Seminole formation.

*Detailed sections.* For measured outcrop sections of the Seminole formation see sections numbered 6, 9, 10, 43, 45, 46, 66, 71, 114, 115, Appendix B.

### CHECKERBOARD FORMATION

The name Checkerboard formation is applied here to limestone and calcareous shale lying above the Seminole formation, and below the Coffeyville formation. As found in this area the Checkerboard consists of five members as shown in Fig. 4. Member 1, the lower member, is the limestone called the Checkerboard limestone in the older literature. Recent workers have found other members in isolated exposures of the Checkerboard in the north part of the area.

*First reference.* The first published recognition of the bed now known as the Checkerboard limestone was by Gould, Ohern, and Hutchison,[19] in 1910. On a sketch map of part of eastern Oklahoma, they showed its outcrop extending southward as far as North Fork of Canadian River, but erroneously considered it, and designated it, the southward extension of the Lenapah limestone.

*Nomenclators.* The name seems to have crept into general usage without formal definition. Hutchison[20] made reference to it by name in 1911. Carl D. Smith described it by name in 1914.

> About 215 feet above the Dawson coal and 680 to 780 feet above the top of the Fort Scott is a thin hard limestone of remarkable persistence and uniformity, which outcrops in a number of places in the Glenpool area. This bed is exposed in Tulsa at the junction of the St. Louis & San Francisco and Missouri, Kansas, and Texas and Midland Valley railroads, near the north end of the St. Louis & San Francisco Railroad bridge over Arkansas River, at a number of places between Red Fork and Jenks,

19. Gould, Chas. N., Ohern, D. W., and Hutchison, L. L., "Proposed Groups of Pennsylvanian Rocks of Eastern Oklahoma": *The State Univ. of Okla. Research Bull.* 3. map 1910.

20. Hutchison, L. L., "Preliminary Report on the Rock Asphalt, Asphaltite, Petroleum, and Natural Gas in Oklahoma": *Okla. Geol. Survey Bull.* 2, p. 157, 1911.

at many places in Glenpool proper, and a short distance northeast of Mounds. It varies little from 2 feet 6 inches in thickness and is an excellent datum surface for working out details of structure. It is known to drillers as the Checkerboard lime.[21]

Fath and Emery mentioned it by name in 1917.

Two outcrops of the Checkerboard lime, a bed which is about two feet thick, were noted by the writers along Flat Rock Creek (name later changed to Checkerboard Creek) at the west side of the area described in this report. These exposures are in sec. 22, T. 15 N., R. 11 E. —one in and north of the road at the south side of this section and a short distance west of the creek, and the other in the creek bed at old "Checkerboard Crossing" near the east-west quarter line of the section.[22]

*Type locality.* In 1925 Gould[23] designated its exposures on Checkerboard Creek in T. 15 N., R. 11 E., as the type locality.

*Original description*: No description can be quoted as original. In 1925 Gould gave the following description:

The Checkerboard limestone member of the Coffeyville formation lies near the base of the formation. It is 2½ to 3 feet thick, fine grained and fossiliferous; bluish-white on fresh surfaces but becomes yellowish-white on weathered surfaces. In bare areas the limestone presents a "checkerboard" appearance, due to solution channels along the joints, which occur in two sets, the one crossing the other. From this characteristic feature the limestone was for years known as the "Checkerboard lime", but the geographic locality which is here designated as its type locality is the exposures on Checkerboard Creek in T. 15 N., R. 11 E. A good exposure may be seen at "Checkerboard Crossing" of the creek, near the east-west quarter line of sec. 22, T. 15 N., R. 11 E.[24]

*History of usage.* There is nothing in the literature to indicate that the term Checkerboard has ever been used in any but

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21. Smith, Carl D., "The Glenn Oil and Gas Pool and Vicinity, Oklahoma": *U. S. Geol. Survey Bull.* 541, p. 41, 1912.
22. Fath, A. E., and Emery, Wilson B., "A Structural Reconnaissance in the Vicinity of Beggs": *Okla. Geol. Survey Bull.* 19, pt. 2, p. 370, 1917.
23. Gould, Charles N., "Index to the Stratigraphy of Oklahoma": *Okla. Geol. Survey Bull.* 35, p. 72, 1935.
24. *Idem.*

its present sense. Moore, Newell, Dott, and Borden, in 1937,[25] included the sandy basal beds of the Coffeyville in the Seminole formation, restricted the Coffeyville to apply only to strata between the Checkerboard limestone and the Hogshooter (Dennis) formation, and raised the Checkerboard limestone to formation rank.

*Distribution.* The Checkerboard limestone is shown on the Geologic Map of Oklahoma[26] extending from the latitude of Okmulgee to a point west of Nowata. Ohern, in his unpublished manuscript, evidently discussing the Checkerboard limestone, says: "Four miles west of Nowata it crops out here and there on the lower slopes of the bluff* * * and northward to the headwaters of California Creek. Northward of this locality no indications of its continuation were observed."

In January, 1933, Ronald J. Cullen and Robert H. Dott, as a field research project of the Tulsa Stratigraphic society, made a reconnaissance trip to the vicinity of Nowata, and found a calcareous zone and limestone, near the E¼ cor. of sec. 28, T. 26 N., R. 15 E., 3 miles west of Nowata, which they identified as Checkerboard limestone because of its position above the upper Seminole sandstone. This zone was followed north to South Coffeyville, and limestone outcrops were seen in enough places to indicate that the Checkerboard is continuous to the Kansas-Oklahoma line, one exposure being seen 100 yards north of the line on the east side of U. S. highway 169 north of South Coffeyville.

During the field season of 1938 John R. Davis, a graduate student of the University of Oklahoma, checked the mapping of the Checkerboard under supervision of the writer, from the north edge of Tulsa to its northernmost extension as shown on the Geologic Map of Oklahoma,[27] and added details to the mapping from that point to the Kansas-Oklahoma line, in the north edge of South Coffeyville.

*Thickness and character.* The Checkerboard formation, in this area, is composed of five members, three of limestone and two

25. Moore, Newell, Dott, and Borden, *Op. cit.*
26. Miser, Hugh D., "Geologic Map of Oklahoma": *U. S. Geol. Survey*, 1926.
27. *Idem.*

of gray calcareous, fossiliferous shale. The following composite section may be taken as typical:

TABLE II

COMPOSITE SECTION OF CHECKERBOARD FORMATION COMPILED FROM MEASURED OUTCROP SECTIONS FROM THE KANSAS-OKLAHOMA LINE SOUTHWARD TO SEC. 11, T. 25 N., R. 14 E. MEMBERS ARE NUMBERED TO CORRESPOND WITH FIG. 4.

| | Feet |
|---|---|
| Coffeyville formation. | |
| Lowermost part, black, fissile shale with phosphatic concretions in the base | 3.0 to 30.0 |
| Checkerboard formation | |
| 5. Limestone, gray, marly, fossiliferous | 0.1 to 1.0 |
| 4. Shale, gray, calcareous, fossiliferous | 1.0 to 2.5 |
| 3. Limestone, dense, dark-bluish, nodular, fossiliferous | 0.5 to 1.0 |
| 2. Shale, gray, calcareous, fossiliferous | 5.5 to 7.5 |
| 1. Limestone, from the Kansas-Oklahoma line to the south side of T. 24 N., R. 14 E. This member is gray, sparingly fossiliferous, breaks into thin plates and sharp-edged lenses in weathering and is usually 1 to 2 feet thick. In T. 23 N., R. 13 E. and southward it is more massive and blocky and corresponds more closely with the description quoted above from Gould, and with its development in Tulsa County and southward. It is the Checkerboard limestone of older literature | 1.0 to 3.0 |
| Seminole formation. | |
| Uppermost beds, sandstone and very sandy shale, not measured. | |

Exposures of the Checkerboard are hard to find in the field since it does not form scarps, crops out in relatively flat country, and seems to be unusually soluble. Its outcrop lies about a mile east of the escarpment formed by the sandstones in the middle of the overlying Coffeyville formation (zones 2, 4, and 6), and a short distance west of the outcrop of the upper Seminole sandstone.

Three criteria were most useful in tracing the outcrop: (1) The Checkerboard, in this area, lies on sandy, uppermost beds of the Seminole formation. (2) It is overlain by the lowermost part of the Coffeyville formation, consisting of 3 to 30 feet of black, fissile shale, containing in its lower 2 feet a persistent zone of small, round, black, phosphatic nodules. This black shale and the overlying thick clay shale of the lower part of the Coffeyville formation yield a dark, sticky, clay soil which is in sharp contrast to the sandy soil derived from the Seminole formation below the Checkerboard. The contrast is especially marked in rainy weather, and furnishes a useful guide to mapping. (3) Phosphatic concretions, such as those in the shale above the Checkerboard formation, are very resistant to weathering. Inasmuch as they remain in the soil when all other constituents of the enclosing rock have become unrecognizable, they afford a reliable basis for mapping the position of the formation between good exposures.

On the east side of U. S. highway 169,[28] 100 yards north of the Kansas-Oklahoma line, an exposure of the upper part of the Checkerboard includes: member 2, calcareous shale with abundant fossils, 4 feet thick; member 3, dense, blue, nodular, fossiliferous limestone, 0.5 foot thick; member 4, gray, calcareous, fossiliferous shale, 1.0 foot thick; and member 5, gray fossiliferous limestone, 0.1 foot thick. The overlying shale and phosphatic nodules are gray in color, probably due to weathering.

In his field notes of January 20, 1933, Dott[29] states: "Much limestone is present around the house southwest of South Coffey-

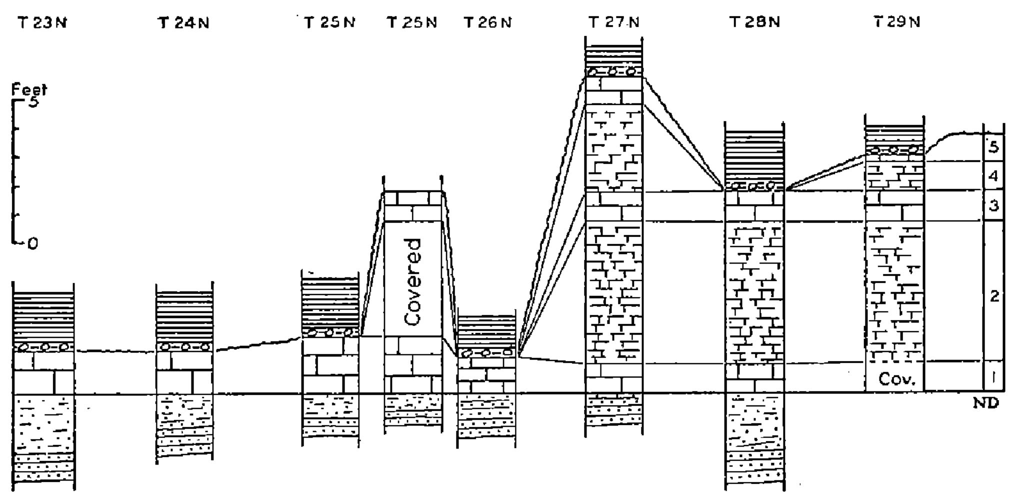


FIG. 4. Outcrop sections of Checkerboard formation by townships, showing subdivisions and relation to underlying Seminole formation and overlying black, fissile shale containing phosphatic nodules in the base of Coffeyville formation: (1) Limestone, gray, sparingly fossiliferous, 1 to 3 feet thick, the Checkerboard limestone of earlier writers; (2) Shale, gray, calcareous, fossiliferous, 5.5 to 7.5 feet thick; (3) Limestone, dense, dark-bluish, nodular, fossiliferous, 0.5 to 1.0 foot thick; (4) Shale, gray, calcareous, fossiliferous, 1.5 to 2.5 feet thick; (5) Limestone, gray, marly, fossiliferous, 0.1 to 1.0 foot thick.

ville, just west of railroad (NW¼ NE¼ sec. 25, T. 29 N., R. 15 E.), dug up in well and pipeline ditch. We inquired of the farmer

28. This is the outcrop mentioned in *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society*, p. 54, 1937.
29. Robert H. Dott.

and he said it all came from the place—none had been hauled in. We saw a few pieces in a field. It is undoubtedly Checkerboard."

In T. 28 N., Rs. 15 and 16 E., only three exposures of the Checkerboard limestone were found.

The basal part of the black fissile shale with its contained phosphatic nodules, which immediately overlies the Checkerboard limestone in this area, is exposed in a small draw near the W¼ corner sec. 5, T. 28 N., R. 16 E. Along the creek which flows southeastward across sec. 18, T. 28 N., R. 16 E., members 1 and 3 are exposed but the intervening shale, member 2, is covered. Member 1 is gray, platy, fossiliferous limestone about 1 foot thick, and member 3 is dark-bluish, nodular limestone about 1 foot thick. Member 3 is exposed along the road near W¼ corner sec. 19, T. 28 N., R. 16 E. It is dark-blue nodular limestone about 0.5 foot thick. An unusually good exposure of the Checkerboard occurs in the north bank of a small creek near the center of the NE¼ sec. 25, T. 28 N., R. 15 E., less than a half mile west of Bell's Spurr, which contains members 1, 2, and 3. Member 1 is granular to flaky limestone, 0.5 foot thick. Member 2 is gray, calcareous, extremely fossiliferous shale, 5.5 feet thick. Member 3 is dark-blue, nodular limestone, 0.5 foot thick. Member 3 is overlain by the lowermost part of the Coffeyville formation, the usual black, fissile shale containing phosphatic nodules.[30]

Member 3 is exposed on the south side of the road 200 feet west of the NE corner of sec. 14, T. 27 N., R. 15 E. It is hard, blue, nodular fossiliferous limestone 0.5 foot thick and is underlain by member 2, gray calcareous shale 2 feet thick with the base not exposed. Other exposures of these members occur in the same vicinity. The overlying black, fissile shale with its contained phosphatic nodules is exposed in the draw near the S¼ corner of sec. 22, T. 27 N., R. 15 E. In the same draw across sec. 27, T. 27 N., R. 15 E., limestone members 1, 3, and 5, are exposed with their usual thickness and characteristics but the shale members, 2 and 4, are poorly exposed. The overlying black, fissile shale with phos-

30. This is the exposure mentioned in *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society*, p. 55, 1937.

phatic nodules crops out in the road near the S¼ cor. sec. 28, T. 27 N., R. 15 E. A small exposure of member 1 occurs in the west bank of Wolf Creek south of the N¼ cor. sec. 34, T. 27 N., R. 15 E. It is gray and platy and less than 1 foot thick with the top eroded.

In T. 26 N., R. 16 E. only the lower limestone, member 1, is present. It is gray, platy, about 1 foot thick, and is widespread. Exposures were observed at the following places: in the creek east of the W¼ cor. sec. 9; ¼ mile east of the SW cor. sec. 9; in NE¼ NE¼ SW¼ sec. 16; near the center and near the SW cor. sec. 21; and in the road near the E¼ cor. sec. 28. Good exposures of the overlying black shale with its contained phosphatic nodules are rare but so far as could be determined it everywhere overlies this lower limestone member of the Checkerboard.

In T. 25 N., Rs. 14 and 15 E., member 1, the lower limestone is widely exposed. It is gray, fossiliferous, platy, and 1 to 3 feet thick. Good exposures may be seen at the following places: ⅛ mile north of the W¼ cor. sec. 8, T. 25 N., R. 15 E., along the creek in NE¼ NE¼ sec. 19, T. 25 N., R. 15 E., south bank of creek NW¼ NW¼ sec. 30, T. 25 N., R. 15 E., and at the bridge near S¼ cor. sec. 23, T. 25 N., R. 14 E. The upper part of member 1 is exposed in the bed of the creek just north of the bridge near the S¼ cor. sec. 11, T. 25 N., R. 14 E. The dark-bluish, nodular limestone, member 3, is exposed 300 feet upstream, in the east bank. The intervening shale, member 2, and all beds higher than member 3, are covered by stream debris. This is the southernmost known exposure of member 3.

Member 1, the Checkerboard limestone of the older literature, is widespread in T. 24 N., Rs. 14 and 15 E., where it has about the same thickness and character as in T. 25 N. Good exposures occur ¼ mile north of the S¼ cor. sec. 24, T. 24 N., R. 14 E. and in the NW¼ sec. 35, T. 24 N., R. 14 E.

Only member 1, the lower limestone, was found in T. 23 N., Rs. 13 and 14 E. It is more massive and blocky than farther north and corresponds more closely with the description quoted above from Gould, and with its development in Tulsa County and southward. A good exposure occurs in the railroad cut ½ mile west of the SE cor. sec. 36, T. 23 N., R. 13 E.

*Stratigraphic relations.* The Checkerboard formation is underlain conformably by sandy upper beds of the Seminole formation, and is overlain by the black shale containing phosphatic nodules, which forms the lowermost part of the Coffeyville formation. As indicated in Fig. 4, the phosphatic shale usually rests on the lower member of the Checkerboard, but locally rests on higher members. This relationship suggests the possibility of a slight unconformity between the Checkerboard and the overlying Coffeyville formation. If present, this unconformity may account for the difficulty heretofore encountered in attempts to trace the Checkerboard northward into Kansas.

*Correlation.* The exact Kansas equivalent of the Checkerboard is uncertain, but it may be the Hertha limestone. In Oklahoma it is tentatively correlated with the DeNay limestone of Pontotoc and Seminole Counties.

*Detailed sections.* For measured outcrop sections of the Checkerboard formation see sections numbered 8, 9, 43, 45, 46, 71, 86, 114, 115, Appendix B.

## COFFEYVILLE FORMATION

As used here the name Coffeyville applies to strata between the top of the Checkerboard limestone, below, and the base of the Hogshooter (Dennis) formation, above. It consists of seven zones, four of shale and three of sandstone, shown diagramatically in Fig. 5. Owing to the gradational nature of the changes from sandstone to shale in all instances, the rather indefinite subdivisions are called zones rather than members. Indeed, zone 4 (the middle sandstone) rises in the section from north to south and is probably a series of overlapping sandstone lenses.

*First reference.* Schrader and Haworth,[31] 1905.

*Nomenclators.* Schrader and Haworth, 1906.

31. Schrader, Frank C., and Haworth, Erasmus, "Oil and Gas of the Independence Quadrangle, Kansas": *U. S. Geol. Survey Bull.* 260, p. 448, 1905.

*Type locality.* Vicinity of Coffeyville, Kansas.

*Original description*:

> The name Coffeyville formation, after the town of Coffeyville, is here adopted for the portion of the geologic section included between the base of the Drum and the top of the Parsons (Lenapah).[32]

*History of usage.* The use of Coffeyville as a formation name has had a checkered history which began in 1905 when Schrader and Haworth used the name in a table which indicated that it included the Cherryvale shale, Dennis limestone, Galesburg shale, Mound Valley limestone, and the Ladore-Dudley shale, with a total thickness of 250 feet. A year later, in 1906, the same authors defined it as above under "original description."

In 1910 Ohern[33] applied the name Curl formation to all strata lying above the Lenapah limestone and below the Hogshooter limestone. He correlated the Lenapah limestone with the Parsons of Adams,[34] and of Schrader and Haworth[35] and mentioned that this is the Coffeyville limestone of Haworth and Bennett.[36] He also made the Hogshooter limestone equivalent to the lower part of the Drum of Kansas, whereas we now know that the Hogshooter limestone of Ohern is the direct continuation of the Winterset limestone of Kansas, Missouri, and Iowa, which is considerably lower than the Drum.

In 1910, Gould, Ohern, and Hutchison,[37] through a miscorrelation, confused the Lenapah limestone with that now known as Checkerboard, and thus erroneously extended the Lenapah limestone as far south as North Fork of Canadian River, and for a time unwittingly further restricted the Coffeyville formation to the

32. Schrader, Frank C., and Haworth, Erasmus, "Economic Geology of the Independence Quadrangle, Kansas": *U. S. Geol. Survey Bull.* 296, p. 14, 1906.
33. Ohern, D. W., "The Stratigraphy of the Older Pennsylvanian Rocks of Northeastern Oklahoma": *The State Univ. of Okla. Research Bull.* 4, p. 26, 1910.
34. Adams, George I., Girty, George H., and White, David, "Stratigraphy and Paleontology of the Upper Carboniferous Rocks of the Kansas Section": *U. S. Geol. Survey Bull.* 211, p. 33, 1903.
35. Schrader, Frank C., and Haworth, Erasmus, "Economic Geology of the Independence Quadrangle, Kansas": *U. S. Geol. Survey Bull.* 296, p. 16, 1906.
36. Haworth, Erasmus, and Bennett, John, "Special Report on Oil and Gas": *The Univ. Geol. Survey of Kansas,* Vol. IX, p. 87, 1908.
37. Gould, Chas. N., Ohern, D. W., and Hutchison, L. L., "Proposed Groups of Pennsylvanian Rocks of Eastern Oklahoma": *The State Univ. of Okla. Research Bull.* 3, map, 1910.

strata lying between the Checkerboard limestone, below, and the Hogshooter limestone, above.

In 1918, discussing a paper by F. C. Greene, Ohern corrected this error: "I understood Mr. Greene to say that the Lenapah limestone is the equivalent of the 'Checkerboard'. I used to think so and I am sorry to say that I am in print to that effect. But such is not the case. The Lenapah limestone is the one that caps the hill in the western part of the city of Nowata. But it does not extend south beyond that point. It is replaced by the Dawson coal. * * * *"[38]

The last statement introduced another error, for it is now known that the Dawson coal departs widely from the horizon of the Lenapah, between Nowata and Tulsa, and that a considerable thickness of lower Missouri sandstone and shale is present below the Dawson coal. This error was evidently continued by Miser,[39] because the base of the Coffeyville formation, as shown on the Geologic Map of Oklahoma, between Nowata and the vicinity of Tulsa, coincides with the trace of the outcrop of the Dawson coal.

In 1925, Gould, following Ohern (unpublished manuscript, 1914), stated: "Due to its position above the Lenapah limestone and below the Hogshooter limestone the Coffeyville is equivalent to the Curl formation of Ohern (a later name)."[40] By accepting the opinion that the Hogshooter was the lower part of the Drum, Gould actually excluded the Cherryvale shale and Winterset limestone from the upper part of the Coffeyville formation, as originally defined by Schrader and Haworth, although he did include them in his note on correlation. Subsequent usage, in Oklahoma, including the Geologic Map, assigned the term Coffeyville to all strata between the Lenapah and Hogshooter limestones.

Moore[41] discontinued the name Coffeyville in a formational sense, but says that in southern Kansas, except for thin apparently

38. Ohern, D. W., "Discussion": *Bull. Amer. Assoc. Petro. Geol.*, Vol. 2, p. 122, 1918.
39. Miser, Hugh D., "Geologic Map of Oklahoma": *U. S. Geol. Survey*, 1926.
40. Gould, C. N., "Index to the Stratigraphy of Oklahoma": *Okla. Geol. Survey Bull.* 35, pp. 72-73, 1925.
41. Moore, Raymond C., "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas": *Kansas Geol. Survey Bull.* 22, p. 90, 1935.

discontinuous limestone that probably represents the Checkerboard limestone of Oklahoma, there is a continuous shale section extending from the base of the Winterset (Hogshooter) limestone downward to the base of the Missouri subseries. In 1937, Jewett[42] listed Coffeyville shale (Galesburg-Ladore?), as a term that should properly be applied in southern Kansas, south of T. 32 S.

Prior to the work of the writer in this area, studies by Newell[43] seemed to indicate the approximate equivalence of the Checkerboard limestone to the DeNay limestone, of Pontotoc and Seminole Counties, and that strata lying between the unconformity at the base of the Missouri subseries and the Checkerboard limestone, formerly classed as lower Coffeyville, therefore should be tentatively referred to the Seminole formation. Moore, Newell, Dott, and Borden in 1937, restricted the " * * * definition of Coffeyville to apply only to strata between the Checkerboard limestone, below, and the Dennis (Hogshooter) limestone, above"[44] and the name is here used in that sense.

*Distribution.* The Coffeyville formation enters Oklahoma from Kansas in the vicinity of South Coffeyville, T. 29 N., Rs. 15 and 16 E., and extends southwestward across northwestern Nowata County and southeastern Washington County, leaving the area in the vicinity of Vera, T. 23 N., R. 13 E. The outcrop is about 4 miles wide at the Kansas-Oklahoma line but ranges in width from 2 miles in T. 26 N., R. 15 E., to 8 miles in T. 24 N., Rs. 13 and 14 E., where nearly 2 miles is covered by the alluvium of Caney River. The variation in width is due to changes in topography and to structural anomalies.

*Thickness.* The Coffeyville formation ranges in thickness from 175 to 235 feet, being least in Tps. 24 and 25 N. It is 205 feet in T. 29 N., increases to 235 feet in T. 27 N., decreases to 175 feet

42. Jewett, John M., "Lateral Changes in the Lower Missouri Beds of Southeastern Kansas": *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society,*
43. Moore, Raymond C., Newell, Norman D., Dott, Robert H., and Borden, Joseph L., "Definition and Classification of the Missouri Subseries of the Pennsylvanian Series in Northeastern Oklahoma": *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society*, p. 41, 1937.
p. 35, 1937.
44. *Idem.*, p. 42.

in T. 24 N., and increases again to 230 feet in T. 23 N. This marked variation results from thickening and thinning of individual units, especially in the middle part (zones 2-6, inclusive). This interval is 130 feet in T. 29 N., 180 feet in T. 27 N., 100 feet in T. 24 N., and 155 feet in T. 23 N.

*Character.* The Coffeyville formation consists of seven zones, three sandstone zones and four shale zones, as indicated in Fig. 5. The boundaries of these zones are so gradational that they can hardly be called members.

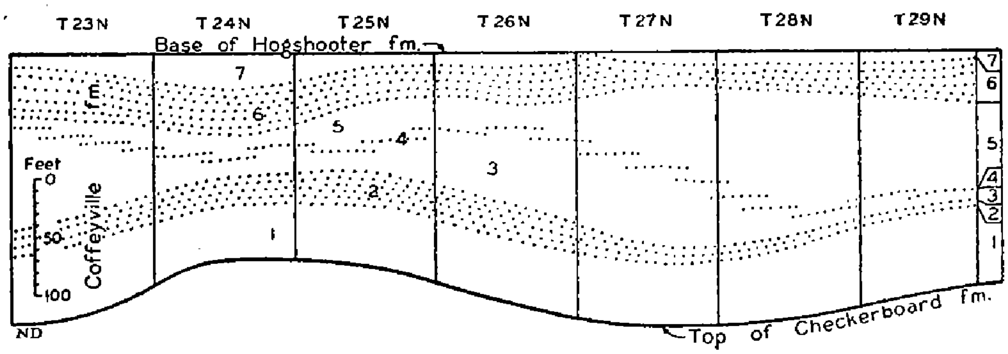


FIG. 5. Generalized outcrop section of Coffeyville formation. Numbers refer to zones described in the text. Note lenticular, transgressive character of Zone 4 and the absence of Zone 7 in the south part of T. 27 N.

Zone 1 is shale, 45 to 70 feet thick. At the base throughout is a black, fissile shale usually less than 10 feet thick, but 30 feet thick in sec. 12, T. 25 N., R. 15 E. A band of phosphatic nodules in the lower 2 to 5 feet of this black, fissile shale proved extremely useful in mapping the underlying Checkerboard limestone. The upper part is somewhat sandy, especially in the southern part of the area. Shale from zone 1 has been used for brick-making in Coffeyville, Kansas, and Tulsa, Oklahoma. Zone 1 is 70 feet thick in T. 29 N., but thins southward to 45 feet in T. 24 N., then thickens rapidly to 65 feet in T. 23 N.

Zone 2 is usually reddish-brown and thin-bedded sandstone. Its thickness is irregular, ranging from 5 to 30 feet.

Zone 3 is sandy to clay shale. It is about 100 feet thick in T. 23 N., but almost pinches out on the north side of the area.

Zone 4 is sandstone. It is very irregular in thickness and seems to rise in the section from north to south, nearly merging with zone 2 in the north and with zone 6 in the south. It is probably made up of overlapping sandstone lenses, as indicated in Fig. 5.

Zone 5 is clay to sandy shale. It is 105 feet thick in the north but practically pinches out in the south.

Zone 6 is a sandstone zone, gray to reddish-brown, massive to thin-bedded, and 35 to 50 feet thick. It is probably correlative with the Dodd's Creek sandstone[45] of the Kansas section and with the Layton oil sand of the subsurface in Creek County, Oklahoma, and produces oil in sec. 29, T. 27 N., R. 13 E.,[46] Washington County. A coal seam 0.1 to 0.5 foot thick, near the base, probably corresponds to the Cedar Bluff coal of Kansas. Zones 2-6 inclusive, make up the bulk of the formation, and vary greatly in thickness.

Overlying the Dodd's Creek sandstone is zone 7, a gray, clay shale, sandy in some localities and usually calcareous in its upper part. Coal seams 0.1 to 0.3 foot thick are common in the upper 3 to 7 feet. It ranges in thickness up to 30 feet. Over most of the area it is about 10 feet thick, but owing to the gradational nature of its lower boundary it is often thicker locally and reaches its maximum thickness of 30 feet in T. 24 N., R. 13 E. It is completely absent in an exposure on the south side of sec. 30, T. 27 N., R. 15 E., where the overlying Winterset member of the Hogshooter formation rests on the Dodd's Creek sandstone, zone 6.

*Stratigraphic relations.* The Coffeyville formation is underlain by the Checkerboard formation, and is overlain by the Hogshooter formation. In all but a few localities, the Winterset (upper) member of the Hogshooter is the capping bed, but locally the Coffeyville is succeeded by the Canville, Stark, or Lost City members.

*Correlations.* The upper limit of strata in Kansas, equivalent to the Coffeyville formation, as here restricted, is the base of the Dennis (Hogshooter) formation. The lower limit of equivalent strata in Kansas is uncertain, owing to difficulty in determining the correlative of the Checkerboard formation there. It is probably

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45. *Kansas Geol. Survey Bull.* 22, p. 89, 1935.
46. Weirich, T. E., "Petroleum Geology of Nowata and Washington Counties, Oklahoma": *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society,* p. 89, 1937.

equivalent to the lower part of the Francis formation of south-central Oklahoma.

*Detailed sections.* For measured outcrop sections of the Coffeyville formation see sections numbered 7, 8, 22, 24, 25, 26, 27, 28, 29, 30, 40, 41, 42, 43, 44, 45, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 85, 86, 108, 109, 110, 111, 112, 113, 114, 133, 134, 135, 136, Appendix B.

## HOGSHOOTER FORMATION

The name Hogshooter formation is applied to a dominantly limestone unit, overlying the Coffeyville formation, and underlying the Nellie Bly formation. The Hogshooter usually consists of a single bed of limestone, called the Winterset member, but very locally, there are three members: a thin, siliceous, lower limestone, called Canville; a middle black shale, called Stark; and the main, massive Winterset member. In the vicinity of Sand Springs, Tulsa County, the Winterset is underlain by another member, the Lost City limestone, and a limestone found immediately below the Winterset, in a single exposure in Washington County, is referred to the Lost City member. The Lost City is probably a lateral depositional variant of the combined Canville and Stark.

*First reference*: Adams, 1903,[47] mapped as lower Drum.

*Nomenclator*: Ohern, 1910.

*Type locality*: Along Hogshooter Creek in T. 26 N., R. 14 E.
*Original description*:

> This name is proposed for the limestone which lies immediately above the Curl formation in the Nowata quadrangle. The name is from Hogshooter Creek along whose west bank the limestone is well exposed.
>
> AREA: The area occupied by the Hogshooter limestone enters Oklahoma from Kansas about two miles west of Coffeyville. * * * it continues as a narrow band south

47. Adams, George I., Girty, George H., and White, David, "Stratigraphy and Paleontology of the Upper Carboniferous Rocks of the Kansas Section": *U. S. Geol. Survey Bull.* 211, map, pp. 62-63, 1903. Adams evidently mapped the Winterset limestone member of the Hogshooter formation as Drum limestone from the Kansas-Oklahoma line to the southwest part of T. 26 N., R. 14 E.

> to a point opposite Delaware. In the northeast corner T. 26 N., R. 14 E., it spreads over a wide area, making a dip slope westward to Hogshooter Creek and continuing down the west bank of that stream. It crosses Caney River 3 miles northeast of Ochelata and extends due south to Ramona. * * * * It is traceable to the southern limits of the quadrangle but has not been positively identified beyond. * * * *.
>
> THICKNESS: The thickness of the Hogshooter at the state line is about 10 feet. To the southward it thins slowly, being 6 or 8 feet along Hogshooter Creek and 4 feet at Ramona. At the extreme southern limits of the Nowata quadrangle it is not over 3 feet and is thin bedded * * * *.
>
> STRATIGRAPHY: The Hogshooter consists essentially of a single bed of limestone. This in its northern extension is heavily bedded and massive but to the southward it is thin bedded and argillaceous. Usually fossils are fairly abundant.[48]

*History of usage*: Ohern used the term Hogshooter as synonymous with lower Drum, a usage now known to be erroneous, since the Hogshooter of Ohern has been traced into the Winterset member of the Dennis formation of Kansas. Ohern evidently did not recognize the underlying black shale and siliceous limestone, and included only the Winterset member in his Hogshooter. Bloesch recognized the black shale, and evidently associated it with the Hogshooter, stating: "In sec. 16, T. 28 N., R. 15 E., black carbonaceous shale was observed underlying the limestone, also on the M. K. & T. R. R. southwest of Coffeyville,"[49] and referring to a personal communication from Dott, said: "A sample of such shale associated with the Hogshooter limestone collected behind the store at Hogshooter showed an oil content of two gallons to the ton."[50] Dott's original field notes about this sample (1919) state: "South side of road, west side of grade, behind store at Hogshooter, Oklahoma. In Hogshooter limestone."

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48. Ohern, D. W., "The Stratigraphy of the Older Pennsylvanian Rocks of Northeastern Oklahoma": *The State Univ. of Okla. Research Bull.* 4, p. 28, 1910.
49. Bloesch, Edward, "Oil and Gas in Oklahoma": *Okla. Geol. Survey Bull.* 40, Vol. III, p. 358, 1930.
50. *Idem.*, p. 363.

*Proposed usage.* As defined here, the Hogshooter formation is substantially equivalent to the Dennis formation of Kansas, as redefined by Jewett[51] in 1932. As a formal formation name embracing this unit, Dennis perhaps is the older, although the quotations from Bloesch give Hogshooter some standing in this connection.

For several reasons, it seems advisable to retain the name Hogshooter in Oklahoma: (1) Dennis has been used in several senses in Kansas and, though it has been recently redefined, there seems a tendency to modify it still further.[52] The heterogeneous character of the lower part of the formation in Oklahoma would necessitate another redefinition. (2) The term Hogshooter has for a long time included the Winterset and Lost City members in the Sand Springs area, west of Tulsa, and even the Stark shale and Canville limestone members have been associated, in the literature, with the Hogshooter, rather than with the underlying Coffeyville formation, thus giving Hogshooter some standing in priority. (3) Hogshooter is the oldest name in Oklahoma for this formation, and is firmly entrenched in literature and usage. Dennis is therefore rejected as the name of this formation in Oklahoma, and Hogshooter is retained.

*Distribution.* As indicated by Ohern, the Hogshooter enters Oklahoma from Kansas a few miles west of Coffeyville, across the north line of sec. 14, T. 29 N., R. 15 E. Thence the outcrop passes southwestward across a marked syncline.

The outcrop continues across T. 28 N., R. 15 E., to the southwest corner, thence southward along the west line of T. 27 N., R. 15 E. In T. 26 N., R. 14 E., the formation attains its widest outcrop, covering half of the township. Joseph L. Borden called the writer's attention to the hitherto unmapped inlier of Hogshooter limestone in the SE¼ of sec. 17, T. 26 N., R. 13 E., southeast of Bartlesville, near the Junction of U. S. highways 75 and 60. The outcrop leaves T. 26 N., R. 14 E. in sec. 31, near old Hogshooter

51. Jewett, John M., "Brief Discussion of the Bronson Group in Kansas": *Guide Book, Sixth Annual Field Conference, Kansas Geol. Society*, p. 102, 1932. See also *Kansas Geol. Survey Bull.* 21, pp. 32 and 170, 1935.
52. Moore, Raymond C., "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas": *Kansas Geol. Survey Bull.* 22, p. 97, 1935.

town, and makes a narrow band along the west side of Hogshooter Creek, into sec. 7, T. 25 N., R. 14 E. and from there west, to the north side of Caney River, in sec. 15, T. 25 N., R. 13 E. South of Caney River, the Hogshooter caps the high hills east of Ochelata and a narrow outcrop passes southward through Ramona, crossing T. 24 N., R. 13 E., and leaving Washington County over the south line of sec. 32, T. 23 N., R. 13 E., about 4 miles southwest of Vera.

Subsequent to Ohern's work in the Nowata quadrangle, other geologists mapped the Hogshooter to a point west of Okemah, Okfuskee County, and the results were compiled and published on the Geologic Map of Oklahoma.

*Thickness.* Thickness of the Hogshooter formation in this area ranges from 5 to 25 feet or more. Just south of the Kansas line the thickness is 12 feet, only the Winterset limestone member being present. In T. 28 N., where only the Winterset was seen, the thickness is 5 feet, but in T. 27 N., R. 15 E., with all three members present, the thickness is 9.5 feet.

The maximum measured thickness of the formation, 26 feet, made up principally of the Winterset member, is in T. 26 N., R. 14 E. Southward, the thickness decreases to 6 feet in Tps. 25 and 24 N., and 5 feet in T. 23 N.

*Character.* At the close of Coffeyville time, there appears to have been a slight warping of the depositional surface in northeast Oklahoma, accompanied by a greatly reduced supply of clastic sediments. This warping resulted in several local, shallow downwarps that retained arms of the sea, and broad uplifts, that raised part of the surface slightly above sea-level. There is little evidence to indicate important sub-aerial erosion on this surface.

The down-warped areas were submerged, in lower Hogshooter time, probably as lagoons, and in some of them were deposited the Canville limestone and the overlying Stark shale, and at the same time, the Lost City limestone accumulated in others. That these lagoonal areas were structural depressions, and not erosion channels, is evidenced by the fact that the upper gray shale (zone 7) of the Coffeyville, is not cut out, but passes downward, beneath the lagoonal deposits of the lower Hogshooter. Following the filling of the lagoons, the main body of the Hogshooter sea spread rather uniformly over the entire area, and the Winterset member was deposited.

As an alternative to the hypothesis of warping and the formation of lagoons in post-Coffeyville time, it may be suggested that the Canville, Stark, and Lost City should be classified with the Coffeyville, and represent small erosion remnants, preserved in synclines resulting from post-Coffeyville folding. This hypothesis was considered by the writer, but rejected because the lithologic character of these members is wholly unlike that of the Coffeyville, and closely related to that of the overlying Winterset. Neither hypothesis implies any great hiatus or lapse of time between the end of Coffeyville and beginning of Hogshooter time.

*Canville limestone member.*[53] The Canville limestone, lower member of the Hogshooter formation, is a dense, fine-grained, siliceous limestone with prominent vertical joints and is usually less than 1 foot thick. The following three small patchy-outcrops are known: SW¼ SW¼ NW¼ sec. 18, T. 27 N., R. 15 E.; NW¼ NW¼ SE¼ sec. 31, T. 26 N., R. 14 E.; and NW¼ NW¼ NE¼ sec. 6, T. 25 N., R. 14 E. The Canville limestone is regarded as the direct equivalent of the Canville limestone of Kansas, described by Jewett as the basal member of the Dennis formation.

*Stark shale member.*[54] Overlying the Canville limestone, and with similar patchy, though somewhat more widespread distribution, is the Stark shale, consisting of 3 to 10 feet of black, fissile shale. As indicated by Bloesch,[55] the Stark is carbonaceous, and a sample from Hogshooter Store, near the N¼ corner of sec. 6, T. 25 N., R. 14 E., showed an oil content of 2 gallons per ton. The following six exposures of Stark shale are known: in the M. K. & T. R. R. cut, SW¼ SW¼ SE¼ sec. 14, T. 29 N., R. 15 E., where it is about 10 feet thick with the base not exposed; in sec. 16, T. 28 N., R. 15 E.; center of NW¼ sec. 18, T. 27 N., R. 15 E., where it is 2 feet thick; along a pipeline ditch near the center of the NE¼ sec. 30, T. 27 N., R. 15 E.; NW¼ NW¼ SE¼ sec. 31, T. 26 N., R. 14 E.,

53. Jewett, John M., "Brief Discussion of the Bronson Group in Kansas": *Guide Book, Sixth Annual Field Conference, Kansas Geol. Society*, p. 102, 1932.
54. *Idem.*
55. Bloesch, Edward, *Op. cit.*

where it is 4 feet thick and contains sideritic concretions 1 foot in diameter; NW¼ NW¼ SE¼ sec. 6, T. 25 N., R. 14 E., where it is 3 feet thick.

*Lost City limestone member.*[56] Directly beneath the Winterset member in a few areas, is a distinct limestone that appears to be assignable neither to the Winterset, nor to the Canville members. For this reason, it is regarded as the time equivalent of both the Canville limestone and Stark shale, deposited in separate lagoons, under slightly different conditions of sedimentation. The Lost City attains its maximum thickness, approximately 40 feet, near Sand Springs, Tulsa County, and is named from a locality in that area.

In a single exposure along the west bank of Hogshooter Creek, 1,500 feet east of the SW cor. sec. 9, T. 26 N., 14 E., Washington County, is a limestone that immediately underlies the distinctive lower bed of the Winterset member. It is gray, soft, and platy, with an exposed thickness of 1.7 feet. The base is covered, and the total thickness is estimated at about 5 feet. This bed is definitely not Winterset, and is wholly unlike the Canville, so is referred to the Lost City limestone member. The fact that no such bed as this is described from the Dennis formation of Kansas, is one reason for rejecting "Dennis" as the name of the formation here called Hogshooter in Oklahoma.

*Winterset limestone member.*[57] The upper, and most important member of the Hogshooter, and the original Hogshooter of Ohern, is directly continuous with the Winterset limestone member of the Dennis formation of Kansas, and the Winterset limestone of Missouri and Iowa. It was named from exposures near Winterset, Iowa.

The Winterset consists wholly of limestone, with a very distinctive, phosphatic, basal bed that makes an excellent marker along the entire outcrop. This basal bed is less than 1 foot thick, dark in color, packed with segments of small crinoid stems and arms, and contains round phosphatic nodules up to 1 inch in diameter, nearly

56. Gould, Chas. N., "Preliminary Report on the Structural Materials of Oklahoma": *Okla. Geol. Survey Bull.* 5, p. 179, 1911.
57. Moore, Raymond C., "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas": *Kansas Geol. Survey Bull.* 22, pp. 92-95, 1935.

always arranged in one regular layer. Chemical analyses show a content of $P_2O_5$ ranging usually from 1.0 to 2.0 percent, and a $CaCO_3$ and $MgCO_3$ content of 77.0 to 87.0 percent, suggesting that this bed might prove beneficial for agricultural use.

Ordinarily, the basal phosphatic bed occurs at the base of small cliffs and is rather inaccessible for mining. However, all along the outcrop there are many small areas where the upper part of the Winterset has been eroded back down the dip, and the basal bed is exposed. Altogether, there are probably several hundred acres over which the phosphatic, basal bed could be picked up from the surface. The largest single area where the basal bed is at or near the surface is in secs. 26, 27, 34, and 35, T. 25 N., R. 13 E., where there are 10 to 30 acres with practically no cover and probably 100 acres with no more than 0.5 to 3 feet of limestone cover.

The almost universal occurrence of this distinctive basal bed, permits the mapping of the lower limit of the Winterset with absolute certainty, and the definite separation of the Winterset from the underlying Stark shale or lost City members, where present. While the greatest thickness of the Winterset is found in T. 26 N., R. 14 E., and the greatest thickness of the whole Hogshooter formation is in T. 19 N., R. 11 E., near Sand Springs, the presence of the phosphatic, basal Winterset bed shows definitely that the Lost City member lies *below* the Winterset.

The upper Winterset is a variable thickness of lighter-colored, fossiliferous limestone which contains much larger crinoid stems than those in the basal bed. Brachiopods and bryozoans are common to abundant, but seldom weather out enough to make good collecting. It is sufficiently high in calcium carbonate to make a good agricultural limestone for treating sour soils. The Winterset limestone member ranges in thickness from 26 feet in sec. 9, T. 26 N., R. 14 E., to less than 5 feet in T. 23 N., R. 14 E. Except for the area of greatest development in T. 26 N., R. 14 E., it shows a surprisingly uniform thickness of about 5 feet.

The following measured sections give details of lithology and thickness of the members of the Hogshooter formation in different parts of the area.

## TABLE III

SECTION OF HOGSHOOTER FORMATION, SHOWING DEVELOPMENT OF CANVILLE AND STARK MEMBERS IN THE NORTHERNMOST COMPLETE EXPOSURE, MEASURED IN SW¼ SW¼ NW¼ SEC. 18, T. 27 N., R. 15 E.

| | Feet |
|---|---|
| Nellie Bly formation. | |
| Shale with prominent sandstone beds in the upper part. | |
| Hogshooter limestone. | |
| Winterset limestone member. | |
| Limestone, gray, fossiliferous | 6.0 |
| Limestone, dark, crinoidal, contains phosphatic nodules | 1.0 |
| Stark shale member | |
| Shale, black, fissile | 2.0 |
| Canville limestone member. | |
| Limestone, dark, slightly siliceous, prominent vertical joints | 0.5 |
| Coffeyville formation. | |
| Shale, gray, calcareous | 0.2 |
| Sandstone, not measured. | |

## TABLE IV

SECTION OF HOGSHOOTER FORMATION, SHOWING MAXIMUM THICKNESS OF WINTERSET MEMBER, AND UNDERLYING LOST CITY MEMBER, MEASURED 1,500 FEET EAST OF SW CORNER SEC. 6, T. 26 N., R. 14 E.

| | Feet |
|---|---|
| Nellie Bly formation. | |
| Shale with prominent sandstone beds in the upper part | |
| Hogshooter limestone. | |
| Winterset limestone member. | |
| Limestone, gray to buff, abundantly to sparingly fossiliferous | 24.0 |
| Limestone, dark, crinoidal, contains phosphatic nodules | 0.3 |
| Lost City limestone member | 1.7 |
| (Limestone, gray, soft, platey, not represented in other localities visited in Washington and Nowata Counties, base covered, total thickness about 5 feet, analogous to the Lost City limestone in the vicinity of Sand Springs, Tulsa County.) | |

## TABLE V

COMPOSITE SECTION OF HOGSHOOTER FORMATION, SHOWING DEVELOPMENT OF CANVILLE AND STARK MEMBERS IN THEIR SOUTHERNMOST EXPOSURES, IN THE VICINITY OF N¼ CORNER SEC. 6, T. 25 N., R. 14 E.

| | Feet |
|---|---|
| Nellie Bly formation. | |
| Shale with prominent sandstone beds in the upper part. | |
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, gray, calcareous, fossiliferous | 20.0 |
| Limestone, dark, crinoidal, with phosphatic nodules | 1.0 |
| Stark shale member. | |
| Shale, yellow, calcareous | 0.5 |
| Shale, black, fissile | 3.0 |
| Canville limestone member. | |
| Limestone, siliceous, nodular | 1.1 |
| Coffeyville formation. | |
| Shale, yellow calcareous to sandy | 6.0 |
| Sandstone, not measured. | |

Good exposures, showing complete section of the Winterset, may be seen at the following places: NE cor. sec. 29, T. 29 N., R. 15 E.; center of NW¼ sec. 18, T. 27 N., R. 15 E.; 1,500 feet east of SW cor. sec. 9, T. 26 N., R. 14 E., in the west bank of Hogshooter Creek; vicinity of N¼ cor. sec. 6, T. 25 N., R. 14 E.; 500 feet north of the E¼ cor. sec. 10, T. 24 N., R. 13 E.; ¼ mile west of NE cor. sec. 28, T. 23 N., R. 13 E.

*Stratigraphic relations.* The Hogshooter formation is usually underlain by the upper shale of the Coffeyville formation. This shale zone is absent along the south side of sec. 30, T. 27 N., R. 15 E., where the Winterset member of the Hogshooter rests on Dodds Creek sandstone, suggesting slight local erosion.

Except where the Canville, Stark, or Lost City members are present, the Winterset member always lies on upper Coffeyville strata.

The Winterset is everywhere succeeded, with apparent conformity, by shale of the overlying Nellie Bly formation.

*Correlation.* The Hogshooter formation is equivalent to the Dennis formation of Kansas, and its horizon probably lies about the middle of the Francis formation, in south-central Oklahoma.

*Detailed sections.* For measured outcrop sections of the Hogshooter formation, see sections numbered, 21, 23, 24, 39, 59, 60, 61, 62, 64, 65, 66, 84, 108, 132, 133, 134, Appendix B.

## NELLIE BLY FORMATION

The name Nellie Bly is applied to the shales and sandstones above the Hogshooter formation, and below the Dewey limestone, or below the unconformity at the base of the Chanute formation where the Dewey is absent. The Dewey and part of the Nellie Bly were cut out by pre-Chanute erosion in the area from sec. 13, T. 28 N., R. 14 E. north to the Kansas-Oklahoma line, and the remaining Nellie Bly is overlain there by the lowermost beds of the Chanute formation.

*First reference.* Gould, Chas. N., 1925.

*Nomenclator.* Ohern, D. W., in unpublished manuscript, 1914.

*Type locality.* On Nellie Bly Creek, in secs. 31, 32, 29, 28, T. 24 N., R. 13 E., Washington County, Oklahoma.

*Original description*:

> "Alternating shales and hard, gray sandstones, the latter ranging in thickness from a few inches to several feet," from 15 feet on the Kansas line to 200 feet in southeastern Osage County.*** Rests on the Hogshooter limestone and is overlain by the Dewey limestone.[58]

*History of usage.* The name has always been used in its present sense.

*Distribution.* The Nellie Bly formation crops out in a band of varying width from the Kansas-Oklahoma line southwestward across northwestern Nowata County and Washington County and leaves the area on the south side of T. 23 N., Rs. 12 and 13 E.

*Thickness and character.* Except in the area where the top was removed by pre-Chanute erosion, the Nellie Bly formation ranges from 80 feet thick, in T. 28 N., Rs. 14 and 15 E., to 180 feet thick in T. 23 N., R. 13 E. The lower part consists of clay shale, with thin, silty sandstone beds appearing in the south part of the area. The clay shale grades upward into sandy shale with thin, silty sandstone beds, and at the top are prominent ledges of sandstone, some of which are relatively coarse-grained and tree bearing, especially in Tps. 27 and 28 N., R. 14 E.

Thickness of the Nellie Bly formation is variable from the Kansas-Oklahoma line to the center of sec. 13, T. 28 N., R. 14 E. where the upper part was removed by pre-Chanute erosion. Measurements indicate that in the vicinity of Noxie, NW cor. sec. 30, T. 29 N., R. 15 E., practically all the Nellie Bly was removed. Exposures of the underlying Hogshooter formation could not be found in this vicinity but whether the lack of exposure is due to pre-Chanute erosion or recent cover could not be determined. In the NW¼ sec. 28, T. 29 N., R. 15 E., the formation consists of 80 feet of clay shale overlain by the basal limestone conglomerate of the Chanute formation. This is equal to the entire thickness of the Nellie Bly 6 miles farther south, where the section is complete and contains sandstone in the upper part. The inference seems to be that in pre-Chanute time the formation was either thicker or less

58. Gould, Chas. N., "Index to the Stratigraphy of Oklahoma": *Okla. Geol. Survey Bull.* 35, p. 74, 1925.

sandy in its upper part in this locality than farther south. Also such a thickness of Nellie Bly in this locality, in contrast with the considerably thinner sections elsewhere in this part of the area, indicates that there was locally considerable relief on the pre-Chanute erosion surface, and suggests that this surface was probably dissected by several major, subaerial erosion channels. Thin, flaggy, siliceous limestone beds, which have not been seen farther south, appear in the lower part of the Nellie Bly formation, in the vicinity of the N¼ cor. sec. 14, T. 29 N., R. 15 E. They are probably correlative with similar flaggy beds in the vicinity of the City reservoir, on the prominent hill northwest of Coffeyville, Kansas.

A complete section of the Nellie Bly is present along the south side of sec. 19, T. 28 N., R. 15 E., where it is 80 feet thick. The lower 25 feet is clay shale. The succeeding 45 feet grades from shale below to sandstone above. The upper 10 feet is soft, fine- to medium-grained, reddish brown, moderately thick-bedded sandstone. This sandstone extends northward and is present below the Dewey limestone near the center of sec. 13, T. 28 N., R. 14 E., where the Dewey limestone is cut off by pre-Chanute erosion which also removed the upper part of the Nellie Bly formation from this point northward to the Kansas-Oklahoma line. The heavy sandstone, which, on first consideration, seemed to be the northward continuation of the upper sandstone of the Nellie Bly, proves to be the Noxie sandstone of the overlying Chanute formation.

In T. 27 N., Rs. 14 and 15 E. the Nellie Bly crops out on a wide dip slope where it has a thickness of about 100 feet and is overlain by several outliers of Dewey limestone. The lower part is clay shale which grades upward into sandy shale with thin, silty sandstone beds. Borden[59] reports black, fissile shale at the top of the formation, immediately below the Dewey limestone, north of Blue Mound in sec. 16, T. 27 N., R. 14 E., and Bloesch[60] mentions that the Dewey limestone rests on black, fissile, carbonaceous shale in sec. 10, 11, and 15, T. 27 N., R. 14 E.

The Nellie Bly formation crops out across T. 26 N., Rs. 13 and 14 E. in an irregular band between the Hogshooter limestone

59. Borden, Joseph L., personal communication.
60. Bloesch, Edward, "Oil and Gas in Oklahoma": *Okla. Geol. Survey Bull.* 40, Vol. III, p. 358, 1935.

on the east and the Dewey limestone on the west, and as inliers in topographically low areas west of the main outcrop. Such an inlier in sec. 17, T. 26 N., R. 13 E., southeast of Bartlesville is pierced by an inlier of Hogshooter limestone. In this township the Nellie Bly formation has an average thickness of about 115 feet and is more or less sandy and silty. Thin-bedded, silty sandstone is noticeable in the upper part, as at the W¼ cor. sec. 20, T. 26 N., R. 13 E., about 2 miles south of Bartlesville along U. S. Highway 75.

The Nellie Bly crops out in a broad band across T. 25 N., R. 13 E. where it has an estimated thickness of about 140 feet and is composed of sandy, silty shale with minor amounts of thin-bedded, fine-grained to silty sandstone.

The outcrop of the Nellie Bly formation crosses the western part of T. 24 N., R. 13 E. and includes the type locality on Nellie Bly Creek, west of Ramona. The total thickness is about 115 feet. The lower 40 feet and upper 20 feet are silty shale; the middle part, about 55 feet, is silty to sandy shale and thin-bedded, silty sandstone.

The formation continues southward across T. 23 N., Rs. 12 and 13 E. with about the same character as in T. 24 N., but thickens to a maximum of about 180 feet near the center of T. 23 N., R. 13 E.

*Stratigraphic relations.* The Nellie Bly formation is conformably underlain by the Winterset limestone member of the Hogshooter formation. From the Kansas-Oklahoma line to the center of sec. 13 T. 28 N., R. 14 E. it is overlain unconformably by lowermost beds of the Chanute formation, due to pre-Chanute erosion which removed the Dewey limestone and part of the Nellie Bly formation. Southward to the south limits of the area the Nellie Bly is overlain conformably by the Dewey limestone.

*Correlations.* In general the Nellie Bly correlates with the lower part of the Kansas City Group, between the top of the Winterset limestone and the base of the Drum limestone[61] apparently equivalent to the Cherryvale shale of the older Kansas usage. It

61. Moore, Raymond C., "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas": *Kansas Geol. Survey Bull.* 22, p. 98, 1935.

is represented by approximately the upper half of the Francis formation in South-Central Oklahoma.

*Detailed sections.* For measured outcrop sections of the Nellie Bly formation see sections numbered 5, 19, 20, 38, 54, 55, 56, 57, 58, 82, 83, 106, 107, 108, 130, 131, Appendix B.

## DEWEY LIMESTONE

The name Dewey limestone is applied to a dominantly limestone unit underlain by the Nellie Bly formation and overlain by the Chanute formation. Its outcrop extends from sec. 13, T. 28 N., R. 14 E. southwestward across the area.

*First reference.* Adams, 1903

> In studying the oil and gas fields of the Indian Territory, the Drum limestone was traversed by Adams from the outcrop west of Coffeyville to Bartlesville. It occurs on the divide between the Verdigris and Caney, extending southward to Hogshooter Creek, and thence northwestward to Bartlesville.[62]

It is evident from text and map that Adams was following the Hogshooter limestone from the Kansas-Oklahoma line to the southeast corner of T. 26 N., R. 13 E., where he stepped up to the Dewey limestone and followed it to Bartlesville.

*Nomenclator.* Ohern, D. W., 1910.[63]

*Type locality.* Old quarry of the Dewey Portland Cement Co., sec. 26, T. 27 N., R. 13 E.

*Original description*:

> The most striking stratigraphic feature of the Copan beds is a lentil of limestone which is continuous and prominent from a point 2 miles east of Wann, south and west to and beyond the limits of Nowata Quadrangle. The name is

62. Adams, George I., Girty, George H., and White, David, "Stratigraphy and Paleontology of the Upper Carboniferous Rocks of the Kansas Section": *U. S. Geol. Survey Bull.* 211, map, pp. 62-63, 1903. Adams evidently mapped the Winterset limestone member of the Hogshooter formation as Drum from the Kansas-Oklahoma line to the south part of T. 26 N., R. 14 E. and mapped the Dewey limestone as Drum limestone from that locality to Bartlesville.
63. Ohern, D. W., "The Stratigraphy of the Older Pensylvanian Rocks of Northeastern Oklahoma": *The State Univ. of Okla. Research Bull.* 4, p. 30, 1910.

from the town of Dewey where the limestone is admirably exposed in the quarry of the cement plant. ***

The Dewey lens is a bluish, semi-crystalline limestone, usually somewhat shaly, but often massively bedded. On weathering it gives surface fragments which abound in seams of calcite which resist solution more effectually than the non-crystalline mass. Wherever examined, the Dewey abounds in fossils, *Campophylum torquium* being especially abundant.[64]

*History of usage.* The name has always been used in its present sense, except that from sec. 13, T. 28 N., R. 14 E., northeastward to the Kansas-Oklahoma line it has been erroneously[65] applied to sandstone and to limestone conglomerate at the base of the Chanute formation.

*Distribution.* As a result of its thickness, its resistance to erosion, and its position above the thick, shaly Nellie Bly formation, the Dewey limestone characteristically crops out either as the capping ledge of an eastward-facing escarpment or on extensive westward dip slopes, and in outliers.

From the Kansas-Oklahoma line southward to the center of sec. 13, T. 28 N., R. 14 E., the Dewey limestone was removed by pre-Chanute erosion. (See Fig. 6) Near the center of section 13, it is 6 feet thick and consists of the alternating wavy beds of dark-bluish limestone and dark calcareous shale usually found in the lower part of the Dewey. The outcrop extends southwestward in a narrow band across the southeast part of T. 28 N., R. 14 E.

The Dewey outcrops spread widely on dip slopes in T. 27 N., Rs. 13 and 14 E., where there are several outliers in addition to an extensive area which is almost cut off from the main outcrop. The total width of the area of outcrops is nearly 10 miles, with easternmost outliers less than 1 mile from outcrops of Hogshooter limestone.

There are also outliers as well as a widespread main outcrop in T. 26 N., Rs. 13 and 14 E., east of Bartlesville. An inlier occurs near the northeast corner of Bartlesville and another in and near

64. *Idem.*, p. 30.
65. Miser, Hugh D., "Geologic Map of Oklahoma": *U. S. Geol. Survey*, 1926.

the southeast corner. One inlier is shown on the accompanying map, Plate I, in the west part of Bartlesville and there are several others in the vicinity of the cemetery, in the west edge of the city, which are too small to be shown. An accessible and interesting exposure occurs in the bed of Caney River at the bridge on U. S. Highway 75 in the north edge of Bartlesville. The fossil coral, *Caninia torquium,* is abundant in this exposure. The Dewey is exposed as an inlier in the SE¼ sec. 11, and NE¼ sec. 14, T. 26 N., R. 12 E., along the east-west road leading to the smelter. A larger inlier occurs in secs. 15 and 16, T. 26 N., R. 12 E., southwest of the smelter, in the vicinity of the M. K. and T. railroad cut near the W¼ cor. sec. 15.

A good section of the Dewey, at its maximum known thickness, is exposed in the west road cut, about 2 miles south of Bartlesville, along U. S. Highway 75, near the E¼ corner of sec. 19, T. 26 N., R. 13 E., where it is 32 feet thick and consists of typically interbedded limestone and calcareous shale in the lower part, grading upward into massive beds at the top.

The Dewey is exposed on the south side of a small creek near the E¼ cor. sec. 31, T. 26 N., R. 13 E., about 4 miles south of Bartlesville, along U. S. Highway 75. This outcrop seems abnormally low in the topography. On the hill in secs. 5 and 6, T. 25 N., R. 13 E., the Dewey is abnormally high, topographically, and dips southwestward into the syncline which diverts Caney River from the west to the east side of the county. These unusual relationships probably result from structural anomolies.

The Dewey is exposed in the bed and west bank of Caney River, in NW¼ NE¼ sec. 1, T. 25 N., R. 12 E. This exposure may be found by following the A. T. and S. F. railroad from Matoka about ¾ mile north to the river. This locality is of further interest in connection with the Chanute and Iola formations. The Dewey outcrops extend southward across T. 25 N., Rs. 12 and 13 E., and may be seen conveniently in the road west of Caney River near the NW cor. sec. 12, T. 25 N., R. 12 E. and on the east side of the road in the north bank of the small stream near the W¼ corner of the same section, where it is overlain by a good exposure of the Chanute formation. Another convenient exposure is in sight of and on the west of U. S. Highway 75, capping an east-facing escarpment in secs. 24 and 25, T. 25 N., R. 12 E.

U. S. Highway 75 crosses the outcrop of the Dewey in the vicinity of the NW cor. sec. 5, T. 24 N., R. 13 E., and the lower part is well exposed along the west side of this section where it caps a low, east-facing escarpment. It continues southward in a band from 1/8 to 1½ miles wide to sec. 31, T. 24 N., R. 13 E. Locally the outcrop extends westward into T. 24 N., R. 12 E.

The outcrop of the Dewey is a narrow band at the NW cor. sec. 6. T. 23 N., R. 13 E. where it turns southeastward, extending nearly to the NE cor. sec. 16, T. 23 N., R. 13 E., whence it runs southwestward with many re-entrants and a few outliers, finally leaving the area mapped near the S¼ corner sec. 33, T. 23 N., R. 12 E., in Osage County.

The Dewey limestone is shown on the State Map of Oklahoma as far south as the north part of T. 16 N., R. 10 E., a few miles southwest of Kellyville, Creek County.

*Thickness.* The Dewey limestone is variable in thickness, due in part at least to pre-Chanute erosion. It is 6 feet thick at the point where it is cut off, in sec. 13, T. 28 N., R. 14 E., and consists of interbedded dark-bluish limestone and dark, calcareous shale, typical of the lower part, elsewhere. It is 10 feet thick ¼ mile east of the SW cor. sec. 6, T. 27 N., R. 14 E., and thickens rapidly southward, probably reaching its maximum thickness in secs. 14, 15, 22, 23, T. 27 N., R. 13 E., where a thin bed, containing phosphatic nodules occurs at the top. This phosphatic bed was not seen elsewhere. The Dewey is about 25 feet thick in the old quarry of the Dewey Portland Cement Co., sec. 26, T. 27 N., R. 13 E., 24 feet thick at the base of Blue Mound, sec. 16, T. 27 N., R. 14 E., 17 feet thick a little more than 2 miles southwest of Blue Mound, at the SW cor. sec. 30, T. 27 N., R. 14 E.; and 32 feet thick at the E¼ cor. sec. 19, T. 26 N., R. 13 E., on U. S. Highway 75 about 2 miles south of where the highway leaves Bartlesville.[66] This last is the maximum thickness measured. From this place the Dewey lime-

66. Stop 24, *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society*, p. 61, 1937.

stone thins southward to 10 feet in sec. 32, T. 25 N., R. 13 E. and maintains about that thickness to the south side of the area.

*Character.* The Dewey limestone is so uniform in all its characteristics, other than thickness, that it will not be described here in detail by townships. It is usually gray to dark-bluish in color, but is sometimes pinkish. It is semi-crystalline and fossiliferous, with *Caninia torquium* conspicuously abundant. Usually fossils do not weather out well enough to make good collecting. An abandoned quarry in SW¼ sec. 33, T. 28 N., R. 14 E. afforded the best collecting on account of the number of good brachiopods that have been cracked free and cover the quarry floor. Well-preserved fossils also are abundant at the crusher site. In a few localities, notably in part of the old quarry of the Dewey Portland Cement Co., sec. 26., T. 27 N., R. 13 E., the Dewey limestone consists of a few massive beds with very thin shale partings, but usually at the base there is a very sandy, shaly, fossiliferous bed 0.1 to 2 feet thick, succeeded by alternating, wavy beds of dark, calcareous shale and dark-bluish limestone. The proportion of limestone is greater toward the top, and locally there are massive beds in the upper part.

Whether the Dewey limestone is thick or thin, the upper part has a characteristic appearance. Even in relatively fresh exposures, such as quarries or road cuts, it has a yellow, ocherous, weathered appearence, and is softer and more broken than is usual for other limestones of this region.

The limestone beds of the Dewey are sufficiently high in calcium carbonate for use as agricultural limestone, while the interbedded calcareous shale is suitable in quality and sufficient in quantity to be used with the limestone in the manufacture of Portland cement. The crushed limestone makes excellent concrete aggregate and is much used as road gravel in the vicinity of Dewey outcrops, where the stone can be gathered and crushed by local labor and portable equipment. The Dewey is also used to some extent as rough building stone and as veneer stone.

In one locality, secs. 14, 15, 22, and 23, T. 27 N., R. 13 E., a bed 0.3 foot thick and packed with phosphatic nodules occurs at the top of the Dewey limestone. A representative sample of this bed contained 2.22% $P_2O_5$. So far as known it is too thin and carries too much overburden to be attractive as a source of phosphatic limestone. Phosphatic nodules weathered from this bed are abundant in the gravels of Wolf Creek and its tributaries in this locality and might serve as a limited local source of phosphate for agricultural use. A representative sample of the nodules contained 23.55% $P_2O_5$.

*Stratigraphic relations.* The Dewey limestone is underlain conformably by the Nellie Bly formation and overlain unconformably, probably throughout the area, by the Chanute formation. North of the center of sec. 13, T. 28 N., R. 14 E., it was removed by pre-Chanute erosion.

*Correlation.* The Dewey probably is equivalent to the Cement City member of the Drum limestone of present Kansas usage. No part of the Dewey limestone seems to correspond to the Corbin City member of the Drum, but the Corbin City may be equivalent to the limestone conglomerate at the base of the Chanute formation. In south-central Oklahoma the Dewey probably is represented by the Belle City limestone.

*Detailed sections.* For measured outcrop sections of the Dewey limestone, see sections numbered 3, 4, 18, 33, 53, 54, 76, 78, 79, 80, 81, 82, 106, Appendix B.

## Ochelata Group

"The name Ochelata was introduced as a stratigraphic term by Ohern[67] for beds between the Dewey and Avant limestones, but subsequent usage has extended its application to include all of the strata above the Dewey and beneath the Nelagony formation. Since the base of the Nelagony happens to coincide with the Missouri-Virgil boundary, the Ochelata beds comprise the upper Missouri deposits of northern Oklahoma. It is proper to consider them as a group, and also to extend application of the term slightly into Kansas on the north and to the northeastern flank of the Arbuckle Mountains on the south. The lower boundary of the group is defined as the base of the Chanute shale (*Chanute formation*),[68]

67. Ohern, D. W., "The Stratigraphy of the Older Pennsylvanian Rocks of Northeastern Oklahoma": *The State Univ. of Okla. Research Bull.* 4, p. 38, 1910.
68. Italics by the writer.

which corresponds to the top of the Drum(*Dewey*) limestone where this rock is present, but in places where the Drum is absent the basal Chanute sandstone may extend downward a varying distance below the Drum horizon. The upper boundary of the Ochelata group is defined to coincide with the Missouri-Virgil disconformity."[69]

TABLE VI

SUBDIVISIONS OF THE OCHELATA GROUP IN WASHINGTON AND ADJACENT COUNTIES

Virgil subseries.
        Nelagony formation.
    *Unconformity.*
Missouri subseries.
    Ochelata group.
        Weston shale.
            Undifferentiated shale and sandstone.
            "The Okesa", sandstone and shale.
        Birch Creek limestone.
        *Unconformity.*
        Unnamed shale.
        Torpedo sandstone.
        Wann formation.
        Iola formation.
            Avant limestone member.
            Muncie Creek shale member.
            Paola limestone member.
        Chanute formation
            Carbonaceous shale member.
            Cottage Grove sandstone member.
            Thayer coal member.
            Unnamed shale member.
            Noxie sandstone member.
            Basal conglomerate member.
    *Unconformity.*
    Skiatook group

## CHANUTE FORMATION

The name Chanute was formally introduced into Oklahoma nomenclature by Moore, Newell, Dott, and Borden in 1937,[70] to include the shale, sandstone, limestone conglomerate, and coal that lie below the base of the Iola formation and above the Dewey (Drum) limestone, or in its absence, above the unconformity at the top of the Nellie Bly formation.

*First reference.* Haworth and Kirk, 1894.

*Nomenclator.* Haworth and Kirk, 1894.

69. Moore, Raymond C., Newell, Norman D., Dott, Robert H., and Borden, Joseph L., "Definition and Classification of the Missouri Subseries of the Pennsylvanian Series in Northeastern Oklahoma": *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society*, pp. 42-43, 1937.
70. *Idem.*, p. 43.

*Type locality.* Vicinity of Chanute, Kansas.

*Original description*:

Above the Erie limestone(*above the Winterset limestone*)[71] there is another system of shales and sandstones which in places reach a thickness of nearly 150 feet, but which along the Neosho River section (Kansas) possibly does not exceed 100 feet. It reaches its maximum thickness in the vicinity of Thayer (Kansas), where it is estimated to be 150 feet thick. It extends from below Osage mission to above Chanute (Kansas), which town may well give it a name, so that it may be called the Chanute shales. Here, as elsewhere, sandstone appears and disappears with great readiness. Around Thayer the sandstone occurs in heavy beds, some of which produces excellent building material.

Below the sandstone at Thayer a seam of coal is found of sufficient thickness and quality to justify its being worked extensively enough to furnish fuel to Thayer and the surrounding country.

Above the Chanute shales lies the heavy system of limestone in which the Iola quarries are situated, the so-called Iola marble.[72]

*History of usage.* Moore says:

Early usage of the term Chanute shale is somewhat confused because of miscorrelations of the limestones below and above. It is clear, however, that it was intended to designate by this name the shale and thin sandstone beds that form the plain extending eastward from Chanute to the prominent escarpment made by the Bronson limestones. The Iola limestone is well exposed in the vicinity of Chanute and it can be traced without difficulty to Iola, about 20 miles to the north. The term Thayer shale is a subsequently introduced, synonymous unit. In 1908, Haworth and Bennett restricted application of Chanute shale to include only the upper part of the original Chanute, that is to the beds between the top of the Drum (*Dewey*)[73] limestone and the base of the Iola limestone. * * * * application of Chanute in the restricted sense has come to be accepted generally.[74]

71. Italics by the writer, to accord with present usage.
72. Haworth, Erasmus and Kirk, Z. M., *Kansas Univ. Quarterly* Vol. 2, No. 3, p. 109, 1894.
73. Italics by the writer to accord with Oklahoma nomenclature.
74. Moore, Raymond C., "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas": *Kansas Geol. Survey Bull.* 22, p .109, 1935.

In 1935 Newell[75] restricted application of the synonymous term Thayer to the persistent coal bed mined near Thayer, Kansas. The Thayer coal lies at the base of the prominent upper sandstone of the Chanute, which Newell named the Cottage Grove sandstone member.

The rocks assigned to the Chanute formation were included by Ohern[76] in the lower part of his Ochelata member of the Ramona formation (southern area), and in the lower part of the unnamed interval between the Dewey and Avant limestone lentils of his Copan member, Wann formation, (Northern area).

According to the classification used on the Geologic map of Oklahoma,[77] these beds lie at the base of the Ochelata formation (Ochelata group), occupying the lower part of the interval between the Dewey and Avant limestones.

*Distribution.* The outcrop of the Chanute formation attains its greatest width, about 6 miles, across T. 29 N. and the north part of T. 28 N., Rs. 14 and 15 E., where it fills a pre-Chanute erosion channel. All six members are present as shown in Fig. 6.

The Chanute outcrop is more than 5 miles wide from the east side of sec. 10, T. 28 N., R. 14 E. to the center of sec. 10, T. 28 N., R. 15 E., and only about 2 miles wide in the next row of sections to the south. This abrupt contraction in width of outcrop is due, in large part, to the absence of the basal conglomerate and Noxie sandstone which fill the pre-Chanute erosion channel in T. 29 N., and the north part of T. 28 N., Rs. 14 and 15 E. (Fig. 6).

The outcrop continues southwestward with a width of 2 to 4 miles, to the alluvium of Caney River, north of Dewey.

Chanute outliers are widely distributed over the southeast part of T. 27 N., R. 13 E.; the west part of T. 27 N., R. 14 E.; in T. 26 N., R. 13 E.; and extend into T. 26 N., R. 14 E. West of Caney River the outcrop covers nearly all of Bartlesville and extends westward into Osage County.

75. Newell, Norman D., "The Geology of Johnson and Miami Counties, Kansas": *Kansas Geol. Survey Bull.* 21, p. 49, 1935.
76. Ohern, D. W., "The Stratigraphy of the Older Pennsylvanian Rocks of Northeastern Oklahoma": *The State Univ. of Okla. Research Bull.* 4, 1910.
77. Miser, Hugh D., "Geologic Map of Oklahoma": *U. S. Geol. Survey*, 1926.

The Chanute crops out in the west bank of Caney River above the Dewey limestone, in the NW¼ NE¼ sec. 1, T. 25 N., R. 12 E. It extends southward to the southeast corner of T. 24 N., R. 12 E. and is present in the northwest part of T. 23 N., R. 13 E. and the east side of T. 23 N., R. 12 E. as a narrow band midway in the hillsides, where it follows a devious course to round the spurs and head the valleys.

South of Bird Creek the outcrop extends from the SW¼ sec. 7, T. 23 N., R. 12 E., to the vicinity of the S¼ cor. sec. 33, T. 23 N., R. 12 E., where it leaves the area.

*Thickness and character.* The Chanute formation has its maximum thickness of about 150 feet in that part of the area north of the center of sec. 13, T. 28 N., R. 14 E., where the lower part fills a pre-Chanute erosion channel. In the east-Central part of T. 28 N., R. 14 E., south of this erosion channel, it is about 65 feet thick. It is 15 feet thick in sec. 9, T. 27 N., R. 13 E.; 35 feet near the N¼ cor. sec. 1, T. 25 N., R. 12 E.; 30 feet near the W¼ cor. sec. 30, T. 24 N., R. 13 E.; 15 feet thick near the SE cor. sec. 5, T. 23 N., R. 13 E.; and 25 feet thick near the E¼ cor. sec. 13, T. 23 N., R. 12 E.

*Basal conglomerate member.* The limestone conglomerate member at the base of the Chanute attains its maximum thickness of 20 feet near the NE cor. sec. 15, T. 29 N., R. 15 E. There is a dark, crinoidal limestone bed at the base, in this locality, which contains phosphatic nodules and resembles the dark, crinoidal, phosphatic basal bed of the Winterset member of the Hogshooter formation. Otherwise the conglomerate is composed of beds 0.5 to 2 feet thick, containing reworked limestone fragments in a gray, fossiliferous, limy matrix. The basal conglomerate is exposed in the road south of the store at Noxie, NW cor. sec. 30, T. 29 N., R. 15 E., where it is about 5 feet thick and is composed of reworked limestone fragments in a gray to reddish, limy, matrix. It appears at the base of the Noxie sandstone capping the hill in the SW¼ NW¼ sec. 28, T. 29 N., R. 15 E., where it is about 2 feet thick, brown, and sandy. The southernmost exposure of the basal conglomerate known, is in the south side of the road ¼ mile west of the NE cor. sec. 16, T. 28 N., R. 15 E., where it is a reddish-brown limy sandstone containing a few limestone fragments.

*Noxie sandstone member.*[78] The Noxie sandstone member (2 of Fig. 6) crops out as shown on the accompanying map (Plate I). It has its maximum thickness of about 60 feet in the vicinity of Noxie, NW cor. sec. 30, T. 29 N., R. 15 E. It is thinnest across secs. 16, 17, and 18, T. 28 N., R. 15 E., where the upper part overlaps Nellie Bly beds along the south side of the pre-Chanute erosion channel. It is massive, coarse-grained, cross-bedded, and buff to reddish-brown. The Noxie is an excellent aquifer, being unusual in this respect among Pennsylvanian sandstones of this area. For details as to size of wells and subsurface extent see discussion of Underground Water Resources.

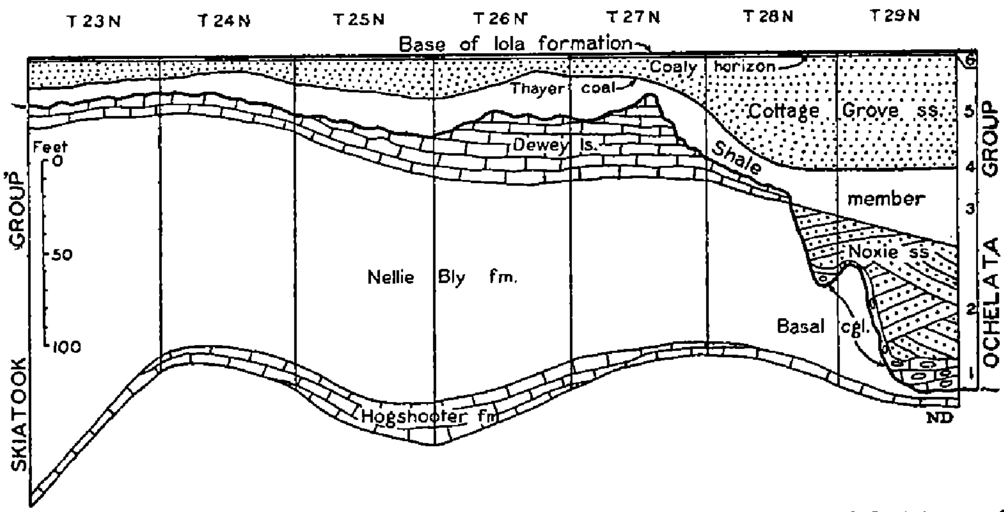


FIG. 6. Generalized outcrop section showing character and subdivision of Chanute formation and its unconformable relation to underlying units. Numbers refer to members of Chanute formation.

*Unnamed shale member.* Member 3 of Fig. 6 is an unnamed shale member of the Chanute formation which conformably overlies the Noxie sandstone north of sec. 13, T. 28 N., R. 14 E., and overlies the Dewey limestone unconformably immediately south of section 13, and probably throughout the area to the south. The shale is about 60 feet thick at the Kansas-Oklahoma line; 15 feet thick at the point where it overlaps the eroded edge of the Dewey limestone in sec. 13. T. 28 N., R. 14 E.; 6 feet ⅛ mile east of the SW cor. sec. 6, T. 27 N., R. 14 E.; 2.5 feet near the center of the SW¼ sec. 9, T. 27 N., R. 13 E.; 11 feet ⅛ mile east of the SW cor. sec. 30, T. 27

78. Moore, Raymond C., Newell, Norman D., Dott, Robert H., and Borden, Joseph L., "Definition and Classification of the Missouri Subseries of the Pennsylvanian Series in Northeastern Oklahoma": *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society*, p. 43, 1937.

N., R. 14 E.; 14.7 feet ⅛ mile north of the SE cor. sec. 11, T. 26 N., R. 13 E.; 22 feet ¼ mile south of the NE cor. sec. 14, T. 26 N., R. 13 E.; 15 feet near the E¼ cor. sec. 19, T. 26 N., R. 13 E., about 2 miles south of Bartlesville along U. S. Highway 75; 16 feet in the NW¼ NE¼ sec. 1, T. 25 N., R. 12 E.; 6 feet in the NW¼ NW¼ sec. 12, T. 25 N., R. 12 E.; 8 feet on the east side of the road in the north bank of the small stream near the W¼ cor. sec. 12, T. 25 N., R. 12 E.; about 2 feet in the ravine near the W¼ cor. sec. 25, T. 25 N., R. 12 E.; extremely thin or absent in sec. 24, T. 24 N., R. 12 E.; 10 to 15 feet immediately east of the W¼ cor. sec. 30, T. 24 N., R. 13 E.; 10 feet near the SE cor. sec. 5, T. 23 N., R. 13 E.; and 10 feet thick near the E¼ cor. sec. 13, T. 23 N., R. 12 E.

This member of the Chanute formation is usually clay shale but is noticeably sandy in T. 26 N., R. 13 E. It is dark when fresh but weathers gray, bluish, or yellow. The upper part contains local coal seams up to 0.1 foot thick which are closely related to the overlying Thayer coal.

*Thayer coal member.*[79] A thin coal member (4 of Fig. 6), about the middle of the Chanute formation is correlated with the Thayer coal member of Kansas. It overlies the unnamed shale member and underlies the Cottage Grove sandstone member. It is from 0.1 to 1.5 feet thick, but is of considerable stratigraphic importance because of its persistence. In spite of its thinness it is a well developed, clean coal in many places, though it is shaly in the one locality where it is more than 1 foot thick. It is used for fuel at one farm where it is 0.5 foot thick and conveniently exposed. Following are localities where outcrops of Thayer coal were found: west side of the road at the Kansas-Oklahoma line ¼ mile east of the NW cor. sec. 18, T. 29 N., R. 15 E.; in road 0.1 mile east of S¼ cor. sec. 23, T. 29 N., R. 14 E.; south side of road, 0.1 mile west of NE cor. sec. 24, T. 29 N., R. 14 E.; east side of road 0.1 mile north of SW cor. sec. 24, T. 29 N., R. 14 E.; in an outlier about ⅛ mile north of SE cor. sec. 25, T. 29 N., R. 14 E.; in road 0.1 mile east of SW cor. sec. 36, T. 29 N., R. 14 E.; 0.1 mile west of the S¼ cor. sec. 6, T. 28 N., R. 15 E.; S¼ cor. sec. 7, T. 28 N., R. 15 E.; 0.1 mile east of S¼

79. Newell, Norman D., "The Geology of Johnson and Miami Counties, Kansas": *Kansas Geol. Survey Bull.* 21, p. 49, 1935.

cor. sec. 12, T. 28 N., R. 14 E.; at the place where the Dewey limestone is cut off near the center of sec. 13, T. 28 N., R. 14 E.; ¼ mile west of SE cor. sec. 13, T. 28 N., R. 14 E.; in the road near the top of the hill about 0.1 mile east of the SW cor. sec. 5, T. 27 N., R. 14 E.; just east of the SW cor. sec. 30, T. 27 N., R. 14 E.; in the creek bank near the center of the SW¼ sec. 9, T. 27 N., R. 13 E.; 0.1 mile north of the SE cor. sec. 11, T. 26 N., R. 13 E.; ¼ mile south of the NE cor. sec. 14, T. 26 N., R. 13 E.; 0.1 mile west of the SE cor. sec. 16, T. 26 N., R. 13 E., a good place to collect associated plant fossils; near the top of the hill on the east side of the road opposite the E¼ cor. sec. 19, T. 26 N., R. 13 E., 2 miles south of Bartlesville along U. S. Highway 75; ¼ mile south of the NW cor. sec. 29, T. 26 N., R. 13 E.; NW¼ NE¼ sec. 1, T. 25 N., R. 12 E., NW¼ NW¼ sec. 12, T. 25 N., R. 12 E.; on the east side of the road in the north bank of the small stream near the W¼ cor. sec. 12, T. 25 N., R. 12 E.; at the base of the vertical bank along the south side of the stream in the SW¼ SW¼ sec. 12, T. 25 N., R. 12 E. where it is taken out for local use. It was not found south of sec. 12, T. 25 N., R. 12 E. in the area covered by this investigation, but has been found a short distance farther south in Osage County.

*Cottage Grove sandstone member.* A persistent sandstone member in the upper part of the Chanute (5 of Fig. 6), is correlated with the Cottage Grove sandstone member of Miami County, Kansas.[80] In sec. 23, T. 29 N., R. 14 E. it is 40 feet thick, thin- and even-bedded, fine-grained, micaceous, and buff colored. Along the south side of secs. 10, 11, and 12, T. 28 N., R. 14 E. it is 50 feet thick, thin- and even-bedded, micaceous, shaly, and cream to buff in color. The upper 10 feet is very sandy shale.

The Cottage Grove sandstone is exposed in the bed of the tributary of Post Oak Creek between the SE cor. and the center of the SW¼ sec. 9, T. 27 N., R. 13 E., where it is about 6 feet thick, massive to thin-bedded, fine-grained, micaceous, and is overlain by an equal thickness of the massive, limy sandstone which represents the Paola limestone member of the overlying Iola formation.

The Cottage Grove sandstone is 20 feet thick or more in T. 26 N., R. 13 E. and is thin-bedded to massive, fine-grained, and gray

80. *Idem.*

to buff. In the NW¼ NE¼ sec. 1, T. 25 N., R. 12 E., it is poorly exposed in the west bank of Caney River where it is about 20 feet thick, thin-bedded to massive, fine-grained, and gray, yellow, or light-buff in color. Along the small stream which flows eastward across the SW¼ SW¼ sec. 12, T. 25 N., R. 12 E. it is 22 feet thick, thin-bedded to massive, fine-grained, and buff.

From this point southward, the Cottage Grove sandstone thins rapidly and is inconspicuous from the south side of sec. 13, T. 25 N., R. 12 E. to the southwest corner of T. 24 N., R. 13 E. but its presence is indicated by the following outcrops: an exposure of the upper beds ½ mile south of the NW cor. sec. 24, T. 25 N., R. 12 E. where it is overlain by member 6 of Fig. 6; 3 feet of soft, thin-bedded, brown sandstone, probably the lower part, in a ravine at the W¼ cor. sec. 25, T. 25 N., R. 12 E.; an exposure of the upper part in the creek bed in the NW¼ sec. 24, T. 24 N., R. 12 E.; and poorly exposed sandstone beds 2 or 3 feet thick in the south roadside ditch just east of the W¼ cor. sec. 30, T. 24 N., R. 13 E. which lie about 15 feet above the Dewey limestone and a few feet below the Paola limestone member of the Iola formation.

The Cottage Grove sandstone member is thicker and more conspicuous to the southward in T. 23 N. Near the SE cor. sec. 5, T. 23 N., R. 13 E. it is about 4 feet thick, thin-bedded and brown. Near the E¼ cor. sec. 13, T. 23 N., R. 12 E. it is 15 feet thick, thin-bedded to massive, fine-grained, and light to reddish-brown.

*Carbonaceous shale member.* At the top of the Chanute formation is a zone of carbonaceous shale and coal, (6 of Fig. 6), usually less than one foot thick and absent locally. It usually consists of sooty shale and in places contains a coal seam 0.1 foot thick. A coal is mentioned by Newell as occurring at this horizon in Johnson and Miami Counties, Kansas,[81] and Jewett and Newell found coal locally at the top of the Chanute in Wyandotte County, Kansas.[82] In Oklahoma the coal is known to extend as far south as the vicinity of Avant, Osage County.

Coal appears at the following places: ⅛ mile north of the S¼ cor. sec. 22, T. 29 N., R. 14 E.; south ditch of the abandoned rail-

81. *Idem.*

82. Jewett, John M., and Newell, Norman D., "The Geology of Wyandotte County, Kansas": *Kansas Geol. Survey Bull.* 21, p. 174, 1935.

road grade, center of the NW¼ sec. 10, T. 28 N., R. 14 E.; in the road at the top of a hill about 600 feet east of the SW cor. sec. 5, T. 27 N., R. 14 E.; in the west bank of the A. T. and S. F. railroad cut along the west bank of Caney River NW¼ NE¼ sec. 1, T. 25 N., R. 12 E.; in the creek bed near the center of the NW¼ sec. 24, T. 24 N., R. 12 E.; in the road just east of the W¼ cor. sec. 30, T. 24 N., R. 12 E.; and on the east side of State Highway 11, about a mile and a half southeast of Avant, near the N¼ cor. sec. 17, T. 23 N., R. 12 E.

*Stratigraphic relations.* The Chanute formation lies unconformably on older strata immediately south of the Kansas-Oklahoma line, and probably throughout the area. Pre-Chanute erosion removed the Dewey limestone and the underlying Nellie Bly formation from the Kansas-Oklahoma line to the center of sec. 13, T. 28 N., R. 14 E. and, locally, may have extended as deep as the top of the Hogshooter formation. The channel so formed was partly filled by the basal conglomerate member and the Noxie sandstone member, which are found nowhere else in Oklahoma. The westward extension of the Noxie sandstone in this channel, underground, is demonstrated by subsurface studies. See Fig. 19. The upper part of the channel is occupied by the basal part of the shale member, the upper part of this member overlapping the eroded Dewey limestone southward. The variation in thickness, and the absence of an uppermost phosphatic bed of the Dewey limestone, except in a single locality, near Dewey; and the yellow, ocherous, weathered appearance of the upper surface of the limestone, wherever exposed, indicate that the unconformity underlying the Chanute extends throughout the area. The Chanute formation is overlain conformably by the Iola formation.

*Correlation.* This formation is the direct continuation of the Chanute formation of Kansas and heretofore has been included in the lower part of the Ochelata group of Oklahoma.

*Detailed sections.* For measured outcrop sections of the Chanute formation see sections numbered 2, 3, 4, 17, 18, 31, 32, 33, 34, 35, 36, 37, 51, 52, 53, 76, 77, 78, 79, 100, 101, 102, 103, 104, 105, 106, 124, 125, 126, 127, 128, 129, 130, Appendix B.

## Iola Formation

Due mainly to field studies by Newell, Moore[83] introduced the term Iola formation into Oklahoma nomenclature to designate certain beds cropping out west of Ramona which he considered equivalent to the Iola limestone of Kansas. Further field work by the writer has established the direct continuity of these beds with the Iola of Kansas and their continuation southward beyond the limits of the present investigation. The Iola formation is conformable with the underlying Chanute formation and the overlying Wann formation. It is composed of the lower Paola limestone member, the middle Muncie Creek shale member, and the upper Avant limestone member.

*First reference.* Haworth and Kirk, 1894.

*Nomenclators.* Haworth and Kirk, 1894.

*Type locality.* Town of Iola, Kansas.

*Original description*:

> Above the Chanute shales lies the heavy system of limestone in which the Iola quarries are situated, the so-called Iola marble. For this reason it may be called the Iola limestone.*** At Iola it is 30 or 40 feet thick.*** The character of the rock is remarkable, particularly regarding the unusually thick layers it produces, in this respect surpassing any thing else known in the state. On this account rock of any dimensions can be obtained from it, as is practically demonstrated at the Iola quarries.[84]

*History of Usage.* Various limestone outcrops in Kansas have been erroneously correlated with the Iola limestone of the type locality,[85] but these misuses of the name are of little interest in Oklahoma. Newell found that the Iola limestone of the type locality

83. Moore, Raymond C., Newell, Norman D., Dott, Robert H., and Borden, Joseph L., "Definition and Classification of the Missouri Subseries of the Pennsylvanian Series in Northeastern Oklahoma": *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society*, p. 43, 1937.
84. Haworth, Erasmus, and Kirk, M. Z., "A Geologic Section along the Neosho River from the Mississippian Formation of the Indian Territory to White City, Kansas, and along the Cottonwood River from Wycoff to Peabody": *Kansas Univ. Quarterly*, Vol. 2, No. 3, p. 109, 1894.
85. Moore, Raymond C., "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas": *Kansas Geol. Survey Bull.* 22, pp. 111-112, 1935.

is composed of a thick upper limestone member separated from a lower limestone member 1.5 to 2 feet thick by a few inches of shale containing phosphatic nodules, and that this threefold division is widespread in Kansas. He also found that the upper member is equivalent to the Raytown limestone of Missouri and extended the use of that name into Kansas. He named the lower and middle members respectively the Paola limestone, from a town in Miami County, Kansas, and Muncie Creek shale, from Muncie Creek in Wyandotte County, Kansas. Newell recognized the formation as far south as the Kansas-Oklahoma line.[86] The writer has been able to distinguish all three members in Oklahoma.

The terms Iola formation, Paola limestone member, and Muncie Creek shale member are acceptable for use in Oklahoma but the term Avant limestone member is used instead of Raytown limestone, on the basis of priority and equal or greater use.

*Distribution.* An inlier of the Iola formation occurs along tributaries of Cotton Creek in the northeast part of T. 29 N., R. 13 E. and the northwest part of T. 29 N., R. 14 E. The main outcrop crosses the Kansas-Oklahoma line just east of the NW corner of sec. 14, T. 29 N., R. 14 E. and extends southwestward in a narrow band to the alluvium of Caney River in sec. 8, T. 27 N., R. 13 E.

The outcrop reappears in the west side of the railroad cut on the west bank of Caney River near the N¼ cor. sec. 1, T. 25 N., R. 12 E. and continues southward in a narrow band to sec. 13, T. 24 N., R. 12 E., where it begins to broaden, owing to the increasing thickness of the Muncie Creek shale and Avant limestone members. Farther south, in T. 23 N., Rs. 12 and 13 E. the outcrop is widespread. Owing to rugged topography the outcrop is relatively narrow south of Bird Creek and leaves the area mapped west of the S¼ cor. sec. 33, T. 23 N., R. 12 E.

*Thickness and character.* Moore[87] says that the Iola formation is about 30 feet thick near Iola, Kansas, and that the average thickness of the formation in northeastern Kansas is about 7.5 feet.

86. Jewett, John M., and Newell, Norman D., "The Geology of Wyandotte County, Kansas": *Kansas Geol. Survey Bull.* 21, p. 175, 1935.
87. Moore, Raymond C., "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas": *Kansas Geol. Survey Bull.* 22, p. 112, 1935.

From the Kansas-Oklahoma line southward to the alluvium of Caney River in sec. 8, T. 27 N., R. 13 E., the Iola formation is 4 to 8 feet thick. In the exposure in the west side of the A. T. and S. F. railroad cut, on the west bank of Caney River, near the N¼ cor. sec. 1, T. 25 N., R. 12 E., where all three members are recognizable, it is 2.2 feet thick. It is 11 feet thick in the NW¼ NW¼ sec. 12, T. 25 N., R. 12 E. and 25 feet thick on South Fork Double Creek NW¼ sec. 24, T. 24 N., R. 12 E. From that point southward the Iola formation increases in thickness to about 70 feet in the vicinity of Avant, T. 23 N., R. 12 E. The greater part of the increase is due to the increased thickness of the Avant limestone and Muncie Creek shale members.

*Paola limestone member.* The Paola limestone member (1 of Fig. 7) was named by Newell,[88] from the town of Paola, in Miami County, Kansas. He describes it as a single layer of dense, dark, bluish-gray, very brittle limestone, the upper surface of which is highly irregular and pitted. It weathers in angular blocks.

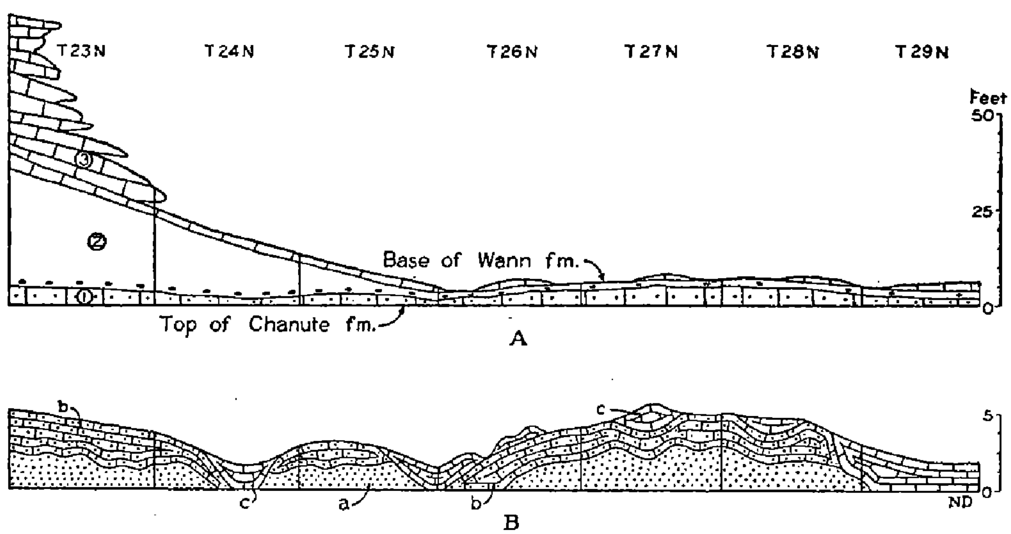


FIG. 7. (A) Generalized outcrop section of Iola formation: (1) Paola limestone member; (2) Muncie Creek shale member, containing phosphatic nodules in the base; (3) Avant limestone member, 40 feet or more thick in T. 23 N., but thin, lenticular, and possibly absent locally farther north.
(B) Generalized outcrop section of Paola limestone member, vertical scale exaggerated to show: (a) Massive, non-limy sandstone; (b) Limey sandstone; (c) Lenticular limestone fossiliferous to non-fossiliferous, gray to white, marly and granular to dense. Actually a, b, and c grade into each other both laterally and vertically.

88. Newell, Norman D., "The Geology of Johnson and Miami Counties, Kansas": *Kansas Geol. Survey Bull.* 21, pp. 51-52, 1935.

In Oklahoma the Paola limestone is 3 to 5 feet of massive, calcareous sandstone, and comprises three lenticular phases, which grade into each other, both laterally and vertically. (See Fig. 7)

Exposures of the Paola were found at the following places: In the stream bed, 1/8 mile north of the S1/4 cor. sec. 22, T. 29 N., R. 14 E., soft, yellow, sandy marl 0.3 foot thick; along the stream channel, in the NW1/4 NE1/4 sec. 25, T. 29 N., R. 13 E., sandy limestone, surface pitted, 1 foot thick; south ditch of the abandoned railroad grade, center of the NW1/4 sec. 10, 28 N., R. 14 E., limy sandstone and marly fossiliferous limestone, 2 feet thick; under the bridge, just south of the NE cor. sec. 16, T. 28 N., R. 14 E., massive sandstone with pitted top, thickness not known; vicinity of the SE cor. sec. 30, T. 28 N., R. 14 E., soft massive sandstone,, not limy, probably leached, about 3 feet thick; just east of the SW cor. sec. 36, T. 28 N., R. 13 E., massive, limy sandstone with pitted top, about 5 feet thick; in the stream channel, near the SE cor. sec. 9, T. 27 N., R. 13 E., massive sandstone with local lenses of bluish-white limestone in the top, total thickness about 5 feet; in the west side of the A. T. and S. F. railroad cut on the west bank of Caney River near the N1/4 cor. sec. 1, T. 25 N., R. 12 E., marly sandy limestone, 0.2 foot thick; in the NW1/4 NW1/4 sec. 12, T. 25 N., R. 12 E., marly fossiliferous limestone, 0.5 foot thick; along the south bank of the small stream which flows east across the SW1/4 sec. 12, T. 25 N., R. 12 E., limy sandstone with pitted top, about 5 feet thick; in the south roadside ditch, just east of the W1/4 corner sec. 30, T. 24 N., R. 13 E., granular, marly, fossiliferous limestone, 1.8 feet thick; vicinity of the SE cor. sec. 5, T. 23 N., R. 13 E., brown limy sandstone with local bluish-white limestone lenses in the upper part, 2 feet thick; vicinity of the E1/4 cor. sec. 13, T. 23 N., R. 12 E., massive brown sandstone, upper part limy with local limestone lenses in the upper part; on the E. side of State highway 11, about 2 miles southeast of Avant, in NW1/4 NE1/4 sec. 17, T. 23 N., R. 12 E., gray, marly, limestone, 0.2 foot thick; in the road from Avant to Skiatook, NE1/4 sec. 33, T. 23 N., R. 12 E., gray, marly, granular, fossiliferous limestone, 1 foot thick.

*Muncie Creek Shale Member.* The Muncie Creek Shale member (2 of Fig. 7) was named by Newell[89] after Muncie Creek in south-

89. *Idem.*

ern Wyandotte County, Kansas. According to Moore[90] the member is present in south central Iowa and the Platte Valley in Nebraska. In Kansas it ranges in thickness from less than 1 foot to a maximum of about 3 feet and contains black fissile shale in some areas and in others is composed of light colored shale alone, but it always contains a band of phosphatic nodules. Jewett and Newell[91] say that this zone of phosphatic nodules is the most constant feature of the Iola formation in Kansas, and that it was observed by Newell as far south as the Kansas-Oklahoma line.

In northeast Oklahoma the Muncie Creek shale is more variable in composition and thickness than in Kansas but it always contains the phosphatic nodules. By following the band of phosphatic nodules weathering out of the Muncie Creek shale, good exposures of the Iola formation were found.

The Muncie Creek shale ranges in thickness from 1 foot in the railroad cut near the N¼ cor. sec. 1, T. 25 N., R. 12 E. to 38 feet in the NW¼ NE¼ sec. 17, T. 23 N., R. 12 E. It is composed of calcareous shale in sec. 25, T. 29 N., R. 13 E. but over most of the area mapped is composed of dark clay shale and contains black, fissile shale in the base in Tps. 24 and 23 N.

Exposures of the Muncie Creek shale or its residual phosphatic nodules occur at the following places: ⅛ mile north of the S¼ cor. sec. 22, T. 29 N., R. 14 E., dark shale weathers gray, phosphatic nodules in the base, 3 feet thick; NE¼ NW¼ sec. 25, T. 29 N., R. 13 E., gray calcareous, fossiliferous shale, 3 feet thick; south ditch of abandoned railroad grade, center of the NW¼ sec. 10, T. 28 N., R. 14 E., calcareous shale with phosphatic nodules, 3 feet thick; SE cor. sec. 17, T. 28 N., R. 14 E., gray shale with phosphatic nodules; railroad cut E¼ cor. sec. 16, T. 28 N., R. 14 E., nodules; railroad cut E¼ cor. sec. 20, T. 28 N., R. 14 E., nodules; in gullies, SE cor. sec. 30, T. 28 N., R. 14 E., nodules; in creek bed just east of the SW cor. sec. 36, T. 28 N., R. 13 E., nodules; in stream bed near SE cor. sec. 9, T. 27 N., R. 13 E., gray shale with phosphatic nodules; in railroad cut near N¼ cor. sec. 1, T. 25 N., R. 12 E., yellow clay shale

90. Moore, Raymond C., "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas": *Kansas Geol. Survey Bull.* 22, pp. 112-113, 1935.

91. Jewett, John M., and Newell, Norman D., "The Geology of Wyandotte County, Kansas": *Kansas Geol. Survey Bull.* 21, p. 175, 1935.

with phosphatic nodules, 1 foot thick; NW¼ NW¼ sec. 12, T. 25 N., R. 12 E., shale with phosphatic nodules, weathers light buff, 9 feet thick; in the barrow pit of the A. T. and S. F. railroad, SW¼ SW¼ sec. 12, T. 25 N., R. 12 E., gray shale with phosphatic nodules; South Fork Double Creek, in the NW¼ sec. 24, T. 24 N., R. 12 E., upper part dark clay shale with some thin-bedded sandy shale, lower 3 feet black, fissile shale, nodules in stream but not found in place, total thickness 20 feet; just east of the W¼ cor. sec. 30, T. 24 N., R. 13 E., dark clay shale with 1 to 3 feet of black, fissile shale at the base containing phosphatic nodules, total thickness 21 feet; near SE cor. sec. 5, T. 23 N., R. 13 E., nodules present but not in place, shale is covered but is about 30 feet thick; near the E¼ cor. sec. 13, T. 23 N., R. 12 E., nodules present but not in place, shale is covered but is about 20 feet thick; about 2 miles southeast of Avant, on the east side of State highway 11, NW¼ NE¼ sec. 17, T. 23 N., R. 12 E., dark shale, weathers yellowish-gray contains at the base 2 feet of black, fissile shale with phosphatic nodules, thickness 38 feet.

*Avant limestone member.* The upper member of the Iola formation (3 of Fig. 7) was named the Avant limestone by Ohern[92] in 1910 and the name is here used instead of the term Raytown, on the basis of priority and equal or greater use. According to Jewett and Newell[93] it is about 5 feet thick in Wyandotte and Johnson Counties, Kansas, becoming thicker southward to the vicinity of Iola where it is 28 feet thick. It is thin or locally absent in southern Kansas. In Oklahoma the Avant is variable in thickness and character. In many of the places where it is thin it is gray to buff and crinoidal, but some exposures consist of a single massive, dense, yellowish-white bed 1 to 2 feet thick in which brachiopods predominate, as at the E¼ cor. sec. 25, T. 24 N., R. 12 E. In T. 23 N., Rs. 12 and 13 E., where the Avant is tens of feet thick, a bed resembling this latter appears at the base, and the overlying beds are white to gray, massive, and relatively less fossiliferous.

Exposures of the Avant were seen at the following places: in a draw near the center of SW¼ sec. 14, T. 29 N., R. 14 E., white

92. Ohern, D. W., "The Stratigraphy of the Older Pennsylvanian Rocks of North eastern Oklahoma": *The State Univ. of Okla. Research Bull.* 4, p. 31, 1910.
93. *Op. cit.*

fossiliferous limestone about 2 feet thick; ⅛ mile north of the S¼ cor. sec. 22, T. 29 N., R. 14 E., gray to buff crinoidal limestone about 1 foot thick; along the stream in the NW¼ NE¼ sec. 25, T. 29 N., R. 13 E., two layers of yellow crinoidal limestone, each 1 foot thick, separated by gray, calcareous, fossiliferous shale, 3 feet thick, total thickness 5 feet; in the south ditch of the abandoned railroad grade center of the NW¼ sec. 10, T. 28 N., R. 14 E., limestone, hard, blue, crinoidal, 1 foot thick; in the south roadside ditch about 0.1 mile west of the NE cor. sec. 16, T. 28 N., R. 14 E., the top of a gray, fossiliferous limestone; in the stream just above the railroad bridge center of the NW¼ sec. 29, T. 28 N., R. 14 E., gray fossiliferous limestone about 2 feet thick; in the stream bed about ¼ mile south of the N¼ cor. sec. 2, T. 27 N., R. 13 E. top of a gray limestone; in the west side of the A. T. and S. F. railroad cut, on the west side of Caney River, in railroad cut near the N¼ cor. sec. 1, T. 25 N., R. 12 E., yellow limestone 1 foot thick packed with crinoid stems; South Fork Double Creek in the NW¼ sec. 24, T. 24 N., R. 12 E., gray fossiliferous limestone about 5 feet thick; at the E¼ cor. sec. 25, T. 24 N., R. 12 E., a single dense, massive, yellowish-white bed 1 to 2 feet thick containing crinoids and brachiopods.

*Stratigraphic relations.* The Iola formation is underlain conformably by the Chanute formation and overlain conformably by the Wann formation.

*Correlation.* The Iola formation in Oklahoma is the direct continuation of the Iola formation of Kansas and lies in the lower part of the Ochelata group (formation) of northeast Oklahoma.

*Detailed sections.* For measured outcrop sections of the Iola formation see sections numbered 2, 3, 4, 15, 16, 17, 18, 32, 33, 34, 35, 36, 77, 100, 123, 124, Appendix B.

### WANN FORMATION

The name Wann formation, as restricted and redefined by the writer,[94] applies to all strata between the top of the Iola forma-

94. Oakes, Malcolm C., "Results of Recent Field Studies in Osage, Washington, and Nowata Counties, Oklahoma": *Bull. Amer. Assoc. Petro. Geol.*, Vol. 24, pp. 726-727, 1940.

tion, below, and the base of the Torpedo sandstone, above, or the base of the Birch Creek limestone in areas where the Torpedo sandstone was removed by pre-Birch Creek erosion. The Wann formation is composed of four lithologic zones which probably are not definite stratigraphic subdivisions. Zones of the Wann are: (1) dark clay shale; (2) shale and thin, platy limestones, gray to yellow, and fossiliferous to non-fossiliferous; (3) limestone and calcareous shale containing an assemblage of fossils similar in many respects to the fauna of the Wewoka formation of the Des Moines sub-series,[95] (4) sandstone and shale containing, in the south part of the area, the Clem Creek sandstone of Emery[96] and its overlying limestone lenses. (See Fig. 8).

*First reference.* Ohern, 1910.

*Nomenclator.* Ohern, 1910.

*Type locality.* As restricted, the area southwest, west, and northwest of Wann.

*Original description*: Ohern's original description reads:

> The term Wann formation is proposed for a series of shales, sandstones, and limestones which occupy the interval between the top of the Curl (Coffeyville) formation and that of the Stanton limestone as that term is used by Haworth and Bennett.[97]

The bed most frequently mentioned by Ohern as the top of his Wann formation ("upper Stanton") is that mapped by the writer as the Birch Creek limestone, and since the top of Curl formation was defined as the base of the Hogshooter limestone, his Wann formation included all strata between the base of the Hogshooter limestone and the top of the Birch Creek limestone.

*History of usage.* The term Wann formation has received little use. Ohern ignored it entirely in his unpublished manuscript of 1914 and Gould does not mention it in his Index to the Strati-

95. Girty, George H., "Fauna of the Wewoka Formation of Oklahoma": *U. S. Geol. Survey Bull.* 544, 1915.
96. White, David, and others, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma": *U. S. Geol. Survey Bull.* 686, p. 3, 1922.
97. Ohern, D. W., "The Stratigraphy of the Older Pennsylvanian Rocks of Northeastern Oklahoma": *The State Univ. of Okla. Research Bull.* 4, p. 28, 1910.

graphy of Oklahoma.[98] The strata covered by the original Wann formation were subsequently included by Ohern in his Ochelata formation.[99] This latter term has been generally used.

A formation name seemed desirable for the unit, mappable in Oklahoma, between the top of the Iola formation and the base of the Torpedo sandstone, or the base of the Birch Creek limestone where the Torpedo sandstone was removed by pre-Birch Creek erosion. The equivalent strata were first studied farther north in east-central Kansas, where several units were recognized and named, but these units can not be differentiated in southern Kansas or Oklahoma. This has caused uncertainty as to exact equivalents and has led to the use of such hyphenated names as "Lane-Vilas", which are acceptable expedients in southern Kansas but are inadequate in Oklahoma. This unit is clearly a part of the Wann formation as originally defined and, since the term Wann formation had been little used and is appropriate, the writer revived, restricted, and redefined it to apply to all strata between the top of the Iola formation, below, and the base of the Torpedo sandstone, above, or the base of the Birch Creek limestone[100] where the Torpedo sandstone was removed by pre-Birch Creek erosions.

*Distribution.* The Wann formation crops out in a belt 1/8 to 8 miles wide from the north line of T. 29 N., Rs. 13 and 14 E. to the south side of the area mapped, in T. 23 N., Rs. 11 and 12 E. It is 4 to 5 miles wide in the area immediately south of the Kansas-Oklahoma line but is narrower as it passes southwestward to the alluvium of Caney River along the line between Tps. 28 and 27 N., R. 13 E. The outcrop is relatively narrow in the escarpments west of Caney River, as well as on both sides of Sand Creek, but is wider in the south part of T. 25 N., Rs. 11 and 12 E. and reaches its maximum width in the south part of the area where it occupies most of T. 23 N., R. 11 E. and a large part of T. 23 N., R. 12 E.

*Thickness.* The Wann formation varies greatly in thickness. There is a general thickening southward to secs. 14 and 15, T. 25

98. Gould, Chas. N., "Index to the Stratigraphy of Oklahoma": *Okla. Geol. Survey Bull.* 35, 1925.
99. *Idem.*, p. 75.
100. White, David, and others, *Op. cit.*, p. 17.

N., R. 12 E, and the slight amount of thinning south of that point probably is due to pre-Birch Creek erosion. In addition to these regional trends there are local differences in thickness which seem to be related to structure. The formation is 95 feet thick in sec. 13, T. 29 N., R. 13 E., where it lies on the northwest flank of a large anticlinal feature indicated by the inliers of the Iola formation and Cottage Grove sandstone member of the Chanute formation in secs. 29 and 30, T. 29 N., R. 14 E. It is about 135 feet thick in sec. 22, T. 29 N., R. 14 E., where the structure is apparently synclinal. It is 100 feet thick in secs. 19 and 29, T. 28 N., R. 14 E. and 110 feet thick in the SW¼ of sec. 10, T. 28 N., R. 14 E., near Wann. The entire thickness is not exposed in T. 27 N. but 140 feet is exposed in sec. 26, T. 27 N., R. 12 E. and the total thickness is estimated to be about 240 feet near the southeast corner of the township. The base of the formation is not exposed in the valley of Sand Creek but 80 feet was measured in sec. 19, T. 26 N., R. 12 E., and 120 feet along the east side of secs. 28 and 33, T. 26 N., R. 12 E. The entire formation with a thickness of 283 feet is exposed on the flanks of Circle Mountain, south of Bartlesville in sec. 36, T. 26 N., R. 12 E. It is 250 feet thick in the SE¼ sec. 2, T. 25 N., R. 12 E., and 304 feet thick across secs. 14 and 15, T. 25 N., R. 12 E. These extremely thick sections of the Wann seem to lie in the westward continuation of the syncline that deflects Caney River from the west side to the east side of Washington County.

Outcrops cover such relatively wide areas in Tps. 24 and 23 N., that it is difficult to make direct measurements, but compiled outcrop sections indicate 240 feet for T. 24 N., Rs. 11 and 12 E., and 230 feet for T. 23 N., Rs. 11 and 12 E.

*Character*. The Wann formation is composed of four lithologic zones: (1) dark clay shale, (2) dark shale and thin, platy limestone, (3) calcareous, fossiliferous shale and limestones, (4) sandstone and shale, which probably do not follow true stratigraphic levels. See Fig. 8.

(1) The basal zone is poorly exposed throughout the area east of Caney River but seems to be predominantly dark clay shale. It is covered by alluvium across most of Tps. 28, 27, and 26 N. West

of Caney River it is composed of gray to dark calcareous shale and contains a few very thin, fine-grained sandstone beds. The best exposure is in the road just west of the E¼ cor. sec. 25, T. 24 N., R. 12 E. where it occupies the 50-foot interval between the Avant limestone at the corner and the first limestone, in the escarpment to the west, which is fossiliferous, yellow, and 2.5 feet thick. In this exposure it is gray to dark, calcareous shale and contains two fine-grained sandstone beds each 1 foot thick.

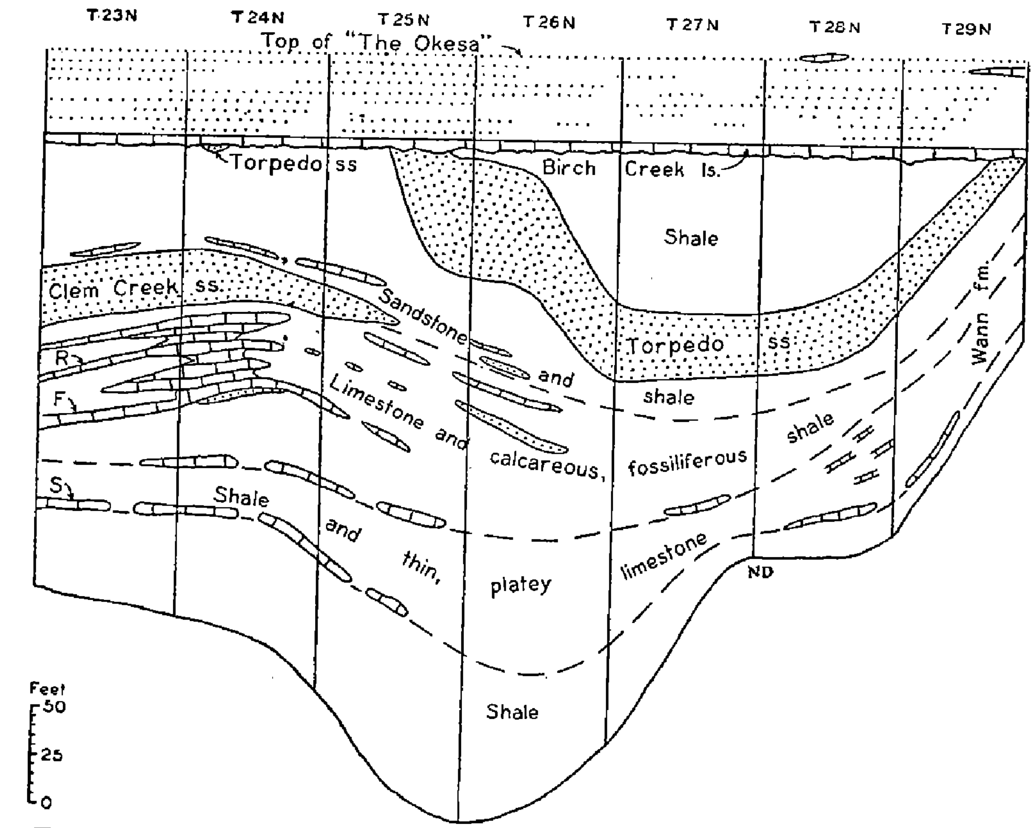


FIG. 8. Generalized outcrop section from base of Wann formation to top of "The Okesa" showing lateral gradation in the Wann and the unconformable relation of Birch Creek limestone to older formations.

(2) This zone consists of dark shales and thin, platy limestones. In the south part of the area, west of Caney River, the shale is calcareous. It is 30 to 40 feet thick in Tps. 29 and 28 N. and contains several lenses of thin, platy, shaly, fossiliferous to unfossiliferous limestones which may be seen conveniently at the following places: in the road just south of the E¼ cor. sec. 20, T. 29 N., R. 14 E.; in the ditch 50 feet north of the road and a little west of the S¼ cor. sec. 8, T. 28 N., R. 14 E.; near the S¼ cor. sec. 18, T. 28 N., R. 14 E.; in the road ¼ mile north of the

SE cor. sec. 19, T. 28 N., R. 14 E.; and in the draw 1/4 mile west of the SE cor. sec. 13, T. 28 N., R. 13 E.

The zone seems to be thinner in T. 27 N. where it is poorly exposed, but is thicker southward and reaches a maximum of 50 to 60 feet in T. 25 N., R. 12 E. where it is gray to drab in color and contains a few thin, fine-grained sandstone beds. A good exposure occurs in the road just west of the E1/4 cor. sec. 25, T. 24 N., R. 12 E., where it is 67 feet thick, extending from the top of zone 1, to the base of the massive limestone, zone 3. Zone 2 is only 35 feet thick in the south part of the area. In T. 23 N., R. 12 E. it contains, at the base, the "shelly" limestone of Emery.[101]

(3) The limestone and calcareous, fossiliferous shale zone is about 15 feet thick in T. 29 N., R. 13 E. where it is mostly shale. It reaches its maximum thickness of about 80 feet in T. 27 N., R. 12 E., and from that township to the south side of the area is from 50 to 70 feet thick. Limestone is noticeably frequent in the south side of T. 26 N., R. 12 E. and reaches its maximum development in T. 24 N., R. 12 E. west of Ramona. The calcareous shale of this zone is freely effervescent in dilute acid and contains an assemblage of fossils similar in many respects to the fauna of the Wewoka formation of the Des Moines sub-series.[102] *Trepospira depressa* and *Leiorhynchus rockymontanus* are conspicuous forms.

The best collecting ground is along the abandoned railroad grade about 1/4 mile east of the SW cor. sec. 23, T. 29 N., R. 13 E., where the zone seems to be about 15 feet thick and consists of gray, calcareous, fossiliferous shale. The fossils are unusually well preserved and literally hundreds of individuals cover the sides of the grades and the barrow pits after rains.

The zone is not well exposed in T. 28 N. but the fossils can be found from place to place. The zone is certainly present in the escarpment west of Caney River and north of Butler Creek in T. 27 N., R. 12 E. Calcareous, gray shale and thin limestone beds are exposed in the pit along the west side of the road near the center of the SW1/4 sec. 13, T. 27 N., R. 12 E., where fossils typical of the

101. White, David, and others, *Op. cit.*, p. 3.
102. Girty, George H., "Fauna of the Wewoka Formation": *U. S. Geol. Survey Bull.* 544, 1915.

zone are plentiful. Loose pieces of limestone are present on the talus slope above the pit and another exposure of limestone occurs 500 feet west of the pit and somewhat higher. The zone is about 70 feet thick in this locality. Calcareous shale and occasional specimens of *Trepospira depressa* and other forms common to the zone are found along the escarpment. In the north side of the road cut along the south side of sec. 26, T. 27 N., R. 12 E. occurs 20 feet or more of gray shale which effervesces freely with dilute acid. The zone is poorly exposed in the northeast flank of Blue Mound in sec. 16, T. 27 N., R. 14 E. where *Leiorhynchus rockymontanus* and *Trepospira depressa* were found 80 feet above the top of the Dewey limestone.

Good exposures of the zone with included limestone lenses occur in the escarpment above the A. T. and S. F. railroad in sec. 36, T. 26 N., R. 12 E., west of Caney River. The usual assemblage of fossils is present, though individuals are only moderately abundant. The shale is gray and freely effervescent with dilute acid. The zone is well exposed in the SW cor. sec. 14 and the SE cor. sec. 15, T. 25 N., R. 12 E., where at least two limestone beds are exposed in the road up the escarpment. Two limestone beds occur in the escarpment near the E¼ cor. sec. 21, T. 25 N., R. 12 E.

The zone is well exposed and accessible north of the road which runs from the NE cor. sec. 12, southwest to the west side of sec. 11, T. 24 N., R. 12 E. A 3-foot, gray, and sparingly fossiliferous limestone, with pitted surface, near the base of the zone, caps the point of the escarpment ¼ mile west of the NW cor. sec. 12, and has been traced southwest to the road along the Osage-Washington County line. On the west side of sec. 11 it is overlain by 27 feet of calcareous shale, succeeded by 6 feet of thin, fossiliferous limestone and calcareous shale in which *Myalina*-like forms are conspicuous. Next above is 8 feet of calcareous shale succeeded by the Clem Creek sandstone. The same succession of beds is continuous southward around the wooded, promontory-like hill in secs. 13 and 14, T. 24 N., R. 12 E. More limestone beds appear in this zone in the escarpment in sec. 23, T. 24 N., R. 12 E. It is difficult to correlate one with another, but it is thought that the various lenses and beds coalesce by thickening at the expense of the calcareous shale to form the continuous limestone section 40 feet thick in the road just west of the E¼ cor. sec. 25, T. 24 N., R. 12 E. The limestone splits into individual beds and lenses south of this point and contains, in T. 23 N., the "*Fusulina*-bearing gray" limestone and the "red" limestone of Emery.[103] See Fig. 8. A good section of zone 3 is exposed in the road up the escarpment north of Avant ¼ mile west of the E¼ cor. sec. 6, T. 23 N., R. 12 E. Limestones of the zone extend to the south limits of the area, being found at the following widely distributed places: along the road from Avant to Skiatook, in sec. 18, T. 23 N., R. 12 E.; near the S¼ cor. sec. 22, T. 23 N., R. 11 E.; and near the SW cor. sec. 36, T. 23 N., R. 11 E.

(4) The sandstone and shale zone is about 35 feet thick in T. 29 N. but is thicker southward, reaching a maximum of about 80 feet on the south side of the area. Usually it is poorly exposed on grassy slopes or in rubble strewn escarpments immediately below the Torpedo sandstone or the Birch Creek limestone. From the Kansas-Oklahoma line to the south side of T. 26 N. it consists of gray to dark clay shale containing inconspicuous local sandstone beds. Noticeable sandstone lenses crop out in the lower part of this zone in the flanks of Circle Mountain south of Bartlesville in secs. 25, 26, 35, 36, T. 26 N., R. 12 E. These lenses are more prominent southward and culminate in the massive, medium-grained sandstones and thin lenticular shales named the Clem Creek sandstone by Emery[104] The Clem Creek is conspicuous along the Osage-Washington County line in sec. 27, T. 25 N., R. 12 E. It is shaly and inconspicuous along the east side of Candy Creek in T. 24 N., R. 12 E., but is 50 to 60 feet thick in T. 24 N., R. 11 E. and consists of massive to thin-bedded, medium-grained sandstone and thin, lenticular beds of shale. Emery says that the Clem Creek sandstone consists of massive, medium-grained sandstone and thin lenticular shales 60 to 65 feet thick along Clem Creek in the northwestern part of T. 23 N., R. 11 E.

Both Emery and Hopkins mention a thin limestone a few feet above the Clem Creek sandstone. This limestone contains fusulinids where it crops out in the east-west road across the south

103. White, David, and others, *Op. cit.*, p. 3.
104. *Idem.*

part of sec. 34, T. 25 N., R. 12 E. The shale part of the zone, above the Clem Creek sandstone, is about 60 feet thick in Tps. 24 and 25 N., R. 12 E. and in Tps. 23 and 24 N., R. 11 E.

*Stratigraphic relations.* The Wann formation, as restricted, is underlain conformably by the Iola formation and overlain conformably by the Torpedo sandstone or unconformably by the Birch Creek limestone where the Torpedo sandstone was removed by pre-Birch Creek erosion.

*Correlation.* As restricted, the Wann formation corresponds to that part of the southern Kansas section above the Iola formation and below the uppermost limestone member of the Stanton limestone, probably the South Bend limestone member. Strata occurring between these limits have been studied in east-central and southern Kansas and subdivided as follows:

TABLE VII

SUBDIVISION OF STRATA BETWEEN THE TOP OF THE IOLA FORMATION AND THE TOP OF THE STANTON LIMESTONE IN KANSAS.

| EAST CENTRAL KANSAS[105] | SOUTHERN KANSAS[106] |
|---|---|
| Pennsylvanian series. | |
| Missouri sub-series. | |
| Weston shale. | |
| Stanton limestone. | Stanton limestone |
| South Bend limestone. | |
| Rock Lake shale. | |
| Stoner limestone. | Stoner limestone |
| Eudora shale. | Eudora shale |
| Captain Creek limestone. | Captain Creek ls. |
| Vilas shale. | |
| Plattsburg limestone. | |
| Spring Hill limestone. | |
| Hickory Creek shale. | |
| Merriam limestone. | |
| Bonner Springs shale. | |
| Wyandotte limestone. | Lane-Vilas shale |
| Farley limestone. | |
| Island Creek shale. | |
| Argentine limestone. | |
| Quindaro shale. | |
| Frisbie limestone. | |
| Lane shale. | |
| Iola formation. | Iola formation |

So far as known neither the Torpedo sandstone nor its unnamed overlying shale are present in Kansas. In Oklahoma the Wann formation is part of the Ochelata group.

105. Moore, Raymond C., "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas": *Kansas Geol. Survey Bull.* 22, pp. 111-137, 1935.

106. Moore, Raymond C., "Upper Carboniferous Rocks of Southeastern Kansas and Northeastern Oklahoma": *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society,* p. 15, 1937.

*Detailed sections.* For measured outcrop sections of the Wann formation, see sections numbered 1, 11, 12, 13, 14, 15, 16, 31, 32, 47, 49, 50, 72, 73, 74, 75, 76, 95, 96, 97, 98, 99, 120, 121, 122, Appendix B.

### TORPEDO SANDSTONE AND OVERLYING SHALE

The Torpedo sandstone and overlying shale constitute a large erosion remnant, preserved in a pre-Birch Creek syncline in Osage and Washington Counties. So far as known these units do not crop out elsewhere in Oklahoma or Kansas. The Torpedo conformably overlies the Wann formation and conformably underlies the shale. Both the sandstone and shale are overlain unconformably by the Birch Creek limestone. See Fig. 8. The Torpedo is thin-bedded to massive, medium-grained, reddish-brown, and 30 to 60 feet thick, in areas where it has not suffered pre-Birch Creek erosion. In a few places it contains limy, fossiliferous beds, but is usually nonfossiliferous. The overlying shale is usually not over 60 to 70 feet thick. The lower part is dark clay shale while the upper part is lighter, calcareous, and fossiliferous.

*First reference, Torpedo sandstone.* Hopkins.

*Nomenclator, Torpedo sandstone.* Hopkins.

*Type locality, Torpedo sandstone.* In the hills "***** 1 mile northwest of Torpedo, on the north side of the creek.***" Torpedo switch is on the A. T. and S. F. R. R., in the SW¼ sec. 17, T. 26 N., R. 12 E., Osage County.

*Original description, Torpedo sandstone*:

> The lowest bench of massive cliff-making sandstone about 75 feet above the valley floor at Torpedo is here named the Torpedo sandstone. ***It rims the valley of Sand Creek and is typically exposed 1 mile northwest of Torpedo, on the north side of the creek. Here it consists of about 30 feet of massive, medium-grained sandstone which breaks into large, ripple-marked blocks.[107]

*History of usage.* The term Torpedo has always been used in its original sense, though it was not previously known to be equiva-

107. White, David, and others, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma": *U. S. Geol. Survey Bull.* 686, p. 76, 1922.

lent to the sandstone in the vicinity of Copan, northwestern Washington County, which was informally called "the big sandstone in the Eudora shale." So far as known, the overlying shale has never been named.

*Distribution.* The Torpedo sandstone and overlying shale crop out in a belt up to 7 miles wide from the northwest corner of Nowata County to the vicinity of Wolco, in the east central part of T. 24 N., R. 11 E., Osage County. Its greatest width is in T. 28 N., R. 13 E., where it occupies most of the township. The outcrop is narrow in the escarpment west of Caney River and north of Butler Creek. It is present on both sides of Sand Creek as far west as the center of T. 26 N., R. 11 E. The outcrop is present in the escarpment west of Caney River as far south as sec. 15, T. 25 N., R. 12 E. where it is cut off by the pre-Birch Creek unconformity. Remnants are present around the headwaters of Candy Creek in the south part of T. 25 N., Rs. 11 and 12 E. and a remnant of the lower part of the Torpedo sandstone is present at the, junction of State highway 11 and the Ramona road south of Wolco. So far as known the Torpedo is not present farther south.

*Thickness and character.* The Torpedo sandstone and overlying shale vary greatly in thickness as shown in Fig. 8. While part of the variation is due to original differences in thickness of the individual units, the greater part is due to pre-Birch Creek erosion.

*Torpedo sandstone.* In Tps. 25 and 26 N. the Torpedo is a massive cliff-making sandstone which contains a shale parting locally. Elsewhere it contains prominent lenses of sandy shale and soft sandstone beds. In a few localities it contains sandy, fossiliferous limestone but is usually nonfossiliferous. This makes the Torpedo sandstone relatively easy to distinguish from the thin-bedded fossiliferous Okesa sandstone where the two are separated by thin, sandy Birch Creek limestone. Usually outcrops of the Torpedo sandstone are tree-bearing but in some parts of the area its outcrop is grassy. The Torpedo sandstone is reduced to 2 to 5 feet in thickness at the Kansas-Oklahoma line as shown in Fig. 8, and is not recorded in published sections from southern Kansas. Likewise it is cut off at its southern extremity in Tps. 24 and 25 N., Rs. 11 and 12 E., and at both extremities, it is succeeded directly by the

Birch Creek limestone. It reaches its maximum thickness of 60 feet a short distance east of the W¼ cor. sec. 14, T. 26 N., R. 11 E., in the north bluff of Sand Creek. Here also, it is succeeded directly by the Birch Creek limestone.

Outliers of Torpedo sandstone, reduced by pre-Birch Creek erosion, to 5 feet or less in thickness, occur in secs. 15, 16, 21 and 28, T. 29 N., R. 14 E. and in sec. 24, T. 29 N., R. 13 E. The main outcrop at the Kansas-Oklahoma line, 0.1 mile east of the NW cor. sec. 13, T. 29 N., R. 13 E. consists of 2 feet of brown sandstone, but it is 30 feet thick, thin-bedded to massive, medium-grained and reddish-brown along the south side of sec. 22, T. 29 N., R. 13 E. where the entire section is present.

In T. 28 N., Rs. 13 and 14 E., the Torpedo sandstone generally consists of three parts: a lower part of rather massive sandstone about 15 feet thick; a middle part of very sandy shale 15 to 20 feet thick; and an upper part of thinner-bedded sandstone 20 to 25 feet thick. Locally, as in sec. 34, T. 28 N., R. 13 E., it consists of thin-bedded to massive, medium-grained, reddish-brown sandstone only 20 feet thick. In this township large parts of the Torpedo outcrop are grassy. Outcrops are so covered by debris in the escarpment west of Caney River and north of Butler Creek that it is difficult to measure a complete section. It consists of 25 feet or more of massive medium-grained, reddish-brown sandstone in the SW¼ sec. 13, T. 27 N., R. 12 E.

In the road in the NW¼ NW¼ sec. 19, T. 26 N., R. 12 E. the Torpedo consists of 60 feet of thin-bedded to massive, medium-grained, reddish brown sandstone. In the north bank of Sand Creek about ¼ mile east of the W¼ cor. sec. 14, T. 26 N., R. 11 E. it consists of massive, reddish-brown, medium-grained sandstone with a few limy lenses 1 to 2 feet long. Individual beds are 1 to 3 feet thick in the lower half and 3 to 10 feet thick in the upper half. Pre-Birch Creek erosion left the top irregular in this locality, with local relief of 2 to 5 feet. This irregular surface is overlain by Birch Creek limestone which fills the depressions and covers the highest points.

The Torpedo consists of 30 feet of massive nonfossiliferous sandstone near the NW cor. sec. 3, T. 25 N., R. 12 E. It is not well exposed along the south side of sec. 3, T. 25 N., R. 12 E., but seems to be about 40 feet thick. The Torpedo is massive, nonfossiliferous and about 20 feet thick in the NE¼ sec. 15, T. 25 N., R. 12 E. and is cut off a short distance south of the W¼ cor. of the same section. North of that point the Torpedo sandstone is the scarp-capping member above the Wann shale, but southward the escarpment is capped by the Okesa sandstone, which is here directly underlain by the Birch Creek limestone. The absence of the Torpedo would not be noticed readily if it were not for the fact that it is massive and almost devoid of fossils in this part of the area while the Okesa sandstone is thin-bedded and fossiliferous. The massive, nonfossiliferous Torpedo sandstone is found to the west around the headwaters of Candy Creek in Tps. 24 and 25 N., Rs. 11 and 12 E. A pre-Birch Creek outlier of reddish-brown nonfossiliferous Torpedo sandstone about 8 feet thick occurs below the Birch Creek limestone at the junction of the Ramona road and State highway 11 near the E¼ cor. sec. 25, T. 24 N., R. 11 E., about 1 mile south of Wolco. The Torpedo sandstone is not known south of this point.

*Overlying shale*. Owing to pre-Birch Creek erosion, the shale overlying the Torpedo sandstone ranges in thickness from a thin edge up to a possible maximum of 95 feet. It reaches a thickness of 60 to 70 feet in several places, and usually crops out on grass covered slopes where little can be seen of its character. The lower part is dark clay shale with a few fine-grained sandstone beds. The upper part is lighter colored, calcareous shale. In some places the upper few feet is packed with crinoid stems, brachiopods, and Bryozoa.

The shale was reduced to a feather edge by pre-Birch Creek erosion in sec. 14, T. 29 N., R. 12 E., but increases rapidly in thickness southward and westward. It occurs as outliers in secs. 8, 9, 10, 15, 34 and 35, T. 28 N., R. 13 E. It is best exposed in the north side of the mound in sec. 15, T. 28 N., R. 13 E. where it has a thickness of 70 feet, the lower 40 feet dark clay shale and the upper 30 feet gray, calcareous, fossiliferous shale. Approximately the same section is present in sec. 10, T. 28 N., R. 13 E., but was not measured. It is 75 feet thick in the flank of the west mound of Twin Mounds, sec. 34, T. 28 N., R. 13 E., where the upper part is gray, calcareous, and fossiliferous. It is 64 feet thick in the vicinity of the NE cor. sec. 12, T. 28 N., R. 12 E. The maximum thickness of 90 feet, as reported by the writer[108] was measured in the escarpment above the school house in SE¼ SW¼ sec. 12, T. 27 N., R. 12 E. and may be too great. In this vicinity the face of the escarpment carries considerable debris and it is now thought that shale below the Okesa sandstone and above the Birch Creek limestone may have been included. A better section was measured in the SE¼ sec. 26, T. 27 N., R. 12 E., where the shale above the Torpedo sandstone is 45 feet thick. It extends westward in the hills north of Butler Creek to sec. 20, T. 27 N., R. 12 E.

The shale above the Torpedo sandstone is about 20 feet thick in the mound SE cor. sec. 3, T. 26 N., R. 12 E., immediately northwest of Bartlesville. As usual little can be seen of its character but it is evident that the upper part is calcareous and fossiliferous. It crops out to the west in sec. 4, T. 26 N., R. 12 E. The lower part extends southwestward in the hills north of Sand Creek as far as the center of sec. 14, T. 26 N., R. 11 E., where it was cut off by pre-Birch Creek erosion. From this point to the south side of sec. 24, T. 26 N., R. 11 E., the Birch Creek limestone rests on unevenly eroded Torpedo sandstone, and from there southeastward, a few feet of the shale is present between the Torpedo sandstone and the Birch Creek limestone to sec. 15, T. 25 N., R. 12 E., where the shale was cut off by pre-Birch Creek erosion, and the Birch Creek and Torpedo are in contact. Remnants of the overlying shale, a few feet thick, are present above the Torpedo sandstone around the headwaters of Candy Creek in Tps. 24 and 25 N., Rs. 11 and 12 E.

*Stratigraphic relations.* The Torpedo sandstone and overlying shale lie between the Wann formation, below, and the Birch Creek limestone, above. The Torpedo sandstone overlies the Wann formation conformably and is overlain conformably by the shale. The unconformity at the base of the Birch Creek limestone cuts off both the Torpedo sandstone and the overlying shale at their northern and southern extremities. Thus the Birch Creek unconformably overlies each in turn.

108. Oakes, Malcolm C., "Results of Recent Field Studies in Osage, Washington, and Nowata Counties, Okla.": *Bull. Amer. Assoc. Petro. Geol.*, Vol. 24, p. 728, 1940.

*Correlations.* The Torpedo sandstone and overlying shale are cut off at the Kansas-Oklahoma line and, so far as known, are not present in Kansas, but are probably represented there by the disconformity in the upper part of the Stanton formation mentioned by Moore.[109] In Washington and east-central Osage Counties, Oklahoma, the Torpedo and overlying shale are included in the Ochelata group, but are not present to the south.

*Detailed sections.* For measured outcrop sections of the Torpedo sandstone, and overlying shale, see sections numbered 32, 47, 48, 49, 50, 72, 73, 74, 75, 76, 91, 92, 93, 94, 95, 96, 97, 98, 118, 119, 120, 121, 122, Appendix B.

### BIRCH CREEK LIMESTONE

Strata mapped by the writer as Birch Creek limestone have been mapped previously as Birch Creek[110] limestone, Panther Creek[111] limestone, Stanton (?),[112] and Stanton[113] by other geologists working in different parts of the area. Field study over the larger area mapped by the writer discloses that the Birch Creek limestone rests unconformably on the eroded Wann formation, Torpedo sandstone, and its overlying shale. It is conformably overlain by a unit here called "the Okesa", composed of the Okesa sandstone of Clark[114] and its underlying shale. "The Okesa" is predominantly shale in parts of the area and entirely sandstone in others. The Birch Creek ranges in character from a ferruginous, limy sandstone to an argillaceous, bluish-white limestone.

*First reference.* Bowen, 1918.

*Nomenclator.* Bowen, 1918.

*Type locality.* In the bluffs on the north side of Birch Creek, near the east edge of the SE¼ sec. 25, T. 24 N., R. 10 E.

*Original description:*

109. Moore, Raymond C, "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas": *Kansas Geol. Survey Bull.* 22, p. 137, 1935.
110. White, David, and others, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma": *U. S. Geol. Survey Bull.* 686, p. 17, 1922.
111. *Idem.*, p. 397.
112. *Idem.*, pp. 95-96.
113. Ohern, D. W., "The Stratigraphy of the Older Pennsylvanian Rocks of Northeastern Oklahoma": *The State Univ. of Okla. Research Bull.* 4, pp. 32-33, 1910.
114. White, David, and others, *Op. cit.*, p. 77.

> It is a hard, light-gray, crystalline, somewhat dolomitic limestone and is sparingly fossiliferous. It contains a considerable percentage of iron, which gives it an unusually high specific gravity and produces a deep rusty brown color on the weathered surfaces. Laterally it grades into limy sandstone.[115]

*History of usage.* It has always been used in its original sense as applied to the limestone on Birch Creek, in T. 24 N., R. 10 E. It was used by the writer[116] to supplant the synonymous terms "Panther Creek", "Stanton (?)", and "Stanton".

*Distribution.* The Birch Creek limestone is present in the hills in T. 29 N., Rs. 13 and 14 E. It crops out in the escarpment west of Caney Creek and Caney River and north of Butler Creek as far west as sec. 20, T. 27 N., R. 12 E. It is present in The Mound immediately northwest of Bartlesville, and at the base of the hills to the west and on both sides of the valley of Sand Creek as far west as the center of T. 26 N., R. 11 E. It crops out widely in T. 25 N., R. 12 E. but is usually covered by debris. Outcrops are also widely distributed in T. 24 N., R. 11 E., but are confined to the west half of T. 23 N., R. 11 E., leaving the area in the vicinity of the southwest corner of that township.

*Thickness and character.* The Birch Creek limestone is extremely variable throughout the area. Thickness ranges from less than 1 to more than 15 feet but is usually from 1 to 3 feet. In some exposures it is extremely sandy and brown to reddish-brown, and in others it is argillaceous and bluish-white. In some localities where it is several feet thick, the lower part is sandy and brown, and the upper part is argillaceous and bluish-white. Generally the argillaceous phase is associated with shale, above or below, or both, and the sandy phase is associated with underlying Torpedo sandstone or overlying sandy beds in "the Okesa", or both. The Birch Creek contains brachiopods, fragments of crinoids, fusulinids, ostracods, bryozoans, and other fossils.

The Birch Creek limestone in the hills in secs. 15 and 16, T. 29 N., R. 14 E. consists of 1 to 3 feet of gray to brown, fossiliferous

115. *Idem.*, p. 17.
116. Oakes, Malcolm C., "Results of Recent Field Studies in Osage, Washington and Nowata Counties, Oklahoma": *Bull. Amer. Assoc. Petro. Geol.*, Vol. 24, p. 728-730, 1940.

limestone resting on a thin remnant of Torpedo sandstone. The hill in sec. 28, T. 29 N., R. 14 E. is capped by Birch Creek limestone, gray to brown and sandy. Where it caps the east end of the hill in sec. 24, T. 29 N., R. 13 E. it is gray to brown, contains many crinoid stems and rests on a remnant of Torpedo sandstone about 5 feet thick. One tenth mile east of the NW cor. sec. 13, T. 29 N., R. 13 E. it is 2 feet thick, brown, sandy, and fossiliferous, and rests on a remnant of Torpedo sandstone 2 feet thick. In the drainage ditch south of the abandoned railroad grade in the center of the SE¼ NW¼ sec. 21, T. 29 N., R. 13 E., the Birch Creek consists of a lower brown, sandy, and fossiliferous limestone, 2.5 feet thick, resting on the unnamed shale above the Torpedo sandstone, an upper very sandy, brown, fossiliferous, oolitic limestone 2.0 feet thick; and an intervening bluish-gray, calcareous shale 2 feet thick.

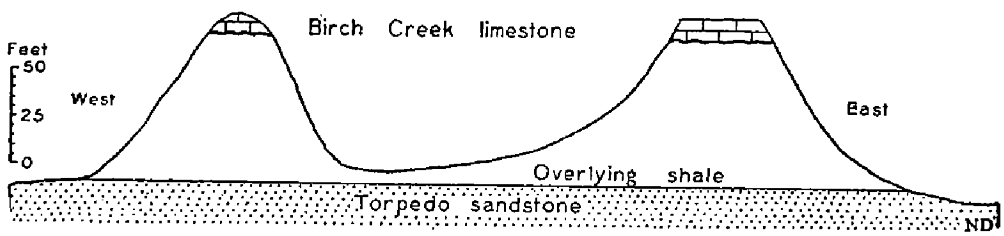


FIG. 9. Generalized west-east section through Twin Mounds in secs. 34 and 35, T. 28 N., R. 13 E.

Southward in outliers capping the "mounds" in T. 28 N., R. 13 E., the Birch Creek limestone is more nearly pure, and in Twin Mounds in secs. 34 and 35, it is 10 feet or more of relatively pure, white, sparingly fossiliferous limestone with eroded top. The unnamed shale above the Torpedo sandstone is 75 feet thick in Twin Mounds. The same shale is 64 feet thick in the vicinity of the NE cor. sec. 12, T. 28 N., R. 12 E., but the overlying fossiliferous Birch Creek limestone is brown and sandy and only 1 foot thick, and is in turn overlain by sandy beds in "the Okesa". The Birch Creek is 2 feet thick in the southwest part of sec. 23, T. 28 N., R. 12 E. In this locality the underlying shale is probably 60 feet or more thick and the lower part of "the Okesa" is also shale.

In sec. 26, T. 27 N., R. 12 E., the Birch Creek limestone is dense, bluish-white, fossiliferous, and about 2 feet thick. It has the same character, though it is poorly exposed, from there to the

SW cor. sec. 21, T. 27 N., R. 12 E. It is very sandy in the exposure near the center of the NE¼ sec. 20, T. 27 N., R. 12 E.

On both sides of Sand Creek in T. 26 N., Rs. 11 and 12 E., the Birch Creek is sandy to argillaceous and brown to bluish-white. In an exposure at the top of the cliff on the north bank of Sand Creek about ¼ mile east of the W¼ cor. sec. 14, T. 26 N., R. 11 E., it is 11 feet thick and rests on the eroded surface of the Torpedo sandstone, which has 5 feet of relief, the lower part of the limestone filling depressions and covering high points of the sandstone. The limestone is gray on fresh exposures but weathers rusty red, because of the high iron content which also gives it an unusually high specific gravity for limestone.

The Birch Creek limestone is rusty-brown, fossiliferous and about 1 foot thick across secs. 4 and 9, T. 25 N., R. 12 E. where it is separated by only a few feet of shale from the unfossiliferous, massive Torpedo sandstone below and from fossiliferous sandstone beds in "the Okesa" above. In the road up the escarpment in the southwest part of sec. 15, T. 25 N., R. 12 E., the Birch Creek is represented by thin-bedded, sandy, fossiliferous limestone about 3 feet thick, which rests on the Wann formation and is immediately overlain by thin, fossiliferous sandstone beds of "the Okesa". An exposure of sandy, brown, fossiliferous Birch Creek limestone occurs in the bed of Candy Creek near the SW cor. sec. 24, T. 25 N., R. 11 E. Wherever exposed across the south side of T. 24 N., R. 11 E., the Birch Creek limestone is sandy, brown, and fossiliferous.

An interesting section is exposed at the junction of the Ramona road with State highway 11, near the E¼ cor. sec. 25, T. 24 N., R. 11 E. about 1 mile south of Wolco, in which the brown, sandy, fossiliferous Birch Creek limestone, about 1 foot thick, is underlain by an outlying remnant of Torpedo sandstone about 8 feet thick and overlain immediately by sandstone beds of "the Okesa". The Torpedo in this exposure was an outlier in pre-Birch Creek time.

From this point southward the Birch Creek limestone occurs from place to place as a hard, light-gray, crystalline, somewhat dolomitic limestone, usually sandy, and contains a high percentage of iron which gives it a high specific gravity and a deep, rusty-brown color on weathered surfaces. It grades laterally into more sandy limestone and over much of the area is little more than a limy sandstone. In this part of the area it rests on shale of the Wann formation and is overlain by sandstone or shale beds of "the Okesa". It may be studied conveniently in the following localities: NW¼ NW¼ sec. 22; in the west bank of the Midland Valley railroad cut, near the W¼ cor. sec. 20; in the top of the hill in the SW cor. sec. 29; in the east side of the road near the top of the hill in the SW¼ sec. 31, all in T. 24 N., R. 11 E. The rapid gradation from limestone to sandstone may be seen in and a little west of the road near the E¼ cor. sec. 6, T. 23 N., R. 11 E.

*Stratigraphic relations.* The Birch Creek limestone rests unconformably on the Wann formation, on the Torpedo sandstone, and on the shale overlying the Torpedo sandstone and is conformably overlain by a unit, here tentatively called "the Okesa", composed of the Okesa sandstone of Clark[117] and its underlying shale.

*Correlation.*

The extremely variable nature of the Birch Creek limestone and its various associations with sandstone and shale, both above and below, contributed considerable confusion to the task of correlating its various exposures. For instance, it appeared to Hopkins, who did not recognize the presence of an unconformity, that the Okesa and Torpedo sandstones merged into one series, by thickening of the Okesa of Clark at the expense of its underlying shale, in Tps. 24 and 25 N., Rs. 11 and 12 E. He thought the Birch Creek limestone lay at the base or at some places 12 to 15 feet above the base of this series of sandstones[118] in T. 24 N., R. 11 E., and therefore at or near the base of the Torpedo sandstone. In this township the Birch Creek locally rests on pre-Birch Creek remnants of Torpedo sandstone, and therefore is at the base of "the Okesa", as elsewhere, rather than at the base of the combined Okesa-Torpedo unit. Hopkins saw limestone in the north part of T. 25 N., R. 12 E.[119] (later named the Panther Creek) but since it was clearly above the Torpedo sandstone, which is at that point 15 to 20 feet thick, he believed that this limestone was 15 to 20 feet above

117. White, David, and others, *Op. cit.*, p. 77.
118. *Idem.*, p. 239.
119. *Idem.*, p. 77.

the horizon of the Birch Creek. Field work and the stratigraphic considerations set forth above convince the writer that the Birch Creek and Panther Creek limestones are directly equivalent. Since Birch Creek has priority it is retained as the proper name.[120]

On the basis of the associated unconformity and its position below "the Okesa", the Birch Creek limestone was traced northward and correlated with some of the Stanton mapped by Ohern.[121] It is equivalent to some part of the upper Stanton limestone of Kansas. The Stoner limestone is the highest member of the Stanton limestone that is recognized in southern Kansas and may represent the Birch Creek limestone. However, if the unconformity at the base of the Birch Creek is equivalent to that mentioned by Moore[122] at the base of the Victory Junction shale of east central Kansas and in the Rock Lake shale of Nebraska, the Birch Creek limestone is probably equivalent to the Little Kaw limestone of Kansas and to the South Bend limestone of Nebraska.

*Detailed sections.* For measured outcrop sections showing the Birch Creek limestone see sections numbered 11, 31, 32, 47, 48, 72, 73, 88, 91, 92, 93, 94, 117, 118, 120, 121, 122, Appendix B.

## STRATA ABOVE THE BIRCH CREEK LIMESTONE

Strata above the Birch Creek limestone in northwestern Washington County are here referred to the Weston[123] shale of the Kansas section. They comprise about 300 feet of strata and include "the Okesa", Gap sandstone, Hulah sandstone, and Cheshewalla sandstone. All are in the Missouri sub-series with the possible exception of the Cheshewalla, which may lie in the Nelagoney formation of the Virgil sub-series. However, Carpenter,[124] following the Geologic Map of Oklahoma and unpublished work by D. W. Ohern, placed the boundary lower. Excepting "the Okesa", at the base, no attempt will be made to consider these strata separately, since they are unimportant in Washington County.

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120. Oakes, Malcolm C., *Op. cit.*, pp. 729-730.

121. Ohern, D. W., "The Stratigraphy of the Older Pennsylvanian Rocks of Northeastern Oklahoma": *The Univ. of Okla. Research Bull.* 4, p. 32, 1910.

122. Moore, Raymond C., "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas": *Kansas Geol. Survey Bull.* 22, p. 137, 1935.

123. *Idem.*, pp. 139-140.

124. Carpenter, Everett, "Oil and Gas in Oklahoma": *Okla. Geol. Survey Bull.* 40, Vol. III, p. 135, 1930.

*"The Okesa"*. Immediately above the Birch Creek limestone is a unit here tentatively called "the Okesa". Owing to its limited outcrop in Washington County, it was not studied in more detail than was necessary to an understanding of the stratigraphic relations of the underlying Birch Creek limestone. Known details of its character are summarized in Fig. 8. It seems to be made up of the Okesa sandstone of Clark[125] and its underlying shale. It is predominantly shale in some localities and entirely sandstone in others. In consequence, the Birch Creek limestone is immediately overlain by sandstone in parts of the area, but elsewhere it is overlain by tens of feet of shale.

The sandstone beds of "the Okesa" are usually a few inches to one or two feet thick and contain fossils in the form of casts and molds. Locally beds are literally packed with *Linoproductus* and an unidentified pelecypod genus. Limestone beds are present[126] locally. Drillers working west of the outcrop have been practically unanimous in logging these fossiliferous sandstone beds as limestone. "The Okesa" seems to be more shaly and limy in T. 29 N., R. 13 E. than farther west or south. The limestone beds, in the hills in secs. 16 and 17, not shown on Plate I, here considered part of "the Okesa", are probably equivalent to the Stanton of Goldman.[127]

## QUATERNARY SYSTEM

*Terrace deposits.* Occasional deposits of fine sand and silt on the east side of Caney River, above the present flood plain, indicate westward migration of the river down the prevailing dip of the strata, but there are no large or well developed terrace deposits in Washington County.

*Flood plain deposits* are present along Caney River and its tributaries and range in character from fine sand to clay. Occasionally the streams overflow their banks and add to these deposits. Well records indicate that locally the material at the base of these valley fills is coarser and a few water wells in such material are reported to yield as much as 70,000 gallons per day.

125. White, David, and others, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma": *U. S. Geol. Survey Bull.* 686, p. 95, 1922.
126. *Idem.*
127. *Idem.*, pp. 367-368.

## SUBSURFACE STRATIGRAPHY

The extent, thickness, character, and correlation of the formations encountered in drilling for oil and gas in Washington County are given here briefly. The following table gives the succession of the subsurface formations and indicates important oil and gas producing horizons found in them.

TABLE VIII

SUBSURFACE STRATIGRAPHY OF WASHINGTON COUNTY

| FORMATIONS | OIL AND GAS PRODUCING HORIZONS |
|---|---|
| Carboniferous system | |
| Pennsylvanian series | |
| Des Moines subseries | |
| Memorial shale | |
| Lenapah limestone | |
| Nowata shale | Wayside sand |
| Altamont limestone | |
| Bandera shale | |
| Pawnee limestone | |
| Labette shale | Peru sand |
| Ft. Scott limestone | Oswego lime |
| Cherokee shale | Squirrel (Prue) sand<br>Bartlesville sand<br>Burgess (Hogshooter) sand |
| *Unconformity* | |
| Mississippian series | |
| "Mississippi lime" | |
| Chattanooga shale | |
| *Unconformity* | |
| Ordovician system | |
| Cotter dolomite (Arbuckle limestone or "Siliceous lime") | |
| *Unconformity* | |
| Pre-Cambrian | |
| Spavinaw granite | |

## PRE-CAMBRIAN

The Spavinaw granite probably underlies all of Washington County at comparatively shallow depths, and four wells are known to have penetrated it. The Empire Gas and Fuel Company's Maggie Thompson No. 1, sec. 22, T. 29 N., R. 13 E., reports granite at 2,500 feet. Barnsdall Oil Company's Wm. Rigdon No. 7, SW¼ sec. 30, T. 28 N., R. 13 E., completed in 1920, found pink granite at 2,548 feet. Link Oil Company's Whiteturkey No. 1, NE¼ NE¼ SW¼ sec. 17, T. 26 N., R. 13 E., on the Bartlesville anticline, found granite at 1,775 feet. R. A. Crowe and Company's No. 3 McElmore, sec. 25, T. 25 N., R. 12 E. went into granite at 2,340 feet.

## ORDOVICIAN

*Cotter Dolomite* (*Arbuckle limestone or "Siliceous lime"*). Limestone of Ordovician age is probably present under all of Washington County. It has been called the "Siliceous lime" by drillers and is here called the Cotter Dolomite, but it may include more than the Cotter. Relatively few wells have gone through the Cotter but known thicknesses range from about 100 feet to more than 700 feet. The thinnest known section is on the Bartlesville anticline and the thickest on the north flank of the Caney River syncline. This apparent relation of thickness to structure may be accounted for on the basis of pre-Cotter topography, the thicker sections filling the valleys, or post-Cotter, pre-Mississippian folding and planation. It is probably due in some measure to both. The Cotter is medium- to fine-grained, crystalline to dolomitic, cherty limestone. It lies upon the pre-Cambrian granite, is overlain unconformably by the Chattanooga shale or by the "Mississippi lime", and is generally correlated with the upper part of the Arbuckle limestone.

## CARBONIFEROUS

### *Mississippian*

#### CHATTANOOGA SHALE

The Chattanooga shale is present in the subsurface under most of Washington County but is absent locally. It ranges in thickness from a knife edge to about 80 feet. It is black and carbonaceous and usually contains disseminated pyrite. It rests unconformably on the Cotter dolomite and is overlain by the "Mississippi lime" with at least local unconformity. The Chattanooga is correlated with Woodford formation of the Arbuckle Mountain area, with the upper part of the Arkansas novaculite and with the upper part of the Talihina chert. Though some authorities classify the Chattanooga as Devonian, general usage of Mid-Continent geologists classes it as Mississippian.

#### "MISSISSIPPI LIME"

So far as is known the "Mississippi lime" underlies all of Washington County and ranges from about 225 to 350 feet thick. Well logs sometimes report thin shale partings and sands but these are, at least in part, sandy and shaly limestones. It rests upon the Chattanooga shale with at least local unconformity and unconformably upon the Cotter dolomite where the Chattanooga is absent. It is overlain unconformably by the Cherokee shale. The "Mississippi lime" resembles and has been correlated with the Boone limestone of the Oklahoma Ozark area, but may contain other Mississippian units.

### *Pennsylvanian*

#### CHEROKEE SHALE

The Cherokee shale is present beneath all of Washington County and ranges in thickness from 350 feet to 700 feet or more. It consists chiefly of shale but contains prominent sandstone lenses, coal seams, and thin limestones. Some of the lenticular sandstones have produced large quantities of oil, the most important being the Bartlesville sand. Because of its lenticularity, accumulation of oil is not entirely dependent upon structure and the Bartlesville produces in the county, wherever found. The Squirrel (Prue) sand, at the top of the Cherokee, is an important oil producer. The Burgess (Hogshooter) sand occurs locally at the base of the Cherokee shale, immediately above the "Mississippi lime" and has produced large quantities of gas. Probably more than half the original oil content remains in the sands.

The Cherokee shale rests upon the "Mississippi lime" unconformably and is conformably overlain by the Ft. Scott limestone. Because of the unconformity at its base the Cherokee of Washington County may not contain units which are included in the basal part of its outcrop to the east. The Cherokee of the outcrop is continuous with the Cherokee of southeastern Kansas and probably comprises beds from the McAlester shale to the Calvin sandstone inclusive, of east-central Oklahoma.

#### FT. SCOTT LIMESTONE

Ft. Scott limestone (Oswego lime) underlies all of Washington County. Drillers' logs show it 50 to 100 feet thick. Along the outcrop to the east it usually consists of a lower limestone member 5 to 20 feet thick, a middle shale member 3 to 10 feet thick, and an upper limestone member 10 feet or more thick. The shale member, along the outcrop is black, carbonaceous, and fissile and contains an abundance of black phosphatic nodules. A small amount of oil has been produced from the "Oswego lime" in Washington County. The Ft. Scott limestone rests conformably on the Cherokee shale and is overlain conformably by the Labette shale. It is directly continuous with the Ft. Scott limestone of Kansas and is correlated with part of the Wetumka shale in the area north of the Arbuckle Mountains.

### LABETTE SHALE

In the subsurface the Labette shale is present beneath all of Washington County. It is about 100 feet thick in T. 29 N. but is generally thicker southward, being as much as 180 feet in T. 23 N. It consists of clay shale, usually dark in color, which grades into local sandstone lenses. One of these sandy zones, the Peru sand, produces oil locally. The Labette shale rests conformably on the Ft. Scott limestone and is overlain conformably by the Pawnee limestone. It is directly continuous with the Labette shale of Kansas and the lower part of the Wewoka formation of central Oklahoma.

### PAWNEE LIMESTONE

The Pawnee limestone is recognizable in most well records from Washington County. It ranges from about 30 to about 55 feet thick. On the outcrop it consists of upper and lower fossiliferous limestone members separated by a middle black, carbonaceous, fissile shale 3 to 5 feet thick which contains abundant black phosphatic nodules. This shale member is recognizable in some drillers' logs. The Pawnee is underlain conformably by the Labette shale and overlain conformably by the Bandera shale. It is directly continuous with the Pawnee limestone of Kansas and forms the lower part of the Oologah limestone in the vicinity of Tulsa.

### BANDERA SHALE

The Bandera shale is probably present beneath all of Washington County, though it does not appear in some well logs from the south part. It is 40 to 60 feet thick in T. 29 N., but is regularly thinner southward, being 5 feet or less in T. 23 N. Beyond the southern limits of the county it becomes a mere parting between Pawnee and Altamont members of the Oologah limestone. It is underlain conformably by the Pawnee limestone, and overlain conformably by the Altamont limestone. It is directly continuous with the Bandera shale of Kansas and is present as a black shale, 1 foot thick in the upper part of the Oologah limestone of the Tulsa area.

### ALTAMONT LIMESTONE

The Altamont limestone is present beneath all of Washington County. It is 50 to 60 feet thick in T. 29 N., but is thinner southward, being 30 feet or less along the south side of the county. Along the outcrop to the east it is hard, bluish-gray, and siliceous. It is underlain conformably by the Bandera shale and overlain conformably by the Nowata shale. It is directly continuous with the Altamont limestone of Kansas and forms the upper part of the Oologah limestone of the Tulsa area. The Pawnee limestone, Bandera shale, and Altamont limestone together make up the "Big lime" of the drillers, a term synonymous with Oologah limestone, which in turn correlates with the middle part of the Wewoka formation in the area north of the Arbuckle Mountains.

### NOWATA SHALE

The Nowata shale underlies all of Washington County. It is generally less than 100 feet thick in T. 29 N., but thicker southward, being as much as 280 feet in T. 23 N., and thicker southward beyond the limits of the county. It rests conformably on the Altamont limestone and is overlain conformably by the Lenapah limestone, where the latter is present. Where the Lenapah is not present the Nowata shale is generally overlain unconformably by beds of the Seminole formation, but in some localities may be overlain conformably by the Memorial shale, the Lenapah being absent because it was never deposited. The name Nowata shale has been applied by Moore[128] to directly continuous strata in Kansas. Southward the Nowata shale is probably equivalent to the upper part of the Wewoka formation.

128. Moore, Raymond C., "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas": *Kansas Geol. Survey Bull.* 22, p. 65, 1935.

### LENAPAH LIMESTONE

The subsurface distribution of the Lenapah limestone beneath Washington County is not known with certainty. It may not have been deposited in some places and in others was removed by pre-Missouri erosion. Along the outcrop to the east it is 20 feet thick at Lenapah, 7 feet or less at the Kansas-Oklahoma line, 6 to 8 feet at Nowata, and thinner southward. In the vicinity of Lenapah the main part consists of dense, bluish, partly crystalline, siliceous, fossiliferous limestone but at the top are thin limestone beds and black, fissile, carbonaceous shale containing phosphatic nodules. These upper beds are not present elsewhere. The Lenapah limestone rests conformably on the Nowata shale and is generally overlain unconformably by the Seminole formation which is discussed under Surface Stratigraphy. Locally it may be overlain by the Memorial shale. Moore[129] has applied the name Lenapah to a directly continuous limestone in southern Kansas. The Lenapah is cut off by the unconformity at the base of the Missouri subseries in the vicinity of Watova but is thought to be represented by the Eleventh Street limestone east of Tulsa.

### MEMORIAL SHALE

A shale, named the Memorial shale by Dott,[130] overlies the Eleventh Street limestone east of Tulsa, and Moore[131] has applied the name to similar shale overlying the Lenapah limestone in southern Kansas. Remnants of this shale may occur in the subsurface of Washington County. The Lenapah, Eleventh Street limestone, and the Memorial shale are probably equivalent to the Holdenville shale in the area north of the Arbuckle Mountains.

## STRUCTURE

The structure of Washington County was not mapped in detail but the following features were noted in the course of the work. Considered regionally the county is part of a monocline in which the strata dip north 65° west at the approximate rate of 30 feet per mile. In Washington County this regional monocline is broken locally by a number of westward plunging anticlinal

129. *Idem.*, p. 66.
130. Dott, Robert H., cited by Moore, Raymond C., *op. cit.*, p. 67.
131. *Idem.*, p. 67.

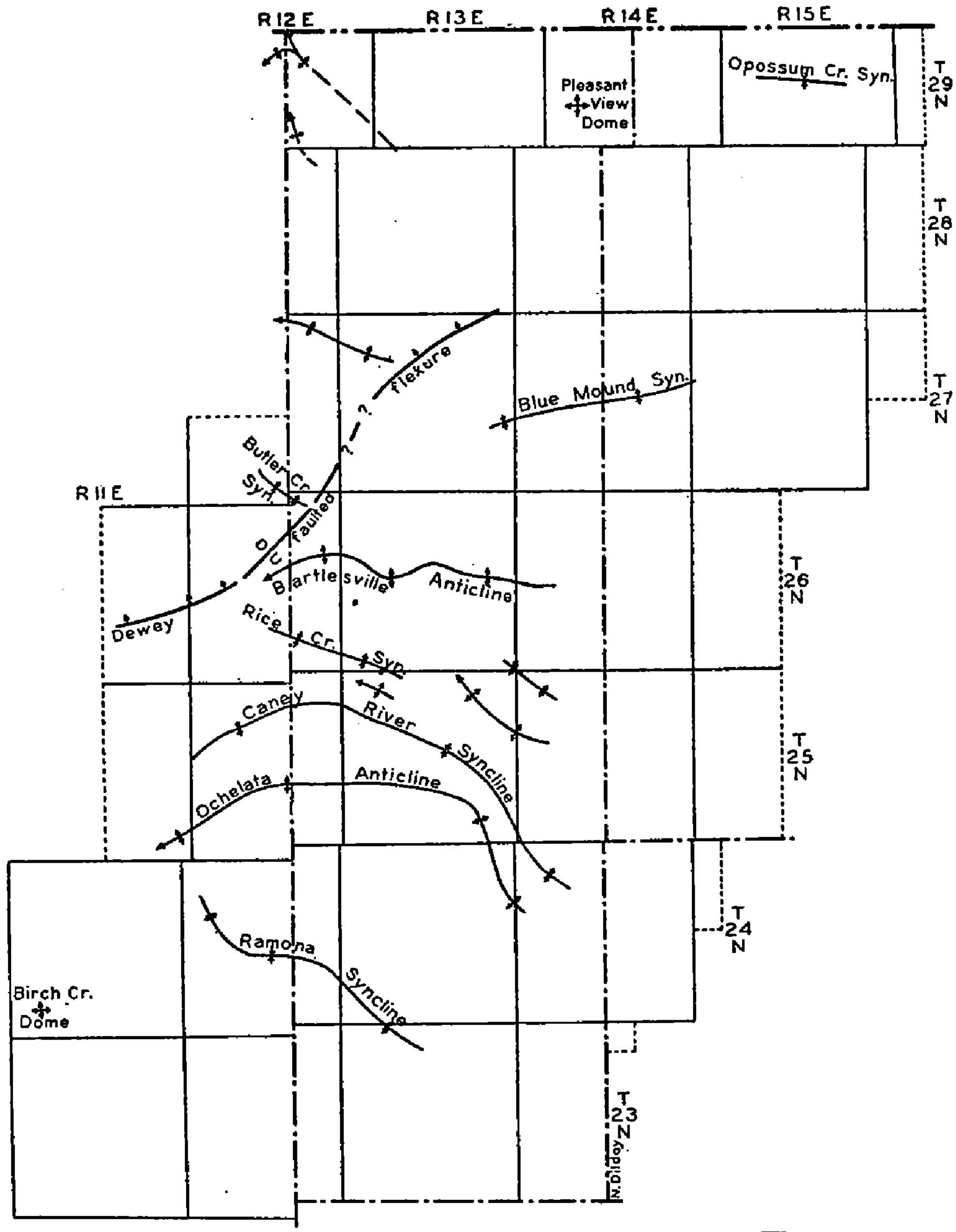



FIG. 10. Sketch map showing principal structural features in Washington and adjacent Counties.

noses and intervening synclines and by the feature here called the Dewey faulted flexure, as shown in Fig. 10.

*Opposum Creek syncline,* in T. 29 N., R. 15 E., is a conspicuous structural feature. The outcrop of the Winterset limestone member of the Hogshooter formation drops rapidly in elevation from the top of the hill near the E¼ cor. sec. 14 to the outlier in the NE¼ sec. 28 then rises equally rapidly to the outlier along the line between secs. 33 and 34 while the westward dip across secs. 20, 21, and 22 near the axis is abnormally low.

*Pleasant View dome,* is named from Pleasant View school house in sec. 30, T. 29 N., R. 14 E. A conspicuous inlier of the Cottage Grove sandstone member of the Chanute formation occupies the central part of the uplift. The Iola formation crops out conspicuously as an inlier on the northwest, north, and northeast flanks, but is covered by soil on the south flank where the lowest formation recognized is the Wann.

*Two anticlines in T. 29 N., R.* 12 E. were mapped by Goldman[132] in connection with his work in adjoining Osage County. The north one of the two is indicated in Washington County by the presence of the Torpedo sandstone along the east side of the township, considerably northwest of its normal position, and by its attitude. The top of the Torpedo is covered by the alluvium of Caney Creek, while it is several feet above the level of the alluvium west of the creek in secs. 24 and 26, T. 29 N., R. 12 E., indicating south dip. Twelve feet of south dip was measured on the top of the Torpedo sandstone, between the northeast and southeast corners of sec. 8, T. 28 N., R. 13 E.

An *anticline in T. 27 N., Rs.* 12 *and* 13 *E.,* northwest of Dewey, was mapped by Goldman in adjoining Osage County[133] and is indicated in Washington County by outcrops of the Wann formation and Torpedo sandstone on the west side of Caney River, which are considerably higher than outcrops of the same formations immediately east of the river in T. 28 N., R. 13 E. Also the Dewey limestone is abnormally high in a small, obscure outcrop in the bed of a tributary of Post Oak Creek in SW¼ sec. 9, T. 27 N., R. 13 E. The top of this anticline seems to be broad and relatively flat, and in consequence, the exact position of the axis is uncertain.

*Butler Creek syncline.* Strata dip northwestward from the Dewey faulted flexure in secs. 9 and 10, T. 26 N., R. 12 E. at the approximate rate of 120 feet per mile, carrying the Birch Creek limestone down to the alluvium of Butler Creek in sec. 33, T. 27 N., R. 12 E. while on the north side of Butler Creek, in sec. 26, T. 27 N., R. 12 E., the same limestone is about 200 feet above the

132. White, David, and others, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma": *U. S. Geol. Survey Bull.* 686, pp. 350-351, 1922.
133. *Idem.,* p. 393.

alluvium. These observations indicate a syncline, possibly faulted, along Butler Creek. This feature is probably interrupted by the Dewey faulted flexure.

*Blue Mound syncline.* The Dewey limestone descends northward from the axis of the Bartlesville anticline into a broad, flat-bottomed syncline east of Dewey, and then rises northward. In the bottom of this syncline is a large outlier of the Chanute formation on which stands Blue Mound, sec. 16, T. 27 N., R. 14 E., a conspicuous topographic feature from which the syncline is named. Owing to lack of detailed data the exact position of the axis is uncertain. It is possible that it passes south of Dewey and that the Blue Mound syncline is the eastern extension of the Butler Creek syncline west of the Dewey faulted flexure.

*Dewey faulted flexure.* The northwest flank of the Bartlesville anticline is cut by a fault in secs. 9 and 10, T. 26 N., R. 12 E. with a throw of about 150 feet. The downthrow is on the northwest side, bringing the Torpedo sandstone into contact with the Cottage Grove sandstone member of the Chanute formation. The fault passes into a flexure to the southwest where it is approximately in line with the westward extension of the axis of the Bartlesville anticline. The dip is essentially normal on the south side of the flexure, but on the north side the dip is as high as 200 feet per mile in a direction slightly west of north. Both rate and direction are abnormal. Northeastward the fault passes beneath the alluvium of Caney River, but unusually steep northwest dips in secs. 2 and 3, T. 27 N., R. 13 E. indicate that it passes into a flexure north of Dewey, hence this feature is called the Dewey faulted flexure.

*Bartlesville anticline.* The axis of this widely known feature, as shown in Fig. 10, is drawn in part from a map by Carpenter,[134] in part from unpublished work by Ohern,[135] and in part from field observations. Dips northward and southward from the axis are noticeable in the area immediately east of Bartlesville and inliers

134. Carpenter, Everett, "Oil and Gas in Oklahoma, Washington County": *Okla. Geol. Survey Bull.* 40, Vol. III, p. 143, 1930.
135. Ohern, D. W., "Geology of the Nowata and Vinita Quadrangles": unpublished manuscript.

in and west of the town indicate its westward extension. The axis probably merges with the Dewey faulted flexure farther west.

*Rice Creek syncline.* Strata dip southward from the Bartlesville anticline into the Rice Creek syncline. An exposure of Dewey limestone along the south bank of a small tributary ¼ mile south of Rice Creek along U. S. highway 75, near the E¼ cor. sec. 31, T. 26 N., R. 13 E., probably marks the bottom of the syncline.

*Anticline in secs.* 5 *and* 6, *T.* 25 *N., R.* 13 *E.* An outcrop of Dewey limestone in secs. 5 and 6, T. 25 N., R. 13 E. is at least 60 feet higher than the Dewey in the bottom of the Rice Creek syncline. Southwest dips into secs. 7 and 8, indicate that there is an anticlinal fold, or possibly a fault, between the Rice Creek syncline and the Caney River syncline.

*A syncline in secs.* 5 *and* 6, *T.* 25 *N., R.* 14 *E.,* noted in reconnaissance, may be connected with the Rice Creek syncline.

An *anticline through secs.* 2, 11, 12 *and* 13, *T.* 25 *N., R.* 13 *E.,* may be an extension of the one in secs. 5 and 6 of the same township.

*Caney River syncline.* Structural reconnaissance in T. 25 N., Rs. 12, 13, and 14 E. indicates that Caney River follows the axis of a syncline which diverts its course from the west side of the county to the east side, and work by Hopkins[136] indicates that the same syncline probably extends into Osage County with considerable change in direction. Conspicuous evidence of this syncline may be seen conveniently in exposures already mentioned, in secs. 5, 6, 7, and 8, T. 25 N., R. 13 E., along U. S. highway 75, where the Dewey limestone dips southwestward into the syncline.

The *Ochelata anticline* is an anticlinal nose immediately south of the Caney River syncline, and their axes are closely related in direction and curvature. The Ochelata anticline is extended into Osage County on the basis of work done by Hopkins.

*Ramona syncline.* The presence of a syncline southwest of Ramona is indicated by the flatness of dip on the Dewey limestone, between the center of sec. 4, T. 23 N., R. 13 E., and the NW cor.

136. White, David, and others, *Op. cit.,* p. 81.

sec. 6, of the same township, and approximately 30 feet of north dip along west line of sec. 31, T. 24 N., R. 13 E. The axis is extended northwestward into Osage County on the basis of Hopkin's map.

The *Birch Creek Dome* is a conspicuous structural feature mapped by Hopkins. It lies in secs. 29, 30, 31, and 32, T. 24 N., R. 11 E. on the road south from Barnsdall. Many structural features have been mapped by geologists of the United States Geological Survey,[137] working in Osage County, which are not shown in Fig. 10 because they are outside Washington County and were not checked in the field.

137. *Idem.*

# ECONOMIC GEOLOGY

## OIL AND GAS RESOURCES

### INTRODUCTION

Public records probably contain less information about oil conditions in Washington and adjoining counties than any other producing area in the state. With the passing of the men who made oil history in the area, and with the present rate of abandonment of wells, it will be impossible to know, within a few years, which tracts of land have produced.

The following discussion is given for the purpose of preserving and making more available to the public something of what is known about conditions in the area. The writer has drawn freely from Bulletin 19, part 2, and Bulletins 40-Q and 40-V of the Oklahoma Geological Survey. In addition, an article by Weirich[138] has been helpful. Bulletin 19, part 2, is now out of print and the article by Weirich has had limited circulation.

*History of development.*

Owing to its proximity to producing fields in Kansas, Washington County received early development. In 1894 the Cudahy Oil Company leased 200,000 acres in the vicinity of Bartlesville. The first operations were carried on in this area. Development was retarded up to 1904 on account of the necessary approval of allottees' leases by the Department of the Interior. During 1904 development became very active in the vicinity of Dewey and Bartlesville. ***In 1905 development continued in the Bartlesville-Dewey pool and a new pool was opened northwest of Dewey. In 1906, besides the development in the above pools, a remarkable pool was opened a little south of Dewey. Rapid development followed. Some of the wells had an initial production of 1,000 barrels. During 1907 a good field was developed along Hogshooter Creek, about 15 miles southeast cf Bartlesville. Some of the large wells had a daily initial production of 500 barrels, and gas wells produced 5 to 15 million cubic feet per day. During the next few years no remarkable

138. Weirich, T. E., "Petroleum Geology of Nowata and Washington Counties, Oklahoma": *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society*, pp. 85-92, 1937.

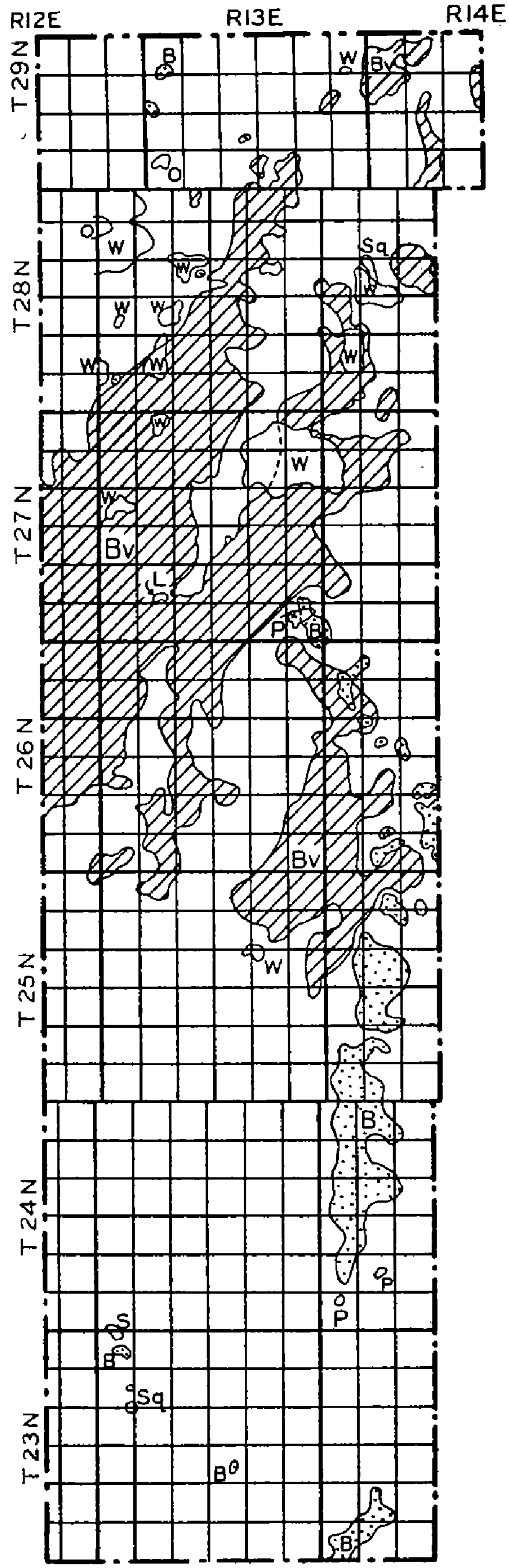



FIG. 11. Oil producing areas of Washington County, after T. E. Weirich, Guide Book, Eleventh Annual Field Conference, Kansas *Geological Sociey*, p. 88, 1937.

LEGEND

L—Layton sand.
W—Wayside sand
P—Peru sand
Sq—Squirrel sand
Bv—Bartlesville sand
B—Burgess sand

pool was opened. In 1911 production in the Hogshooter pool increased. From 1906 production in the county began to decline and has continued to do so.[139]

The period of exploration began to wane in 1915, and since that time the history of oil development in Washington County has been one of slowly declining wells, and their abandonment, with a minor amount of new drilling.

The decline in production is so slow as to be almost imperceptible. Fluctuations in annual production are more responsive to price and market conditions than to the decline in capacity to produce, and Washington County promises to be an important factor in Oklahoma's oil production for many years. Pipe line runs during recent years are given in the following table:

TABLE IX

PIPE LINE RUNS FROM WASHINGTON COUNTY, 1933-1938[140]

| Year | Barrels |
|---|---|
| 1933 | 1,290,893 |
| 1934 | 1,308,995 |
| 1935 | 1,275,437 |
| 1936 | 1,252,693 |
| 1937 | 1,305,094 |
| 1938 | 1,256,903 |

*Present conditions.* Some of the larger companies have sold properties to smaller organizations or to individual operators. In recent years some pumpers have acquired leases which they formerly operated for the companies. Many leases produce only 1 to 5 barrels of oil per day per well and wells are still producing which make less than 1 barrel per day. In operating such a property the individual has an advantage because of the absence of overhead expense, and if he is ingenious, industrious, and prudent in the management of the wells, he may find it quite profitable in a small way.

Most of the wells are 1,200 feet deep or less. The typical lease is equipped with a central gas-engine-driven "power" which operates the pumps mechanically through rod lines and pump jacks. Being entirely mechanical and extremely simple, such an installation requires little supervision.

139. Shannon, C. W., and others, "Petroleum and Natural Gas in Oklahoma": *Okla. Geol. Survey Bull.* 19, pt. 2, p. 508, 1917.

140. *Year Book, National Oil Scouts Association of America*, p. 209, 1939.

The greatest operating difficulty seems to be the entrance of water, from above the Bartlesville sand through holes in the casing occasioned by the corrosive action of the water at certain horizons. The usual remedy is to pump the wells sufficiently to keep the water from accumulating to such an extent that it interferes seriously with drainage of oil to the well. When the amount of water that must be pumped and disposed of becomes too burdensome, it is necessary to shut off the water or abandon the well. Often, if the casing can be pulled successfully, only a few lengths need be replaced to recondition the string and shut off the water. Because an unsuccessful attempt to pull the casing may cause the loss of the well, it is safer, though it may be more expensive, to run a smaller string inside the existing casing. Shutting off the water and cleaning out frequently returns a well to profitable production. Although the Bartlesville sand is generally thought to be free from water, many pumpers say that it contains water locally in the lower part, but that this water does not tend to rise in the wells.

Since gas pressure is almost exhausted the principal force tending to bring oil to the well is gravity which operates so slowly that the decline rate is low. If a lease can be reconditioned without undue expense the operator can be reasonably sure of a long period of production. The principal speculative elements seem to be operating costs and markets.

*Future possibilities.* Writing of Washington and Nowata Counties, Weirich says: "Certain sands have been extensively cored in recent years. Analyses of these cores indicate that 10,000 to 25,000 barrels of oil per acre still remain in the sand. That is, only 10 to 30% of the original content, or an average of 2,000 barrels per acre has been removed, an average of 11,000 barrels per acre remaining."[141] He also states that the oil from the Bartlesville sand is consistently 33° to 34° Baume gravity. Such a large reservoir of high grade oil will long continue to challenge the ingenious operator to devise means of increasing recovery, and any considerable increase in demand for oil will result in increased activity.

141. Weirich, T. E., *Op. cit.*, p. 90, 1937.

Already attempts have been made to revive production. The earliest method to receive much attention was application of vacuum to the wells which resulted in production of considerable casinghead gas, from which gasoline was extracted profitably for a time, while the supply of gas was large and the price of natural gasoline high. Relatively few properties now use vacuum and most of the gasoline plants have been abandoned.

Repressuring with gas, or gas and air, was used extensively for a time. It resulted in increased oil recovery and some natural gasoline. Not enough natural gas was available for repressuring and in most instances a mixture of gas and air was used. Because of the explosive nature of this mixture, the practice was dangerous, and in some instances costly. Like the use of vacuum this method is now on the wane.

Water flooding is used extensively at present in Nowata County, and its use is spreading into Washington County. Water, free from suspended matter and incapable of forming a precipitate, or otherwise clogging the sand, is admitted through certain selected wells. In some instances the pressure due to gravity suffices, but this is usually augmented by pump pressure. As the water invades the sand it forces part of the oil ahead by displacement. When the wave of displaced oil reaches other wells, it increases their production materially for a time. In systematic attempts at water-flooding in Washington and Nowata Counties, the water is usually secured from surface sources and treated to produce the necessary characteristics. A more haphazard method is to admit water from a higher horizon by perforating casing and relying on gravity alone to force the water through the oil sand. Indeed, accidental drives are sometimes occasioned by defective casing. Such drives may be ineffective because of insufficient pressure or clogging the oil sand by precipitates due to chemical reaction between mixed waters from different horizons. Water-flooding does not recover all the oil in the sand. Owing to differences in permeability between different parts of the sand, the water advances more rapidly in some portions than in others and much of the oil in the least permeable zones is surrounded or trapped by water.

No method of producing through wells is known which will extract all of the oil from the sand, and since the sands of Washington County and adjacent Nowata County are relatively shallow they may be mined for the residual oil, when easily obtained supplies in the nation are no longer adequate to meet the needs. In France similar shallow sands are being mined.

CORRELATION AND DESCRIPTION OF OIL AND GAS SANDS[142]

Commercial quantities of oil and gas have been produced from seven horizons in Washington County. They are discussed below in descending order.

*Layton sand.* The Dodds Creek or upper sandstone zone of the Coffeyville formation, correlated with the Layton sand of Pawnee County by Weirich, is productive in sec. 29, T. 27 N., R. 13 E.

*The Wayside sand,* in the Nowata shale, is second in importance to the Bartlesville sand in Washington County.

The following analysis of oil from the Wayside Sand was supplied by the United States Bureau of Mines.

ANALYSIS OF OIL FROM WAYSIDE SAND
(U. S. Bureau of Mines)

Location: T. 27 N., R. 14 E. Depth: 470-490 feet

GENERAL CHARACTERISTICS

Specific gravity, 0.875 A. P. I. gravity, 30.2
Sulfur, percent, 0.36 Color, brownish black
Saybolt Universal viscosity at 77° F., 120 sec., at 100° F., 80 sec.

DISTILLATION, BUREAU OF MINES HEMPEL METHOD

Distillation at atmospheric pressure, 745 mm First drop 43°C. (109°F.)

| Fraction No. | Cut at °C. | °F. | Percent | Sum percent | Sp. Gr. 60/60°F. | °A.P.I. 60°F. | C. I. | S. U. visc. 100°F. | Cloud test |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 50 | 122 | | | | | | | |
| 2 | 75 | 167 | 1.1 | 1.1 | 0.664 | 81.6 | .... | | |
| 3 | 100 | 212 | 2.7 | 3.8 | .711 | 67.5 | 17 | | |
| 4 | 125 | 257 | 4.6 | 8.4 | .737 | 60.5 | 20 | | |
| 5 | 150 | 302 | 3.9 | 12.3 | .754 | 56.2 | 21 | | |
| 6 | 175 | 347 | 4.0 | 16.3 | .773 | 51.6 | 23 | | |
| 7 | 200 | 392 | 4.3 | 20.6 | .791 | 47.4 | 25 | | |
| 8 | 225 | 437 | 4.3 | 24.9 | .808 | 43.6 | 28 | | |
| 9 | 250 | 482 | 5.1 | 30.0 | .823 | 40.4 | 30 | | |
| 10 | 275 | 527 | 6.4 | 36.4 | .837 | 37.6 | 32 | | |
| Distillation continued at 40 mm | | | | | | | | | |
| 11 | 200 | 392 | 3.9 | 40.3 | 0.856 | 33.8 | 37 | 42 | Below 5 |
| 12 | 225 | 437 | 6.0 | 46.3 | .863 | 32.5 | 36 | 48 | 20 |
| 13 | 250 | 482 | 5.7 | 52.0 | .877 | 29.9 | 39 | 62 | 40 |
| 14 | 275 | 527 | 5.1 | 57.1 | .888 | 27.9 | 41 | 97 | 55 |
| 15 | 300 | 572 | 6.2 | 63.3 | .896 | 26.4 | 42 | 180 | 75 |
| Residuum | | | 36.5 | 99.8 | .964 | 15.3 | | | |

Carbon residue of residuum 13.6 percent; carbon residue of crude 5.0 percent.

142. Drawn largely from Weirich, T. E., *Op. cit.*

APPROXIMATE SUMMARY

| | Percent | Sp. Gr. | °A.P.I. | Viscosity |
|---|---|---|---|---|
| Light gasoline | 3.8 | 0.697 | 71.5 | |
| Total gasoline and naphtha | 20.6 | 0.751 | 56.9 | |
| Kerosene distillate | 9.4 | .816 | 41.9 | |
| Gas oil | 14.2 | .849 | 35.2 | |
| Nonviscous lubricating distillate | 10.6 | .865- .888 | 32.1-27.9 | 50-100 |
| Medium lubricating distillate | 6.8 | .888- .898 | 27.9-26.1 | 100-200 |
| Viscous lubricating distillate | 1.7 | .898- .900 | 26.1-25.7 | Above 200 |
| Residuum | 36.5 | .964 | 15.3 | |
| Distillation loss | 0.2 | | | |

Nov. 1, 1938.

*The Peru sand,* in the Labette shale, produces at several places in Tps. 26 and 27 N., R. 13 E., and in secs. 17 and 18, T. 26 N., R. 14 E.

*"The Oswego lime"* (Ft. Scott limestone) produces oil in sec. 31, T. 29 N., R. 13 E. and in the northwest corner of T. 28 N., R. 13 E.

*The Squirrel* (*Prue*) *sand* at the top of the Cherokee shale, has produced in a few places in the northern part of the county. Weirich lists secs. 8 and 17, T. 28 N., R. 14 E.; secs. 6 and 29, T. 28 N., R. 13 E.; and sec. 31, T. 29 N., R. 13 E.

The following analysis of oil from the Squirrel Sand was supplied by the United States Bureau of Mines.

ANALYSIS OF OIL FROM SQUIRREL SAND

(U. S. Bureau of Mines)

Location: T. 26 N., R. 14 E. Depth 890-920 feet

GENERAL CHARACTERISTICS

Specific gravity, 0.901 A.P.I. gravity, 25.6
Sulfur, percent, 0.43 Color, greenish black
Saybolt Universal viscosity at 100°F., 220 sec., at 130°F., 115 sec.

DISTILLATION, BUREAU OF MINES HEMPEL METHOD

Distillation at atmospheric pressure, 741 mm First drop 108°C. (226°F.)

| Fraction No. | Cut at °C. | Cut at °F. | Percent | Sum percent | Sp. Gr. 60/60°F. | °A.P.I. 60°F. | C. I. | S. U. visc. 100°F. | Cloud test °F. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 50 | 122 | | | | | | | |
| 2 | 75 | 167 | | | | | | | |
| 3 | 100 | 212 | | | | | | | |
| 4 | 125 | 257 | | | | | | | |
| 5 | 150 | 302 | | | | | | | |
| 6 | 175 | 347 | 2.2 | 2.2 | 0.798 | 45.8 | .... | | |
| 7 | 200 | 392 | 1.9 | 4.1 | .821 | 40.9 | 40 | | |
| 8 | 225 | 437 | 2.9 | 7.0 | .833 | 38.4 | 40 | | |
| 9 | 250 | 482 | 3.8 | 10.8 | .844 | 36.2 | 40 | | |
| 10 | 275 | 527 | 6.7 | 17.5 | .849 | 35.2 | 37 | | |

Distillation continued at 40 mm

| Fraction No. | Cut at °C. | °F. | Per-cent | Sum per-cent | Sp. Gr. 60/60°F. | °A.P.I. 60°F. | C. I. | S. U. visc. 100°F. | Cloud test °F. |
|---|---|---|---|---|---|---|---|---|---|
| 11 | 200 | 392 | 5.0 | 22.5 | 0.860 | 33.0 | 38 | 42 | 5 |
| 12 | 225 | 437 | 9.2 | 31.7 | .862 | 32.7 | 36 | 48 | 25 |
| 13 | 250 | 482 | 7.3 | 39.0 | .873 | 30.6 | 37 | 62 | 45 |
| 14 | 275 | 527 | 7.0 | 46.0 | .884 | 28.6 | 40 | 95 | 60 |
| 15 | 300 | 572 | 8.4 | 54.4 | .895 | 26.6 | 42 | 170 | 80 |
| Residum | | | 45.3 | 99.7 | .946 | 18.1 | | | |

Carbon residue of residuum 8.5 percent; carbon residue of crude 3.9 percent.

APPROXIMATE SUMMARY

| | Percent | Sp. Gr. | °A.P.I. | Viscosity |
|---|---|---|---|---|
| Light gasoline | | | | |
| Total gasoline and naphtha | 4.1 | 0.809 | 43.4 | |
| Kerosene distillate | — | — | — | |
| Gas oil | 24.2 | .852 | 34.6 | |
| Nonviscous lubricating distillate | 14.8 | .863- .885 | 32.5-28.4 | 50-100 |
| Medium lubricating distillate | 10.2 | .885- .899 | 28.4-25.9 | 100-200 |
| Viscous lubricating distillate | 1.1 | .899- .901 | 25.9-25.6 | Above 200 |
| Residuum | 45.3 | .946 | 18.1 | |
| Distillation loss | 0.3 | | | |

*The Bartlesville sand,* in the lower Cherokee shale, is the most important producing sand of Washington County. It is a lenticular sand and is not present everywhere. Its lenticular nature fulfills all the requirements for a closed reservoir and in consequence it has produced wherever found in the county. Weirich says that there is a small area in Nowata County where it is present but does not produce.

The following analysis of oil from the Bartlesville sand was supplied by the United States Bureau of Mines.

ANALYSIS OF OIL FROM BARTLESVILLE SAND

(U. S. Bureau of Mines)

Location: T. 26 N., R. 14 E. Depth: 1,340-1,360 feet.

GENERAL CHARACTERISTICS

Specific gravity, 0.853 A.P.I. gravity, 34.4
Sulfur, percent, 0.24 Color, greenish black
Saybolt Universal viscosity at 77° F., 62 sec., at 100° F., 52 sec.

DISTILLATION, BUREAU OF MINES HEMPEL METHOD

Distillation at atmospheric pressure, 740 mm First drop 46°C. (115°F.)

| Fraction No. | Cut at °C. | Cut at °F. | Percent | Sum percent | Sp. Gr. 60/60°F. | °A.P.I. 60°F. | C. I. | S. U. visc. 100°F. | Cloud test °F. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 50 | 122 | | | | | | | |
| 2 | 75 | 167 | | | | | | | |
| 3 | 100 | 212 | 1.9 | 1.9 | 0.690 | 73.6 | .... | | |
| 4 | 125 | 257 | 4.3 | 6.2 | .732 | 61.8 | 18 | | |
| 5 | 150 | 302 | 5.5 | 11.7 | .750 | 57.2 | 19 | | |
| 6 | 175 | 347 | 5.7 | 17.4 | .769 | 52.5 | 21 | | |
| 7 | 200 | 392 | 5.2 | 22.6 | .788 | 48.1 | 24 | | |
| 8 | 225 | 437 | 5.9 | 28.5 | .804 | 44.5 | 26 | | |
| 9 | 250 | 482 | 6.2 | 34.7 | .819 | 41.3 | 28 | | |
| 10 | 275 | 527 | 6.7 | 41.4 | .831 | 38.8 | 29 | | |
| Distillation continued at 40 mm | | | | | | | | | |
| 11 | 200 | 392 | 5.0 | 46.4 | 0.849 | 35.2 | 33 | 41 | 5 |
| 12 | 225 | 437 | 6.8 | 53.2 | .858 | 33.4 | 34 | 47 | 25 |
| 13 | 250 | 482 | 5.7 | 58.9 | .870 | 31.1 | 36 | 61 | 45 |
| 14 | 275 | 527 | 5.6 | 64.5 | .881 | 29.1 | 38 | 91 | 60 |
| 15 | 300 | 572 | 6.0 | 70.5 | .891 | 27.3 | 40 | 160 | 80 |
| Residuum | | | 28.9 | 99.4 | .938 | 19.4 | | | |

Carbon residue of residuum 5.9 percent; carbon residue of crude 1.7 percent

APPROXIMATE SUMMARY

| | Percent | Sp. Gr. | °A.P.I. | Viscosity |
|---|---|---|---|---|
| Light gasoline | 1.9 | 0.690 | 73.6 | |
| Total gasoline and naphtha | 22.6 | 0.755 | 55.9 | |
| Kerosene distillate | 12.1 | .812 | 42.8 | |
| Gas oil | 16.5 | .844 | 36.2 | |
| Nonviscous lubricating distillate | 11.3 | .861- .882 | 32.8-28.9 | 50-100 |
| Medium lubricating distillate | 8.0 | .882- .896 | 28.9-26.4 | 100-200 |
| Viscous lubricating distillate | — | — | — | Above 200 |
| Residuum | 28.9 | .938 | 19.4 | |
| Distillation loss | 0.6 | | | |

*The Burgess (Hogshooter) sand,* at the base of the Cherokee, is lenticular, occurring in patches resting on the "Mississippi lime". It is almost wholly a gas sand, being the most important single gas producing sand of the district. The large gas production formerly enjoyed by Washington and adjoining counties was the deciding factor in the establishment of such manufacturing enterprises as the cement plant at Dewey, the smelter at Bartlesville, and the smelter and brick plant at Collinsville, Tulsa County.

The following analyses of oil from the Burgess sand were supplied by the United States Bureau of Mines.

## ANALYSIS OF OIL FROM BURGESS SAND

(U. S. Bureau of Mines)

**Location:** Ts. 24 and 25 N., R. 13 E. **Depth:** 700-1550 feet.

### General Characteristics

Specific gravity, 0.893 — A.P.I. gravity, 27.0
Sulfur, percent, 0.31 — Color, greenish black
Saybolt Universal viscosity at 100°F., 140 sec., at 130°F., 83 sec.

### Distillation, Bureau of Mines Hempel Method

Distillation at atmospheric pressure, 749 mm — First drop 70°C. (158°F.)

| Fraction No. | Cut at °C. | Cut at °F. | Per-cent | Sum per-cent | Sp. Gr. 60/60°F. | °A.P.I. 60°F. | C. I. | S. U. visc. 100°F. | Cloud test °F. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 50 | 122 | | | | | | | |
| 2 | 75 | 167 | | | | | | | |
| 3 | 100 | 212 | 1.6 | 1.6) | 0.744 | 58.7 | .... | | |
| 4 | 125 | 257 | 1.2 | 2.8) | | | | | |
| 5 | 150 | 302 | 0.2 | 3.0) | .765 | 53.5 | .... | | |
| 6 | 175 | 347 | 2.2 | 5.2 | .793 | 46.9 | 32 | | |
| 7 | 200 | 392 | 2.6 | 7.8 | .813 | 42.6 | 36 | | |
| 8 | 225 | 437 | 3.1 | 10.9 | .829 | 39.2 | 38 | | |
| 9 | 250 | 482 | 4.7 | 15.6 | .838 | 37.4 | 37 | | |
| 10 | 275 | 527 | 7.3 | 22.9 | .848 | 35.4 | 37 | | |
| Distillation continued at 40 mm | | | | | | | | | |
| 11 | 200 | 392 | 4.4 | 27.3 | 0.862 | 32.7 | 39 | 43 | Below 5 |
| 12 | 225 | 437 | 8.4 | 35.7 | .870 | 31.1 | 39 | 49 | 10 |
| 13 | 250 | 482 | 7.8 | 43.5 | .880 | 29.3 | 41 | 66 | 30 |
| 14 | 275 | 527 | 6.6 | 50.1 | .891 | 27.3 | 43 | 105 | 50 |
| 15 | 300 | 572 | 8.2 | 58.3 | .899 | 25.9 | 44 | 200 | 65 |
| Residuum | | | 40.6 | 98.9 | .944 | 18.4 | | | |

Carbon residue of residuum 8.5 percent; carbon residue of crude 3.5 percent.

### Approximate Summary

| | Percent | Sp. Gr. | °A.P.I. | Viscosity |
|---|---|---|---|---|
| Light gasoline | 1.6 | 0.744 | 58.7 | |
| Total gasoline and naphtha | 7.8 | .785 | 48.8 | |
| Kerosene distillate | — | — | — | |
| Gas oil | 24.2 | .850 | 35.0 | |
| Nonviscous lubricating distillate | 13.9 | .871- .889 | 31.0-27.7 | 50-100 |
| Medium lubricating distillate | 8.3 | .889- .899 | 27.7-25.9 | 100-200 |
| Viscous lubricating distillate | 4.1 | .899- .903 | 25.9-25.2 | Above 200 |
| Residuum | 40.6 | .904 | 18.4 | |
| Distillation loss | 1.1 | | | |

## ANALYSIS OF OIL FROM THE BURGESS SAND

(U. S. Bureau of Mines)

**Location:** T. 26 N., R. 14 E. **Depth:** 1,380-1,405 feet.

### General Characteristics

Specific gravity, 0.906 — A.P.I. gravity, 24.7
Sulfur, percent, 0.36 — Color, greenish black
Saybolt Universal viscosity at 100° F., 240 sec., at 130°F., 120 sec.

DISTILLATION, BUREAU OF MINES HEMPEL METHOD

Distillation at atmospheric pressure, 741 mm First drop 115°C. (239°F.)

| Fraction No. | Cut at °C. | Cut at °F. | Percent | Sum percent | Sp. Gr. 60/60°F. | °A.P.I. 60°F. | C. I. | S. U. visc. 100°F. | Cloud test °F. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 50 | 122 | | | | | | | |
| 2 | 75 | 167 | | | | | | | |
| 3 | 100 | 212 | | | | | | | |
| 4 | 125 | 257 | | | | | | | |
| 5 | 150 | 302 | 1.1 | 1.1 | 0.749 | 57.4 | .... | | |
| 6 | 175 | 347 | 1.1 | 2.2 | .769 | 52.5 | 21 | | |
| 7 | 200 | 392 | 1.4 | 3.6 | .785 | 48.8 | 23 | | |
| 8 | 225 | 437 | 2.5 | 6.1 | .819 | 41.3 | 33 | | |
| 9 | 250 | 482 | 3.7 | 9.8 | .839 | 37.2 | 37 | | |
| 10 | 275 | 527 | 6.6 | 16.4 | .853 | 34.4 | 39 | | |
| Distillation continued at 40 mm | | | | | | | | | |
| 11 | 200 | 392 | 5.6 | 22.0 | 0.871 | 31.0 | 44 | 44 | Below 5 |
| 12 | 225 | 437 | 8.7 | 30.7 | .880 | 29.3 | 44 | 53 | do. |
| 13 | 250 | 482 | 8.3 | 39.0 | .893 | 27.0 | 47 | 75 | 10 |
| 14 | 275 | 527 | 8.1 | 47.1 | .905 | 24.9 | 49 | 130 | 25 |
| 15 | 300 | 572 | 9.4 | 56.5 | .914 | 23.3 | 51 | 270 | 45 |
| Residuum | | | 43.2 | 99.7 | .948 | 17.8 | | | |

Carbon residue of residuum 7.4 percent; carbon residue of crude 3.2 percent.

APPROXIMATE SUMMARY

| | Percent | Sp. Gr. | °A.P.I. | Viscosity |
|---|---|---|---|---|
| Light gasoline | | | | |
| Total gasoline and naphtha | 3.6 | 0.769 | 52.5 | |
| Kerosene distillate | 2.5 | .819 | 41.3 | |
| Gas oil | 17.9 | .858 | 33.4 | |
| Nonviscous lubricating distillate | 14.6 | .877- .899 | 29.9-25.9 | 50-100 |
| Medium lubricating distillate | 8.9 | .899- .909 | 25.9-24.2 | 100-200 |
| Viscous lubricating distillate | 9.0 | .909- .919 | 24.2-22.5 | Above 200 |
| Residuum | 43.2 | .948 | 17.8 | |
| Distillation loss | 0.3 | | | |

## PRINCIPAL PRODUCING AREAS

The names used in the following discussion of pools are those designated by the Standing Committee on Oil Field Nomenclature, Kansas-Oklahoma Division, Mid-Continent Oil and Gas Association, as of July 1, 1938.

### Caney Pool

*Location.* Secs. 30 and 31, T. 29 N., R. 13 E.; all production in T. 29 N., R. 12 E., extending into Osage County; secs. 5, 6, 7, and 8, T. 28 N., R. 13 E.; secs. 1 and 12, T. 28 N., R. 12 E. Discussion applies only to that part of the pool which lies in Washington County.

*Surface stratigraphy.* Torpedo sandstone and overlying shale; Birch Creek limestone; Weston shale.

*Structure.* Occupies a broad westward plunging anticlinal nose, see Figure 10.

*Depth to sands.* Wayside sand, found locally at 650 to 800 feet; "Oswego lime" (Ft. Scott limestone), 815 feet; Squirrel sand, 875 feet; Bartlesville sand 1,185 feet; "Mississippi lime" (Burgess sand sometimes logged on top), 1,500 to 1,550 feet.

*Development and production.* The pool was opened in 1909. According to well logs, drilling was active from 1917 to 1927 with some activity as late as 1932. Initial production from the Bartlesville is reported to have been 10 to 100 barrels per day. According to logs initial gas production from "Mississippi lime" or Burgess sand was 1 to 5 million cubic feet per day.

## Canary Pool

*Location.* Northwest portion of T. 29 N., R. 14 E.; all production in the east 2/3 of T. 29 N., R. 13 E.; secs. 1, 2, 3, 10, 11, 12, N½ 14, and N½ 15, T. 28 N., R. 13 E.; all in Washington County.

*Surface stratigraphy.* Cottage Grove sandstone member of the Chanute formation; Iola formation; Torpedo sandstone and overlying shale; Birch Creek limestone.

*Structure.* In general a westward-dipping monocline, locally broad anticlinal and synclinal folds. There is a pronounced dome in secs. 29 and 30, T. 29 N., R. 14 E., where the most important production is on the northwest flank, in the Bartlesville sand. This relation of production to structure seems to be common in the Bartlesville sand of northeast Oklahoma.

*Depth to sands.* Bartlesville sand, about 1,175 feet; Burgess sand, about 1,450 feet.

*Development and production.* The pool was opened in 1907. In the northeast part of the field the Bartlesville sand is about 50 feet thick, and produced gas from the upper part and oil from the lower part. The west part of the pool produced principally gas from the Burgess sand. The average initial gas production from the earliest wells was about 31,500,000 cubic feet per day, and the average pressure 444 pounds per square inch. By 1911 the capacity of these wells was reduced to about 915,000 cubic feet per day, and the pressure to about 18 pounds per square inch.

### Copan Pool

*Location.* S½ sec. 14, S½ sec. 15, and all production in the S½ T. 28 N., R. 13 E.; secs. 25, 35, and 36, T. 28 N., R. 12 E.

*Structure.* Probably on the southwest flank of a broad low anticline trending northwest.

*Depth to sands.* Wayside sand, 625 feet; Peru sand, about 800 feet; Squirrel sand, about 1,050 feet; Bartlesville sand, about 1,300 feet; Burgess sand, 1,450 to 1,500 feet.

*Development and production.* The Copan field was opened in 1907 and development was immediately active. The Bartlesville sand produced oil and gas. The average initial production in 1909 was 54.4 barrels per day and was 33.7 barrels per day in 1910. The average gradually declined from that time. These figures are from U. S. Geological Survey, Mineral Resources, for 1910, and probably represent average of both the Copan and Canary pools.

The Burgess sand produced gas, principally on the east side of the pool. The pressure was originally 450 to 530 pounds per square inch but had been so depleted that during the fall of 1911 the pressure was not more than 25 pounds per square inch, mainly because the sand was coarse and the drain rapid. Probably the maximum capacity of the field was about 300 million cubic feet per day. In 1914 its capacity was probably not more than 50 to 75 million cubic feet per day.

### Wann Pool

*Location.* All production in T. 28 N., R. 14 E.; extending eastward into Nowata County. The following discussion applies primarily to that part of the pool in Washington County.

*Surface stratigraphy.* Nellie Bly formation; Dewey limestone; Chanute formation; Iola formation; Wann formation; and Torpedo sandstone.

*Structure.* In general a westward dipping monocline higher than the Blue Mound syncline to the south.

*Depth to sands.* Wayside sand, 600 feet; Squirrel sand, 800 feet; Bartlesville sand, 1,000 to 1,200 feet; Burgess sand, 1,200 to 1,400 feet.

*Development and production.* The pool was opened in 1907 and its development paralleled that of the Copan pool. Here also the Bartlesville sand was the oil producer and the Burgess sand the gas producer.

Dewey Pool

*Location.* All production in W½ T. 27 N., R. 14 E.; all production in T. 27 N., R. 13 E.; all production in T. 27 N., R. 12 E., extending westward into Osage County. The following discussion applies only to that part of the pool which lies in Washington County.

*Surface stratigraphy.* Nellie Bly formation; Dewey limestone; Chanute formation; Iola formation; Wann formation; Torpedo sandstone and overlying shale; Birch Creek limestone; Weston shale.

*Structure.* A westward dipping monocline broken by broad synclines and anticlinal noses, and by the Dewey faulted flexure. Production extends to the bottoms of the synclines.

*Depth to sands.* Layton sand, 200 to 300 feet; Wayside sand, 400 to 800 feet; Peru sand, 800 to 900 feet; "Oswego lime" (Ft. Scott limestone), 900 to 1,100 feet; Squirrel sand, 1,000 to 1,100 feet; Bartlesville sand, 1,200 to 1,300 feet. Burgess sand, 1,400 to 1,500 feet.

*Development and production.* The pool was opened in 1904 and development proceeded rapidly during 1904, 1905, and 1906. The Bartlesville was the most important oil producer, followed by the Wayside sand. Some of the wells had initial production of 1,000 barrels per day, but the average gradually decreased to about 10 barrels per day in 1914. The great demand for oil in 1915 and 1916 stimulated new drilling and some wells were drilled which had an initial production of 60 barrels per day, but the average initial production was about 20 barrels per day for that period. A small gas field was developed southeast of Dewey where the initial pressure was about 500 pounds per square inch.

## Bartlesville Pool

*Location.* All production in the NW¼ of T. 26 N., R. 14 E.; all production in T. 26 N., R. 13 E., except sec. 24, 25, and 36; secs. 1, 2, 11, 12, 13, 14, 23, 24, 25, and 26, T. 26 N., R. 12 E., extending west into Osage County; secs. 3, 4, and 5, T. 25 N., R. 13 E. Only that part of the pool lying in Washington County is included in the following discussion.

*Surface stratigraphy.* Coffeyville formation; Hogshooter formation; Nellie Bly formation; Dewey limestone; Chanute formation; Iola formation; Wann formation; Torpedo sandstone and overlying shale; Birch Creek limestone; Weston shale.

*Structure.* The dominant structural features are the Bartlesville anticline and the Dewey faulted flexure. Writing of the closure on the Bartlesville anticline southeast of Bartlesville, Weirich says:

> Here structural relief is approximately 125 feet on the base of the 'Oswego' (*Ft. Scott*) limestone. A well was drilled in 1924 on the apex of this anticline to pre-Cambrian granite. This well encountered a normal section of Pennsylvanian and Mississippian, but only 108 feet of Arbuckle is present. Granite was encountered at 1,050 feet (*below sea level*). No commercial oil or gas was found in pre-Pennsylvanian rocks''.[143]

*Depth to sands.* Wayside sand, 500 feet; Peru sand, 750 feet; Bartlesville sand, 1,250 feet; Burgess sand, 1,450 feet.

*Development and production.* The first oil well in Washington County was completed in 1897 in the city park at Bartlesville and is still producing (1940). Development was active during 1904, 1905, and 1906. Some of the early wells had initial production in excess of 1,000 barrels per day. In 1906, the average initial production was about 73 barrels per day. Average initial production gradually declined to about 10 barrels per day in 1914. At the present time an occasional new well is drilled which has an initial production of 20 barrels per day.

143. Weirich, T. E., "Petroleum Geology of Nowata and Washington Counties, Oklahoma": *Guide Book, Eleventh Annual Field Conference, Kansas Geol. Society*, p. 86, 1937. Italics by M. C. O.

## Hogshooter Pool

*Location.* SW¼ T. 26 N., R. 14 E.; secs. 24, 25, and 36, T. 26 N., R. 13 E.; NW¼ T. 25 N., R. 14 E.; secs. 1, 2, 11, 12, 13, and N½ sec. 24, T. 25 N., R. 13 E. Originally the term Hogshooter pool covered the Hogshooter gas production as far south as sec. 30, T. 24 N., R. 14 E.

*Surface stratigraphy.* Coffeyville formation; Hogshooter formation; Nellie Bly formation; Dewey limestone.

*Structure.* Dips are generally westward. There is some evidence of gentle folds with east-west axes in the north part of the area. The south end of the pool lies on the north limb of the Caney River syncline.

*Depth to sands.* Sands of doubtful correlation occur at 500, 710, and 880 feet. The Bartlesville sand is about 1,080, and the Burgess sand is about 1,275 feet deep.

*Development and production.* The pool was opened in 1907 and during that year development was active. The Bartlesville sand produced oil and gas in the west side of the Hogshooter pool, as at present defined, while the Burgess sand produced gas from an elongated lens 1 to 2 miles wide, along the east side of the pool. Production from this Burgess sand lens extended as far south as sec. 30, T. 24 N., R. 14 E.

Some of the larger Bartlesville sand wells had initial production of 500 barrels per day. In 1909 the average initial production was 50 barrels per day. This average remained practically the same for the next three years but decreased considerably from 1913 to 1916. The Burgess sand lens constituted, at the time of its development, the largest gas field in the state.

## Ochelata Pool

*Location.* Secs. 22, 25, 26, 27, 34, 35, and 36, T. 25 N., R. 13 E.; sec. 2, T. 23 N., R. 13 E.

*Surface stratigraphy.* Coffeyville formation, Hogshooter formation.

*Structure.* The pool lies on the southwest flank of the Ochelata anticline.

*Depth to sands.* Peru, 690 feet; "Oswego" (Ft. Scott limestone), 730 feet; Bartlesville sand, 1,185; "Mississippi lime" (Burgess?), 1,380 feet.

*Development and production.* The pool was opened in 1910. Initial production from the Peru sand was 20 to 40 barrels per day; from the Bartlesville sand, 15 to 60 barrels per day; from the "Oswego lime" (Ft. Scott limestone), 1 million cubic feet of gas per day; from the "Mississippi lime", 1 to 3 million cubic feet of gas per day.

### Vera Pool

*Location.* Secs. 29, 31, and 32, T. 23 N., R. 14 E.; sec. 6, T. 22 N., R. 14 E.

*Surface stratigraphy.* Seminole formation.

*Structure.* Appears to be normal west dip, possibly broken by gentle folding.

*Depth to sands.* Bartlesville sand, about 1,350 feet; Burgess sand, about 1,500 feet.

*Development and production.* The Vera pool was opened in 1915 and much activity followed. The Bartlesville sand produced oil and some gas while the Burgess sand was a gas producer. At the end of the year about 40 wells had been completed. Of these, 25 were oil wells, 9 were gas wells and 6 were dry holes. The average initial production was about 60 barrels per day. Initial production for individual wells ranged from a few barrels to 300 barrels per day. During the first half of 1916 about 70 wells were completed, the average initial production being about 60 barrels per day. Initial production of Burgess sand wells ranged from 2 to 18 million cubic feet of gas per day.

## OTHER POOLS

The following Osage County pools have unimportant extensions into Washington County.

### Forty-Five Pool

*Location.* Sec. 35, T. 26 N., R. 12 E., extending west into Osage County.

## North Ochelata Pool

*Location.* Secs. 1, 2, 11, 12, 14, and 23, T. 25 N., R. 12 E., extending west into Osage County.

## Candy Creek Pool

*Location.* Sec. 2, T. 24 N., R. 12 E., extending west into Osage County.

## Ramona Pool

*Location.* Secs. 11, 14, and 23, T. 26 N., R. 12 E., extending west into Osage County.

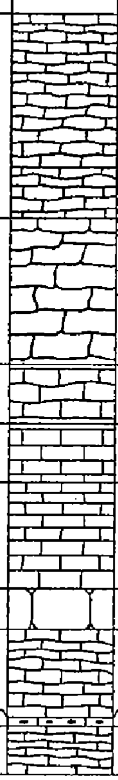
In order to preserve the record, and make the information available once more, production maps showing locations of oil and gas wells, and dry holes, are reproduced without change from Bulletin 19, Part 2, 1917, as Plate III of this report.

# LIMESTONE

Washington County is adequately supplied with limestone suitable for cement manufacture, rock wool, crushed stone, and agricultural limestone, as well as for some types of building stone.

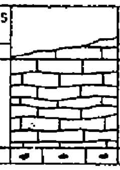
The Checkerboard limestone, though thin, could be used in some localities to supply strictly local needs. The outcrop of the Checkerboard crosses the southeast corner of the county. No analyses of samples from that locality are available, but analyses of a number of samples from the same bed in Nowata County indicate that it is lower in calcium carbonate than is usually recommended for agricultural limestone, and is rather high in silica. A typical analysis of Checkerboard limestone is: CaO, 42.90 percent (equivalent to 76.56 percent calcium carbonate); MgO, 1.18 percent (equivalent to 2.47 percent magnesium carbonate); $SiO_2$, 15.42 percent; $Fe_2O_3$, 2.29 percent; $Al_2O_3$, 2.73 percent; $MnO_2$, 0.16 percent; $CO_2$, 35.90 percent.

The Winterset limestone member of the Hogshooter formation (the Hogshooter limestone of former usage) is excellent for many purposes. The phosphatic character of the lower bed has been mentioned in discussing phosphate. Analyses of samples from other beds of the Winterset member will be found in the accompanying table (XI). It will be noted that the percentage of calcium and magnesium carbonate is variable but is sufficiently high in nearly all samples to indicate that the material is usable for agricultural limestone. In sec. 9, T. 26 N., R. 14 E., where the Winterset is thickest, the upper 14 feet contains more than 90 percent calcium and magnesium carbonate. The small amount of magnesium carbonate present may give it added value in treating certain types of soil.



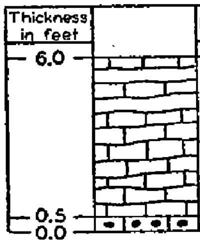
| Thickness in feet | Lab. No. | CaO | MgO | $CO_2$ | $P_2O_5$ | $Al_2O_3$ | $Fe_2O_3$ | $MnO_2$ | Insoluble Residue | $H_2O$ by ign. | Total | $CaCO_3$ | $MgCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26.0–19.0 | 6902 | 51.65 | 1.06 | 41.10 | tr | 0.70 | 1.50 | 0.07 | 3.96 | | 100.04 | 92.17 | 2.22 |
| 19.0–14.0 | 6898 | 49.90 | 1.94 | 40.83 | - | 0.63 | 1.07 | 0.03 | 5.84 | | 100.24 | 89.05 | 4.06 |
| 14.0–12.0 | 6893 | 51.26 | 1.10 | 40.57 | - | 0.69 | 0.86 | 0.10 | 4.62 | | 99.20 | 91.48 | 1.20 |
| 12.0–10.0 | 6891 | 46.37 | 2.54 | 38.81 | - | 0.59 | 1.93 | 0.18 | 8.94 | | 99.36 | 82.75 | 5.31 |
| 10.0–6.4 | 6889 | 44.80 | 2.46 | 38.23 | - | 0.98 | 1.79 | 0.03 | 10.80 | | 99.09 | 79.95 | 5.14 |
| 6.4–5.0 | 6890 | 50.40 | 1.50 | 40.96 | - | 1.18 | 1.29 | 0.03 | 4.86 | | 100.22 | 89.94 | 3.14 |
| 5.0–2.0 | 6905 | 51.42 | 1.14 | 41.40 | - | 0.59 | 0.81 | 0.07 | 5.02 | | 100.45 | 91.76 | 2.38 |
| 2.0–1.7 | 6900 | 28.63 | 1.66 | 21.56 | 1.80 | 2.73 | 4.43 | 0.13 | 36.14 | 2.21 | 99.28 | 51.09 | 3.47 |
| 1.7–0.0 | 6886 | 45.00 | 1.40 | 36.12 | tr | 1.18 | 1.64 | 0.06 | 13.94 | | 99.34 | 80.31 | 2.93 |

FIG. 12. Complete graphic section with chemical analyses of the Winterset limestone member of the Hogshooter formation and partial section of the Lost City member (Lab. No. 6886), in the west bank of Hogshooter Creek, 1,500 feet east of W¼ cor. sec. 9, T. 26 N., R. 14 E.



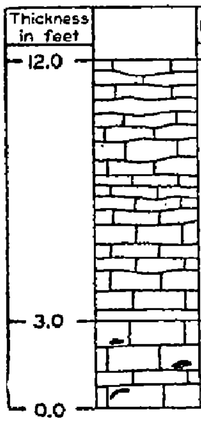
| Thickness in feet | Lab. No. | CaO | MgO | $CO_2$ | $P_2O_5$ | $Al_2O_3$ | $Fe_2O_3$ | $MnO_2$ | Insoluble Residue | $H_2O$, by ign. | Total | $CaCO_3$ | $MgCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5–0.5 | 7259 | 49.43 | 1.08 | 39.46 | - | 1.04 | 2.00 | 0.04 | 6.40 | | 99.45 | 88.21 | 2.26 |
| 0.5–0.0 | 7257 | 44.43 | 1.18 | 34.32 | 2.06 | 1.92 | 2.72 | 0.21 | 12.94 | | 99.76 | 79.29 | 2.47 |

FIG. 13. Graphic section with chemical analyses of Winterset member of Hogshooter formation, near E¼ cor. sec. 34, T. 25 N., R. 13 E.



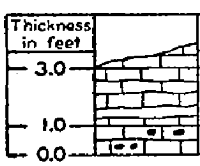

| Lab. No. | CaO | MgO | $CO_2$ | $P_2O_5$ | $Al_2O_3$ | $Fe_2O_3$ | $MnO_2$ | Insoluble Residue | $H_2O$ by ign. | Total | $CaCO_3$ | $MgCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7264 | 45.09 | 0.98 | 37.22 | - | 1.41 | 2.43 | 0.18 | 11.94 | | 99.25 | 80.47 | 2.05 |
| 7263 | 45.20 | 1.14 | 35.02 | 1.79 | 1.89 | 3.57 | 0.15 | 12.02 | | 100.78 | 80.76 | 2.38 |

FIG. 14. Graphic section with chemical analyses of the Winterset limestone member of the Hogshooter formation, just north of E¼ cor. sec. 10, T. 24 N., R. 13 E.




| Lab. No. | CaO | MgO | $CO_2$ | $P_2O_5$ | $Al_2O_3$ | $Fe_2O_3$ | $MnO_2$ | Insoluble Residue | $H_2O$ by ign. | Total | $CaCO_3$ | $MgCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7275 | 46.85 | 1.20 | 38.19 | - | 1.45 | 2.08 | 0.15 | 9.90 | | 99.82 | 83.61 | 2.51 |
| 7274 | 46.83 | 1.18 | 38.02 | 0.78 | 1.54 | 2.43 | 0.06 | 8.54 | | 99.38 | 83.57 | 2.47 |

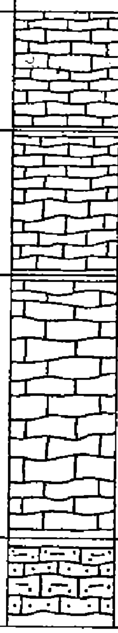
FIG. 15. Graphic section with chemical analyses of the Winterset limestone member of the Hogshooter formation ⅛ mile west of SE cor. sec. 16, T. 24 N., R. 13 E.




| Lab. No. | CaO | MgO | $CO_2$ | $P_2O_5$ | $Al_2O_3$ | $Fe_2O_3$ | $MnO_2$ | Insoluble Residue | $H_2O$ by ign. | Total | $CaCO_3$ | $MgCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7273 | 46.04 | 1.26 | 37.75 | - | 1.47 | 2.50 | 0.06 | 10.30 | | 99.38 | 82.16 | 2.64 |
| 7272 | 42.06 | 1.12 | 34.23 | 0.77 | 1.44 | 3.58 | 0.19 | 15.52 | 1.13 | 100.04 | 75.06 | 2.34 |

FIG. 16. Graphic section with chemical analyses of the Winterset limestone member of the Hogshooter formation, ¼ mile west of W¼ cor. sec. 34, T. 24 N., R. 13 E.

The Dewey limestone is even better than the Winterset for many purposes. It has long been used with shale for cement manufacture by the Dewey Portland Cement Company. Analyses are available from two localities and indicate that practically all the Dewey is usable for agricultural limestone. The upper 15 to 18 feet contains more than 90 percent calcium and magnesium carbonate. The Dewey crops out almost entirely across the county and is thus available to all farms in the county without excessive haul.



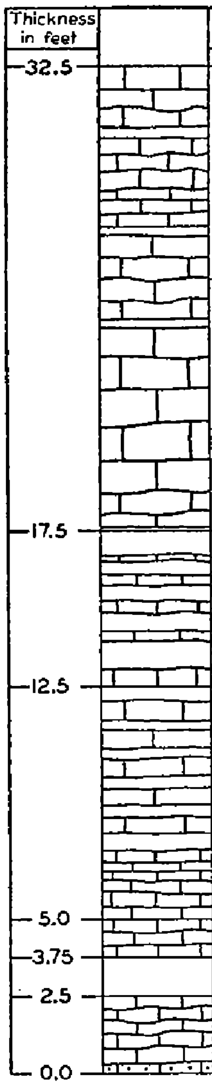
| Thickness in feet | Lab. No. | CaO | MgO | $CO_2$ | $P_2O_5$ | $Al_2O_3$ | $Fe_2O_3$ | $MnO_2$ | Insoluble Residue | $H_2O$ by ign. | Total | $CaCO_3$ | $MgCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21.0–17.0 | 7866 | 50.25 | 0.52 | 40.36 | - | 1.47 | 1.15 | tr | 5.12 | 0.76 | 99.63 | 89.68 | 1.09 |
| 17.0–12.0 | 7865 | 50.88 | 0.50 | 40.94 | - | 1.24 | 1.00 | tr | 4.80 | 0.55 | 99.91 | 90.80 | 1.05 |
| 12.0–3.0 | 7864 | 50.14 | 0.72 | 40.26 | - | 1.29 | 1.07 | tr | 5.20 | 0.90 | 99.58 | 89.48 | 1.51 |
| 3.0–0.0 | | | | | | | | | | | | | ND |

FIG. 17. Complete graphic section with chemical analyses of the Dewey limestone, old quarry of the Dewey Portland Cement Company, center SE¼ NW¼ sec. 26, T. 27 N., R. 13 E.

In the southwest part of the county, thick limestone lenses are present in the calcareous zone of the Wann formation. These limestones afford good road material and would supply stone suitable for certain types of buildings, particularly foundations and outbuildings on farms. No analyses are available. Some of the calcareous shales from this zone might be used for agricultural lime on nearby land, their low lime content being offset by the short haul and no necessity for fine grinding. Lime content should be determined before expense is incurred in attempting to use calcareous shale.

The problem of preparing crushed stone and agricultural limestone for local use could probably be met by portable crushing and grinding machinery operated under some form of cooperative arrangement similar to that long in vogue among farmers for threshing grain and filling silos. With such an arrangement, agricultural limestone should be obtained without great cash outlay.

Limestone is one of Oklahoma's most valuable resources, and is destined to play an important role in the future industrial development in the state, especially in chemical industries. Limestone and its chief basic products, lime and carbon dioxide, are intimately con-




| Lab. No. | CaO | MgO | $CO_2$ | $P_2O_5$ | $Al_2O_3$ | $Fe_2O_3$ | $MnO_2$ | Insoluble Residue | $H_2O$ by ign. | Total | $CaCO_3$ | $MgCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7730 | 50.16 | 0.38 | 39.70 | - | 1.01 | 1.29 | tr | 6.79 | 0.63 | 99.96 | 89.52 | 0.79 |
| 7729 Shales | 11.40 | 2.04 | 7.72 | - | 17.04 | 4.00 | tr | $SiO_2$ 50.23* | 6.71 | 99.14 | 20.34 | 4.27 |
| 7728 Limestone | 48.26 | 0.64 | 38.30 | - | 1.85 | 2.07 | tr | 8.19 | 0.73 | 100.04 | 86.12 | 1.34 |
| 7727 Shales | 14.38 | 2.40 | 10.24 | - | 14.97 | 4.43 | tr | $SiO_2$ 48.18* | 4.56 | 99.16 | 25.66 | 5.02 |
| 7726 Limestone | 46.92 | 0.66 | 38.26 | - | 1.53 | 2.00 | 0.13 | 10.17 | 0.05 | 99.72 | 83.73 | 1.38 |
| 7725 | 46.50 | 0.22 | 37.00 | - | 1.64 | 2.36 | tr | 10.75 | 1.04 | 99.50 | 82.98 | 0.46 |
| 7724 | 24.00 | 2.38 | 17.68 | tr | 12.67 | 4.43 | 0.21 | $SiO_2$ 34.61* | 3.59 | 99.57 | 42.83 | 0.50 ND |

FIG. 18. Complete graphic section with chemical analyses of the Dewey limestone, near E¼ cor. sec. 19, T. 26 N., R. 13 E., 2 miles south of Bartlesville along U. S. Highway 75.

nected with the production of many of the important chemicals and are used in numerous industrial and chemical processes. With the increasing importance of industrial chemistry, the basic raw materials from which chemicals may be derived are also becoming of more value as potential mineral resources.

Most of the important chemicals are derived from a relatively small number of raw materials. In a study of the sources of 150 important chemicals produced in this country, it was found that only 34 mineral raw materials are used.[144] Listed in the order of

[144] Keller, R. N., and Quirk, T. T., "Mineral Resources of the Chemical Industries": *Economic Geology*, Vol. 34, pp. 287-296, 1939.

frequency in which they are used, the first ten are: water, air, coal, sulphur, mineral salt, limestone, sulphide ores, brines, petroleum, and natural gas. Omitting water and air, limestone becomes fourth on the list. In the listing of frequency of use as a basic raw material in the manufacture of the 150 chemical products, water, coming first, was listed 99 times, and natural gas 16 times in tenth place. Limestone was listed 63 times. Thus, on the basis of the number of chemical processes in which they find a use, the ten basic materials listed above appear to be of dominant importance to industrial chemistry.

In addition to limestone, Oklahoma has an abundance of most of the other ten leading chemical raw materials, and especially coal, sulphide ores, petroleum, and natural gas. Availability of these additional minerals increases the potential value of the limestones, should attempts be made to develop chemical industries in Oklahoma.

Washington County is especially well situated with respect to these resources, because coal, sulphur, salt, and limestone are used together by many chemical industries. Sulphur is used principally as a source of sulphuric acid which is now being produced in the county, as a by-product of zinc smelting. Coal is available in nearby counties, and salt can be obtained from oil field brines.

In Table X, some of the general uses of limestone are given, together with brief remarks on the quality of material required. Rock wool manufacturing, a comparatively new and growing industry, utilizes impure, siliceous or shaly limestone, or high-calcium limestone mixed with silica or clay, as a raw material.

## TABLE X
### Uses of Limestone, Depending on Chemical Composition

| Use | Minimum percent $CaCO_3$ | $MgCO_3$ | CaO | MgO | Remarks |
|---|---|---|---|---|---|
| Agricultural | 90 | | | | 10-mesh and finer. 100-mesh desired by some users. Some $MgCO_3$ permissable, required on some soils. |
| Alkali | 93 | 5 | | | Maximum of 3% $SiO_2$[a]. Calcined, both CaO and $CO_2$ required. |
| Baking soda | 95? | | | | |
| Calcium carbide | 97 | 2 | | | Maximum of .5% $Al_2O_3$, 3% $SiO_2$, .01% $P_2O_5$, trace sulphur. |
| Carbon dioxide ($CO_2$) | high | high | | | $MgCO_3$ contains more $CO_2$. |
| Calcium nitrate | high | | | | |
| Dye works | high | | | | Finely ground. Used as base. |
| Explosives | high | b | | | Average of 1.5% blasting explosive is limestone. |
| Fertilizers | high | b | | | Mfg. nitrogenous fertilizer, and as filler in some other types. |
| Filter, sewage | high | b | | | Pyrite and clay not tolerated. |
| Flux, blast furnace | 90-95 | c | | | Maximum of 2% $Al_2O_3$, 3% $SiO_2$, .1% phosphorous and sulphur. |
| Bessemer, acid | | | | | Not over .01% phosphorous. |
| Open hearth, basic | | 10 | | | Maximum 1.5% $Al_2O_3$, 3% $SiO_2$, low sulphur and phosphorous. |
| Food, animal | high | | | | Finely ground, often mixed with feed to furnish calcium to livestock. |
| Glass manufacture | | | | | |
| Class 1 | | | 96 | b | Max. 3% $Al_2O_3$, .2% $Fe_2O_3$, 4% $SiO_2$. |
| Class 2 | | | 91 | b | Max. 5% do., .4% do., 9% do. |
| Class 3 | | | 83 | b | Max. 5% do., .8% do., 17% do. |
| Lime | 97 | | | | Magnesium may or may not be used. |
| Paint manufacture | high | b | | | Inert filler in many paints. |
| Paper manufacture | | | | | |
| Tower system | | | 53.0 | 1.5 | Max. organic matter .5% $Al_2O_3$, $Fe_2O_3$ and $SiO_2$ 1.5%. |
| Tank system | | | 29.8 | 17.9 | do., magnesian limestone usually preferred in tank or milk of lime system. |
| Portland cement | 75 | | | | 20% clay; 5% $MgCO_3$; sulphur, and alkali permitted. |
| Poultry grit | high | low | | | Must have less than .1% flourine, size less than 4-mesh, greater than 10-mesh. |
| Rock wool | 45-65 | c | | | Remainder mainly $SiO_2$ and $Al_2O_3$, very little $Fe_2O_3$. |
| Sugar refining | 97 | 1 | | | Maximum of 1% $SiO_2$. Used in 2 to 8 inch blocks. |

TABLE X—(Continued)
USES OF LIMESTONE, DEPENDING ON CHEMICAL COMPOSITION

| Use | Minimum percent $CaCO_3$ | $MgCO_3$ | CaO | MgO | Remarks |
|---|---|---|---|---|---|
| Whiting substitute | 95-97 | 2-8[c] | | | Must be finely ground. |
| Precipitated chalk | high | | | | Made by precipitation of $CaCo_3$ from high calcium limestone. |

[a] Maximum percentages of alumina, iron and silica are those indicated as standard limits for purpose, and are approximate averages of several authorities. Some users permit higher percentages of impurities, others demand higher carbonate content.

[b] Indicates magnesian limestone is satisfactory for purpose.

[c] Part of the percentage indicated for $CaCO_3$ may be $MgCO_3$. Some users prefer limestone, others magnesian limestone.

In general, if no notaton is given relative to percentage of impurities, impurities are not obnoxious, but increase the amount of material necessary to obtain the required carbonate.

This table compiled chiefly from information obtained from the following publications:

Lamar, J. E., and Willman, H. B., A summary of the uses of limestone and dolomite. Illinois Geological Survey, Report of Investigations, No. 49, 1938.

Miller, Benjamin Leroy, Limestones of Pennsylvania, Pennsylvania Geological Survey, Bulletin M 20, 1934.

Whitlatch, George I., Limestone, Tennessee Geological Survey, Markets Circular No. 3, 1937.

Publications of the National Lime Association.

U. S. Bureau of Mines, Information Circulars 6723, 6830, 7088, 6984.

Rock Products, chiefly vols. 41 and 42, 1938 and 1939.

Limestone has been termed the "Monarch of the Mineral Kingdom", and is described as "**** the one mineral he (man) could not do without****".[145] In addition to the uses of limestone and lime (calcium oxide), another derivative, carbon dioxide, is also a raw material of great importance. It can be recovered as a by-product in the manufacture of burned lime, cement, rock wool, and other processes that require the calcination of limestone or dolomite. Nathan C. Rockwood, editor of Rock Products, quotes J. H. Hillman, III, in listing the following 17 uses of this gas:[146]

(1) dry ice; (2) liquid carbonic; (3) acetylsalicylic acid (better known as aspirin) which is the starting point for manufacture of numerous drugs and dyes; (4) with ammonia to make ammonium carbonate and ammonium carbamate; (5) with lime to make precipitated calcium carbonate or whiting (chalk); (6) with lime

145 Rockwood, Nathan C., "Monarch of the Mineral Kingdom": *Rock Products*, pp. 23-24, May, 1940.

146. *Idem.*

to make calcium carbamate; (7) with barium oxides or hydroxides to make barium carbonate; (8) with ferrous chloride to make ferrous carbonate; (9) with lead oxide or lead nitrate to make basic lead carbonate (white lead); (10) with lithium chloride to make lithium carbonate; (11) with potassium hydroxide, manganese dioxide and potassium chlorate to make potassium permanganate; (12) with sodium phenate to make salicylic acid; (13) with sodium chloride (salt) and ammonia to make soda ash and sodium bicarbonate; (14) with ammonia to make synthetic urea; (15) with zinc chloride to make zinc carbonate; (16) with various salts or hydroxides to make corresponding carbonates such as bismuth subcarbonate, caesium carbonate, cobaltus carbonate, lithium carbonate, nickel carbonate; (17) with calcium cyanimide to make thiourea.

But that is not all, for carbon dioxide can easily be converted into relatively pure carbon monoxide by passing it over hot coke, and then carbon monoxide becomes available for chemical manufacture as follows: (1) with chlorine to make phosgene; (2) with ammonia to make various amides and cyanides; (3) with aliphetic alcohols and ethers to make various esters; (4) with halogen derivatives to make aldehydes; (5) with olefines to make organic acids and esters; (6) with hydro aromatic hydrocarbons to make various ketones; (7) with hydrogen to make methanol, ethanol and other alcohols; (8) with water to make formic acids; (9) with sodium hydroxide or calcium hydroxide to make sodium or calcium formate; (10) with metals to make various volatile metallic carbonyls; (11) with calcium hydroxide to form hydrogen and precipitated calcium carbonate.

## PHOSPHATE

It has become evident that the current interest in soil conservation and soil improvement indicates a need for large quantities of phosphate for rebuilding the soil and the desirability of finding cheaper local supplies, in order that it may be more extensively used. At the suggestion of staff members of the Agricultural Experiment Station and Extension Division, Oklahoma Agricultural and Mechanical College, the Oklahoma Geological Survey has undertaken the preliminary survey and sampling of the phosphate deposits of the state in the hope that Oklahoma material might prove useful, and in order that representative lots of the richer materials might be applied to test plots at the Experiment Station to determine their suitability. The following is a summary of the phosphate deposits of Washington County.

A black fissile shale at the base of the Coffeyville formation and usually resting on the Checkerboard limestone, contains phosphatic concretions that are useful as a horizon marker in mapping. Analyses made in the chemical laboratory of the Survey show that these concretions or nodules contain more than 30 percent $P_2O_5$, but the quantity available is too small to make them of any importance as a source of phosphate.

A dark crinoidal bed, 1 foot or less in thickness, containing phosphatic concretions, or nodules, is always present at the base of the Winterset limestone member of the Hogshooter formation. The Winterset limestone attains its maximum thickness of 26 feet in sec. 9, T. 26 N., R. 14 E., but is thinner both to the north and south of this point. South of T. 26 N. the entire thickness is seldom more than 12 feet and over much of the area it is less. Analyses made in the chemical laboratory of the Survey indicate that all the Winterset is usable for agricultural limestone, but the phosphate is confined to the lower, dark, crinoidal, nodular bed. Consequently, the only places where mining of the phosphatic limestone would be practical are along the outcrop of this basal bed. The most suitable places are on the dip slopes where the higher beds have been nearly or completely removed by erosion. Such places have been mapped and sampled with more than usual care. (See Table XI.) This basal bed may be unusually valuable as agricultural limestone if the contained phosphate proves to be available to growing crops.

A representative lot of this phosphatic limestone was collected by the Agricultural Experiment Station and applied to plots for growing tests during the summer of 1938. Owing to unfavorable conditions prevailing during the growing seasons of 1938 and 1939, results to date are inconclusive. Several seasons are necessary to obtain definite results on such tests.

## TABLE XI

CHEMICAL ANALYSIS OF THE DARK, CRINOIDAL, BASAL BED OF THE WINTERSET LIMESTONE[147] MEMBER OF THE HOGSHOOTER FORMATION

(Usually less than 1 foot thick)

| Lab. No. | Location | Sec. | T. N. | R. E. | CaO % | MgO % | $CO_2$ % | $P_2O_5$ % | $Al_2O_3$ % | $Fe_2O_3$ % | $MnO_2$ % | Insol. Res. % | $H_2O$ by ign. % | Total | $CaCO_3$ % | $MgCO_3$ % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7311 | N¼ cor. | 32 | 23 | 13 | 42.17 | 0.90 | 30.18 | 2.62 | 3.80 | 6.58 | 0.07 | 11.00 | 2.09 | 99.41 | 75.26 | 1.88 |
| 7268 | *SE SW NE | 28 | 24 | 13 | 48.27 | 0.94 | 38.37 | 1.32 | 1.52 | 2.41 | 0.16 | 6.43 | ........ | 99.36 | 86.14 | 1.97 |
| 7269 | *SE SW NE | 28 | 24 | 13 | 49.12 | 1.00 | 39.34 | 1.10 | 1.15 | 2.00 | 0.13 | 5.44 | ........ | 99.28 | 87.66 | 2.09 |
| 6106 | NW NW NW | 34 | 24 | 13 | 43.10 | ........ | 32.91 | 3.70 | 4.33 | 3.15 | 0.14 | 10.64 | 0.75 | 98.72 | 76.92 | ........ |
| 6887 | SW SW SW | 20 | 26 | 14 | 47.25 | 0.80 | 37.05 | 1.67 | 1.54 | 1.93 | 0.13 | 9.56 | ........ | 99.93 | 84.32 | 1.67 |
| 6888 | SW SW SE | 21 | 26 | 14 | 48.63 | 0.24 | 36.56 | 2.15 | 2.23 | 1.57 | 0.05 | 9.34 | ........ | 100.77 | 86.79 | 0.50 |
| 6901 | NW NW NE | 33 | 26 | 14 | 45.50 | 1.34 | 36.34 | 0.43 | 1.49 | 2.28 | 0.12 | 11.86 | ........ | 99.36 | 81.20 | 2.80 |

* Samples taken in the bank of the creek on the school ground in Ramona. No. 7268 lies at the base of the Winterset and is 3.0 feet thick, No. 7269 lies immediately above No. 7268 and is 1.5 foot thick, the basal, phosphatic bed having a total thickness of 4.5 feet at this place.

147. Analyses made in the chemical laboratory of the Okla. Geol. Survey.

Locally, in secs. 15 and 22, T. 27 N., R. 13 E., northeast of Dewey, there is a thin limestone bed 0.3 foot thick at the top of the Dewey limestone which is literally packed with phosphatic nodules. Nodules weathered from this bed are plentiful in places along the channel of Deer Creek, and a sample of these nodules contained 23.55 percent $P_2O_5$. A few tons of the nodules might be secured by hand gathering for local use.

The Iola formation contains a band of phosphatic nodules which was useful as a marker in mapping the formation, but the quantity available is too small to be of any consequence as a source of phosphate. A sample of the nodules contained 30.62 percent $P_2O_5$.

*Two Phosphate Horizons in Nowata and Craig Counties* are mentioned here because of the possibility of treating rock phosphate from that source with sulphuric acid from the plant at the Bartlesville smelter, to make superphosphate for local agricultural use.

The Fort Scott limestone crops out in a belt 1 to 10 miles wide from the Kansas line to Arkansas River, south of which it thins rapidly and soon disappears. Its outcrop crosses Craig, Nowata, and Tulsa Counties. It is composed of:

| | | Feet |
|---|---|---|
| (1) | Upper limestone, white, semi-crystalline and massive, about | 20.0 |
| (2) | Black fissile shale, containing phosphatic concretions, usually | 6.0 |
| (3) | Lower limestone, white semi-crystalline and massive, usually | 5.0 |

The writer has seen the black fissile shale in the park north of Oswego, Kansas; at a point where U. S. Highway 60 crosses the outcrop east of Nowata, Oklahoma, sec. 31, T. 26 N., R. 18 E.; where state highway 20 crosses the outcrop in T. 21 N., R. 15 E., west of Claremore, Oklahoma; and along U. S. Highway 66, approximately 1 mile southwest of Catoosa, Oklahoma. At all four places this shale contains phosphatic concretions.

East of Nowata, 0.3 mile west of the NE corner of sec. 31, T. 26 N., R. 18 E., the black shale is 6 feet thick, and nodules and plates are most abundant in the upper half. A representative sample of these contained 26.20 percent $P_2O_5$. West of Claremore, the black shale is thinner and coaly and the nodules are less abundant.

It seems that the black fissile shale in the Fort Scott limestone may be fairly uniform, both in thickness and in its content of phosphatic nodules, from the Kansas line to some point south of Nowata, Oklahoma, and that localities may be found where conditions are suitable for winning the phosphatic nodules. At the locality east of Nowata, the black shale crops out on a dip slope from which the upper member of the Fort Scott limestone has been eroded, leaving 50 acres or more free from overburden, and strewn with nodules and fragments.

The Pawnee limestone crops out widely on the headwaters of Big Creek and in a band from ½ to 2 miles wide west of Big Creek, from the Kansas line to Verdigris River. It crops out in a narrower band west of Verdigris River to the vicinity of Oologah, and thence southward to Broken Arrow. The Pawnee limestone is composed of the following:

| | | Feet |
|---|---|---|
| (1) | Upper limestone member 20 feet thick at the Kansas line but gradually thickening southward to 30 feet or more in southern Nowata County and 65 feet east of Tulsa. Average thickness | 40.0 |
| (2) | Black fissile shale containing phosphatic concretions. Maximum thickness | 12.0 |
| (3) | Lower limestone member, hard, gray, and partly crystalline | 6.0 |

The writer has seen the black shale member in one locality only, along U. S. Highway 60, east of Nowata, Oklahoma, in T. 26 N., Rgs. 16 and 17 E. There the shale is 3 feet thick and contains an abundance of black phosphatic nodules and plates. The shale is best exposed east of Verdigris River but even there it is usually covered by about 3 feet of the upper limestone member which forms dip slopes on the hilltops. A representative sample of the nodules and plates from the south side of the road in the NW cor. sec. 32, T. 26 N., R. 17 E. contained 32.68 percent $P_2O_5$. Owing to the wider exposure farther north, it is hoped that areas may be found where the upper limestone member has been removed by erosion, leaving the black shale better exposed for winning the phosphatic nodules.

Probably none of the phosphate horizons mentioned in this report can ever be worked on a large scale to produce phosphate for export to other states or foreign countries, but it is possible that a considerable amount of material may be recovered for local use. Gathering the nodules could supply part-time employment for people who would not be otherwise employed, much as tie making has done in the past. Local merchants could buy and forward the nodules to a central grinding and treating plant where they could be prepared for distribution as superphosphate in the same trade territory. Agricultural experience shows that rock phosphate similar to these nodules must be ground extremely fine before it can be used for fertilizer. Feasibility of such use will depend on results of growing tests by the Agricultural Experiment Station.

## BUILDING STONE

There are few if any places in Washington County where first class dimension stone could be quarried. However, there are many places where stone suitable for ordinary purposes may be secured with a minimum of effort.

Some common uses for stone are spillways for ponds, outlets for terraces, for culverts, bridges, barns and other outbuildings on farms, schools and residences, and for foundations for wooden buildings. In recent years stone 3 to 6 inches thick has become popular for use as veneer in the construction and reconditioning of private residences.

The various relief agencies operating throughout the country in recent years have demonstrated that good serviceable buildings may be constructed of stone heretofore neglected. Even an unskilled workman can construct a farm outbuilding like a pig sty, poultry house, or cow shed. With more experience he can erect a barn, milk house, or dwelling. The finer kinds of stone work are rightly classed as skilled trades, but so is expert carpentry. Farmers have long done the rougher sorts of building in wood, and they can likewise do it in stone. With the passing of the virgin forests, wood is no longer cheap, and it is bound to be more dear with the passing years. Stone can replace wood wherever it can be made to serve. When stone is close at hand and the building can be done when other work is not pressing, the cash outlay for stone is often less than for wood.

The dampness of stone buildings has been a major objection to their use in the past, but this can now be avoided without excessive expense. One method is to waterproof the exterior with cement stucco or a wash of portland cement. Another method is to lay all or a part of the stone edgewise. It has been found that sandstone has many impervious laminae parallel to the bedding and in consequence is almost or quite waterproof when laid with these laminae vertical.

The accompanying table compiled from the files of the mineral survey lists numerous exposures of both sandstone and limestone, many of which no doubt will yield stone suitable for various purposes.

TABLE XII
BUILDING STONE[148]

| Location | Formation | Thickness of layers (inches) | Remarks |
|---|---|---|---|
| | | T. 23 N., R. 12 E. | |
| E½ 1 | | | Limestone 3 to 6 ft. thick |
| E½ 11 | | | Limestone 3 to 6 ft. thick |
| E½ 12 | | | Limestone 3 to 6 ft. thick |
| E & W sides 13 | | | Limestone 3 to 6 ft. thick |
| W side 14 | | | Limestone 3 to 6 ft. thick |
| E½ 24 | | | Limestone 3 to 6 ft. thick |
| SW¼ 25 | | | Limestone 1 to 8 ft. thick |
| NW¼ 25 | | 1 to 36 | Sandstone 5 ft. thick, overburden 5 ft. |
| SE¼ 26 | | | Limestone 1 to 8 ft. thick. |
| | | T. 23 N., R. 13 E. | |
| Center 8 | | | Limestone 15 ft. thick. |
| SE SW NE 9 | Dewey ls. | | Limestone 3 to 14 in. thick. |
| SE SW SE 36 | Checkerboard ls. | | Limestone 3 ft. thick. |
| | | T. 24 N., R. 13 E. | |
| SE SE NW 8 | Nellie Bly | | Sandstone outcrop 175 ft. long, 60 ft. wide, 4 in. thick. |
| NE cor. 34 | Coffeyville Dodds Creek | 6 to 12 | Has been used for building stone. |

148. 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.

TABLE XII—Cont.

| Location | Formation | Thickness of layers (inches) | Remarks |
|---|---|---|---|
| | | T. 24 N., R. 14 E. | |
| NE NW SE 6 | Coffeyville | | Sandstone, 300 ft. long, 20 ft. wide, 4 ft. thick; overburden 0 to 20 ft. |
| Sec. 7, E. of river | Coffeyville | | Sandstone blocks 1 x 2 x 6 ft.; overburden 0 to 3 ft. |
| SW SW NE 9 | Coffeyville | 4 to 16 | Sandstone. |
| SE NE SW 9 | Coffeyville | 4 to 16 | Sandstone. |
| Sec. 19, E. of river | Coffeyville | | Sandstone 4,000 ft. long, 50 ft. wide, 12 ft. thick; overburden 3 ft. |
| S½ SW¼ 20 | Coffeyville | | Sandstone may not be suitable for building stone. |
| | | T. 25 N., R. 12 E. | |
| Sec. 25 | Dewey ls. | | Limestone, overburden 0 to 10 ft. |
| SW SW SW 35 | Clem Creek ss. | 3 to 6 | Sandstone, many loose pieces. |
| | | T. 25 N., 13 E. | |
| NE NE SW 13 | Coffeyville | 3 to 12 | Sandstone 600 ft. long, 100 ft. wide, 10 ft. thick; overburden 0 to 10 ft. |
| NE NE NW 13 | Hogshooter ls. | 3 | Limestone exposure 100 ft. long. |
| SW SW SW 17 | Dewey ls. | | Limestone 600 ft. long, 5 ft. wide; overburden 0 to 2 ft. |
| SW SE SW 18 | Dewey ls. | | Limestone 600 ft. long, 100 ft. wide, 4 to 5 ft. thick. |
| N½ of SW 20 | Dewey ls. | | 1,500 ft. long, 650 ft. wide, 2 ft. thick. |
| W½ 29 | Dewey ls. | | Limestone 4,000 ft. long, 20 to 300 ft. wide. |
| Sec. 30 | Dewey ls. | | Limestone well distributed over the section. |
| | | T. 25 N., R. 14 E. | |
| SW SE SE 8 | Coffeyville | 6 to 12 | Sandstone 100 ft. long, 4 ft. thick; overburden 2 ft. This is crushing rock. |
| SE NE NW 8 | Coffeyville | 6 to 12 | WPA quarry, rock was used for school house in Oglesby. |
| NE NW NW 21 | Coffeyville | 1 to 6 | Sandstone 500 ft. long, 50 ft. wide, 5 ft. thick; overburden 4 ft. |
| E½ of NE 31 | Coffeyville | 1 to 6 | Sandstone 70 ft. long, 50 ft. wide, 5 ft. thick. |
| | | T. 26 N., R. 12 E. | |
| Along S side 23 | Clem Creek? ss. | 6 to 12 | Sandstone ledge 15 ft. thick. |
| | | T. 26 N., R. 13 E. | |
| | Dewey ls. | | Outcrops cover most of township. See geologic map of county. |
| | | T. 26 N., R. 14 E. | |
| | Dewey and Hogshooter ls. | | Outcrops cover most of township. See geologic map of county. |

TABLE XII—Cont.

| Location | Formation | Thickness of layers (inches) | Remarks |
|---|---|---|---|
| | | T. 27 N., R. 12 E. | |
| W side 14 (Bar-Dew lake) | Uncertain | | In descending order: Overburden 3 ft., sandstone 2 ft., sandy shale 5 ft., sandstone 8 ft. |
| N½ of SW¼ 23 | Uncertain | | Scattered blocks of sandstone 3½ ft. thick. |
| E½ 26 | Torpedo ss. | 6 to 12 | Sandstone outcrop 200 ft. long and 25 ft. thick. |
| | | T. 27 N., R. 13 E. | |
| | Dewey ls. | | Outcrops cover most of township. See geologic map of county. |
| Sec. 9 | Cottage Grove ss. | 4 to 6 | Along Postoak Creek and tributaries sandstone outcrops frequently. Soft but easily worked, would do for some purposes. |
| Sec. 27 | Dewey ls. | | Quarry of Dewey Portland Cement Company. |
| SW NE NE 32 | Cottage Grove ss. | 4 to 6 | Soft but useful for some purposes. |
| | | T. 27 N., R. 14 E. | |
| | Dewey ls. | | Outcrops cover most of township. See geologic map of county. |
| | | T. 28 N., R. 12 E. | |
| W½ 2 | Uncertain | 3 to 8 | Sandstone, 160 acres 3 to 5 ft. thick; overburden 0 to 5 ft. |
| NW 11 | Uncertain | 3 to 8 | Sandstone 350 ft. long, 300 ft. wide, and up to 3 ft. thick; no overburden. |
| Near W¼ cor. 13 | Okesa ss. ? | 3 to 6 | Sandstone 500 ft. long, 10 ft. wide, 2 to 4 ft. thick. |
| SW NE 23 | Uncertain | 6 to 12 | Sandstone 500 ft. long, 100 ft. wide, 5 ft. thick. |
| SW NW 24 | Uncertain | 6 to 12 | Sandstone 1,000 ft. long, 500 ft. wide, 3 ft. thick. |
| NW SE 24 | Uncertain | 3 to 12 | Sandstone 500 ft. long, 100 ft. wide, 5 ft. thick. |
| | | T. 28 N., R. 13 E. | |
| S½ SW SW 3 | Torpedo ss. | 3 to 12 | Sandstone 600 ft. long, 200 ft. wide, 10 ft. thick; no overburden. |
| NE SE SE 4 | Torpedo ss. | 3 to 12 | Sandstone 200 ft. long, unlimited width, 8 ft. thick. |
| SW NW 6 | Torpedo ss. | 3 to 12 | Sandstone ¼ mile long, width unknown, thickness 2 to 6 ft.; overburden 0 to 5 ft. |
| SW SW 16 | Torpedo ss. | 3 to 12 | Sandstone about 10 acres; thickness unknown. |
| NW NW 20 | Torpedo ss. | | Sandstone in three layers 150 ft. by 150 ft., 6 ft. thick; good building stone. |
| SE SE NE 34 | Birch Creek ls. | | Caps hill, 6 ft. thick. |
| SE NE 35 | Birch Creek ls. | | Caps hill, 6 ft. thick. |

TABLE XII—Cont.

| Location | Formation | Thickness of layers (inches) | Remarks |
|---|---|---|---|
| | | T. 28 N., R. 14 E. | |
| SE SE NW 6 | Torpedo ? ss. | | Sandstone 300 ft. long, unknown width, 15 ft. thick. |
| SE SE SE 6 | Torpedo ss. | 3 to 12 | Sandstone 200 ft. long, unknown width, 4 ft. thick. |
| NW NE NE 9 | Torpedo ss. | 3 to 12 | Sandstone 400 ft. long, 50 ft. wide, 2 ft. thick. |
| NE NE 28 | Cottage Grove ss. | 3 to 6 | Sandstone 200 ft. long, 100 ft. wide, ½ to 2 ft. thick. |
| NW NW SE 28 | Cottage Grove ss. | 3 to 6 | Sandstone 100 ft. long, 50 ft. wide, 3 ft. thick; overburden 6 ft. |
| SW SW SW 33 | Dewey ls. | | Limestone, old quarry. |
| Along creek E½ 29 | Cottage Grove ss. | ½ to 1 | Sandstone, thin-bedded. Possibly make sand if crushed. |
| | | T. 29 N., R. 12 E. | |
| NE cor. to SW cor. 14 | Uncertain | | Sandstone 3,000 ft. long, 1,000 ft. wide, 3 ft. thick; composed of large regular grains, uniform texture, satisfactory for building. |
| NW¼ 15 | Uncertain | | Sandstone 300 ft. long, indefinite width, 3 ft. thick. |
| SW¼ 22 | Uncertain | 6 | Sandstone 2,500 ft. long, 150 ft. wide. |
| N to S across middle of 27 | Uncertain | 6 | Sandstone; N½ of outcrop loose blocks, S½ a ledge 1,000 ft. long, width unknown, 2 ft. thick; overburden ½ to 2 ft. |
| S½ of NW¼ 34 | Uncertain | | Sandstone 500 ft. long, 250 ft. wide, 3 to 4 ft. thick, overburden 2 ft. Blocks available 2 to 4 ft. thick and 5 to 6 ft. long. |
| SW SW NW 35 | Okesa? ss. | | Loose sandstone blocks. |
| SE SW NW 35 | Okesa? ss. | | Sandstone 100 ft. long, 30 ft. wide, 0 to 4 ft. thick; overburden 3 ft. |
| SE SE NW 35 | Okesa? ss. | | Sandstone 400 ft. long, 50 ft. wide, 2 to 5 ft. thick; overburden 0 to 8 ft. |
| | | T. 29 N., R. 13 E. | |
| NE SW NW 14 | Torpedo ss. | 3 to 12 | Sandstone 200 ft. long, width unknown, 1 to 6 ft. thick. |
| NE NW SW 14 | Birch Creek ls. | | Limestone 1 to 2 ft. thick, sandy. |
| NW NE SE 23 | Iola ls. | | Limestone ledge 150 ft. long, 20 ft. wide, 2 to 14 in. thick. |
| NE NE SE 23 | Iola ls. | | Limestone 100 ft. long, 40 ft. wide, thickness unknown. |
| S½ SE NW 27 | Torpedo ss. | 3 to 12 | Sandstone ¼ mile long, 25 ft. wide, 3 to 8 ft. thick; overburden 0 to 4 ft.; good for building stone. |

TABLE XII—Cont.

| Location | Formation | Thickness of layers (inches) | Remarks |
|---|---|---|---|
| | | T. 29 N,. R. 13 E.—Con't. | |
| NE SE SE 34 | Torpedo ss. | 3 to 12 | Sandstone 400 ft. long, width irregular, thickness 12 ft. Not good for cutting as face indicates irregular composition. |
| | | T. 29 N., R. 14 E.* | |
| Sec. 16 | Birch Creek ls. & Torpedo ss. | | Crops out in hill. |
| Sec. 18 | Iola ls. | | Crops out in creek beds. |
| Sec. 19 | Iola ls. | | Crops out in creek beds. |
| Sec. 28 | Birch Creek ls. & Torpedo ss. | | Crops out in hills. |
| N½ 29 | Cottage Grove ss. | | Crops out in creek bed. |
| N½ 30 | Iola ls. | | Crops out in creek bed. |

## SHALE

*Clay shale.* There is no clay-products industry in Washington County. This is probably due to the proximity of the well established works at Coffeyville, Kansas, which have amply supplied the needs of the adjacent trade territory. These plants utilize the clay shale in the lower part of the Coffeyville formation. (Zone 1, Fig. 5.) The outcrop of this part of the Coffeyville formation extends southwestward across western Nowata County into southeastern Washington County.

In 1929-1930, three samples of shale were collected from Washington County by John S. Redfield, of the Oklahoma Geological Survey, in the course of a state-wide 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.[149] These tests indicate that shales in the Nellie Bly and Wann formations also are suitable for making brick and tile. The following quotations are from this report with minor corrections of stratigraphic nomenclature in conformity with the present report:

* No stone reported by the mineral survey but stone suitable for some purposes crops out in the localities given.

149. Sheerar, Leonard F., and Redfield, John S., "The Clays and Shales of Oklahoma": *Okla. Agric. and Mech. College, Engineering Publication*, Vol. 3, No. 5, pp. 240-241, Sept., 1932.

SAMPLE NO. 127

NE NE Sec. 25, T. 25 N., R. 12 E. County: Washington.
Geologic formation: Nellie Bly.
Working properties: Fair plasticity, easy to mold.
Tempering water: 24.8%.
Drying linear shrinkage: 6.8%.
Drying volume shrinkage: 22.0%.
Average transverse strength: 339 lbs. per sq. in.

| Burning Temperature in Cones | Per Cent Linear Shrinkage | Per Cent Volume Shrinkage | Per Cent Porosity | Hardness | Color* |
|---|---|---|---|---|---|
| 010 | 1.6 | 4.8 | 30.9 | <steel | 11''b |
| 08 | 4.2 | 12.0 | 21.1 | <steel | 9''b |
| 06 | 6.8 | 10.0 | 14.8 | <steel | 9''b |
| 04 | 8.3 | 22.9 | 9.8 | <steel | 7''i |
| 02 | 8.3 | 23.0 | 7.8 | <steel | 7''i |
| 1 | 9.9 | 26.8 | 2.2 | <steel | 7''i |

Overburning temperature: Cone 1 (2102°F-1150°C).
Best burning range: Cone 08 to Cone 04 (1814°F-990°C to 1958°F-1070°C).
Total linear shrinkage: 15.5% at Cone 04 (1958°F-1070°C).
Possibilities: Common and face brick, hollow tile.

The Nellie Bly also outcrops in a bluff on the west side of the road one mile south of Tuxedo (a suburb of Bartlesville). Road metal was formerly obtained from this outcrop. A one-foot sandstone caps the outcrop. The remaining 36 feet of the exposure is buff shale with occasional sandstones that are thin and inconspicuous. The base of the shale is not seen.

SAMPLE NO. 128

SE Sec. 8, T. 26 N., R. 13 E. County: Washington.
Geologic formation: Nellie Bly.
Working properties: Fair plasticity, easy to mold.
Tempering water: 23.0%.
Drying linear shrinkage: 4.9%.
Drying volume shrinkage: 15.4%.
Average transverse strength: 280 lbs. per sq. in.

| Burning Temperature in Cones | Per Cent Linear Shrinkage | Per Cent Volume Shrinkage | Per Cent Porosity | Hardness | Color |
|---|---|---|---|---|---|
| 08 | .4 | 1.3 | 34.5 | <steel | 11''b |
| 06 | 2.8 | 8.2 | 28.5 | steel | 11'' |
| 04 | 4.1 | 11.8 | 24.1 | >steel | 9'' |
| 02 | 7.1 | 19.9 | 21.6 | >steel | 7''i |
| 1 | 6.6 | 18.5 | 13.6 | >steel | 7''k |
| 3 | 5.7 | 16.2 | 10.2 | >steel | 7''k |

Overburning temperature: Cone 1 (2102°F-1150°C).
Best burning range: Cone 06 to Cone 02 (1886°F-1030°C to 2030°F-1110°C).
Total linear shrinkage: 11.4% at Cone 02 (2030°F-1110°C).
Possibilities: Common brick.

A shale of the *Wann* formation forms a hill west of the town of Ochelata. A 4-foot sandstone caps the hill and overlies 30 feet of sandy shale containing several thin sandstone beds.

* Ridgway Color Scale. See Sheerar and Redfield, *op. cit.*, pp. 33-36.

SAMPLE NO. 126

SW SE Sec. 35, T. 25 N., R. 12 E. County: Washington.
Geologic formation: *Wann**.
Working properties: Fair plasticity, easy to mold.
Tempering water: 27.3%.
Drying linear shrinkage: 9.6%.
Drying volume shrinkage: 31.7%.
Average transverse strength: 1077 lbs. per sq. in.

| Burning Temperature in Cones | Per Cent Linear Shrinkage | Per Cent Volume Shrinkage | Per Cent Porosity | Hardness | Color |
|---|---|---|---|---|---|
| 08 | .67 | 2.1 | 28.1 | >steel | 11''b |
| 06 | 2.0 | 6.1 | 22.4 | >steel | 11'' |
| 04 | 2.9 | 8.5 | 18.5 | >steel | 11''i |
| 02 | 3.4 | 9.9 | 16.1 | >steel | 11''i |
| 1 | 4.2 | 12.0 | 15.2 | >steel | 7''i |
| 3 | 5.3 | 15.2 | 12.7 | >steel | 7''i |

Overburning temperature: Above Cone 3 (2174°F-1190°C).
Best burning range: Cone 06 to Cone 1 (1886°F-1030°C to 2102°F-1150°C).
Total linear shrinkage: 12.6% at Cone 1 (2102°F-1150°C).
Possibilities: Common and face brick, sewer pipe.

*Road shale.* Sandy shale from all the shale formations of the county have been much used for surfacing roads where the traffic is light. This material makes a smooth, water-resisting top which wears fairly well. It requires no special preparation and often the only equipment needed is shovels and wagons, which fits in well with the requirements of work relief programs. The field men of the State Mineral Survey[150] reported numerous localities where pits have been or could be opened, and no doubt there are others not reported. The following table is compiled from the records of the mineral survey.

TABLE XIII
ROAD SHALE REPORTED BY THE STATE MINERAL SURVEY[151]

| Location Section | Formation | Length feet | Width feet | Thickness feet | Over-burden feet | Remarks |
|---|---|---|---|---|---|---|
| | | T. 23N., R 12E. | | | | |
| NE¼ 26 | | 200 | 150 | 5 | | |
| | | T. 23N., R 13E. | | | | |
| NE¼ 2 | | 200 | 100 | 9 | | Now used |
| SE NW 22 | | 200 | 150 | 15 | | |
| | | T. 23N., R 14E. | | | | |
| SE SW NW 4 | | 100 | 25 | 4 | 3 | |
| Center N½ 5 | | 2,000 | 500 | 15 | | |
| NW NE NE 5 | | 500 | 300 | 25 | 0 | |
| C SE NW 8 | | 500 | 150 | 10 | 8 | |
| SE SW NE 29 | | 150 | 40 | 5 | 0 | |

* Italics by M. C. Oakes, indicating revised classification.
150. Works Progress Administration project No. 65-65-538, sponsored and directed by the Oklahoma Geological Survey, 1936-37.

TABLE XIII (Continued)

| Location Section | Formation | Length feet | Width feet | Thickness feet | Over-burden feet | Remarks |
|---|---|---|---|---|---|---|
| | | T. 24N., R. 13E. | | | | |
| Center SE¼ 5 | Nellie Bly | 200 | 6 | 5 | 2 | |
| C. S½ SE¼ 9 | Nellie Bly | 150 | 200 | 5 | 2 | |
| SE SE NW 10 | Nellie Bly | 300 | 100 | 6 | 0-2 | |
| SW SE SE 11 | Coffeyville | 300 | 100 | 15 | 0-3 | |
| SE SW SW 28 | Nellie Bly | 300 | 200 | 8 | 2 | |
| W¼ Cor. 28 | Nellie Bly | 400 | 150 | 10 | 3 | |
| | | T. 24N., R. 14E. | | | | |
| NE NW NW 6 | Coffeyville | 300 | 25 | 6-8 | 0-10 | |
| SE NE SW 8 | Coffeyville | 500 | 100 | 10 | 5 | |
| NE NW NW 20 | Coffeyville | | | | | Shale pit. |
| West side 21 | Coffeyville | | | | 2 | |
| | | T. 25N., R. 12E. | | | | |
| NE NE SE 35 | Wann | 100 | 50 | | 3 | |
| | | T. 25N., R. 13E. | | | | |
| S½ SE SW 1 | Nellie Bly | 300 | 200 | 15 | 1 | |
| NW NW NW 3 | Nellie Bly | 150 | | 3-20 | 0-10 | |
| SW SE 4 | Nellie Bly | 300 | 150 | 5 | 1 | |
| N¼ Cor. 13 | Coffeyville | 100 | | 3 | 1 | |
| SW SE 15 | ? | 55 | 75 | 30 | 6 | |
| SW corner 16 | Nellie Bly | 320 | 75 | 30 | 3 | |
| NW NE SW 30 | Nellie Bly | 75 | | 5 | 0-3 | |
| NW SW SW 34 | Nellie Bly | 100 | 75 | 3-12 | 3-10 | |
| | | T. 25N., R. 14E. | | | | |
| Center 7 | Coffeyville | 160 | | 3 | 8 | |
| ¼ mi. W Cen. 16 | Coffeyville | 500 | 500 | 15 | 1 | |
| W¼ corner 16 | Coffeyville | 300 | 150 | 8 | 1 | |
| S½ NE NE 21 | Coffeyville | 500 | 500 | 6 | 0 | |
| SW SW SE 32 | Coffeyville | 75 | 65 | 3 | 3 | |
| | | T. 26N., R. 13E. | | | | |
| SE SE SE 8 | Nellie Bly | 100 | 50 | 15 | 5 | Used on road. |
| | | T. 26N., R. 14E. | | | | |
| S½ SW NE 9 | Coffeyville | 2,000 | 100 | 10 | 1-10 | |
| | | T. 27N., R. 12E. | | | | |
| Cen. SW 13 | Wann, lower sh. | 50 | 50 | 6 | 0 | |
| S¼ corner 35 | Wann, lower sh. | 350 | 100 | 25 | 10 | |
| NE corner 35 | Wann, lower sh. | 1,320 | 100 | 3 | 1-5 | |
| SW corner 36 | Wann, lower sh. | 1,320 | | | | |
| | | T. 28N., R. 12E. | | | | |
| S of center 23 | Below Okesa ss. | 200 | 300 | 20 | 0 | |
| | | T. 28N., R. 13E. | | | | |
| NW NW SE 2 | Wann | 400 | 90 | 10 | | |
| NE SE SE 8 | Wann, upper sh. | 150 | 15 | 15 | 1 | |
| W¼ corner 9 | Wann, lower sh. | 100 | 85 | 7 | 2 | |
| SW NW NW 33 | Wann, lower sh. | 500 | 500 | 6 | 6 | |
| | | T. 28N., R. 14E. | | | | |
| Center SE 9 | Wann, lower sh. | 600 | 400 | 30 | 3 | |
| | | T. 29 N., R. 12E. | | | | |
| NE NW NE 34 | Wann, upper sh. | 200 | 90 | 15 | 3 | |
| NW SW SW 35 | Wann, upper sh. | 75 | 30 | 2-8 | 0-8 | |
| | | T. 29 N., R. 13E. | | | | |
| SE SE SW 21 | Wann, upper sh. | 300 | 200 | 15 | 2 | |

151. *Idem.*

## SAND AND GRAVEL

Sand and gravel are conspicuously absent in Washington County. The State Mineral Survey[152] reports no sand and only two gravel deposits, one a deposit of sandstone gravel in the NW¼ sec. 1, T. 23 N., R. 13 E., estimated at 1,300 cubic yards; overburden, 2 feet; thickness, 7 feet. No screen analysis available. It was the writer's observation in the county that sandstone gravels are too much weathered and soft to be of much use as a building material or road metal.

A deposit of limestone gravel is reported in the SW¼ sec. 28, T. 27 N., R. 14 E., estimated at 40,000 cubic yards. No screen analysis available.

The lack of good gravel can be amply compensated by crushing limestone which is plentiful and well distributed. The Checkerboard limestone could be depended on for small amounts locally, say for bridge work and farm buildings. The Hogshooter and Dewey limestones offer widespread opportunities for small quarries, and in most places sufficient stone can be picked up loose to supply local requirements for many years. It is possible to prepare an artificial sand by finely crushing both limestone and sandstone, but the cost should be carefully compared with the cost of good sand from commercial sources.

## COAL

Several thin coal seams occur in Washington County but so far as observed none of them is usually more than a fraction of an inch thick. They are discussed below in ascending order.

The lowest coal seam that crops out in the county is at about the horizon of the Cedar Bluff coal of Kansas, and in Oklahoma lies about 40 feet below the top of the Coffeyville formation. It is usually less than 0.1 foot thick and so far as known is not thick enough anywhere to be of any economic value.

One or more coal seams occur in the upper shale zone of the Coffeyville formation, usually less than 10 feet below the top. No production of coal from this zone was noted in Washington County but one pit was seen in Nowata County, sec. 30, T. 27 N.,

152. *Idem.*

R. 15 E., where the coal was 1 foot thick and had been mined to supply fuel for a nearby farm house.

The Thayer coal member of the Chanute formation of Kansas extends entirely across the county but is seldom more than 0.1 foot thick. It is 1.5 feet thick in the west bank of Caney River, NW¼ NE¼ sec. 1, T. 25 N., R. 12 E., but has several shale partings and is probably unfit for use. It is about 0.5 foot thick and of good quality in the SW¼ sec. 12, T. 25 N., R. 12 E., where it is mined for use at a nearby farm house.

Coal is found from place to place in the carbonaceous shale member of the Chanute formation, immediately below the Paola limestone member of the Iola formation, but is nowhere thick enough to have any practical value.

## OIL FIELD BRINES

Large quantities of oil field brines are going to waste in Washington and adjoining counties. In other counties such brines have been used experimentally in road building, for base stabilization and to prevent dust. The hygroscopic chlorides hold moisture and tend to keep dust from forming.

Oil field brines are mentioned under the section on Mineral Manufactures as a possible source of material for a chemical industry. In 1934 and 1935 a plant in the vicinity of Tulsa, operating on oil field brine, placed Oklahoma in second place in the nation in the production of magnesium salts.[153] Table XIV gives analyses of oil field brines from Washington County. These analyses were supplied by the United States Bureau of Mines and from private files.

153. *Minerals Yearbook, U. S. Bureau of Mines,* 1937.

## TABLE XIV

### Analyses of Oil Field Brines from Washington County

| Source of Analysis | 2 | 2 | 2 | 3 | 3 | 3 |
|---|---|---|---|---|---|---|
| Sand | Below Miss. Lime | Miss. lime | Burgess | | Bartlesville | |
| Location | T. 24N., R. 14E. | 24N., 14E. | 26N., 13E. | | T. 25N., R. 12E. | |
| Radical | | | Parts per million | | | |
| Calcium (Ca) | 1,983 | 2,532 | 3,376 | 6,238 | 7,543 | 7,648 |
| Magnesium (Mg) | 1,128 | 1,451 | 1,313 | 1,681 | 1,466 | 1,411 |
| *Sodium (Na) | 26,563 | 22,629 | 43,863 | 36,229 | 37,435 | 37,314 |
| Bicarbonate ($HCO_3$) | 137 | 105 | 521 | 187 | 285 | 66 |
| Sulfate ($SO_4$) | 888 | 67 | 88 | 169 | 183 | 212 |
| Chloride (Cl) | 47,060 | 43,680 | 76,960 | 71,611 | 75,085 | 75,010 |
| Total solids | 77,772 | 70,602 | 126,160 | 116,115 | 121,997 | 121,661 |
| Specific gravity at 15.6° C. (60°F.) | | | | 1.0864 | 1.0918 | 1.0891 |
| Date | 6-13-18 | 5-25-18 | 1-3-18 | 1935 | 1935 | 1935 |

| Source of Analysis | 1 | 1 | 2 | 1 | 3 | 3 |
|---|---|---|---|---|---|---|
| Sand | Bartles-ville | Squirrel | Peru | Wayside | Wayside | Wayside |
| Location | T. 27N., R. 13E. | 26N., 14E. | 26N., 13E. | 27N., 13E. | 28N., 14E. | 28N., 14E. |
| Radical | | | Parts per million | | | |
| Calcium (Ca) | 3,947 | 2,725 | 3,524 | 3,516 | 3,120 | 3,220 |
| Magnesium (Mg) | 2,252 | 1,672 | 1,511 | 1,187 | 925 | 690 |
| Sodium* (Na) | 33,194 | 23,687 | 22,766 | 24,211 | 20,000 | 21,000 |
| Bicarbonate ($HCO_3$) | 67 | 235 | 125 | 79 | 105 | 95 |
| Sulfate ($SO_4$) | ........... | 1 | 33 | ....... | 62 | 115 |
| Chloride (Cl) | 64,713 | 46,097 | 45,760 | 46,983 | 39,100 | 40,100 |
| Total solids | 104,173 | 74,417 | 73,870 | 75,976 | 63,340 | 65,300 |
| Specific gravity at 15.6°C. (60°F.) | 1.073 | 1.053 | | 1.051 | | |
| Date | 2-10-38 | 11-12-29 | 1-3-18 | 2-10-38 | 1926 | 1926 |

1. Analyses supplied by the U. S. Bureau of Mines. 2. Analyses supplied by Empire Companies, Chemical Department. 3. Analyses from other sources.
* May include a small amount of potassium.

# MINERAL MANUFACTURES

## Portland Cement

The Dewey Portland Cement Company operates a plant at Dewey, Oklahoma, using Dewey limestone as raw material. The plant has rail connections with the Missouri, Kansas and Texas Railroad and with the Santa Fe Railroad. Products are portland cement, masons cement, high early strength cement, fiber cement, and crushed stone. The capacity is 5,000 barrels of cement per day, (four sacks or 376 pounds per barrel).

The plant was originally built to use gas for fuel but with the decline of gas production in the vicinity coal has been gradually substituted. The Dewey limestone is about 25 feet thick and is composed of limestone beds of high purity interbedded with calcareous shale. At the top limestone beds are relatively thick and shale beds thin, but the shale beds are more prominent in the lower part. The limestone and shale are mined together with steam shovels by the open pit method. The material is crushed and separated by screening into two parts, one high in lime, the other low. The two parts are mixed in proper proportions to make the desired product. By regulating the depth of the mining operations there is no excess of either lime or shale. The mixture is burned in large rotary kilns fired by pulverized coal and the resulting clinker is ground to make the familiar portland cement of Commerce. Special cement which develops less heat in setting, for use in massive concrete structures, such as large dams, is made by adding iron and silica. Small quantities of other materials are ground with the clinker to hasten or retard the rate of setting, or otherwise fit the cement for its various uses.

## Smelting

The National Zinc Company operates a smelter in the west edge of Bartlesville. It has rail connections with the Missouri, Kansas, and Texas Railroad. The bulk of its ore comes from the northeast part of Oklahoma, some from Missouri, and a minor amount from the western states. Products are zinc, sulphuric acid, and cadmium.

The standard process is used. Zinc sulfide ore (ZnS) is roasted to remove the sulfur, which unites with oxygen to form sulfur dioxide gas. The zinc also unites with oxygen to form zinc oxide, which is charged into retorts with the amount of coal necessary to effect its reduction to the metal. Six blocks of gas fired retorts are in operation. Cadmium is collected from the roaster gases by passing them through bags similar to the bags of a vacuum cleaner.

## Sulfuric Acid

The process used in the acid plant is as follows: Gases from the roasters, containing a considerable amount of sulfur dioxide and an excess of air, are passed through drums filled with tungsten zeolite, in the form of pellets, which act as a contact material or catylist to convert the sulfur dioxide to the trioxide. The sulfur trioxide is then absorbed in concentrated sulfuric acid to make fuming sulfuric acid or oleum. Oleum mixed with water makes the sulfuric acid of commerce. Processes like this in which a chemical reaction is effected by the presence of a substance, such as tungsten zeolite, which does not itself enter into the reaction, are called contact processes and the reaction-promoting material is called the catylist.

Concentrated sulfuric acid does not affect iron containers seriously, especially if the containers have had certain preliminary treatment, and concentrated acid may be shipped in steel tank cars similar to those employed for shipping petroleum and its products. Sulfuric acid diluted with water rapidly attacks the metal of such containers and consequently only the concentrated form is usually shipped, the user diluting it as required.

## Other Possibilities

Sulfuric acid, limestone, and common salt are the bases of many chemical industries and all are or could be produced in the county. Sulfuric acid is used in the manufacture of superphosphate for agricultural use. Rock phosphate is ground and mixed with the acid in proper amount to convert the phosphorus to forms more available to plants. Deposits of rock phosphate in the vicinity of Bartlesville are lean but a small supply of high grade material might be developed which could be converted into superphosphate for local use. It would be technically possible to use salt recovered from the oil field brines to make hydrochloric acid, soda ash, salt cake, glauber salt, sodium silicate, and many other products. The small amount of calcium and magnesium chlorides would be of value as byproducts. Other chemical manufacturing would be technically possible from the mineral raw materials available.

Any utilization of these resources will depend on availability or development of markets.

## WATER RESOURCES

### SURFACE WATER

It is not difficult to secure small supplies of water from underground sources and relatively large wells are reported in the alluvium of certain streams, nevertheless, with the possible exception of T. 29 N., any really large supply, on the order of 100,000 gallons or more per day, must be secured from surface sources. Caney River has been the main source for such large supplies to date, but in the driest weather of the last few years the river has almost ceased to flow. Fortunately, the clay soils of the county seem to be sufficiently impervious to permit the use of large earthen storage reservoirs and, should the demand for large supplies of water increase, such reservoirs probably offer the best solution.

### UNDERGROUND WATER RESOURCES

No systematic study of the underground water conditions was undertaken in connection with the present investigation. Data on 770 rural water wells and springs were obtained by crews of the State Mineral Survey, filling in a questionnaire at each farm house visited. Results of this survey are summarized below, and the data are tabulated in Appendix A.

The Noxie sandstone member of the Chanute formation seems to offer the best possibilities for developing supplies of underground water in the county, and the writer made a study of its subsurface distribution and thickness from logs of wells drilled for oil and gas. Results of this study are summarized in Figure 19, and in a subsequent paragraph.

Data obtained by the State Mineral Survey[154] are not all that might be desired for a scientific study of underground water conditions, having been assembled by untrained, relief workers, depending on the memory and opinions of farm owners and tenants. The mass of information available and the rather definite nature of some of the inquiries, however, should give a fairly good idea of average conditions, and the data are included here in the hope that they may be useful to residents of the district. Information on depths should be fairly reliable since most wells in the district are equipped with bucket, rope, and pulley. The estimates of capacity are very rough, being in most instances little more than the farmer's guess, and are of value only for comparative purposes, while the information on quality of water represents only the opinion of the user. The reports on the effects of drouth should be reliable, since people depending on wells for water supplies would be extremely conscious of their failure, and the investigation was made during a protracted drouth.

Identification of the water-bearing horizon, or aquifer, of each well is made from data on the depth and location of the well together with information on the aquifer contained in the questionnaire. Many of these identifications are approximations only.

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

Washington County is rather widely supplied with underground water in small amounts. That is, the wells are well distributed but each well is likely to be so small as to supply only enough water for one family, and perhaps a few head of stock. Table XV is a summary of the data contained in Appendix A. It will be noted that the alluvium has the greatest number of wells producing from any one aquifer. Likewise the average capacity is more

154. Works Progress Administration project No. 65-65-538, sponsored and directed by the Oklahoma Geological Survey, 1936-37.

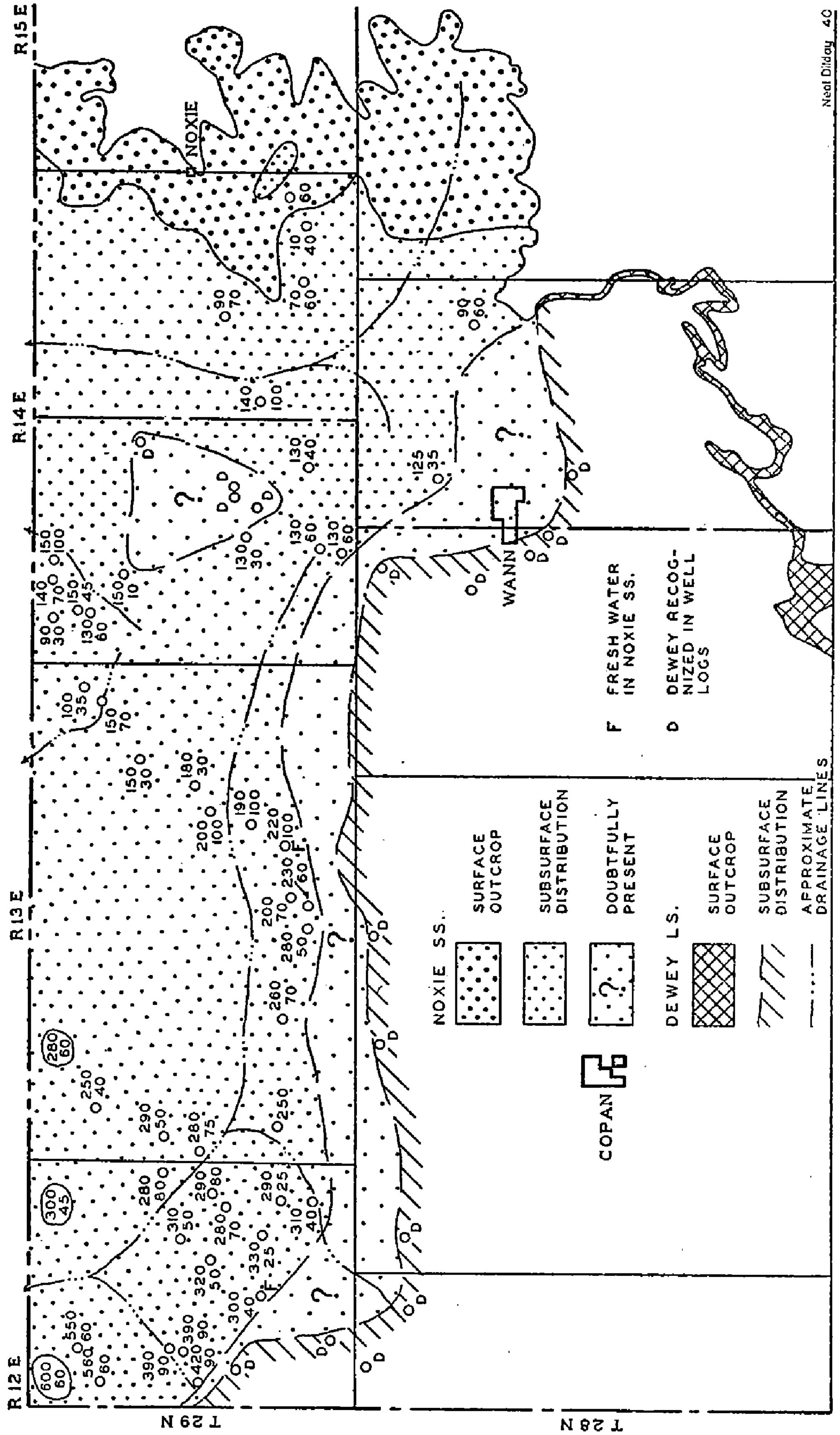



FIG. 19. Pre-Chanute valley later filled with Noxie sandstone. Circles indicate location of wells used in subsurface study. Upper numbers indicate depth to top of Noxie in feet. Lower numbers indicate thickness of Noxie in feet.

than double that of the next highest. Many alluvium wells are quite small, the high average capacity being due to comparatively few extremely productive wells. The high percentage of hard water wells is noticeable, and only in "the Okesa" and Torpedo sandstones does soft water predominate. The Torpedo sandstone is further notable for the large proportion of wells which show no change in extremely dry weather. It appears that the shales of the Wann formation are relatively barren as a source of water. The Cottage Grove sandstone equals the Torpedo sandstone as a source but the water is much more apt to be hard. The Dewey limestone is noticeable for the high proportion of wells which fail in drouth.

TABLE XV

AQUIFERS IN WASHINGTON COUNTY[155]

| Formation | Number of Wells Reported | Average Capacity Gallons Per Day | No Change During Drouth Percent | Quality Soft Percent | Quality Hard Percent | Rock |
|---|---|---|---|---|---|---|
| Alluvium | 191 | 1,800 | 75 | 28 | 72 | Sand and gravel |
| "The Okesa" ss. | 10 | 790 | 40 | 70 | 30 | Sandstone |
| Torpedo sandstone | 97 | 260 | 97 | 75 | 25 | Sandstone |
| Wann formation | 19 | 170 | 44 | 10 | 90 | Limestone and limy shale |
| Iola formation | 5 | 562 | 60 | 0 | 100 | Limestone and shale |
| Chanute formation Cottage Grove sandstone member | 87 | 390 | 76 | 37 | 63 | Sandstone |
| *Noxie ss. member | 3 | 2,000 | 100 | 100 | 0 | Sandstone |
| Dewey limestone | 71 | 215 | 25 | 0 | 100 | Limestone |
| Nellie Bly formation | 108 | 145 | 47 | 27 | 73 | Silty shale and sandstone |
| Hogshooter formation | 9 | 230 | 56 | 0 | 100 | Limestone |
| Coffeyville formation | 147 | 470 | 51 | 41 | 59 | Sandstone and sandy shale |
| Seminole formation | 25 | 185 | 44 | 28 | 72 | Sandstone |

* See Figure 19.

*Noxie Sandstone.* The Noxie sandstone, not considered in the above summary, should be an excellent aquifer across T. 29 N., but usually the existing wells are too shallow to reach it. Only three wells reported seem to produce from the Noxie sandstone.

155. Summary of Appendix A.

All produce soft water. One is rated at 3,000 gallons per day, the others as "unlimited." All show no change in drouth. Figure 19 gives the areal distribution, depth, and thickness of the Noxie sandstone as determined from available oil well logs. It will be noted that drillers report fresh water in this sandstone almost to the Osage County line. It might prove feasible to develop sufficiently large water supplies from the Noxie sandstone to serve the small towns in the north end of the county and for supplemental irrigation of gardens and feed crops.

## MUNICIPAL WATER SUPPLIES

Analyses of water given below were supplied by Dr. O. M. Smith, head of the Department of Chemistry, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma.

TABLE XVI
CHEMICAL ANALYSES OF MUNICIPAL WATER AT BARTLESVILLE[156]
RAW WATER FROM CANEY RIVER

| Hypothetical Combinations | 35 Samples 2-23-1923 to 7-17-1937 Average | Max. | Min. | 1 Sample 6-28-1934 | 1 Sample 3-19-1931 |
|---|---|---|---|---|---|
| $CaCO_3$ | 160 | 275 | 100 | 140 | 216 |
| $CaSO_4$ | 42 | 80 | 0 | 62 | 71 |
| $CaCl_2$ | 50 | 367 | 8 | | |
| $MgSO_4$ | 7.5 | 38 | 0 | 14 | 7 |
| $MgCl_2$ | 55 | 206 | 0 | 40 | 99 |
| NaCl | 516 | 1270 | 32 | 385 | 165 |
| $Fe_2O_3$ | 0.2 | 0.8 | 0.1 | 4 | 2.8 |
| $SiO_2$ | 10 | 18 | 1 | 5 | 3 |
| Total Solids | 864 | 2200 | 230 | 650 | 563 |
| Total Hardness | | | | 239 | 391 |
| Alkalinity M. O. | | | | 140 | 216 |
| Analyst | | | | S.E.L. | S.E.L. |
| Number | | | | W-88 | 103 |

156. Analyses supplied by O. M. Smith, head of Dept. of Chemistry, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma.

*Bartlesville*. The City of Bartlesville is supplied from Caney River. There is no large reservoir but water is impounded in the channel of the river above a dam situated under the bridge on U. S. Highway 75, in the north edge of Bartlesville. In time of extreme drouth water almost ceases to flow over the dam, and recently it has been necessary to supplement the flow of the river by water from Lake Bar-Dew, a small lake built as a relief project on a tributary of Caney River above Bartlesville. Until recently, the water system at Bartlesville was owned by a utility corporation but is now owned by the city.

Analyses of samples from the intake to the purification plant are given in Table XVI.

TABLE XVII

CHEMICAL ANALYSES OF LOCAL WATER SUPPLIES AT BARTLESVILLE[157]

| Hypothetical Combinations | I | II | III |
|---|---|---|---|
| $CaCO_3$ | 216 | 99 | 220 |
| $CaSO_4$ | | 84 | 119 |
| $CaCl_2$ | | 192 | 277 |
| $MgCO_3$ | 44 | | |
| $MgCl_2$ | | 52 | 12 |
| $Na_2CO_3$ | 18 | | |
| $Na_2SO_4$ | 105 | | |
| NaCl | 43 | 61 | 285 |
| $Fe_2O_3$ | 3 | 11.4 | 0.4 |
| $SiO_2$ | 10 | 7 | 20 |
| Suspended Matter | | | 12 |
| Total Solids | 440 | 506 | 1,046 |
| Total Incrusting Solids | | | 660 |
| Total Hardness | 269 | 339 | 565 |
| Alkalinity M. O. | 286 | 99 | 220 |
| Analyst | S.E.L. | S.E.L. | I.F. Co. |
| Number | W-269 | 102 | 12308 |

157. *Idem.*

I From Hill Crest Country Club, private well in alluvium, date, January 27, 1935.
II From laundry, private well in alluvium, date, March 19, 1931.
III From O. K. Laundry, private well in alluvium, date, August 29, 1927.

*Dewey.* The town of Dewey is supplied with raw water from Caney River through the pipe line of the Dewey Portland Cement Company. It has been used raw for fire and sanitary purposes, but steps are being taken to install a treating and purification plant. Drinking water is obtained from private wells.

*Ramona.* The town of Ramona is supplied from two wells in alluvial gravel in the valley of Double Creek. One is 25 feet deep and 25 feet in diameter and the other 16 feet deep and 8 feet in diameter. The system has a storage capacity of 65,000 gallons. The supply seems to be adequate except in extremely dry weather. Analyses of samples from Dewey and Ramona are given in Table XVIII.

**TABLE XVIII**

CHEMICAL ANALYSES OF WATER SUPPLIES AT DEWEY AND RAMONA[158]

| Hypothetical Combinations | I | II | III | IV |
|---|---|---|---|---|
| $CaCO_3$ | 182 | 295 | 73 | 98 |
| $CaSO_4$ | 148 | | 256 | |
| $CaCl_2$ | 106 | | | |
| $MgCO_3$ | | 8 | | 43 |
| $MgSO_4$ | | | 48 | 61 |
| $MgCl_2$ | 48 | | | 19 |
| $Na_2CO_3$ | | 94 | | |
| $NaSO_4$ | | 44 | 127 | |
| NaCl | 430 | 95 | 285 | 63 |
| $Fe_2O_3$ | | Tr. | 1.6 | |
| $SiO_2$ | 22 | 20 | 4 | 20 |
| Suspended matter | | 8 | | |
| Total Solids | 1170 | 556 | 796 | 330 |
| Total incrusting solids | 506 | 331 | 380 | 241 |
| Total hardness | 441 | 304 | 316 | 221 |
| Alkalinity M. O. | 193 | 393 | 129 | 151 |
| Phen. | 0 | 0 | 0 | 0 |
| Analyst | O.S.B.H. | I.F. Co. | D.C. Co. | O.S.B.H. |
| Number | 22545 | 12351 | 138030 | 25544 |

158. *Idem.*

I From a shallow well at Dewey, probably in Cottage Grove sandstone, date, February 17, 1932.

II From a private well at the corner of 8th Street and Osage Avenue in Dewey, probably in the Cottage Grove sandstone, date, September 8, 1927.

III Raw water from Caney River as supplied to Dewey, date, March 27, 1931.

IV Composite sample from two City wells at Ramona, in alluvium of Double Creek, date, May 17, 1932.

## APPENDIX A

# PRELIMINARY WATER WELL DATA

# IN

# WASHINGTON COUNTY[159]

159. 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.

## T. 23 N., R. 12 E., WASHINGTON COUNTY

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NE NE | 11 | spring | | | 1000 | no change | hard | limestone | Avant ls. | Not reported .... |
| 2 | SW NW | 12 | dug | 30 | 25 | 400 | 200 | hard | limestone | " " | Little Ranch |
| 3 | SE SW | 13 | dug | 12 | 10 | 700 | 70 | hard | limestone | alluvium | W. H. Neeman |
| 4 | SW SE | 25 | dug | 16 | 12 | 5 | no change | hard | sandstone | Nellie Bly | R. L. Walker |
| 5 | SW SE | 26 | drilled | 27 | 24 | 50 | no change | hard (irony) | quicksand | alluvium | L. E. Clapp |
| 6 | SW SE | 26 | dug | 15 | 12 | 1000 | no change | hard | quicksand | alluvium | C. L. Clapp |
| 7 | NW SE | 26 | drilled | 18 | 12 | 200 | no change | hard | river sand | alluvium | Harrison Meyers |
| 8 | NE NE | 26 | drilled | 85 | 20 | 70000 | no change | soft | gravel | alluvium | W. C. Martin |
| 9 | SE SE | 35 | dug | 27 | 20 | 270 | 50 | hard | limestone | Nellie Bly | G. W. Pearson |
| 10 | NE SE | 35 | dug | 40 | 37 | 670 | 70 | hard | limestone | " " | Not reported |
| 11 | NW NE | 35 | drilled | 26 | 20 | 800 | no change | hard | sandstone | " " | G. W. Blakeman |
| 12 | NW NE | 35 | dug | 27½ | 20 | 1330 | no change | hard | sandstone | " " | G. W. Blakeman |
| 13 | SE SE | 36 | dug | 23 | 21 | Incomplete | ............... | soft | sandstone | " " | W. M. Johnson |
| 14 | NW NE | 36 | dug | 25 | 23 | 100 | dry | hard | limestone | " " | Albright Title & Trust Co. |
| 15 | NW NW | 36 | dug | 25 | 24 | 130 | dry | hard | limestone | " " | Nan Rodgers |
| 16 | SW NW | 36 | dug | 14 | 4 | 200 | no change | hard | limestone | " " | B. S. Killion |
| 17 | SE NW | 36 | drilled | 100 | 80 | 400 | dry | hard | limestone | " " | Mrs. Newcomb |
| 18 | SW NW | 36 | dug | 26 | 25 | 670 | dry | hard | limestone | " " | C. T. Pearler |
| 19 | SW SW | 36 | dug | 19 | 19 | 130 | dry | soft | limestone | " " | Chas. Prather |

## T. 23 N., R. 13 E., WASHINGTON COUNTY

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NW NE | 1 | dug | 40 | 30 | 500 | no change | soft | sandstone | Coffeyville | M. Tucker |
| 2 | SE SE | 1 | dug | 40 | 20 | 500 | 15 | hard | limestone | " | John Pilgram |
| 3 | NE SE | 2 | dug | 35 | 33 | 50 | dry | hard | limestone | " | John Pilgram |
| 4 | NE NE | 2 | dug | 25 | 23 | ? | dry | hard | limestone | " | I. L. Davis |
| 5 | NW NE | 3 | dug | 20 | 17 | 800 | 260 | hard | sandstone | " | C. M. Melcolm |
| 6 | SE NE | 3 | dug | 40 | 38 | ? | ? | hard | sandstone | " | W. E. Miller |
| 7 | SE NE | 3 | dug | 16 | 13 | 660 | no change | hard | sandstone | Coffeyville | W. E. Miller |
| 8 | SW NE | 3 | dug | 20 | 18 | 260 | 26 | hard | sandstone | " | W. E. Miller |
| 9 | SE SW | 3 | dug | 22 | 21 | 260 | dry | hard | sandstone | " | Ross Morgan |
| 10 | SW NW | 3 | dug | 30 | 28 | 130 | 25 | hard | limestone | " | Albert Harold |
| 11 | SW SW | 7 | dug | 30 | 28 | 25 | dry | soft | sandstone | Nollie Bly | G. W. Keefurer |
| 12 | SW SE | 10 | dug | 23 | 10 | 800 | 80 | soft | sandstone | Coffeyville | J. Wilson |
| 13 | SW SE | 10 | dug | 18 | 8 | 660 | 66 | soft | sandstone | " | Not reported |
| 14 | NE SW | 11 | dug | 20 | 5 | 400 | no change | hard | gravel | alluvium | Floyd Beeson |
| 15 | SE SE | 11 | dug | 20 | 19 | 50 | no change | hard | gravel | " | James Cargile |
| 16 | SW SW | 12 | dug | 24 | 22 | 50 | dry | soft | gravel | " | W. W. Ellison |
| 17 | NE SW | 12 | dug | 28 | 25 | 75 | dry | soft | gravel | " | Ida White |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | NW NE | 12 | drilled | 18 | 11 | 150 | no change | soft | gravel | ” | W. J. Vinson |
| 19 | SE SE | 13 | dug | 30 | 28 | 500 | no change | soft | sand | ” | J. A. Campbell |
| 20 | NE NW | 13 | dug | 20 | dry | dry | dry | soft | slate | Coffeyville | W. M. Sears |
| 21 | NE NE | 14 | dug | 19 | 13 | 1000 | no change | hard | limestone | ” | G. Hugo |
| 22 | NW NW | 15 | dug | 16 | 12 | 500 | 100 | soft | sandstone | Nellie Bly | John Dish |
| 23 | NE NE | 15 | dug | 16 | 16 | 200 | dry | hard | sandstone | Coffeyville | Ben Wells |
| 24 | NE NE | 15 | dug | 20 | 16 | 1000 | 400 | hard | sandstone | ” | Ben Wells |
| 25 | NE SW | 15 | drilled | 30 | 23 | 130 | no change | hard | sandstone | ” | Ed Nash |
| 26 | NE SE | 16 | dug | 30 | 26 | 500 | 150 | soft | sandstone | ” | D. Barker |
| 27 | NW NE | 21 | drilled | 141 | 4 | 3000 | 1000 | soft | unknown | ” | Not reported |
| 28 | SE NE | 23 | dug | 22 | 22 | dry | no change | hard | limestone | ” | H. Kepler |
| 29 | SW SW | 23 | dug | 50 | 50 | dry | no change | hard | limestone | ” | F. Hall |
| 30 | NW SE | 24 | dug | 20 | 18 | 200 | no change | soft | gravel | alluvium | O. J. Fox |
| 31 | SW NW | 24 | dug | 18 | dry | dry | no change | hard | limestone | Coffeyville | Bud Polson |
| 32 | SE NE | 25 | dug | 18 | 14 | 200 | 50 | hard | limestone | ” | Martin Butts |
| 33 | SW NE | 25 | dug | 30 | 28 | 200 | dry | hard | limestone | ” | Martin Butts |
| 34 | SE NW | 25 | dug | 18 | 14 | 200 | 50 | soft | sandy gravel | alluvium | Richardson |
| 35 | NE SW | 25 | dug | 18 | 14 | 250 | 75 | soft | sandy gravel | ” | Walter Hummingbird |
| 36 | NW SW | 26 | dug | 25 | 23 | 200 | 40 | hard | limestone | Coffeyville | J. H. Carlisle |
| 37 | SW SW | 27 | dug | 21 | 15 | 150 | no change | soft | sandstone | ” | A. Durbin |
| 38 | NW NW | 27 | dug | 28 | 24 | 15 | dry | hard | limestone | ” | DeWitt Baker |
| 39 | SE NE | 27 | dug | 40 | 38 | 25 | dry | soft | sandstone | ” | Bob Dish |
| 40 | SE SE | 28 | dug | 14 | 11 | 25 | no change | soft | sandstone | ” | V. L. Maxey |
| 41 | SE SE | 28 | dug | 15 | 11 | 25 | no change | hard | sandstone | ” | Frank Littles |
| 42 | NW NE | 28 | dug | 43 | 40 | 100 | not dry | hard | limestone | Hogshooter | J. C. Gilbert |
| 43 | NW NW | 32 | dug | 26 | 23 | 50 | no change | hard | granite ? | ” | J. W. Gifford |
| 44 | SW SW | 32 | drilled | 16 | 6 | 3200 | no change | hard | granite ? | ” | Tom Woodall |
| 45 | NE NW | 32 | dug | 12 | 6 | 2000 | no change | hard | granite ? | ” | Barney Hadock |
| 46 | NE NW | 33 | dug | 20 | 19 | 7 | no change | hard | sandstone | Coffeyville | Walter Lonsinger |
| 47 | SE NE | 34 | dug | 20 | 20 | | dry | soft | sandstone | alluvium | Stubbs |
| 48 | SW SE | 35 | dug | 25 | 22 | 75 | dry | hard | gravel | ” | A. L. Willis |
| 49 | SW SE | 36 | dug | 35 | 30 | 200 | no change | hard | gravel | ” | E. L. Welch |
| 50 | NW NE | 36 | dug | 28 | 26 | 50 | dry | gyp | limestone | Coffeyville | Diming Invest. Co. |
| 51 | NW SW | 36 | dug | 17 | 15 | 50 | no change | hard | gravel | alluvium | M. J. Carr |

## T. 23 N., R. 14 E., WASHINGTON COUNTY

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NW NE | 4 | dug | 20 | 16 | 500 | no change | hard | gravel | alluvium | Alta Woody |
| 2 | NE NE | 4 | drilled | 48 | 10 | 600 | no change | hard | gravel | ” | R. S. White |
| 3 | SE SW | 4 | drilled | 30 | dry | dry | no change | hard | gravel | ” | Felix Sutrick |
| 4 | NW SW | 4 | dug | 12 | 8 | 1000 | no change | hard | gravel | ” | Earl Gogler |
| 5 | SW SE | 4 | spring | 6 | | 700 | no change | hard | black shale | Seminole | Not reported |
| 6 | SW SW | 5 | dug | 25 | 19 | 800 | no change | hard | sandstone | alluvium | Joe Little |
| 7 | NE NE | 6 | dug | 35 | 31 | 1000 | 500 | hard | sandstone | ” | Joe Little |
| 8 | NE SE | 8 | dug | 50 | 40 | 5000 | no change | hard | limestone | ” | Lincoln Inv. Co. |
| 9 | SE SE | 8 | dug | 25 | 21 | 20 | dry | hard | limestone | Coffeyville | W. D. Stinnett |

## T. 23 N., R. 14 E., WASHINGTON COUNTY—Continued.

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | SW SW | 8 | dug | 25 | 20 | 1000 | no change | hard | river sand | alluvium | Joe Little |
| 11 | SW NW | 9 | dug | 20 | 10 | 300 | no change | hard | limestone | Seminole | W. E. Atterman |
| 12 | SE SE | 9 | dug | 18 | 12 | 50 | no change | hard | limestone | ” | S. J. Patterson |
| 13 | NW NE | 9 | dug | 25 | 15 | ? | dry | hard | limestone | ” | ? Loan Company |
| 14 | NE NW | 9 | dug | 7 | 7 | 30 | dry | hard | limestone | ” | Henry Chambers |
| 15 | NE NW | 9 | drilled | 15 | 12 | 20 | no change | hard | limestone | ” | Henry Chambers |
| 16 | SW SW | 9 | dug | 12 | 8 | 50 | no change | hard | limestone | ” | Russell |
| 17 | NW Cor. | 16 | dug | 14 | 8 | 300 | 100 | hard | limestone | ” | Emma Stonehocker |
| 18 | SW SW | 16 | drilled | 30 | 25 | 200 | no change | hard | limestone | ” | John Todd |
| 19 | SE SW | 16 | dug | 18 | 10 | 600 | no change | soft | sulphur ? | ” | Geo. Stapp |
| 20 | NE NE | 16 | drilled | 35 | 20 | 200 | no change | hard | limestone | ” | Aetna Loan Co. |
| 21 | NE Cor. | 17 | dug | 15 | 8 | 500 | 100 | hard | sandstone | ” | C. A. Campbell |
| 22 | SE SW | 17 | dug | 35 | 33 | 20 | dry | hard | limestone | ” | Not reported |
| 23 | NE SE | 17 | dug | 45 | 40 | 500 | no change | hard | sandstone | ” | Hancock Life Ins. Co. |
| 24 | NW SE | 18 | dug | 30 | 25 | 500 | no change | hard | limestone | alluvium | Arthur Hall |
| 25 | NE NW | 21 | drilled | 60 | 10 | 50 | no change | hard | limestone | Seminole | Not reported |
| 26 | SE NE | 21 | drilled | 40 | 18 | 100 | no change | hard | limestone | ” | Not reported |
| 27 | SW SE | 21 | spring | 4 | 0 | ? | low | soft | | ” | J. Ecker |
| 28 | NW NE | 28 | dug | 20 | 10 | 400 | no change | hard | gravel | alluvium | L. B. Bacon |
| 29 | SW SW | 28 | dug | 23 | 22 | 100 | no change | hard | gravel | alluvium | Amey Mance |
| 30 | SE NE | 29 | dug | 30 | 27 | 100 | 5 | soft | limestone | alluvium | E. L. Hall |
| 31 | SE NE | 29 | dug | 30 | 20 | 200 | 100 | hard | limestone | alluvium | E. L. Hall |
| 32 | SE SE | 29 | dug | 20 | 19 | 5 | no change | soft | sandstone | Seminole | Tom Pickard |
| 33 | SW SW | 29 | drilled | 45 | 40 | ? | no change | hard (salty) | limestone | ” | Longsinger |
| 34 | NW NE | 30 | dug | 20 | 17 | 200 | 50 | hard | limestone | ” | Frank Six |
| 35 | SE SE | 30 | dug | 35 | 27 | 200 | 100 | hard (sulfer) | limestone | ” | Jim Pisch |
| 36 | NE NE | 31 | drilled | 85 | 40 | 400 | 200 | hard | limestone | ” | Kettlekamp |
| 37 | NW SW | 31 | drilled | 38 | 18 | 200 | 50 | hard | limestone | ” | C. C. Mathews |
| 38 | SW SW | 31 | drilled | 52 | 12 | 400 | 100 | hard | limestone | ” | C. C. Mathews |
| 39 | NW NW | 31 | dug | 20 | 10 | 300 | 100 | hard | limestone | Coffeyville | Howland |
| 40 | NE NE | 32 | dug | 20 | 17 | 500 | 200 | soft | sandstone | Seminole | J. McNeal |
| 41 | NW SW | 32 | dug | 45 | 40 | ? | no change | soft | sandstone | ” | M. Rips |
| 42 | NE NW | 33 | dug | 26 | 20 | 400 | no change | ? | gravel | alluvium | Chas. Ashlock |

## T. 24 N., R. 12 E., WASHINGTON COUNTY

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SE SE | 1 | dug | 25 | 12 | 25 | no change | hard | limestone | Dewey | J. Tyner |
| 2 | SE NW | 1 | dug | 25 | 24 | 10 | dry | hard | limestone | ” | E. D. Hinsinger |
| 3 | SW SW | 1 | dug | 21 | 20 | 25 | dry | hard | gravel | alluvium | E. J. Gills |
| 4 | NE SE | 11 | dug | 20 | 12 | 500 | no change | hard | limestone | alluvium | A. E. Wills |
| 5 | NW SE | 12 | dug | 20 | 15 | 10000 | no change | hard | limestone | alluvium | W. L. Gilford |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | SW NW | 12 | spring | 8 | 0 | 100 | dry 3 weeks | hard | limestone | Wann | W. L. Gilford |
| 7 | NE SW | 12 | dug | 20 | 15 | ? | no change | hard | limestone | '' | ........................ |
| 8 | NW SW | 12 | dug | 20 | 12 | 50000 | no change | hard | limestone | alluvium | A. E. Wills |
| 9 | NW NE | 12 | dug | 30 | 30 | 3 | dry | hard | limestone | Dewey | A. E. Wills |
| 10 | SW SE | 13 | dug | 23 | 22 | 50 | dry | hard | gravel | '' | C. Ward |
| 11 | NW SE | 13 | drilled | 29 | 20 | 300 | no change | hard | gravel | '' | R. Ward |
| 12 | SW SW | 13 | dug | 28 | 18 | 400 | no change | hard | gravel | '' | Chris Wilcox |
| 13 | SW SW | 13 | dug | 28 | 20 | 200 | dry | hard | gravel | alluvium | O. Wilcox |
| 14 | SE SE | 14 | dug | 30 | 25 | 200 | dry | hard | limestone | '' | Elvin Wilcox |
| 15 | SW SE | 23 | drilled | 83 | 75 | 25 | 16 | hard | limestone | Wann | Lyttle |
| 16 | NE SE | 24 | dug | 21 | 10 | ? | 50 | hard | limestone | Dewey | ........................ |
| 17 | SE NE | 25 | dug | 25 | 18 | 25 | dry | hard | limestone | '' | Upchurch |
| 18 | NW NW | 25 | dug | 26 | 26 | 25 | dry | hard | limestone | '' | J. P. Bibles |
| 19 | NW NE | 25 | dug and drilled | 63 | 23 | 100 | no change | hard | limestone | '' | J. P. Bibles |
| 20 | SE SE | 25 | drilled | 20 | 15 | 2500 | no change | hard | limestone | '' | Fannie Roberts |
| 21 | SW NE | 36 | dug | 35 | 25 | 500 | ? | hard | alluvium | alluvium | V. Larkins |

## T. 24 N., R. 13 E., WASHINGTON COUNTY

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SW SW | 1 | drilled | 22 | 16 | 1000 | no change | hard | limestone | Coffeyville | F. G. Ray |
| 2 | SW SW | 1 | dug | 18 | 12 | 1000 | no change | soft | sand | '' | F. G. Ray |
| 3 | NE SE | 1 | drilled | 25 | 16 | 300 | no change | hard | limestone | '' | W. White |
| 4 | SE SW | 2 | dug | 20 | 16 | 350 | no change | hard | limestone | '' | E. F. Bridges |
| 5 | SE SW | 2 | dug | 23 | 15 | 700 | no report | soft | sandstone | '' | E. F. Bridges |
| 6 | NE SE | 2 | dug | 33 | 27 | 500 | no change | soft | sandstone | '' | A. J. Mitchell |
| 7 | SE NW | 2 | dug | 25 | 25 | 50 | no report | soft | sandstone | '' | Ellis Shoupe |
| 8 | SW NE | 2 | dug | 25 | 4 | 500 | no report | soft | sandstone | '' | Ellis Shoupe |
| 9 | SW SW | 2 | dug | 15 | 9 | 500 | dry | soft | limestone | Coffeyville | Loan Company |
| 10 | SW SW | 2 | dug | 18 | 16 | 50 | 15 | soft | gravel | alluvium | G. E. Robinson |
| 11 | SW NE | 2 | dug | 12 | 6 | 300 | dry | soft | gravel | '' | G. E. Robinson |
| 12 | NE SW | 3 | dug | 22 | 20 | 100 | dry | soft | sandstone | Nellie Bly | David Overacker |
| 13 | NW SE | 3 | dug | 23 | 5 | 200 | no change | soft | sandstone | Coffeyville | Some Loan Company |
| 14 | NE NW | 3 | drilled | 45 | 30 | 600 | no change | ? | sandstone | '' | J. E. Schneider |
| 15 | NE NE | 3 | drilled | 30 | 22 | 500 | no change | soft | sandstone | '' | A. Wilson |
| 16 | SW SW | 4 | dug | 20 | 15 | 600 | dry | soft | gravel | alluvium | R. E. Baggess |
| 17 | NE NE | 4 | drilled | 30 | 22 | 500 | no change | soft | sandstone | Nellie Bly | .................... |
| 18 | SW NE | 5 | dug | 31 | 8 | 600 | dry | hard | limestone | '' '' | Estella Drawbaugh |
| 19 | NE NW | 5 | drilled | 50 | 40 | 50 | no change | hard | limestone | '' '' | Bevt. Sturm |
| 20 | SW NW | 6 | drilled | 30 | 21 | 100 | no change | hard | limestone | '' '' | Huling Macintosh |
| 21 | SW SW | 6 | dug | 25 | 18 | 50 | dry | hard | limestone | '' '' | R. M. Ogle |
| 22 | NW SW | 6 | dug | 11 | 5 | 6000 | no change | hard | gravel | alluvium | R. M. Ogle |
| 23 | SW NW | 6 | dug | 20 | 16 | 500 | no change | hard | no report | Dewey | Huling Macintosh |
| 24 | NE NW | 7 | drilled | 45 | 30 | 600 | no change | gyp | limestone | Nellie Bly | G. W. Lucas |
| 25 | NE NW | 7 | dug | 35 | 25 | 500 | no change | hard | limestone | '' '' | G. W. Lucas |
| 26 | NW NE | 7 | dug | 14 | 10 | 200 | no change | soft | gravel | alluvium | J. F. Lucas |

T. 24 N., R. 13 E., WASHINGTON COUNTY—(Continued)

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 27 | SW SW | 7 | drilled | 30 | 20 | 500 | no change | hard | limestone | Dewey | Geo. V. Sears |
| 28 | NE SW | 7 | dug | 30 | 20 | 500 | no change | hard | unknown | Nellie Bly | Geo. V. Sears |
| 29 | NE SW | 7 | spring | 4 | 0 | 500 | no change | soft | sand | ” ” | Joe Prather |
| 30 | SW SW | 7 | dug | 22 | 18 | 200 | dry | hard | limestone | Wann | Joe Prather |
| 31 | NW SW | 7 | dug | 20 | 5 | 200 | no change | hard | limestone | Nellie Bly | Wm. Sears |
| 32 | NW SE | 9 | dug | 14 | 10 | 400 | no change | hard | gravel | alluvium | John Washington |
| 33 | NE NW | 10 | dug | 12 | 6 | 300 | dry | soft | gravel | ” | Frank Harris |
| 34 | NE NW | 10 | dug | 24 | 14 | 400 | no change | hard | limestone | Coffeyville | Frank Harris |
| 35 | SE NE | 11 | dug | 17 | 15 | 600 | no change | soft | sand | alluvium | Maud E. Adcock |
| 36 | SW SE | 11 | dug | 30 | 20 | 50 | no report | hard | limestone | Coffeyville | Willie McCoulgh |
| 37 | NE SE | 12 | drilled | 20 | ? | 200 | no change | soft | sandstone | ” | Frank Harris |
| 38 | SE NE | 12 | dug | 30 | 25 | 300 | no change | hard | limestone | ” | John Street |
| 39 | NE NW | 12 | drilled | 28 | ? | 200 | dry | hard | limestone | ” | Elva Baker |
| 40 | NW NW | 12 | dug | 20 | 10 | 300 | no change | hard | limestone | ” | T. B. Christian |
| 41 | SE SE | 13 | dug | 20 | 18 | 50 | no change | soft | sandstone | ” | Page Home |
| 42 | SW SW | 13 | dug | 16 | 14 | 75 | no change | hard | limestone | ” | Foster |
| 43 | NE SE | 14 | ? | 28 | 22 | ? | no change | hard | gravel | alluvium | H. C. Rodebaugh |
| 44 | SW SE | 15 | dug | 35 | 30 | 100 | dry | hard | limestone | Coffeyville | J. F. Camel |
| 45 | SW SW | 15 | dug | 18 | 8 | 200 | 150 | hard | limestone | ” | Sinclair-Prairie |
| 46 | NE NE | 15 | dug | 25 | 19 | 500 | 5 | hard | limestone | ” | Frank Harris |
| 47 | NW NW | 18 | dug | 30 | 10 | 350 | no change | hard | gravel | alluvium | Lizzyetter Van Camp |
| 48 | NW NW | 18 | dug | 25 | 0 | 600 | 150 | soft | gravel | ” | Lizzyetter Van Camp |
| 49 | SE NE | 18 | dug | 16 | 7 | 50 | 50 | hard | limestone | Nellie Bly | J. M. Heine |
| 50 | SE NW | 18 | dug | 30 | 10 | 600 | 100 | hard | sandstone | ” ” | S. B. Ward |
| 51 | SW SE | 19 | dug | 24 | 23 | 150 | dry | gyp | limestone | ” ” | Laughlin |
| 52 | NW NE | 19 | dug | 27 | 27 | 1000 | dry | hard | limestone | ” ” | Edna Barlow |
| 53 | NE NW | 21 | drilled | 27 | 17 | 200 | no change | hard | gravel | alluvium | W. W. Tucker |
| 54 | SW SE | 21 | dug | 20 | 16 | 200 | no change | hard | limestone | Nellie Bly | W. H. Critenden |
| 55 | SW SW | 22 | dug | 30 | 21 | 200 | no change | hard | gravel | alluvium | Oran Tuby |
| 56 | SE SW | 22 | dug | 20 | 9 | 300 | no change | hard | sand | alluvium | S. C. Quah-Coffman |
| 57 | SW SE | 22 | dug | 25 | 20 | 300 | no change | hard | sandstone | Coffeyville | Geo. Walker |
| 58 | SE SE | 22 | dug | 15 | 10 | 200 | no change | hard | gray ss | ” | W. D. Donaldson |
| 59 | SW NW | 22 | dug | 30 | 24 | 200 | no change | hard | sandstone | ” | Henry Hotch |
| 60 | NW SW | 22 | dug | 18 | 8 | 300 | dry | gyp | gravel | alluvium | L. F. Robinson |
| 61 | SE SE | 23 | dug | 23 | 20 | 300 | no change | hard | gravel | ” | Carl Harris |
| 62 | NE NE | 23 | dug | 25 | 20 | 300 | no change | hard | gravel | ” | E. V. Lee |
| 63 | NW NW | 24 | drilled | 27 | 15 | 500 | no change | hard | limestone | Coffeyville | J. C. Tuten |
| 64 | NW NW | 24 | dug | 33 | 28 | 500 | no report | hard | limestone | ” | J. C. Tuten |
| 65 | SE SW | 24 | dug | 28 | 26 | 25 | dry | soft | sand | alluvium | Bartlesville ? |
| 66 | SE NE | 25 | dug | 28 | 24 | 600 | no change | soft | sandstone | Coffeyville | Mrs. Johnson |
| 67 | NW NW | 25 | dug | 30 | 27 | 50 | no change | soft | sandstone | ” | Charlie Sears |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 68 | NW NE | 25 | drilled | 20 | 14 | 200 | no change | soft | sandstone | ” | W. M. McRory |
| 69 | SE SW | 25 | dug | 28 | 24 | 600 | no change | hard | gravel | alluvium | W. O. Jones |
| 70 | NW SE | 27 | dug | 20 | 15 | ? | no report | hard | limestone | ” | Not reported |
| 71 | SE SE | 27 | drilled | 20 | 15 | 300 | no change | hard | limestone | ” | C. Russel |
| 72 | SE SW | 28 | dug | 21 | 18 | 5000 | no change | soft | sandstone | ” | Mr. Sears |
| 73 | SW SE | 28 | dug | 35 | 20 | ? | no change | soft | sandstone | ” | City of Ramona |
| 74 | NE SW | 28 | dug | 25 | 18 | 50 | no change | soft | sandstone | ” | Jim Horseman |
| 75 | NE SW | 28 | dug | 24 | 18 | 50 | dry | hard | limestone | ” | Mary Copenhaver |
| 76 | NE SW | 28 | dug | 30 | 28 | 25 | dry | hard | limestone | ” | Harold Works |
| 77 | NE SW | 28 | dug | 40 | 30 | 300 | no change | hard | sandstone | ” | Bill Steel |
| 78 | SW NW | 28 | dug | 30 | 18 | ? | no report | hard | limestone | ” | Not reported |
| 79 | NW NW | 29 | dug | 22 | 19 | 200 | 25 | hard | limestone | ” | A. L. Cole |
| 80 | NW NW | 29 | drilled | 20 | 15 | 100 | 10 | hard | limestone | ” | A. L. Cole |
| 81 | NW NW | 29 | dug | 25 | 20 | 250 | 50 | soft | sandstone | Nellie Bly | A. L. Cole |
| 82 | NE NE | 30 | dug | 40 | 39 | 800 | dry | hard | limestone | alluvium | W. S. Greenwood |
| 83 | NE NE | 35 | dug | 22 | 19 | 100 | no change | soft | gravel | ” | Chas. Williams |
| 84 | NW NE | 35 | dug | 30 | 29 | 50 | no change | soft | sandstone | Coffeyville | Nat'l. Bank of Commerce |
| 85 | NW NW | 35 | dug | 18 | 15 | 1000 | no change | soft | gravel | alluvium | Walter Sears |
| 86 | NW NW | 35 | dug | 28 | 18 | 50000 | no change | soft | gravel | ” | Walter Sears |
| 87 | SW NW | 35 | dug | 35 | 30 | 1000 | no change | soft | sandstone | ” | R. L. Swan |
| 88 | SW NW | 35 | dug | 18 | 12 | 5000 | no change | hard | gravel | ” | R. L. Swan |
| 89 | NE NW | 36 | dug | 40 | 36 | 500 | no change | soft | sandstone | Coffeyville | R. L. Chew |
| 90 | SE SW | 36 | dug | 22 | 3 | ? | no report | soft | gravel | alluvium | Not reported |
| 91 | SW SW | 36 | drilled | 34 | 31 | 10 | no change | hard | gravel | ” | Durther Boone |
| 92 | SW NW | 36 | dug | 35 | 29 | 15 | no change | hard | gravel | ” | Jim Sterp |
| 93 | SE SE | 36 | dug | 30 | 29 | 10 | no change | hard | gravel | ” | Finley |
| 94 | NW SE | 36 | dug | 30 | 26 | 200 | no change | hard | gravel | ” | Not reported |
| 95 | SW NE | 36 | drilled | 34 | 32 | 25 | no change | hard | gravel | ” | Jim Atterberry |

## T. 24 N., R. 14 E., WASHINGTON COUNTY

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SW SW | 5 | dug | 17 | 13 | 400 | no change | soft | sand, gravel | alluvium | T. J. Craig |
| 2 | SE NE | 6 | dug | 16 | 16 | ? | no report | hard | limestone | Coffeyville | S. E. Retcleff |
| 3 | NW NW | 6 | drilled | 62 | 30 | 500 | no report | soft | sandstone | alluvium | H. A. Pendergraft |
| 4 | NE NE | 7 | dug | 26 | 20 | 100 | 15 | soft | sandstone | ” | Not reported |
| 5 | NW NW | 7 | drilled | 26 | 20 | 100 | 20 | soft | sandstone | ” | Not reported |
| 6 | NE NE | 7 | dug | 25 | 21 | 50 | 10 | hard | limestone | ” | Not reported |
| 7 | NE NW | 8 | dug | 20 | 12 | ? | no report | soft | sandstone | Coffeyville | Not reported |
| 8 | NE NW | 8 | ? | 20 | 12 | 100 | no change | soft | sandstone | ” | Tyner School |
| 9 | NW SW | 8 | dug | 36 | 36 | ? | dry | no report | shale | ” | T. W. Gray |
| 10 | NW NW | 8 | spring | 7 | 0 | 50 | no change | soft | sandstone | ” | T. W. Gray |
| 11 | NW NE | 9 | dug | 18 | 16 | 300 | no change | soft | sandstone | ” | Adams Ranch |
| 12 | NE NE | 9 | dug | 20 | 16 | ? | no change | salty | sandstone | ” | Adams Ranch |
| 13 | SW SE | 17 | dug | 22 | 19 | 150 | no change | hard | sandstone | ” | R. M. Steel |
| 14 | NE NE | 30 | dug | 30 | 20 | 500 | no change | soft | sand | alluvium | I. Gilbert |
| 15 | NE SE | 31 | dug | 35 | 30 | 500 | no change | soft | gravel | alluvium | Joe Little |

## T. 24 N., R. 14 E., WASHINGTON COUNTY—Continued

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | NW SE | 31 | drilled | 30 | 25 | 50 | no change | hard | sandy clay | alluvium | Fred Gundey |
| 17 | NE SW | 31 | drilled | 30 | 25 | 100 | no change | hard | gravel | " | T. Odell |
| 18 | SE NE | 31 | drilled | 35 | 34 | 5 | no change | hard | gravel | " | Harve Workman |
| 19 | SW NW | 31 | dug | 35 | 31 | 200 | no change | hard | gravel | " | Pete McCormick |
| 20 | NW NE | 31 | dug | 32 | 31 | 10 | dry | hard | gravel | " | Not reported |
| 21 | NE NE | 32 | dug | 22 | 12 | 300 | no change | hard | black shale | Coffeyville | J. I. Owens |
| 22 | NW NE | 32 | dug | 21 | 16 | 150 | no change | soft | white sand | alluvium | J. I. Owens |
| 23 | NE NW | 32 | dug | 35 | 15 | 400 | no report | hard | gravel | " | E. Harvey |
| 24 | SW SE | 33 | dug | 25 | 15 | 300 | no change | hard | gravel | " | H. Corey |

## T. 25 N., R. 12 E., WASHINGTON COUNTY

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SE SE | 1 | drilled | 30 | 27 | 100 | no change | hard | sandy gravel | alluvium | W. A. Hunt |
| 2 | SE SE | 1 | spring | | | 200 | no change | hard | sandstone | Nellie Bly | W. A. Hunt |
| 3 | SE SW | 1 | dug | 30 | 29 | ? | dry | hard | limestone | " " | John Hays |
| 4 | SW NW | 1 | drilled | 18 | 14 | 100 | 15 | soft | sandstone | Cottage Grove | E. E. Manley |
| 5 | NE SE | 11 | dug | 20 | 18 | 100 | dry | salty | sandstone | " " | Mollie Swannock |
| 6 | SW NE | 11 | dug | 10 | 1 | 50 | dry | hard | sandstone | " " | McItosh |
| 7 | SW NE | 12 | drilled | 30 | 27 | 75 | no change | hard | sandstone | Nellie Bly | Roscoe Hays |
| 8 | NE NW | 12 | drilled | 25 | 23 | 75 | no change | hard | sandstone | " " | Roscoe Hays |
| 9 | SW SE | 12 | dug | 20 | 19 | ? | dry | hard | limestone | Dewey | J. Bryant |
| 10 | NW SE | 12 | spring | 10 | 5 | ? | no change | hard | limestone | Dewey | J. Bryant |
| 11 | SE SW | 13 | dug | 20 | 18 | 200 | 50 | hard | limestone | Dewey | W. Beal |
| 12 | NW SW | 13 | dug | 30 | 30 | 100 | dry | hard | limestone | Dewey | Ralph T. Davis |
| 13 | NW SE | 13 | dug | 45 | 45 | 100 | dry | hard | limestone | Dewey | T. J. Ellis, Jr. |
| 14 | NW SE | 13 | dug | 50 | 48 | 150 | 30 | hard | limestone | Dewey | T. J. Ellis, Jr. |
| 15 | SE SE | 14 | dug | 35 | 33 | 200 | 25 | hard | limestone | Dewey | Duke Bronsen |
| 16 | SW SE | 14 | dug | 40 | 36 | 300 | 50 | hard | limestone | Dewey | J. W. Elan |
| 17 | SW SE | 14 | drilled | 35 | 35 | 100 | dry | hard | limestone | Dewey | J. W. Elan |
| 18 | SE SE | 23 | dug | 25 | 25 | dry | dry | no report | limestone | Dewey | Frank Flannigan |
| 19 | SE SE | 23 | dug | 25 | 25 | dry | dry | no report | limestone | Dewey | Frank Flannigan |
| 20 | SE NE | 24 | dug | 30 | 20 | 300 | dry | soft | sandstone | Nellie Bly | Mrs. T. E. Stacey |
| 21 | SW SW | 24 | spring | 12 | 11 | 200 | 50 | hard | limestone | Dewey | W. C. Smith |
| 22 | NE NW | 24 | dug | 28 | 26 | 100 | dry | soft | sandstone | Nellie Bly | T. J. Ellis |
| 23 | NW NE | 24 | dug | 28 | 27 | 3200 | 200 | hard | sandstone | alluvium | E. S. Biggerstoff |
| 24 | SW SE | 25 | dug | 20 | 18 | 150 | dry | gyp | limestone | Dewey | T. J. Ellis |
| 25 | SW SW | 25 | dug | 35 | 34 | 200 | dry | hard | limestone | Dewey | J. S. Hansard |
| 26 | SE NE | 26 | dug | 20 | ? | 200 | dry | hard | limestone | Wann | Kay Hawks |
| 27 | SE NE | 26 | dug | 21 | 18 | 200 | 100 | hard | limestone | Wann | J. M. McKinney |
| 28 | NE NE | 35 | dug | 22 | 20 | 200 | 100 | hard | limestone | Dewey | I. C. Hadlock |
| 29 | NW NW | 36 | dug | 25 | 23 | 200 | 50 | soft | limestone | Dewey | Roy Boggess |

## T. 25 N., R. 13 E., WASHINGTON COUNTY

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SE NW | 3 | dug | 25 | 21 | 150 | good | hard | limestone | Hogshooter | Jim Walker |
| 2 | SW SW | 3 | dug | 22 | 8 | ? | good | hard | no report | Nellie Bly | Jacob Nichter |
| 3 | SE SW | 4 | dug | 18 | 15 | 500 | good | hard | gravel | alluvium | R. Patterson |
| 4 | NE NW | 5 | drilled | 24 | 20 | 50 | no change | hard | sand | Nellie Bly | W. W. Fugate |
| 5 | SE SE | 5 | dug | 20 | 22 | 400 | no change | hard | gravel | alluvium | J. S. Buoy |
| 6 | SE SW | 6 | drilled | 40 | 38 | 50 | no change | hard | gravel | " | Irvin |
| 7 | NE NW | 7 | dug | 29 | 20 | 600 | no change | soft | gravel | " | Irvin |
| 8 | SE NE | 9 | drilled | 17 | 10 | 500 | very good | hard | quicksand | alluvium | W. M. Melton |
| 9 | NW NW | 9 | drilled | 40 | 38 | 50 | dry | hard | limestone | Nellie Bly | Fred Smith |
| 10 | SE SE | 10 | drilled | 36 | 20 | 100 | fair | hard | limestone | Hogshooter | J. T. Sears |
| 11 | NW SW | 11 | drilled | 32 | 21 | 25 | dry | soft | gravel | alluvium | Frank Bixler |
| 12 | SW SW | 11 | dug | 32 | 30 | 40 | dry | soft | gravel | alluvium | Frank Bixler |
| 13 | NW NW | 11 | dug | 18 | 17 | 10 | dry | hard | limestone | Hogshooter | C. M. Robbison |
| 14 | NW SW | 13 | dug | 40 | 20 | 500 | no change | soft | gravel | alluvium | Phillips Petr. Corp. |
| 15 | NW NE | 14 | dug | 18 | 15 | 200 | no change | hard | sandstone | Coffeyville | J. W. Cranor |
| 16 | NW SE | 14 | dug | 35 | 32 | 500 | no change | hard | gravel | alluvium | Howard Morrow |
| 17 | NW SW | 14 | drilled | 32 | 28 | 100 | no change | hard | gravel | " | Joe Brookshire |
| 18 | NE NE | 15 | drilled | 40 | 25 | 250 | good | hard | limestone | Hogshooter | J. T. Sears |
| 19 | SW SW | 15 | drilled | 30 | 26 | 100 | dry | hard | alluvium | alluvium | Don Tyler |
| 20 | NE SW | 17 | dug | 25 | 22 | 500 | no change | hard | gravel | alluvium | John Stone Ranch |
| 21 | NE SW | 17 | dug | 20 | 10 | 10000 | no change | hard | gravel | " | Ellis Measles |
| 22 | NW NE | 17 | drilled | 20 | 14 | 1000 | no change | soft | sand | " | Myers |
| 23 | SW NW | 18 | dug | 30 | 20 | 500 | no change | hard | ? | Dewey | H. V. Foster |
| 24 | SE NE | 18 | drilled | 34 | 12 | 200 | no change | soft | gravel | alluvium | H. L. Bryant |
| 25 | SW NW | 18 | dug | 15 | 9 | 10000 | no change | hard | gravel | " | E. S. Scrooggins |
| 26 | NW SW | 19 | dug | 12 | 6 | 300 | no change | no report | sandstone | Nellie Bly | H. V. Foster |
| 27 | SW NW | 19 | dug | 20 | 10 | 750 | no change | hard | limestone | " " | H. V. Foster |
| 28 | SE NW | 19 | dug | 25 | 15 | 1250 | no change | hard | limestone | " " | H. V. Foster |
| 29 | SE SE | 22 | dug | 20 | 17 | 50 | no change | soft | sandstone | Coffeyville | Tinker Hains |
| 30 | SE SE | 22 | dug | 45 | 23 | 25 | no change | hard | sandstone | " | Elmer Benifield |
| 31 | SW NW | 23 | dug | 35 | 25 | 100 | no change | hard | limestone | " | W. T. Moore |
| 32 | NW SW | 23 | dug | 20 | 15 | 300 | no change | soft | sandstone | " | Chas. Rotona |
| 33 | NW SW | 23 | spring | 1 | 0 | 50 | no change | soft | sandstone | " | Mrs. Jackson |
| 34 | SW NW | 24 | dug | 45 | 30 | ? | no change | hard | sandy | " | Alma Eastin |
| 35 | SE SW | 26 | drilled | 75 | 65 | 300 | no change | hard | gravel | alluvium | J. J. Serome |
| 36 | NW SW | 26 | dug | 35 | 34 | 710 | 10 | hard | limestone | Coffeyville | R. Rose |
| 37 | NE SE | 27 | dug | 12 | 11 | 50 | dry | hard | sandstone | " | Allen Martin |
| 38 | SW NE | 27 | drilled | 225 | 125 | 300 | no change | hard | limestone | " | Gus Garrett |
| 39 | NE NE | 27 | dug | 40 | 39 | 500 | dry | hard | sandstone | " | L. E. Selby |
| 40 | NW SW | 30 | dug | 30 | 6 | 800 | no report | hard | limestone | " | O. Bennett |
| 41 | SE NE | 31 | drilled | 20 | 18 | 300 | 15 | hard | limestone | Dewey | Dee Waltman |
| 42 | NW SW | 32 | dug | 25 | ? | 200 | dry | hard | limestone | Coffeyville | Mrs. Quickle |
| 43 | NW SE | 34 | dug | 23 | 22 | 200 | fair | hard | limestone | " | W. C. Buttman |
| 44 | NW SE | 34 | dug | 14 | 11 | 100 | no change | hard | limestone | " | Alex Johnson |
| 45 | NE SW | 35 | | 20 | 14 | 300 | no change | hard | limestone | " | Thomas Liver |
| 46 | SE SE | 35 | dug | 35 | 30 | 400 | no change | hard | gravel | alluvium | Ben Allen |
| 47 | SE NE | 36 | drilled | 32 | 17 | 300 | no change | hard | gravel | " | John Hays |

## T. 25 N., R. 14 E., WASHINGTON COUNTY

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NE NW | 5 | drilled | 20 | 19 | 150 | dry | soft | sandstone | Coffeyville | M. L. Pace |
| 2 | NW NW | 5 | drilled | 40 | 32 | 100 | 50 | soft | sandstone | " | M. L. Pace |
| 3 | SE NE | 5 | dug | 20 | 19 | 150 | 50 | soft | sandstone | " | D. T. Kitchen |
| 4 | SW SE | 5 | dug | 20 | 13 | 200 | low | soft | sandstone | " | F. L. Nyhard |
| 5 | SW SW | 5 | dug | 23 | 20 | 600 | 400 | soft | sandstone | " | Carl Greenwood |
| 6 | SW SW | 5 | dug | 24 | 20 | 400 | 150 | hard | sandstone | " | Carl Greenwood |
| 7 | SW SE | 6 | dug | 22 | 20 | ? | unknown | hard | blue mud | alluvium | J. M. Hoss |
| 8 | NW NW | 6 | dug | 25 | 24 | 200 | dry | hard | limestone | Hogshooter | Chas. Bills |
| 9 | SW SW | 7 | drilled | 80 | 65 | 15 | dry | hard | limestone | Coffeyville | ........................ |
| 10 | NE NW | 7 | dug | 15 | 6 | 250 | good | hard | gravel | alluvium | R. D. Miller |
| 11 | SW NW | 8 | dug | 14 | 13 | 200 | dry | hard | gravel | " | C. M. Greenwood |
| 12 | NE NW | 8 | dug | 35 | 15 | 500 | good | hard | limestone | Coffeyville | W. A. Marshall |
| 13 | NW NW | 17 | dug | 25 | 24 | 25 | dry | soft | gravel | alluvium | S. C. Tate |
| 14 | NW SW | 18 | dug | 40 | 40 | 250 | dry | no report | sandstone | Coffeyville | C. L. Hawkins |
| 15 | NE SW | 19 | drilled | 30 | 25 | 400 | 200 | hard | limestone | " | Mrs. Sanders |
| 16 | NE NE | 19 | dug | 30 | 20 | 500 | 150 | soft | sandstone | " | Eugena Styles |
| 17 | NE NW | 19 | dug | 46 | 40 | 600 | 150 | hard | limestone | " | Guy Ash |
| 18 | SW SW | 20 | dug | 12 | dry | 500 | dry | hard | sandstone | " | Walter Topping |
| 19 | SW SW | 21 | dug | 22 | 22 | 100 | dry | soft | sandstone | " | Edson Neely |
| 20 | SE NW | 21 | dug | 35 | 34 | 5 | no change | hard | sandstone | " | Gum Brothers |
| 21 | NW NW | 21 | spring | 6 | 0 | 50 | no change | hard | limestone | Coffeyville | Willions |
| 22 | NE NE | 21 | dug | 20 | 17 | 300 | no change | soft | gravel | alluvium | P. W. Carle |
| 23 | NE NE | 28 | drilled | 65 | 45 | 50 | no change | hard | gravel | " | L. C. Lindley |
| 24 | SE NE | 28 | dug | 25 | 20 | 50 | no change | hard | sandstone | Coffeyville | W. M. Johnson |
| 25 | SW NW | 28 | drilled | 35 | 29 | 300 | no change | soft | sandstone | " | J. W. Blankenship |
| 26 | NW NW | 28 | dug | 28 | 26 | 200 | no change | soft | sandstone | " | Upshaw |
| 27 | NE NW | 29 | dug | 16 | 14 | 50 | good | hard | sandstone | " | J. D. Burris |
| 28 | SW NW | 30 | dug | 28 | 22 | 300 | no change | soft | sandstone | " | W. W. Dart |
| 29 | SE SE | 31 | dug | 65 | dry | dry | dry | ? | no report | ................ | Roy Miller |

## T. 26 N., R. 12 E., WASHINGTON COUNTY

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SW NW | 1 | drilled | 25 | 22 | 50 | dry | hard | limestone | alluvium | E. C. Mullendore |
| 2 | SW NW | 1 | drilled | 35 | 10 | 200 | no change | hard | limestone | " | E. C. Mullendore |
| 3 | NE NW | 1 | dug | 20 | 8 | 500 | no change | hard | blue sand | " | Claude Shipley |
| 4 | NW NE | 1 | drilled | 28 | 26 | 30 | fair | hard | alluvium | " | L. Eisley |
| 5 | NW Cor. | 1 | dug | 20 | 18 | 15 | fair | soft | sand | " | F. H. Horton |
| 6 | SE SE | 2 | dug | 15 | 12 | 30 | no change | soft | sandstone | " | Mrs. Larmore |
| 7 | SW SE | 2 | dug | 17 | 12 | 75 | hard | no change | gravel | " | W. A. Saurer |
| 8 | NE SW | 2 | dug | 12 | 7 | 20 | dry | hard | gravel | " | Oscar Olson |
| 9 | NE SW | 2 | drilled | 25 | 17 | 400 | no change | hard | gravel | " | J. F. Solomon |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | SE NW | 2 | dug | 12 | 11 | 20 | dry | soft | gravel | ” | Harry Baker |
| 11 | SE NW | 2 | drilled | 23 | 17 | 30 | 30 | soft | quicksand | ” | J. C. Price |
| 12 | SE SE | 23 | dug | 25 | 20 | 1000 | no change | soft | sand | ” | D. L. Mercer |
| 13 | SE Cor. | 23 | drilled | 45 | 35 | 300 | 200 | hard | sandstone | Cottage Grove | School District 23 |
| 14 | SE NW | 24 | dug | 40 | 32 | 500 | no change | soft | sand | alluvium | Pearl Doyle |
| 15 | SW SE | 24 | dug | 50 | 30 | 500 | no change | soft | sand | ” | H. I. Bryant |
| 16 | NE SE | 35 | drilled | 37 | 36 | 100 | dry | hard | sandstone | Iola | Lank Reed |
| 17 | NE SE | 35 | dug | 20 | 20 | 100 | dry | hard | sandstone | ” | Lank Reed |
| 18 | NW NE | 35 | dug | 65 | 54 | 150 | 75 | salty | sandstone | ” | Betsy Covel |
| 19 | NW NW | 35 | dug | 23 | 22 | 100 | very low | hard | sandstone | ” | W. Riley |

## T. 26 N., R. 13 E., WASHINGTON COUNTY

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SW SW | 2 | drilled | 40 | 35 | 5 | poor | hard | limestone | Nellie Bly | W. R. Davis |
| 2 | SW SW | 3 | drilled | 136 | 126 | 50 | poor | hard | limestone | Hogshooter | Don Tyler |
| 3 | SE NE | 3 | dug | 20 | 19 | 10 | poor | hard | ” and shale | Dewey | H. E. Sampson |
| 4 | SW SW | 4 | dug | 19 | 14 | 300 | 250 | no report | sandstone | Nellie Bly | Jake Riggs |
| 5 | SE SW | 4 | dug | 18 | 17 | 65 | dry | hard | sandstone | ” ” | W. Phillips |
| 6 | SW SE | 4 | dug | 23 | 13 | 300 | 250 | soft | blue shale | ” ” | Fred J. Spies, Jr. |
| 7 | SE NE | 4 | dug | 16 | 14 | 200 | 100 | hard | blue shale | ” ” | W. F. Fox |
| 8 | NE NW | 4 | dug | 27 | 25 | 400 | 200 | hard | blue shale | ” ” | Vandall Bros. |
| 9 | NW NW | 4 | drilled | 27 | 21 | 200 | 50 | hard | limestone | ” ” | W. F. Hurt |
| 10 | SW NW | 4 | drilled | 65 | 25 | 200 | 20 | hard | sand | ” ” | H. A. Moran |
| 11 | NW SW | 4 | drilled | 40 | 36 | 250 | 20 | hard | limestone | ” ” | L. T. Hathaway |
| 12 | SW NW | 4 | drilled | 92 | 91 | 20 | dry | hard | limestone | ” ” | Mrs. T. H. Craig |
| 13 | SW SW | 4 | dug | 15 | 12 | 100 | no change | hard | blue shale | ” ” | Eula Hutchinson |
| 14 | SW SW | 4 | dug | 18 | 14 | 100 | 75 | hard | blue shale | ” ” | Annie Pasley |
| 15 | SW SW | 4 | dug | 25 | 24 | 300 | dry | soft | blue shale | ” ” | Grant Phillips |
| 16 | SE SE | 5 | dug | 25 | 23 | 200 | 15 | hard | limestone | ” ” | Mr. Stark |
| 17 | SE SE | 5 | drilled | 50 | 35 | 55 | no change | soft | blue shale | ” ” | Merle Johnston |
| 18 | SE SE | 5 | dug | 26 | 21 | 100 | 30 | hard | blue shale | ” ” | C. J. Sark |
| 19 | SE SE | 5 | drilled | 80 | 55 | 250 | 100 | soft | blue shale | ” ” | Ira Myers |
| 20 | NE SE | 5 | dug | 16 | 10 | 100 | 60 | hard | limestone | Dewey | Forrest Producing Co. |
| 21 | SE NE | 5 | dug | 20 | 18 | 100 | 20 | soft | blue shale | Nellie Bly | J. G. Sroufe |
| 22 | NE NE | 5 | dug | 32 | 31 | 100 | 20 | hard | blue shale | ” ” | D. M. Metcalf |
| 23 | NE NE | 5 | dug | 16 | 13 | 100 | 50 | hard | blue shale | ” ” | D. M. Metcalf |
| 24 | NE NE | 5 | dug | 20 | 14 | 100 | 60 | hard | blue shale | ” ” | D. M. Metcalf |
| 25 | SW NE | 5 | dug | 20 | 14 | 100 | 25 | hard | blue shale | ” ” | A. J. Webb |
| 26 | NE SW | 6 | drilled | 28 | ? | dry | dry | hard | limestone | Dewey | John Bitinis |
| 27 | SW SE | 6 | drilled | 30 | 20 | 50 | no change | hard | limestone | ” | Burlingame Oil Co. |
| 28 | SE SE | 7 | drilled | 30 | 26 | 250 | good | hard | sand | alluvium | C. A. Barkhurst |
| 29 | SW NW | 8 | drilled | 24 | 20 | 50 | no change | hard | sand | ” | Albert Pritchard |
| 30 | NE NE | 8 | dug | 12 | 5 | 100 | 75 | hard | blue shale | Nellie Bly | J. C. Colliver |
| 31 | NW NE | 8 | dug | 12 | 10 | 100 | 15 | soft | blue shale | ” ” | Ben Payn |
| 32 | NW NE | 8 | drilled | 75 | 72 | 55 | no change | soft, sulfur | blue shale | ” ” | S. L. Hughes |

## T. 26 N., R. 13 E., WASHINGTON COUNTY—Continued.

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated gallons per day Normal | Capacity Drought | Relative Quality of water | AQUIFER Produces from | AQUIFER Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | NW NE | 8 | dug | 8 | 3 | 150 | 55 | hard | blue shale | Nellie Bly | S. L. Hughes |
| 34 | NE NW | 8 | dug | 30 | 28 | 100 | 15 | hard | blue shale | " " | O. L. McQuinn |
| 35 | NE NW | 8 | drilled | 20 | 19 | 100 | 10 | soft | blue shale | " " | Mont Stevens |
| 36 | NW NW | 8 | dug | 24 | 18 | 300 | no change | hard | sand | alluvium | Luther Holaway |
| 37 | NE NE | 9 | dug | 21 | 18 | 250 | good | hard | limestone | Nellie Bly | B. L. Scurlouk |
| 38 | NW SW | 9 | dug | 23 | 20 | 15 | fair | soft | blue shale | Nellie Bly | J. R. Wade |
| 39 | SW NW | 9 | dug | 18 | 16 | 25 | poor | hard | blue shale | " " | J. Whiteturkey |
| 40 | NW NW | 9 | drilled | 30 | 24 | 15 | poor | hard | limestone | " " | J. Miller |
| 41 | SW SW | 10 | dug | 27 | 15 | 1250 | good | hard | ss. & shale | " " | B. F. Swick |
| 42 | SE SW | 10 | drilled | 84 | 75 | 30 | unknown | salty | limestone | Hogshooter | Don Tyler |
| 43 | SE NE | 13 | drilled | 60 | 55 | 200 | 10 | salt & soda | sandy lime | Nellie Bly | D. H. Snyder |
| 44 | SE NE | 13 | dug | 18 | 16 | 30 | 5 | hard | sandy lime | " " | D. H. Snyder |
| 45 | NW Cor. | 13 | drilled | 90 | 80 | ? | good | soft | sandstone | " " | D. M. Tyler |
| 46 | NW Cor. | 13 | spring | 10 | 10 | 100 | good | soft | sandstone | Cottage Grove | D. M. Tyler |
| 47 | SE SE | 13 | dug | 22 | 12 | 300 | no report | no report | sandy lime | Nellie Bly | P. R. Meyman |
| 48 | NW NE | 16 | dug | 18 | 14 | 750 | holds up | hard | limestone | " " | Jerry Toalson |
| 49 | NW NW | 17 | dug | 25 | 19 | 300 | no change | hard | alluvium | alluvium | C. V. Davis |
| 50 | NE NE | 17 | drilled | 50 | 42 | 500 | not dry | hard | ? | Nellie Bly | Jim Bryant |
| 51 | NE NW | 17 | dug | 25 | 23 | 300 | dry | hard | blue shale | " " | Mr. Bynum |
| 52 | NE NE | 18 | drilled | 30 | 10 | 200 | no change | hard | river gravel | alluvium | A. R. Edmondson |
| 53 | NW NW | 19 | dug | 21 | 16 | 500 | no change | salty | river gravel | " | Mr. Burlingame |
| 54 | SE SW | 19 | dug | 33 | 32 | 200 | dry | hard | river sand | " | John Kane |
| 55 | SE SE | 19 | dug | 18 | 15 | 500 | lowers | hard | limestone | Dewey | C. Burlingame |
| 56 | NE NE | 21 | dug | 18 | 14 | 100 | 50 | hard | blue shale | Chanute | J. L. Lair |
| 57 | NW NW | 22 | drilled | 18 | 16 | 100 | dry | hard | blue shale | " | J. W. Coke |
| 58 | NE NW | 22 | drilled | 60 | 50 | 55 | poor | hard | blue shale | Nellie Bly | James Coke |
| 59 | NW NE | 23 | dug | 10 | 8 | 150 | 50 | hard | limestone | Dewey | Leo McLain |
| 60 | NW NE | 24 | dug | 23 | 13 | 250 | good | hard | limestone | Nellie Bly | W. A. Mayberry |
| 61 | NW NE | 24 | spring | 10 | 5 | 55 | good | hard | limestone | " " | W. A. Mayberry |
| 62 | NW SW | 24 | dug | 20 | 10 | 300 | good | hard | sandy lime | " " | C. M. Kiefer |
| 63 | NE SE | 25 | dug | 18 | 15 | 100 | fair | soft | shale & lime | Coffeyville | W. H. Hutchison |
| 64 | NW Cor. | 25 | dug | 16 | 13 | 200 | 150 | hard | sandy lime | Nellie Bly | Preston Strait |
| 65 | SW SW | 27 | dug | 20 | 13 | 300 | good | soft | blue shale | Nellie Bly | W. G. Leamon |
| 66 | NW SW | 28 | dug | 24 | 16 | 200 | good | hard | blue shale | " " | A. W. Swort |
| 67 | NE NW | 29 | dug | 45 | 41 | 180 | dry | hard | limestone | Dewey | C. C. Wilson |
| 68 | NW SW | 29 | spring | 55 | 54 | 500 | lowers | hard | river sand | alluvium | Bert Warehime |
| 69 | SW NE | 29 | spring | 10 | 5 | 800 | good | hard | no report | " | Andrew Henderson |
| 70 | NE NE | 30 | dug | 14 | 11 | 200 | lowers | hard | limestone | Cottage Grove | Hillcrest Country Club |
| 71 | NE NE | 31 | dug | 30 | 28 | 50 | holds up | hard | river sand | alluvium | Nealas Wilson |
| 72 | SE NE | 31 | drilled | 86 | 35 | 840 | holds up | hard | river sand | " | A. Loriaux |
| 73 | SE NE | 31 | drilled | 40 | 15 | ? | holds up | hard | river sand | " | A. Loriaux |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 74 | SE SE | 31 | dug | 35 | 30 | 150 | holds up | hard | river sand | " | Mrs. Dave Suagee |
| 75 | SW SW | 31 | dug | 30 | 28 | 250 | dry | hard | river sand | " | National Oil Co. |
| 76 | SE SW | 32 | dug | 27 | 20 | 300 | holds up | hard | river sand | Nellie Bly | James Payton |
| 77 | SE NW | 32 | dug | 27 | 20 | 300 | holds up | hard | river sand | alluvium | Mr. Barrett |
| 78 | NE NW | 32 | dug | 35 | 21 | 300 | good | hard | limestone | Nellie Bly | Louis Tinker |
| 79 | NW Cor. | 33 | dug | 28 | 25 | 50 | poor | hard | blue shale | " " | Sykes |
| 80 | SW NW | 33 | dug | 34 | 24 | 100 | 30 | hard | white sand | " " | M. P. Thompson |
| 81 | SE SW | 33 | dug | 20 | 18 | 50 | poor | hard | blue shale | " " | J. C. Suggs |
| 82 | NW Cor. | 34 | dug | 18 | 8 | 150 | 50 | soft | blue shale | " " | J. M. Bird |
| 83 | NW Cor. | 34 | dug | 20 | 4 | 300 | good | soft | blue shale | " " | Not reported |
| 84 | NW Cor. | 34 | dug | 20 | 16 | 250 | good | soft | blue shale | " " | Not reported |
| 85 | SW SW | 34 | drilled | 51 | 48 | 50 | 10 | soft | limestone | " " | Lowe Steel |
| 86 | SW SE | 36 | spring | 14 | 13 | 300 | no water | hard | blue shale | " " | C. O. Pafley |

## T. 26 N., R. 14 E., WASHINGTON COUNTY

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NE SE | 7 | dug | 17 | 15 | 300 | 25 | hard | blue shale | Coffeyville | C. S. Kimbley |
| 2 | NE SE | 7 | spring | 7 | 3 | 250 | good | hard | limestone | Hogshooter | C. S. Kimbley |
| 3 | SE SE | 8 | dug | 18 | 16 | 150 | 50 | soft | sandy shale | Coffeyville | Amos Morter |
| 4 | NW NE | 16 | dug | 42 | 39 | 100 | dry | hard | limestone | " | R. Brinnemon |
| 5 | NW NE | 17 | dug | 48 | 38 | 200 | 100 | soft | blue shale | " | J. F. Rodgers |
| 6 | SE SE | 18 | dug | 33 | 18 | 500 | good | hard | limestone | Coffeyville | O. B. Cole |
| 7 | SW SE | 19 | bored | 27 | 21 | 25 | poor | hard | limestone | " | Keener Oil & Gas |
| 8 | SE SE | 19 | dug | 36 | 26 | 1000 | good | hard | limestone | " | O. B. Cole |
| 9 | SE SE | 20 | spring | 8 | 2 | 300 | good | hard | sandstone | " | C. E. Alexander |
| 10 | SW SW | 20 | dug | 50 | 30 | 500 | good | hard | limestone | " | R. R. Lacey |
| 11 | NE NW | 21 | dug | 25 | 23 | 500 | poor | hard | limestone | " | E. H. Lewis |
| 12 | NE Cor. | 21 | dug | 50 | 40 | 500 | good | soft | sandstone | " | O. Hoffman |
| 13 | SE SE | 21 | dug | 22 | 17 | 250 | good | soft | ls. & shale | " | T. F. Misee |
| 14 | NE SE | 28 | drilled | 160 | 80 | 10 | fair | hard | ls. & shale | " | H. Liston |
| 15 | NE SE | 28 | drilled | 150 | 12 | 1000 | fair | hard | ls. & shale | Hogshooter | H. Liston |
| 16 | SW NW | 29 | dug | 35 | 34 | 5 | poor | hard | soapstone | Coffeyville | Mrs. M. J. Truskett |
| 17 | NW NW | 29 | dug | 20 | 19 | 5 | poor | soft | sandstone | " | T. A. Truskett |
| 18 | SE SW | 30 | dug | 32 | 22 | 600 | good | soft | shale | " | W. S. Melton |
| 19 | SE SE | 30 | dug | 35 | 32 | 100 | good | hard | sandstone | " | J. E. Truskett |
| 20 | NE NW | 31 | dug | 26 | 14 | 300 | good | hard | limestone | " | Washington County |
| 21 | SW SE | 31 | dug | 18 | 13 | 30 | fair | soft | sandy lime | " | W. T. Adams |
| 22 | SE SE | 31 | drilled | 22 | 18 | 1000 | no change | hard | sandstone | " | Arthur Hawk |
| 23 | NE SE | 31 | dug | 35 | 2 | 50 | poor | hard | sandstone | " | Andrew Marshall |
| 24 | SE NE | 31 | drilled | 32 | 25 | 5 | poor | hard | shale | " | G. W. Tenant |
| 25 | SW NW | 32 | dug | 12 | 5 | 100 | poor | hard | limestone | " | Don Tyler |
| 26 | NW Cor. | 33 | spring | 3 | 2 | 25 | good | soft | shale | " | M. T. Clark |

## T. 27 N., R. 12 E., WASHINGTON COUNTY

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SE NW | 2 | dug | 35 | 31 | 600 | 150 | hard | limestone | Torpedo | D. M. Tyler |
| 2 | SE SW | 12 | dug | 27 | 25 | 100 | no change | hard | limestone | Wann | L. C. McLintock |
| 3 | SE NW | 12 | dug | 30 | 25 | 400 | 75 | hard | limestone | " | J. L. May |
| 4 | NE SW | 12 | drilled | 30 | 26 | 300 | no change | hard | limestone | " | D. M. Tyler |
| 5 | SW SW | 13 | dug | 25 | 25 | dry | dry | hard | limestone | " | C. Murphy |
| 6 | SW NW | 14 | dug | 14 | 10 | 500 | no change | hard | gravel | alluvium | W. Green |
| 7 | SE SE | 23 | dug | 36 | 34 | 500 | no change | hard | gravel | alluvium | Enterprise Transit Co. |
| 8 | NW NW | 24 | drilled | 25 | 15 | 500 | no change | hard | gravel | " | National Refining Co. |
| 9 | NW NW | 24 | drilled | 75 | 25 | 200 | no change | hard | gravel | " | Sinclair-Prairie |
| 10 | NW SE | 24 | drilled | 28 | 26 | 20 | no change | hard | gravel | " | Mrs. Fields |
| 11 | SW NW | 25 | dug | 22 | 16 | 100 | 25 | hard | limestone | " | National Oil Ref. Co. |
| 12 | NE NE | 25 | dug | 28 | 24 | 100 | 25 | hard | limestone | " | Don Tyler |
| 13 | SE NE | 25 | dug | 22 | 16 | 200 | 50 | hard | limestone | " | ? Carr |
| 14 | SW SE | 25 | drilled | 20 | 17 | 100 | no change | hard | limestone | " | May Brower |
| 15 | SW SE | 25 | drilled | 65 | 20 | 1000 | no change | gyp, salty | limestone | " | May Brower |
| 16 | SE NE | 26 | dug | 16 | 10 | 100 | 50 | gyp | limestone | " | W. B. Hicks |
| 17 | NE NE | 26 | drilled | 26 | 16 | 100 | no change | gyp | gravel | " | B. F. Scott |
| 18 | SE SW | 35 | dug | 20 | 14 | 200 | no change | soft | sandstone | " | R. G. Holley |
| 19 | NW SW | 36 | dug | 40 | 40 | ? | dry | no report | sandstone | " | C. A. Darnell |
| 20 | NW SW | 36 | dug | 15 | 15 | 100 | dry | soft | sandstone | " | C. A. Darnell |
| 21 | NE SW | 36 | drilled | 27 | 22 | 800 | 300 | hard | limestone | " | D. T Ward |

## T. 27 N., R. 13 E., WASHINGTON COUNTY

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SE NE | 2 | dug | 100 | 12 | 2000 | no change | soft | unknown | Cottage Grove | W. L. Hill |
| 2 | NW NE | 3 | drilled | 50 | 10 | 800 | no change | soft | gravel | " " | Don Tyler |
| 3 | SE SE | 3 | drilled | 50 | 25 | 400 | no change | hard | gravel | " " | Don Tyler |
| 4 | SE SW | 4 | dug | 28 | 20 | 400 | no change | soft | gravel | " " | A. M. Shrider |
| 5 | NE SE | 4 | dug | 20 | 16 | 300 | no change | hard | gravel | " " | Tom Barnes |
| 6 | NE NW | 4 | dug | 50 | 49 | 300 | no change | soft | gravel | " " | Fanney P. Stie |
| 7 | SW NW | 4 | dug | 23 | ? | 300 | no change | soft | gravel | " " | C. L. Bellmyer |
| 8 | SE SW | 5 | drilled | 25 | 21 | 100 | no change | soft | sandstone | " " | E. H. Case |
| 9 | SE SW | 5 | dug | 20 | 20 | 0 | no change | soft | sandstone | " " | E. H. Case |
| 10 | NE NE | 7 | drilled | 35 | 19 | 100 | no change | hard | unknown | alluvium | B. M. Tyler |
| 11 | SE SE | 8 | dug | 30 | 8 | 600 | 300 | soft | sandstone | Cottage Grove | John Demory |
| 12 | SE SW | 8 | drilled | 30 | 25 | 600 | no change | hard | alkali | " " | F. S. Stanley |
| 13 | SE SE | 8 | drilled | 37 | 31 | 500 | no change | hard | gravel | " " | Alex Taylor |
| 14 | SW NW | 9 | dug | 45 | 35 | 200 | no change | hard | limestone | " " | R. M. Fields |
| 15 | NW NW | 9 | dug | 16 | 16 | 300 | dry | gyp | sandstone | " " | Minnie Fouts |
| 16 | SW NW | 9 | dug | 19 | 15 | 400 | no change | hard | sandstone | " " | Minnie Fouts |
| 17 | SE NE | 9 | drilled | 26 | 20 | 200 | no change | hard | sandstone | " " | R. H. Steveson |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | SW SW | 9 | drilled | 22 | 20 | 100 | no change | hard | sandstone | " " | Barnsdall Oil Co. |
| 19 | SW NW | 10 | drilled | 20 | 10 | 500 | no change | soft | sandstone | " " | Quaide |
| 20 | NE NE | 10 | drilled | 18 | 14 | 500 | no change | soft | sandstone | " " | A. H. Bohls |
| 21 | NE SE | 10 | drilled | 35 | 33 | 50 | no change | hard | sandstone | " " | B. M. Tyler |
| 22 | SW SW | 10 | dug | 25 | 18 | 150 | no change | gyp | sandstone | " " | G. W. Baker |
| 23 | SE SE | 12 | drilled | 18 | 12 | 50 | no change | hard | limestone | Nellie Bly | J. Cyrcle |
| 24 | SW SE | 13 | dug | 30 | 25 | 150 | no change | hard | limestone | " " | C. M. McClano |
| 25 | SE NE | 15 | dug | 15 | 9 | 300 | no change | gyp | sandstone | Cottage Grove | I. C. Eakin |
| 26 | SW SE | 15 | drilled | 40 | 15 | 500 | no change | hard | limestone | Nellie Bly | Carl Stats |
| 27 | SW SW | 15 | dug | 12 | 10 | 50 | no change | hard | limestone | Dewey | B. N. Turley |
| 28 | SE SE | 15 | drilled | 29 | 12 | 300 | no change | hard | limestone | Nellie Bly | E. F. Cerpner |
| 29 | SE NE | 16 | dug | 18 | 18 | dry | no change | dry | limestone | Cottage Grove | John Holley |
| 30 | NW SW | 16 | drilled | 20 | 15 | 500 | no change | hard | sandstone | " " | E. R. Cheek |
| 31 | NW SW | 17 | drilled | 35 | 30 | 50 | no change | hard | limestone | " " | C. C. Cooley |
| 32 | SE SE | 17 | drilled | 18 | 9 | 300 | no change | hard | sandstone | " " | J. H. Turman |
| 33 | SW SW | 18 | drilled | 25 | 20 | 50 | no change | hard | sandstone | alluvium | Nona Miller |
| 34 | SE SE | 19 | dug | 40 | 30 | 250 | no change | hard | sandstone | " | Mr. Rowsey |
| 35 | NE SE | 19 | drilled | 25 | 13 | 50 | lowers | hard | sandstone | " | Pearl Colver |
| 36 | SW SW | 19 | drilled | 23 | 11 | 150 | no change | hard | river gravel | " | Cecil Peters |
| 37 | SW SW | 19 | drilled | 35 | 17 | 75 | no change | hard | river gravel | " | B. W. Thaxton |
| 38 | NE SE | 20 | drilled | 22 | 12 | 50 | no change | hard | gravel | Cottage Grove | Hattie Linn |
| 39 | NE NE | 20 | drilled | 25 | 18 | 75 | no change | hard | gravel | " " | Mrs. Harris |
| 40 | SE SW | 20 | drilled | 35 | 23 | 200 | no change | hard | sandstone | " " | Jessie Longbone |
| 41 | SE SW | 20 | drilled | 22 | 10 | 350 | no change | hard | sandstone | " " | Kern Perry |
| 42 | SW SW | 20 | dug | 40 | 30 | 200 | 50 | hard | limestone | Dewey | C. C. Cateman |
| 43 | SW NW | 22 | dug | 40 | 30 | 500 | 150 | hard | limestone | " | C. C. Cateman |
| 44 | SE SW | 23 | spring | 16 | 12 | 800 | no change | soft | limestone | Nellie Bly | W. R. Repp |
| 45 | SW SE | 23 | drilled | 40 | 30 | 300 | no change | soft | gravel | alluvium | Billie Longbone |
| 46 | NW NW | 23 | dug | 20 | 16 | 300 | no change | soft | gravel | Dewey | Sina Miller |
| 47 | NW NE | 24 | drilled | 18 | 16 | 40 | no change | salty | limestone | Nellie Bly | Bert Wilehime |
| 48 | NW NW | 26 | dug | 27 | 24 | 150 | no change | hard | sandstone | " " | Tyler |
| 49 | NW NW | 27 | drilled | 22 | 12 | 150 | 50 | hard | limestone | Dewey | Margaret B. Calvert |
| 50 | NW NW | 27 | drilled | 22 | 12 | 150 | 40 | hard | limestone | " | Margaret B. Calvert |
| 51 | NE NW | 27 | dug | 20 | ? | 300 | 150 | hard | limestone | " | Forres Prod. Co. |
| 52 | SE SE | 27 | dug | 16 | 3 | 400 | 100 | hard | limestone | " | A. A. Malm |
| 53 | NE NE | 28 | drilled | 30 | 28 | 50 | 10 | hard | limestone | " | Emmit Franklin |
| 54 | NE NE | 28 | drilled | 20 | 16 | 500 | no change | soft | sandstone | " | Ray Duncan |
| 55 | NW NE | 28 | drilled | 30 | 27 | ? | dry | hard | limestone | " | Don Tyler |
| 56 | NW NE | 28 | dug | 16 | 12 | 300 | dry | hard | limestone | " | Don Tyler |
| 57 | NW NE | 28 | dug | 15 | 12 | 300 | 50 | hard | limestone | " | Don Tyler |
| 58 | NE NW | 28 | ........ | 30 | 26 | 30 | no change | hard | limestone | " | Orvel Rose |
| 59 | NE SW | 28 | drilled | 21 | 15 | 100 | no change | hard | limestone | " | George Lorenz |
| 60 | SE SE | 29 | dug | 20 | 15 | 500 | no change | soft | sandstone | Nellie Bly | D. M. Tyler |
| 61 | NE SE | 29 | drilled | 24 | 23 | 300 | 50 | soft | sandstone | " " | C. L. Brothers |
| 62 | SW SE | 29 | drilled | 30 | 22 | 200 | no change | soft | sandstone | " " | Charles Gavellas |
| 63 | SW SE | 29 | drilled | 30 | 23 | 200 | no change | hard | limestone | Dewey | Charles Gavellas |

## T. 27 N., R. 13 E., WASHINGTON COUNTY—Continued.

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 64 | SW SE | 29 | drilled | 22 | 19 | 100 | no change | hard | limestone | Dewey | J. M. Haugh |
| 65 | SE SW | 29 | drilled | 17 | 14 | 300 | 50 | hard | limestone | " | Elmer Delozier |
| 66 | SE SW | 29 | drilled | 30 | 20 | 500 | 100 | hard | limestone | " | Ben Cleveland |
| 67 | SW NW | 29 | dug | 16 | 14 | 200 | 100 | soft | sandstone | Cottage Grove | I. E. Kendall |
| 68 | NW SW | 29 | drilled | 18 | 10 | 150 | no change | soft | sandstone | " " | Mary S. Harner |
| 69 | NW NW | 29 | dug | 20 | 18 | 200 | no change | hard | limestone | " " | John Turner |
| 70 | SW SE | 31 | drilled | 22 | 12 | 300 | no change | hard | limestone | Dewey | J. J. Rayner |
| 71 | NE NW | 31 | drilled | 21 | 13 | 100 | 25 | hard | limestone | " | E. D. Rayner |
| 72 | NE NW | 31 | drilled | 21 | 13 | 100 | 25 | hard | limestone | " | E. D. Rayner |
| 73 | NE NW | 32 | drilled | 22 | 14 | 100 | 25 | hard | limestone | " | Bud Hamilton |
| 74 | SE NW | 32 | drilled | 20 | 14 | 150 | 25 | hard | limestone | " | H. M. Hamilton |
| 75 | SE NW | 32 | drilled | 20 | 14 | 100 | 15 | hard | limestone | " | H. M. Hamilton |
| 76 | SE NW | 32 | drilled | 40 | 15 | 1000 | 400 | hard | limestone | " | H. M. Hamilton |
| 77 | SW NW | 32 | dug | 30 | 20 | 300 | 100 | hard | limestone | " | J. R. Hamilton |
| 78 | SE SW | 33 | drilled | 25 | 22 | 150 | 15 | hard | limestone | " | Dora B. Hamilton |
| 79 | SE SW | 33 | drilled | 100 | 50 | 400 | 50 | hard | limestone | Dewey | Dora B. Hamilton |
| 80 | SW SW | 33 | drilled | 18 | 15 | 150 | 15 | hard | limestone | " | Anna Treloggen |
| 81 | SW NW | 33 | dug | 27 | 20 | 400 | 100 | hard | limestone | " | Ola Wilhite |
| 82 | NW SW | 34 | drilled | 32 | 22 | 200 | 50 | hard | limestone | " | "Shorty" Douglass |
| 83 | SW SW | 35 | drilled | 34 | 32 | 15 | no change | soft | sandstone | Nellie Bly | T. T. Eatherly |
| 84 | NW SW | 35 | spring | 15 | 10 | 250 | no change | soft | sandstone | Cottage Grove | Mrs. Robinson |

## T. 27 N., R. 14 E., WASHINGTON COUNTY

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SE SW | 4 | drilled | 106 | ? | 600 | no change | soft | gravel | Nellie Bly | Sandidge |
| 2 | NE SE | 4 | dug | 23 | 21 | 200 | no change | soft | gravel | " " | Idlo Hudson |
| 3 | SE SE | 4 | drilled | 65 | 62 | 50 | no change | hard | gravel | " " | Bell Larmore |
| 4 | SW SW | 6 | dug | 17 | 16 | 25 | no change | hard | limestone | Cottage Grove | J. M. Mason |
| 5 | NE SE | 8 | dug | 12 | 6 | 250 | no change | hard | sandstone | Nellie Bly | Mrs. Scudder |
| 6 | SE SW | 8 | drilled | 35 | ? | 50 | dry | hard | limestone | " " | Mr. Wilson |
| 7 | SE SW | 8 | drilled | 75 | ? | ? | goes dry | hard | limestone | " " | Mr. Longhorn |
| 8 | SW SW | 9 | drilled | 16 | 15 | 200 | no change | hard | sandstone | " " | Orie Yellowjacket |
| 9 | SW SW | 20 | drilled | 47 | 25 | 150 | no change | hard | limestone | " " | Jack Montgomery |
| 10 | SW NE | 28 | spring | 7 | 0 | 100 | no change | hard | limestone | Dewey | W. S. Moore |
| 11 | NE NW | 29 | drilled | 53 | ? | dry | dry | ? | limestone | " | Jack Montgomery |

## T. 28 N., R. 12 E., WASHINGTON COUNTY

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NW NE | 23 | drilled | 20 | 15 | 200 | no change | soft | sandstone | "The Okesa" | Ralph Warren |
| 2 | SW SE | 23 | dug | 20 | 15 | 300 | no change | soft | sandstone | " " | Stella Warren |
| 3 | NW SW | 23 | drilled | 60 | 0 (flows) ? | | no report | no report | sandstone | Torpedo | Sarah T. Moore |
| 4 | NW SW | 24 | dug | 25 | 20 | 200 | dry | soft | sandstone | "The Okesa" | J. A. Metcalf |
| 5 | SW NE | 24 | dug | 42 | 35 | 100 | dry | soft | sandstone | " " | J. W. Metcalf |
| 6 | NE NE | 25 | dug | 30 | 20 | 900 | no change | soft | sandstone | Torpedo | Dewey Buckis |
| 7 | NE NW | 25 | dug | 51 | 35 | 2000 | no change | soft | sandstone | " | M. M. Yard |
| 8 | SE NE | 26 | drilled | ? | ? | 1000 | no change | soft | sandstone | " | Not reported |
| 9 | NE NE | 26 | dug | 22 | 20 | 300 | no change | hard | gravel | alluvium | Sarah T. Moore |
| 10 | SW NW | 26 | drilled | 11 | ? | 400 | no change | soft | sandstone | Torpedo | Sarah T. Moore |
| 11 | SW NE | 35 | dug | 51 | 48 | 200 | no change | hard | water sand | alluvium | T. H. Bellmyer |
| 12 | SW NE | 36 | dug | 18 | 13 | 600 | no change | hard | sand | " | R. L. Owens |
| 13 | SE NE | 36 | dug | 28 | 15 | 700 | no change | hard | gravel | " | John Sanders |

## T. 28 N., R. 13 E., WASHINGTON COUNTY

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SW SW | 1 | dug | 25 | 20 | 400 | no change | soft | sandstone | Torpedo | H. D. Edley |
| 2 | SW SE | 1 | dug | 35 | 30 | 500 | no change | soft | sandstone | " | Central Life Ins. Co. |
| 3 | SE SW | 2 | dug | 16 | 6 | 600 | no change | soft | sandstone | " | Heener Oil & Gas Co. |
| 4 | SE NE | 3 | spring | 2 | 0 | 50 | no change | soft | sandstone | " | O. Q. Stites |
| 5 | SE NE | 3 | drilled | 44 | 21 | 300 | no change | soft | sandstone | " | O. Q. Stites |
| 6 | SE SW | 3 | drilled | 44 | 9 | 300 | no change | soft | sandstone | " | Leslie Coff |
| 7 | SW SW | 3 | drilled | 75 | 35 | 300 | no change | soft | sandstone | " | H. A. Brewer |
| 8 | NE NE | 4 | dug | 18 | 9 | 500 | no change | hard | sandstone | " | W. J. Ingham |
| 9 | SW NE | 4 | drilled | 60 | 40 | 600 | no change | hard | limestone | Wann | Col. Griggs |
| 10 | NW NW | 4 | drilled | 50 | 40 | 50 | dry | hard | limestone | " | Wm. S. Burkins |
| 11 | SE SW | 4 | drilled | 60 | 50 | 600 | no change | soft | sandstone | Torpedo | T. A. Wagaman |
| 12 | SW SE | 4 | drilled | 46 | 28 | 200 | no change | soft | sandstone | " | C. E. Graham |
| 13 | SW SW | 5 | drilled | 180 | 80 | 800 | no change | soft | gravel | Cottage Grove | National Ref. Co. |
| 14 | NE SW | 5 | drilled | 103 | 50 | 800 | no change | soft | sandstone | Torpedo | L. H. Wells |
| 15 | SW SW | 5 | drilled | 70 | 40 | 500 | 300 | soft | sandstone | " | National Ref. Co. |
| 16 | SW SW | 6 | drilled | 45 | 35 | 300 | no change | hard | gravel | alluvium | Pierpoint |
| 17 | NW SE | 6 | drilled | 45 | 35 | 300 | no change | hard | gravel | " | R. E. Garrison |
| 18 | SE NW | 6 | spring | ? | ? | 600 | no change | soft | sandstone | Torpedo | Lulu Wilson |
| 19 | SW SE | 6 | drilled | 62 | 30 | 700 | no change | soft | sandstone | " | E. Johnson |
| 20 | SE NW | 7 | drilled | 57 | 45 | 100 | no change | soft | sandstone | Torpedo | C. E. Burkart |
| 21 | SE NW | 7 | drilled | 70 | 62 | 500 | no change | soft | sandstone | " | C. E. Burkart |
| 22 | NW NW | 7 | drilled | 60 | 40 | 200 | no change | soft | sandstone | " | Independence Oil Co. |
| 23 | NE SE | 7 | drilled | 66 | 40 | 100 | no change | soft | sandstone | " | A. W. Busmann |
| 24 | SW SW | 8 | drilled | 50 | 45 | 10 | no change | hard | limestone | " | H. V. Laprade |
| 25 | SW SW | 12 | drilled | 50 | 25 | 500 | no change | soft | sandstone | " | Gibs Lease |
| 26 | SW NW | 12 | dug | 25 | 20 | 300 | no change | soft | sandstone | " | C. N. Howard |
| 27 | NE NW | 12 | dug | 30 | 20 | ? | no change | soft | sandstone | " | J. E. Howard |
| 28 | SE NE | 12 | drilled | 28 | 18 | 400 | no change | soft | sandstone | " | Floyd Hins |
| 29 | NW SW | 12 | drilled | 40 | 15 | 300 | no change | soft | sandstone | " | J. F. Lucas |

T. 28 N., R. 13 E., WASHINGTON COUNTY—Continued.

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | SE SE | 14 | dug | 80 | 5 | 250 | no change | soft | sandstone | Torpedo | G. H. McClellam |
| 31 | NW NW | 14 | drilled | 36 | 25 | 1000 | no change | soft | sandstone | " | John Holland |
| 32 | NW SW | 14 | drilled | 60 | 48 | 400 | no change | soft | sandstone | " | Georgia Oil & Gas Co. |
| 33 | SE SW | 15 | dug | 40 | 30 | 2000 | no change | soft | sandstone | " | Art Hepner |
| 34 | SW SE | 15 | drilled | 35 | 25 | 500 | no change | soft | sandstone | " | A. C. Hunt |
| 35 | SW NW | 15 | drilled | 175 | 100 | 2000 | no change | soft | sandstone | Cottage Grove | Phillips & Kerlin |
| 36 | SE SW | 16 | drilled | 90 | 20 | 100 | no change | hard | limestone | Torpedo | F. Reynolds |
| 37 | SW NW | 16 | drilled | 75 | 25 | 3000 | no change | soft | sandstone | " | H. Davis |
| 38 | NE NE | 17 | dug | 23 | 14 | 300 | no change | hard | sandstone | " | J. J. Robison |
| 39 | SW SE | 17 | drilled | 75 | 60 | 100 | no change | hard | sandstone | " | B. Falleaf |
| 40 | SE SW | 17 | drilled | 61 | 59 | 50 | no change | soft | sandstone | " | T. Henry |
| 41 | SW SW | 18 | dug | 57 | 55 | 50 | no change | soft | sandstone | " | O. Laggal |
| 42 | SE NW | 18 | dug | 30 | 28 | 100 | no change | hard | limestone | " | H. L. Covtis |
| 43 | NW SW | 19 | dug | 50 | 25 | 25 | no change | hard | gravel | alluvium | D. M. Tyler |
| 44 | SW NW | 19 | spring | 1 | 0 | 100 | no change | soft | sandstone | Torpedo | Walter Wilson |
| 45 | NW NW | 19 | dug | 30 | 27 | 50 | no change | soft | sandstone | Torpedo | D. M. Tyler |
| 46 | SE NE | 19 | dug | 65 | 60 | 100 | no change | hard | sandstone | " | Mortgage Company |
| 47 | NE SE | 19 | dug | 20 | 16 | 50 | no change | soft | sandstone | " | R. L. Hatfield |
| 48 | NW SW | 20 | drilled | 30 | 25 | 50 | no change | hard | sandstone | " | Fred Spies |
| 49 | NW SE | 20 | drilled | 40 | 15 | 50 | no change | soft | sandstone | " | Mrs. Gibson |
| 50 | SE NE | 20 | drilled | 65 | 16 | 300 | no change | hard | sandstone | " | Alex Brenner |
| 51 | SW NW | 21 | drilled | 30 | 25 | 50 | no change | hard | sandstone | alluvium | Shauls |
| 52 | SW NW | 21 | drilled | 75 | 65 | 30 | no change | soft | sandstone | Torpedo | Lizy Walker |
| 53 | SW NE | 21 | drilled | 60 | 25 | 100 | no change | hard | sandstone | " | T. J. Kitterman |
| 54 | NW NE | 22 | drilled | 60 | 50 | 100 | no change | hard | limestone | " | L. Gilland |
| 55 | SW NE | 22 | drilled | 40 | 38 | 10 | no change | hard | sandstone | " | E. Fulton |
| 56 | NE NE | 22 | drilled | 40 | 35 | 100 | no change | hard | limestone | " | A. F. Brown |
| 57 | NE SW | 23 | drilled | 30 | 28 | 100 | no change | soft | sandstone | " | R. Greene |
| 58 | NW NW | 23 | no report | 14 | 14 | ? | dry | soft | sand | " | E. Shurpton |
| 59 | SW SW | 23 | dug | 14 | 5 | 100 | no change | gyp | limestone | Wann | R. E. Chaffey |
| 60 | SW NE | 24 | drilled | 40 | 20 | 50 | no change | hard | sandstone | " | J. F. Lucas |
| 61 | SW NE | 25 | drilled | 25 | 16 | 500 | no change | soft | sandstone | Torpedo | R. B. Rush |
| 62 | NW NW | 25 | no report | 25 | 23 | 50 | no change | soft | sandstone | " | Lupe |
| 63 | NE NE | 25 | drilled | 80 | 77 | 10 | no change | soft | sandstone | Wann | J. M. Ellis |
| 64 | SW SW | 26 | drilled | 55 | 30 | 100 | no change | soft | gravel | Torpedo | Bell Troxell |
| 65 | SW SE | 26 | drilled | 52 | 10 | 100 | no change | soft | sandstone | " | B. C. Buckner |
| 66 | SE SE | 26 | dug | 18 | 15 | 50 | no change | soft | sandstone | " | J. G. Land |
| 67 | NE NW | 26 | dug | 25 | 20 | 25 | no change | soft | sandstone | Wann | J. M. Scott |
| 68 | SW NW | 27 | dug | 30 | 25 | 50 | no change | hard | gravel | alluvium | Robert Cox |
| 69 | NW SW | 27 | dug | 18 | 14 | 500 | no change | soft | gravel | " | L. E. Phillips |
| 70 | NW SW | 27 | drilled | 23 | 7 | 6000 | no change | hard | gravel | " | Sinclair-Prairie |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 71 | SW SW | 27 | drilled | 86 | 16 | 500 | no change | soft | sandstone | Torpedo | F. T. Reed |
| 72 | SE SE | 27 | drilled | 35 | 25 | 700 | no change | hard | gravel | alluvium | E. W. Kirkbide |
| 73 | NW SE | 27 | drilled | 35 | 15 | 6000 | no change | soft | gravel | " | Georgia Oil Co. |
| 74 | SW NW | 28 | drilled | 113 | 65 | 50 | no change | soft | sandstone | Torpedo | Tom Wolff |
| 75 | NE SW | 28 | dug | 13 | 6 | 150 | no change | soft | sandstone | " | G. H. Baker |
| 76 | SE SW | 28 | drilled | 205 | 40 | 50 | no change | soft | sandstone | Cottage Grove | George Seidle |
| 77 | NE NE | 29 | drilled | 12 | 6 | 100 | no change | soft | sandstone | Torpedo | G. W. Rhett |
| 78 | SE NW | 32 | no report | 35 | 15 | dry | dry | hard, salty | gravel | alluvium | H. J. Holms |
| 79 | NW NE | 32 | dug | 26 | 20 | 500 | no change | hard | gravel | alluvium | Hoyt Oil Company |
| 80 | SE NE | 32 | drilled | 26 | 14 | 500 | no change | soft | gravel | " | John Shellack |
| 81 | SE NE | 32 | drilled | 34 | 18 | 500 | no change | soft | gravel | " | M. and S. |
| 82 | SE SE | 32 | drilled | 17 | 10 | 50 | no change | soft | gravel | " | S. A. Hendricks |
| 83 | SE NE | 33 | drilled | 60 | 50 | 100 | no change | soft | sandstone | Torpedo | M. O. Brosius |
| 84 | NW SW | 33 | dug | 26 | 16 | 1000 | no change | hard | sand | alluvium | C. L. Britton |
| 85 | NE SW | 33 | drilled | 50 | 40 | 200 | no change | hard | sand | " | B. H. Cleveland |
| 86 | SW SW | 33 | drilled | 38 | 31 | 25 | no change | soft | sand | alluvium | S. J. Greenwood |
| 87 | SW NW | 34 | drilled | 60 | 50 | 100 | no change | soft | sandstone | Torpedo | J. Hix |
| 88 | NE NE | 34 | drilled | 30 | 25 | 100 | no change | hard | sandstone | " | J. D. Burchett |
| 89 | NW NW | 35 | drilled | 90 | 85 | 250 | no change | soft | sandstone | Wann | C. Franklin |
| 90 | SW SW | 35 | drilled | 35 | 27 | 200 | no change | hard | limestone | " | C. Anderson |
| 91 | NE SE | 36 | dug | 25 | 20 | 12 | no change | hard | sandstone | Iola | Ed Robinson |
| 92 | NW SW | 36 | drilled | 25 | 13 | 300 | no report | hard | dirt (?) | " | C. Swan |

## T. 28 N., R. 14 E., WASHINGTON COUNTY

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SW NE | 4 | dug | 38 | 35 | 100 | no change | soft | sandstone | Cottage Grove | Not reported |
| 2 | SE NW | 4 | drilled | 40 | 30 | 300 | no change | hard | gravel | alluvium | Don Tyler |
| 3 | NE SW | 4 | drilled | 40 | 30 | 300 | no change | soft | gravel | " | W. W. Whitmire |
| 4 | SE SW | 4 | dug | 30 | 20 | 400 | no change | soft | gravel | " | L. M. Winkler |
| 5 | NE SE | 5 | drilled | 45 | 40 | 200 | no change | hard | limestone | Cottage Grove | Not reported |
| 6 | SE NE | 5 | drilled | 60 | 40 | 200 | dry | hard | limestone | " " | Not reported |
| 7 | SW SW | 5 | drilled | 40 | 30 | 300 | 10 | hard | limestone | " " | Not reported |
| 8 | SE NE | 6 | dug | 16 | 9 | 500 | no change | hard | limestone | alluvium | F. T. Johnson |
| 9 | SE NE | 6 | dug | 20 | 17 | 150 | no change | hard | limestone | " | F. T. Johnson |
| 10 | SE SE | 6 | drilled | 80 | 50 | 500 | dry | hard | limestone | Cottage Grove | Netta Roper |
| 11 | NE NW | 7 | drilled | 65 | 25 | 50 | fails | soft | sandstone | Torpedo | J. Washington |
| 12 | NW NW | 7 | drilled | 80 | 10 | 100 | fails | hard | limestone | " | Not reported |
| 13 | SE NW | 9 | drilled | 70 | 35 | 50 | no change | soft | sandstone | Cottage Grove | Not reported |
| 14 | NE NE | 9 | drilled | 40 | 15 | 400 | no change | gyp | sandstone | " " | H. H. Ramey |
| 15 | NE NE | 16 | drilled | 35 | 32 | 25 | no change | hard | limestone | " " | J. R. Hendrickson |
| 16 | NE NE | 20 | dug | 18 | 15 | 50 | no change | hard | sand | " " | F. Pollett |
| 17 | NE NE | 20 | drilled | 14 | 13 | 10 | no change | hard | limestone | " " | C. W. Smith |
| 18 | NW NE | 28 | spring | 3 | 0 | 200 | no change | soft | sandstone | " " | C. W. Reese |
| 19 | NW NW | 29 | dug | 18 | 16 | 100 | no change | hard | sandstone | " " | Duncan |
| 20 | SW NW | 29 | dug | 40 | 12 | 150 | no change | hard | sandstone | " " | J. L. Scholl |
| 21 | NW NE | 29 | drilled | 40 | 12 | 150 | no change | hard | sandstone | " " | M. Hadley |

## T. 28 N., R. 14 E., WASHINGTON COUNTY—Continued.

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | SE SE | 30 | dug | 40 | 38 | 200 | no change | hard | sandstone | Cottage Grove | J. E. Keto |
| 23 | SW SW | 31 | drilled | 61 | 38 | 1000 | no change | hard | sand | " " | A. C. Kneisly |
| 24 | NW NW | 31 | drilled | 50 | 25 | 1000 | no change | hard | limestone | " " | D. M. Tyler |
| 25 | SE SW | 32 | drilled | 30 | 25 | 300 | 15 | hard | limestone | Nellie Bly | J. T. Johnson |
| 26 | SW NW | 32 | drilled | 60 | 55 | 150 | no change | hard | limestone | " " | A. C. Kneisly |
| 27 | NW NE | 32 | drilled | 25 | 23 | 25 | no change | soft | sandstone | Cottage Grove | E. D. Squire |

## T. 29 N., R. 12 E., WASHINGTON COUNTY

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Normal | Drought | Relative Quality of water | Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NE NE | 23 | dug | 30 | 18 | ? | no report | soft | sandstone | Torpedo | Not reported |
| 2 | NW SW | 24 | drilled | 80 | 20 | 300 | no change | hard | limestone | " | Connely Ranch |
| 3 | NE SW | 24 | dug | 12 | 11 | 150 | 100 | hard | limestone | " | Connely Ranch |
| 4 | SE SE | 24 | drilled | 120 | 20 | 400 | no change | hard | limestone | " | Connely Ranch |
| 5 | NW NW | 25 | drilled | 60 | 52 | 400 | no change | soft | sandstone | " | G. W. Connely |
| 6 | SE NE | 26 | dug | 30 | 20 | 200 | no change | soft | sandstone | " | Wiley School |
| 7 | SE NE | 26 | dug | 35 | 20 | 500 | no change | soft | sandstone | " | A.T. & S.F. RR. |
| 8 | NW SW | 26 | drilled | 50 | 15 | 100 | no change | soft | sandstone | " | Wallace Ward |
| 9 | SW SE | 27 | dug | 60 | 5 | 800 | no change | hard | limestone | "The Okesa" | Jenny Feather Lease |
| 10 | SW SE | 27 | drilled | 60 | 10 | 300 | no change | soft | gravel | " " | Jenny Feather Lease |
| 11 | SE NE | 35 | drilled | 45 | 15 | 1000 | no change | soft | sandstone | Torpedo | George Kincaid |
| 12 | NE SE | 35 | drilled | 26 | 7 | 2000 | no change | soft | sandstone | " | George Kincaid |
| 13 | NE NE | 36 | dug | 60 | 50 | 600 | no change | hard | gravel | alluvium | Cole |
| 14 | SW NW | 36 | drilled | 60 | 30 | 700 | no change | hard | gravel | " | Mr. Connely |

## T. 29 N., R. 13 E., WASHINGTON COUNTY

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Normal | Drought | Relative Quality of water | Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NE NE | 14 | drilled | 180 | 140 | 600 | no change | hard | gravel | Cottage Grove | C. P. Detrich |
| 2 | NW SW | 14 | drilled | 17 | 10 | 300 | no change | soft | sand | Torpedo | R. P. Brookin |
| 3 | NW SW | 14 | spring | ? | ? | 400 | no change | soft | sand | " | R. P. Brookin |
| 4 | SE SE | 15 | drilled | 50 | 40 | 400 | no change | hard | limestone | " | S. M. Brown |
| 5 | NE SE | 16 | dug | 26 | 10 | 3500 | failed | soft | alluvium | "The Okesa" | A. C. Holmburg |
| 6 | NE SE | 16 | dug | 26 | ? | 200 | failed | soft | sandstone | " " | A. C. Holmburg |
| 7 | SE SW | 16 | dug | 30 | 18 | 100 | failed | hard | limestone | " " | Geo. Cales |
| 8 | SE SW | 16 | dug | 40 | 18 | 600 | no change | hard | limestone | " " | Geo. Cales |
| 9 | SE SW | 16 | dug | 10 | 2 | ? | no record | ? | soapstone | " " | Geo. Cales |
| 10 | NW SW | 17 | dug | 30 | 8 | 2000 | no change | soft | quicksand | alluvium | R. W. Smith |
| 11 | SW NW | 17 | drilled | 32 | 8 | 2500 | no change | soft | sandstone | Torpedo | Southland Ret. Co. |
| 12 | NW NW | 17 | dug | 17 | 14 | 3200 | no change | hard | quicksand | alluvium | Dick Hicks |
| 13 | NW NE | 17 | drilled | 35 | 8 | 1000 | failed | hard | sandstone | "The Okesa" | Mrs. J. D. Foote |
| 14 | NW NE | 17 | drilled | 50 | 32 | 1080 | no change | soft | sandstone | Torpedo | W. N. Larrobee |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | NW NE | 17 | dug | 15 | ? | unlimited | failed | soft | sandstone | "The Okesa" | W. N. Larrobee |
| 16 | SW SW | 19 | dug | 14 | 10 | 400 | failed | soft | sandstone | " " | Geo. W. Connelly |
| 17 | SE SE | 19 | drilled | 24 | 20 | 400 | no change | hard | limestone | " " | Geo. W. Connelly |
| 18 | SE NW | 22 | drilled | 110 | 30 | 150 | no change | soft | sandstone | Torpedo | C. T. Fields |
| 19 | SW SE | 22 | dug | 28 | 14 | 500 | no change | hard | limestone | " | John Mills |
| 20 | SW SW | 24 | drilled | 130 | 100 | 800 | no change | soft | sand | "Noxie" | Cities Ser. Gas Co. |
| 21 | NE NE | 24 | drilled | 25 | 10 | 260 | no change | soft | sand | Cottage Grove | Henry Durst |
| 22 | SE SE | 24 | drilled | 18 | 2 | 130 | no change | soft | sand | " " | O. S. Taylor |
| 23 | SE SE | 24 | dug | 15 | 3 | 665 | no change | soft | sand | " " | O. S. Taylor |
| 24 | NE SE | 24 | drilled | 25 | ? | 130 | no change | soft | sand | " " | T. Swanson |
| 25 | NW NW | 25 | dug | 20 | 12 | 800 | no change | hard | limestone | " " | F. H. Siegenfuss |
| 26 | NW NW | 25 | drilled | 65 | 20 | 665 | no change | soft | sand | " " | F. H. Siegenfuss |
| 27 | NW SW | 26 | drilled | 67 | 57 | 100 | dry | hard | limestone | " " | E. R. Harris |
| 28 | NW SW | 26 | drilled | 100 | 80 | 1000 | no change | hard | limestone | " " | E. R. Harris |
| 29 | NE NE | 26 | dug | 30 | 20 | 300 | dry | hard | limestone | " " | J. Parr |
| 30 | NE NE | 27 | dug | 20 | 18 | 100 | dry | hard | limestone | Wann | J. Goodman |
| 31 | SW SW | 27 | drilled | 40 | 20 | 200 | no change | hard | limestone | Torpedo | E. M. Hayhurst |
| 32 | SW SW | 27 | dug | 10 | 2 | 600 | fails | soft | sandstone | " | E. M. Hayhurst |
| 33 | NW SW | 27 | drilled | 26 | ? | 20000 | no change | soft | limestone | " | E. M. Hayhurst |
| 34 | NW NE | 27 | drilled | 116 | 26 | 10000 | no change | soft | sandstone | " | C. H. Mills |
| 35 | SW SW | 28 | drilled | 561 | 30 | 70000 | no change | soft, salty | gravel | alluvium | G. W. Connelly |
| 36 | NW SW | 28 | drilled | 25 | 18 | 300 | no change | hard | limestone | Torpedo | G. W. Connelly |
| 37 | SE SE | 28 | spring | 6 | 0 | 200 | no change | soft | sandstone | " | Hill Place |
| 38 | SE SE | 28 | spring | ? | ? | 900 | no change | soft | sandstone | " | E. Hayherst |
| 39 | SW SW | 28 | dug | 25 | 14 | ? | unknown | hard | limestone | " | Not given |
| 40 | SE NE | 29 | dug | 23 | 19 | 500 | no change | hard | limestone | " | G. W. Connelly |
| 41 | NE NE | 29 | dug | 15 | 4 | 200 | no change | hard | gravel | alluvium | Wm. Cargile |
| 42 | NW NW | 29 | dug | 25 | 15 | 300 | no change | soft | sandstone | Torpedo | Jack Hollingsworth |
| 43 | SE SE | 32 | drilled | 50 | ? | 2000 | fails | soft | sandstone | " | W. A. Nally |
| 44 | NE NE | 32 | dug | 23 | 18 | 500 | no change | hard | limestone | " | I. H. Thomas |
| 45 | NE NE | 32 | drilled | 60 | 30 | 2000 | no change | soft | sandstone | " | I. H. Thomas |
| 46 | SW NE | 33 | dug | 20 | 15 | 400 | no change | hard | gravel | " | W. M. Thomas |
| 47 | NW NW | 33 | drilled | 28 | 18 | 500 | no change | soft | sandstone | " | O. H. Edans |
| 48 | SW SW | 33 | dug | 30 | 20 | 300 | no change | soft | sandstone | " | Roy F. Thomas |
| 49 | NW SW | 34 | drilled | ? | 30 | 1000 | no change | hard, salty | limestone | Cottage Grove | Don Tyler |
| 50 | SW NW | 34 | drilled | 82 | 70 | 2000 | no change | soft, salty | sandstone | " " | Oscar Edens |
| 51 | SW NW | 34 | dug | 30 | 15 | 2000 | no change | gyp | limestone | Torpedo | Oscar Edens |
| 52 | NE SE | 34 | drilled | 40 | 32 | 2000 | no change | hard | limestone | Wann | Jane Hill |
| 53 | SE SW | 34 | dug | 24 | 12 | 2000 | no change | soft | sandstone | Torpedo | Clarence Cales |
| 54 | SW SE | 35 | dug | 20 | 15 | 300 | no change | hard | limestone | Wann | M. E. Dearig |
| 55 | SW SW | 36 | drilled | 86 | 22 | 250 | no change | soft | gravel | alluvium | B. H. Jeter |
| 56 | NE NW | 36 | drilled | 35 | 20 | 25 | dry | hard | gravel | " | G. A. Johnson |
| 57 | NE NW | 36 | drilled | 100 | 40 | 1500 | no change | soft | sandstone | Cottage Grove | G. A. Johnson |

## T. 29 N., R. 14 E., WASHINGTON COUNTY

| Well No. | Location | Sec. | Type of well | Depth Total | (Feet) to water | Estimated Capacity gallons per day Normal | Drought | Relative Quality of water | AQUIFER Produces from | Formation | Owner |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SE SE | 16 | drilled | 50 | 10 | 260 | dry | soft | sand | Cottage Grove | S. M. Smoley |
| 2 | NW NW | 18 | drilled | 175 | 30 | 600 | no change | soft | limestone | " " | Not reported |
| 3 | NE NW | 19 | drilled | 67 | 15 | 1000 | no change | hard | limestone | " " | J. O. Cannery |
| 4 | NE NE | 21 | drilled | 158 | 60 | 800 | no change | soft | sand | " " | J. C. Lane |
| 5 | SE SW | 21 | drilled | 275 | 75 | no limit | no change | soft | sandstone | Noxie | Henry Shaffer |
| 6 | SE NE | 28 | drilled | 153 | 33 | 150 | dry | hard | limestone | Cottage Grove | P. Vining |
| 7 | SE NE | 28 | drilled | 197 | 150 | 3000 | no change | soft | sand | Noxie | R. King |
| 8 | SE NE | 30 | drilled | 50 | 30 | 400 | falls | hard | sandstone | Cottage Grove | R. L. Borris |
| 9 | SE SE | 31 | drilled | 111 | 70 | 1064 | no change | hard | limestone | " " | S. M. Williams |
| 10 | NE NE | 31 | dug | 30 | 25 | 650 | no change | hard | limestone | " " | Not reported |
| 11 | SE SE | 32 | drilled | 32 | 20 | 65 | falls | hard | limestone | " " | Not reported |
| 12 | SW SW | 33 | drilled | 35 | 15 | 450 | no change | hard | limestone | " " | C. W. Sears |

# APPENDIX B

# MEASURED STRATIGRAPHIC SECTIONS IN WASHINGTON AND PARTS OF ADJACENT COUNTIES

## TOWNSHIP 23 NORTH

### 1. SEC. 6, T. 23 N., R. 12 E., ALONG ROAD ¼ MILE WEST OF EAST LINE OF SECTION, FROM SOUTH SIDE NORTH ½ MILE.*

| | Feet |
|---|---|
| **Wann formation.** | |
| Sandstone, buff to reddish-brown, medium-grained, the Clem Creek sandstone of Emery | 25.0 |
| Shale, dark with a few thin layers of sandstone | 22.0 |
| Limestone, gray to reddish-brown, fossiliferous | 10.0 |
| Shale, dark | 10.0 |
| Limestone, fossiliferous, weathers red, the red limestone of Emery | 3.0 |
| Shale calcareous, weathers buff | 13.0 |
| Limestone, gray, weathers red, sandy, fossiliferous, the *Fusulina*-bearing limestone of Emery | 6.0 |
| Shale, dark | 28.0 |
| Shale, calcareous, a few thin fossiliferous limestone beds, probably the Shelly limestone of Emery | 12.0 |
| Limestone, dark, fossiliferous | 3.0 |
| Covered, probably shale | 42.0 |
| **Iola formation.** | |
| Avant limestone member. | |
| Limestone, white, top only exposed. | |

### 2. SEC. 8, T. 23 N., R. 12 E. IN THE NE¼ OF THE SE¼ ALONG OKLAHOMA HIGHWAY NO. 11 SOUTH OF AVANT

| | |
|---|---|
| **Iola formation.** | |
| Avant limestone member. | |
| Limestone, not measured. | |
| Muncie Creek shale member. | |
| Shale, dark, weathers yellowish-gray | 36.0 |
| Shale, black, fissile, phosphatic nodules in base | 2.0 |
| Paola limestone member. | |
| Limestone, marly | 0.2 |
| **Chanute formation.** | |
| Carbonaceous shale member. | |
| Coal | 0.1 |
| Clay, underclay? | 0.1 |
| Cottage Grove sandstone member. | |
| Sandstone, light gray, thin-bedded, fine-grained, base not exposed | 5.0 |

### 3. SEC. 5, T. 23 N., R. 13 E., NEAR THE SE CORNER

| | |
|---|---|
| **Iola formation.** | |
| Avant limestone member. | |
| Limestone, weathers in large white blocks, top eroded | 10.0 |
| Muncie Creek shale member. | |
| Shale, covered, in this vicinity it is usually dark clay shale with black fissile shale at the base containing phosphatic concretions | 30.0 |

* Formations arranged in descending order, youngest at top.

| | Feet |
|---|---|
| Paola limestone member. | |
| Sandstone, brown, limy, well-cemented, upper surface weathers pitted, occasionally contains white platy limestone in upper part | 2.0 |
| Chanute formation. | |
| Carbonaceous shale member, not observed. | |
| Cottage Grove sandstone member. | |
| Sandstone, fine- to medium-grained, thin-bedded to massive, reddish-brown | 3.0 |
| Thayer coal member, not observed. | |
| Shale member. | |
| Shale, dark | 10.0 |
| Dewey limestone. | |
| Limestone, white, fossiliferous | 10.0 |

4. SEC. 13, T. 23 N., R. 12 E., NEAR THE E¼ CORNER

| | |
|---|---|
| Iola formation. | |
| Avant limestone member. | |
| Limestone, light-colored, sparingly fossiliferous, top eroded | 10.0 |
| Muncie Creek shale member. | |
| Shale, dark with black fissile shale and phosphatic nodules in the base | 20.0 |
| Paola limestone member. | |
| Sandstone, dense, limy, top pitted, occasionally contains white platy limestone in the top | 5.0 |
| Chanute formation. | |
| Carbonaceous shale member, not observed. | |
| Cottage Grove sandstone member. | |
| Sandstone, light-colored to reddish-brown, fine-grained, thin-bedded to massive | 15.0 |
| Thayer coal member, not observed. | |
| Shale member. | |
| Shale, covered, usually dark clay shale | 10.0 |
| Dewey limestone. | |
| Limestone, gray, fossiliferous | 10.0 |

5. SECS. 10 and 16, T. 23 N., R. 13 E., FROM TOP OF THE HOGSHOOTER LIMESTONE IN BEVAN CREEK NEAR THE SE COR. OF SEC. 10 TO THE BASE OF THE DEWEY LIMESTONE IN THE NE¼ OF SEC. 16

| | |
|---|---|
| Nellie Bly formation, lower part clay shale, upper part contains a few thin fine-grained sandstones which are reddish-brown in color, total thickness | 180.0 |

6. SEC. 28, T. 23 N., R. 13 E., NORTH ¼ CORNER

| | |
|---|---|
| Hogshooter limestone, not measured. | |
| Coffeyville formation. | |
| Shale, dark | 10.0 |
| Sandstone, Dodds Creek, base not exposed, not measured. | |

7. SECS. 33 and 34, T. 23 N., R. 13 E., ALONG SOUTH SIDE FROM ¼ MILE EAST OF SW CORNER OF SEC. 33

| | |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, gray, fossiliferous, top eroded, not measured. | |
| Coffeyville formation. | |
| Shale, not measured, usually about | 10.0 |
| Sandstone, Dodds Creek, thin-bedded to massive, fine- to medium-grained, light to reddish-brown | 35.0 |
| Shale, base not exposed, not measured. | |

8. SECS. 34, 35, 36, T. 23 N., R. 13 E., ALONG SOUTH SIDE OF, FROM RAILROAD CUT IN SEC. 36 TO POINT 1/8 MILE WEST OF SE CORNER OF SEC. 34

| | Feet |
|---|---|
| Coffeyville formation. | |
| Sandstone, not measured. | |
| Covered, shale, dark with a few very thin fine-grained sandstones | 100.0 |
| Sandstone, thin-bedded to massive, fine-grained, light to reddish-brown | 20.0 |
| Covered, shale with a few very thin fine-grained sandstones. | 70.0 |
| Checkerboard formation. | |
| Member 1. | |
| Limestone | 1.5 |

9. SEC. 36, T. 23 N., R. 13 E., IN THE RAILROAD CUT ¼ MILE WEST OF SE CORNER

| | |
|---|---|
| Checkerboard formation. | |
| Member 1. | |
| Limestone | 1.5 |
| Seminole formation. | |
| Shale, dark | 2.0 |
| Sandstone, light-brown, thin-bedded, medium-grained | 6.0 |
| Shale, dark, base not exposed | 3.0 |

10. SEC. 31, T. 23 N., R. 14 E., ALONG EAST SIDE OF SE¼

| | |
|---|---|
| Seminole formation. | |
| Sandstone, light-brown, thin-bedded, medium-grained, top eroded | 5.0 |
| Covered, probably shale | 20.0 |
| Sandstone, light-colored, speckled with brown, thin-bedded to massive, medium-grained, thickness not measured but regionally it may be as much as 100 feet. | |

## TOWNSHIP 24 NORTH

11. SEC. 19, T. 24 N., R. 12 E., IN RAILROAD CUT NEAR E¼ CORNER ON ROAD SOUTH OF BARNSDALL

| | |
|---|---|
| Weston shale. | |
| "The Okesa". | |
| Sandstone, top eroded | 25.0 |
| Covered, appears to be shale, weathers maroon in color | 6.0 |
| Birch Creek limestone. | |
| Limestone, gray, crystalline, weathers red, few fossils, lower part sandy, upper part contains cavities up to 2 inches in diameter filled or encrusted with calcite | 5.0 |
| Wann formation. | |
| Clay shale, dark | 1.0 |
| Sandstone, nodular, limy | 0.5 |
| Clay shale, dark, base not exposed | 6.0 |

12. SEC 11, T. 24 N., R. 12 E., ALONG WEST SIDE NORTH OF PUMP STATION

| | |
|---|---|
| Wann formation. | |
| Sandstone, thin-bedded to massive, buff to reddish-brown | 18.0 |
| Shale, dark, thin-bedded | 1.0 |
| Sandstone, light-yellow, massive | 1.8 |
| Shale, buff | 1.4 |
| Sandstone, light-yellow | 0.4 |
| Thin sandstone and sandy shale strata, alternating, strata 0.5 foot thick | 9.7 |
| Sandstone, gray, base of Clem Creek sandstone | 0.3 |
| Shale, weathers buff | 8.0 |

| | Feet |
|---|---|
| Limestone, reddish-brown, crinoidal | 0.6 |
| Shale | 0.1 |
| Limestone, brachiopods, crinoids, Bryozoa, Myalina-like forms | 0.6 |
| Marl, fossiliferous | 0.5 |
| Limestone, yellow to gray, massive, crinoidal | 1.5 |
| Limestone, yellow, massive, fossiliferous | 1.2 |
| Limestone, yellow, nodular | 1.5 |
| Shale, weathers yellow to buff | 27.0 |
| Limestone, pitted, sparingly fossiliferous | 3.0 |

(This bed was followed to a point ¼ mile south of N¼ cor. sec. 12, T. 24 N., R. 12 E., where it is the highest bed of No. 13.)

13. SEC. 12, T. 24 N., R. 12 E., ¼ MILE SOUTH OF N¼ COR. NORTH OF ROAD OPPOSITE HOUSE. (See No. 12).

Wann formation.

| | |
|---|---|
| Limestone, pitted, sparingly fossiliferous | 3.0 |
| Shale, dark, not well exposed | 45.0 |
| Shale, calcareous with several thin limestone streaks, fossiliferous | 2.0 |
| Shale, dark, base not exposed | 12.0 |

14. SEC. 23, T. 24 N., R. 12 E., NEAR CENTER OF WEST SIDE UP HILL NORTH OF PUMP STATION

Wann formation.

| | |
|---|---|
| Sandstone, weathers brown, thin-bedded, top eroded, soft | 15.0 |
| Shale, sandy | 2.5 |
| Sandstone, massive | 4.0 |
| Shale, gray | 2.0 |
| Sandstone in layers 0.3 to 0.5 foot thick | 3.0 |
| Shale, very sandy | 3.0 |
| Sandstone, soft, base of Clem Creek sandstone | 1.0 |
| Shale, dark sandy | 6.5 |
| Limestone, brachiopods, crinoids, Myalina-like forms | 1.8 |
| Shale, dark, not well exposed | 14.0 |
| Limestone, blue, weathers brown to yellow, fossiliferous | 2.0 |
| Shale, sandy | 3.0 |
| Sandstone in layers 0.1 to 0.5 foot thick, fine-grained | 8.0 |
| Shale, gray, sandy with thin layers of sandstone, base not exposed | 6.0 |

15. SEC. 25, T. 24 N., R. 12 E., FROM E¼ CORNER TO TOP OF HILL, ALONG ROAD WESTWARD

Wann formation.

| | |
|---|---|
| Sandstone, reddish-brown, plant remains, probably lower part of Clem Creek sandstone | 10.0 |
| Limestone, gray, basal part fusulina-bearing | 42.0 |
| Sandstone, cross-bedded | 4.0 |
| Shale, sandy with thin beds of sandstone | 16.0 |
| Shale, dark | 17.0 |
| Limestone, weathers yellow, fossiliferous | 1.0 |
| Shale, dark | 27.0 |
| Limestone, weathers yellow, fossiliferous | 2.5 |
| Shale, dark, calcareous | 16.0 |
| Sandstone, fine-grained | 1.0 |
| Shale | 11.0 |
| Sandstone, white to yellow, calcareous | 1.0 |
| Shale, calcareous | 21.0 |

Iola formation.

Avant limestone member.

| | |
|---|---|
| Limestone | 1.5 |

### 16. SEC. 7, T. 24 N., R. 13 E., ON THE WEST ONE OF TWO PEAKS IN THE SE SW SW

| | Feet |
|---|---|
| Wann formation. | |
| Limestone, caps hill | 2.0 |
| Shale, covered, probably calcareous | 75.0 |
| Iola formation | |
| Avant limestone member. | |
| Limestone | 1.0 |

### 17. SEC. 24, T. 24 N., R. 12 E. IN THE DRAW EAST OF THE PUMP STATION IN THE NW¼. MEASUREMENTS ARE APPROXIMATE.

| | |
|---|---|
| Iola formation. | |
| Avant limestone member. | |
| Limestone | 5.0 |
| Muncie Creek shale member. | |
| Shale, upper part dark with some thin-bedded sandy shale, lower three feet black fissile shale, phosphatic nodules observed in stream but not in place | 20.0 |
| Paola limestone member. | |
| Shale, calcareous clay shale at the stratigraphic position of the Paola limestone | 0.5 |
| Chanute formation. | |
| Carbonaceous shale member. | |
| Coal | 0.2 |
| Cottage Grove sandstone member. | |
| Partly covered, sandstone at the top, not over | 5.0 |
| Dewey limestone, not measured. | |

### 18. SEC. 30, T. 24 N., R. 13 E. FROM THE W¼ CORNER EAST TO BASE OF DEWEY LIMESTONE

| | |
|---|---|
| Iola formation. | |
| Avant limestone member. | |
| Limestone | 1.5 |
| Muncie Creek shale member. | |
| Shale, not well exposed, black fissile shale with phosphatic nodules in the base | 21.0 |
| Paola limestone member. | |
| Limestone, marly, fossiliferous | 0.8 |
| Chanute formation. | |
| Carbonaceous shale member. | |
| Coal | 0.3 |
| Shale, not well exposed | 3.0 |
| Cottage Grove sandstone member. | |
| Sandstone, soft, fine-grained, about | 2.0 |
| Thayer (?) coal member. | |
| Coal, possibly Thayer, but tilted eastward about 15° as if by slumping or faulting, may be the coal 0.3 feet thick mentioned above | 0.3 |
| Shale member. | |
| Shale, poorly exposed | 14.0 |
| Dewey limestone. | |
| Gray, massive to shaly, fossiliferous | 10.0 |

### 19. SEC. 29, T. 24 N., R. 13 E. FROM 1/8 MILE WEST OF E¼ CORNER WEST TO DEWEY LIMESTONE OUTCROP

| | |
|---|---|
| Nellie Bly formation (upper part). | |
| Shale, silty | 12.0 |
| Sandstone, fine-grained | 5.0 |
| Shale, silty | 9.0 |
| Sandstone, fine-grained | 1.3 |

| | Feet |
|---|---|
| Shale, silty | 2.5 |
| Shale, thin-bedded, silty | 3.4 |
| Sandstone, fine-grained | 2.0 |
| Shale, thin-bedded, silty | 20.0 |
| Sandstone, fine-grained, base not exposed | 3.5 |

20. SEC. 28, T. 24 N., R. 13 E. FROM CENTER WESTWARD

| | |
|---|---|
| Nellie Bly formation (lower part). | |
| Sandstone, top eroded | 5.0 |
| Shale, silty | 9.4 |
| Sandstone, fine-grained | 1.5 |
| Shale, silty | 1.5 |
| Sandstone, fine-grained | 2.0 |
| Shale, silty, thin-bedded | 10.7 |
| Sandstone, fine-grained | 1.0 |
| Shale, silty | 3.0 |
| Sandstone | 0.3 |
| Shale, silty | 1.0 |
| Sandstone, fine-grained | 0.4 |
| Shale, thin-bedded, silty | 22.0 |
| Sandstone, fine-grained in beds ¼ inch thick | 3.5 |
| Shale, thin-bedded, silty, base not exposed | 1.4 |

21. SEC. 34, T. 24 N., R. 13 E. NEAR CENTER OF SECTION

| | |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, gray, fossiliferous | 6.0 |
| Coffeyville formation. | |
| Shale, dark, base not exposed | 3.0 |

22. SEC. 16, T. 24 N., R. 13 E., ¼ MILE WEST OF THE SE COR.

| | |
|---|---|
| Hogshooter limestone. | |
| Limestone, top eroded. | |
| Coffeyville formation. | |
| Shale, dark, base not exposed | 26.0 |

23. SEC. 28, T. 24 N., R. 13 E., BACK OF SCHOOLHOUSE AT RAMONA

| | |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, gray, top eroded | 5.0 |
| Limestone, gray, crinoidal | 5.5 |
| Shale, calcareous | 1.8 |
| Limestone, dark, crinoidal | 1.0 |
| Coffeyville formation. | |
| Shale, base not exposed | 10.0 |

24. SEC. 16, T. 24 N., R. 13 E., ¼ MILE WEST OF SE CORNER

| | |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, top eroded | 4.0 |
| Coffeyville formation. | |
| Shale, dark, base not exposed | 26.0 |

25. SEC. 9, T. 24 N., R. 14 E., CENTER OF SE¼

| | |
|---|---|
| Coffeyville formation (middle part). | |
| Shale, top eroded | 2.0 |
| Sandstone, massive, upper 0.5 foot weathers in long slabs, used for fence posts | 6.0 |
| Sandstone, thin-bedded | 17.0 |
| Shale, thin-bedded, sandy, grades upward into sandstone, base not exposed | 8.0 |

26. SEC. 16, T. 24 N., R. 14 E., SW SE NW, IN A DRAW

| | Feet |
|---|---|
| **Coffeyville formation (middle part).** | |
| Shale, top eroded | 2.0 |
| Sandstone, resistant at the top, shaly in lower part | 12.0 |
| Sandstone, resistant at the top, shaly in lower part | 6.0 |
| Sandstone, massive and resistant at the top, thin-bedded and shaly at the base | 12.0 |
| Sandstone, resistant at the top, grades downward into sandy shale | 6.0 |
| Shale, dark, thin-bedded, base not exposed | 20.0 |

27. SEC. 17, T. 24 N., R. 14 E., NE NE NE

| | |
|---|---|
| **Coffeyville formation (middle part).** | |
| Shale, top eroded | 2.0 |
| Sandstone, weathers into long slabs, used for fence posts | 5.0 |
| Shale, sandy | 8.0 |
| Sandstone, thin-bedded to massive | 3.5 |
| Shale, sandy | 5.0 |
| Sandstone | 1.0 |
| Shale, dark, thin-bedded, slightly sandy, base not exposed | 8.0 |

28. SEC. 17, T. 24 N., R. 14 E., SW NW NW

| | |
|---|---|
| **Coffeyville formation (middle part).** | |
| Sandstone, top eroded | 5.0 |
| Sandstone, thin-bedded and shaly | 17.0 |
| Sandstone | 6.0 |
| Shale, thin-bedded and sandy | 14.0 |
| Sandstone | 1.5 |
| Shale, thin-bedded, sandy, sand increases upward | 15.0 |
| Shale, dark and thin-bedded, base not exposed | 26.0 |

29. SEC. 17, T. 24 N., R. 14 E., NEAR BRIDGE IN SW CORNER

| | |
|---|---|
| **Coffeyville formation (lower part).** | |
| Shale, weathers yellow, very sandy, tree covered, top eroded | 14.0 |
| Sandstone, gray, massive | 7.5 |
| Shale, dark, blocky, silty, a few poorly defined nodules | 5.0 |
| Sandstone, gray, massive | 1.5 |
| Sandstone, gray, thin-bedded, fine-grained, shaly | 10.0 |
| Shale, dark | 2.0 |
| Sandstone | 1.0 |
| Shale, gray, thin-bedded, slightly sandy | 5.0 |
| Shale, dark, almost fissile, base not exposed (Bed of Caney River) | 18.0 |

30. SEC. 32, T. 24 N., R. 14 E., SOUTHWEST CORNER

| | |
|---|---|
| **Coffeyville formation (lower part).** | |
| Covered, timbered slope to top of knoll capped by a thin sandstone, bare spots indicate this interval is predominantly shale | 24.0 |
| Covered, grassy timbered slope, probably sandy shale | 17.0 |
| Sandstone | 1.5 |
| Shale, dark, thin-bedded, a few sandy streaks | 42.0 |
| Nodule bed, thin, round, pancake-like sideritic concretions | 0.2 |
| Shale, dark | 2.7 |
| Nodule bed, like that above | 0.1 |
| Shale, dark, base not exposed | 2.0 |

## TOWNSHIP 25 NORTH

### 31. SECS. 13, 14, 15, T. 25 N., R. 12 E. FROM 1/8 MILE NORTH OF S¼ CORNER OF SEC. 16 TO ¼ MILE WEST OF SE CORNER OF SEC. 13. (West Dip Allowed 50 Ft. Per Mile)

| | Feet |
|---|---|
| Weston shale. | |
| "The Okesa". | |
| Sandstone, about | 2.0 |
| Shale, weathers red, poor exposure | 40.0 |
| Sandstone, weathers reddish-brown, fine-grained | 3.0 |
| Shale, weathers red | 70.0 |
| Sandstone, weathers reddish-brown, thin-bedded to massive, shale bands in lower 10 ft., medium to fine-grained | 37.0 |
| Birch Creek limestone. | |
| Limestone, thin-bedded, brown, fossiliferous | 3.0 |
| Wann formation. | |
| Shale, weathers yellow, slightly sandy with a few thin sandstone beds 0.1 foot thick | 65.0 |
| Limestone, gray, shaly | 2.0 |
| Shale, weathers yellow, not well exposed | 80.0 |
| Limestone, shaly, contains *Leiorhynchus rockymontanus* and associated fossils | 2.0 |
| Wann, Iola, and Chanute formations. | |
| Covered, shale for the most part, weathers yellow, probably contains Iola formation and upper part of Chanute formation | 155.0 |
| Chanute formation. | |
| Cottage Grove sandstone member. | |
| Sandstone, poorly exposed, about | 10.0 |
| Thayer coal member, not observed. | |
| Shale member. | |
| Shale, underlain by Dewey limestone | 10.0 |

### 32. SECS. 1, 2, 3, 4, T. 25 N., R. 12 E. FROM POINT 1/8 MILE WEST OF SW CORNER OF SEC. 3 TO POINT 300 FEET EAST OF SE CORNER OF SEC. 2

| | |
|---|---|
| Birch Creek limestone. | |
| Limestone, brown, sandy, a few crinoids | 2.0 |
| Torpedo sandstone and overlying shale. | |
| Overlying shale. | |
| Shale, dark, weathers yellow, not well exposed | 20.0 |
| Torpedo sandstone. | |
| Sandstone, not well exposed, about | 40.0 |
| Wann formation. | |
| Shale, yellow to buff, in part calcareous, contains *Leiorhynchus rockymontanus*, which is common in the limestone and calcareous shale zone | 250.0 |
| Iola limestone. | |
| Avant limestone member. | |
| Limestone, white, crinoids and brachiopods | 2.0 |
| Muncie Creek shale member. | |
| Shale, weathers light buff | 9.0 |
| Paola limestone member. | |
| Limestone, marly, fossiliferous | 0.5 |
| Chanute formation. | |
| Carbonaceous shale member. | |
| Shale, weathers light buff to yellow, no coal | 3.0 |
| Cottage Grove sandstone member. | |
| Sandstone, buff to brown, thin-bedded with shale partings, fine-grained | 10.0 |

| | Feet |
|---|---|
| Thayer coal member. | |
| Coal | 0.1 |
| Shale member. | |
| Shale, dark, weathers yellow | 6.0 |

### 33. SEC. 1, T. 25 N., R. 12 E., NW NE, WHERE CANEY RIVER LEAVES THE RAILROAD AND FLOWS EASTWARD. SECTION BEGINS IN WEST BANK OF RAILROAD CUT AND ENDS 400 FEET DOWN STREAM

| | |
|---|---|
| Iola formation. | |
| Avant limestone member. | |
| Limestone, yellow, fossiliferous, full of crinoid stems | 1.0 |
| Muncie Creek shale member. | |
| Shale, phosphatic nodules in the base | 1.0 |
| Paola limestone member. | |
| Limestone, marly and sandy | 0.2 |
| Chanute formation. | |
| Carbonaceous shale member. | |
| Coal | 0.1 |
| Clay, underclay? | 0.2 |
| Cottage Grove sandstone member. | |
| Sandstone, gray to yellow or light buff, thin-bedded to massive, fine-grained | 20.0 |
| Thayer coal member. | |
| Coal, contains shale partings | 1.5 |
| Shale member. | |
| Covered, probably shale | 16.0 |
| Dewey limestone. | |
| Limestone, massive, base not exposed | 10.0 |

### 34. SEC. 12, T. 25 N., R. 12 E., EASTWARD DOWN DRAW FROM CHURCH SOUTH OF W¼ CORNER TO RAILROAD TRESTLE, SECTION LIES SOUTHWARD ALONG RAILROAD TRACK

| | |
|---|---|
| Iola limestone. | |
| Muncie Creek shale member. | |
| Shale with phosphatic nodules found in stripped area south of draw. Not measured. | |
| Paola limestone member. | |
| Represented by marly limestone in stripped area and by the limy sandstone along edge of draw. This sandstone is dense, massive, and the top is pitted | 4.0 |
| Chanute formation. | |
| Carbonaceous shale member, not present. | |
| Cottage Grove sandstone member. | |
| Sandstone, buff, thin-bedded to massive, fine-grained | 21.5 |
| Thayer coal member. | |
| Coal | 0.5 |

### 35. SEC. 12, T. 25 N., R. 12 E., ¼ MILE NORTH OF W¼ CORNER

| | |
|---|---|
| Iola formation. | |
| Avant limestone member. | |
| Limestone, gray, crinoidal | 2.0 |
| Muncie Creek shale member. | |
| Shale, blue, weathers yellow, phosphatic nodules observed but not in place, lower part of this shale may be Chanute formation | 9.0 |
| Chanute formation. | |
| Carbonaceous shale member not observed. | |
| Cottage Grove sandstone member. | |
| Sandstone, yellow, micaceous | 1.0 |
| Shale, weathers yellow | 10.0 |
| Sandstone | 5.5 |

| | Feet |
|---|---|
| Thayer coal member. | |
| Coal | 0.2 |
| Shale member. | |
| Shale, dark | 8.0 |

36. SEC. 24, T. 25 N., R. 12 E., ¼ MILE SOUTH OF NW CORNER, IN DRAW EAST OF ROAD

| | |
|---|---|
| Iola formation. | |
| Avant limestone member. | |
| Limestone, granular, fossiliferous, top eroded | 1.0 |
| Muncie Creek shale member. | |
| Shale, limy, phosphatic nodules, may represent both Muncie Creek shale and Paola limestone | 1.0 |
| Chanute formation. | |
| Carbonaceous shale zone. | |
| Shale with sooty partings | 0.3 |
| Cottage Grove sandstone member. | |
| Sandstone, very shaly and thin-bedded, base not exposed | 2.0 |

37. SEC. 25, T. 25 N., R. 12 E. AT THE WEST ¼ CORNER IN STREAM

| | |
|---|---|
| Chanute formation. | |
| Cottage Grove sandstone member. | |
| Sandstone, brown, thin-bedded, soft, top eroded | 5.0 |
| Thayer coal member? and shale member? | |
| Covered | 5.0 |
| Dewey limestone. | |
| Limestone, not measured. | |

38. SECS. 33 and 34, T. 25 N., R. 13 E.

| | |
|---|---|
| Nellie Bly formation. | |
| Upper 100 feet silty shale and thin silty sandstone beds, lower 40 feet shale, total thickness | 140.0 |

39. SEC. 6, T. 25 N., R. 14 E., NEAR NW CORNER

| | |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, gray, fossiliferous, top eroded | 6.0 |
| Stark shale member. | |
| Shale, yellow, calcareous | 0.5 |
| Shale, black, fissile | 3.0 |
| Canville limestone member. | |
| Limestone, brown, siliceous, nodular | 1.1 |
| Coffeyville shale. | |
| Shale, yellow, calcareous, base not exposed | 2.0 |

40. SECS. 12 and 13, T. 25 N., R. 13 E. FROM BASE OF HOGSHOOTER LIMESTONE ¼ MILE NORTH OF SE COR. SEC. 12 TO BASE OF DODDS CREEK SANDSTONE AT THE E¼ COR. SEC. 13

| | |
|---|---|
| Coffeyville formation (upper part). | |
| Shale, dark, somewhat sandy | 10.0 |
| Sandstone, (Dodds Creek), thin-bedded, ferruginous (Layton sand of subsurface) | 30.0 |

41. SEC. 10, T. 25 N., R. 14 E. ¼ MILE SOUTH OF WEST ¼ CORNER

| | |
|---|---|
| Coffeyville formation (in middle part). | |
| Shale, sandy, top eroded | 5.0 |
| Sandstone, brown, thin-bedded, medium-grained | 15.0 |
| Shale, sandy, base not exposed, not measured. | |

### 42. SEC. 10, T. 25 N., R. 14 E. ¼ MILE EAST OF SW CORNER

| | Feet |
|---|---|
| Coffeyville formation (in middle part). | |
| Shale, sandy, top eroded, not measured. | |
| Sandstone, gray, brown, or yellow, micaceous, ferruginous, soft cross-bedded | 10.0 |
| Shale, sandy | 5.0 |
| Sandstone, gray, brown, or yellow, micaceous, ferruginous, soft, cross-bedded and thin-bedded | 15.0 |
| Shale, sandy, base not exposed | 6.0 |

### 43. SEC. 23, T. 25 N., R. 14 E., SE¼

| | |
|---|---|
| Coffeyville formation. | |
| Shale, black, fissile, top eroded, contains phosphatic nodules | 2.0 |
| Checkerboard formation. | |
| Member 1. | |
| Limestone, gray, splits into thin flakes in weathering | 2.0 |
| Seminole formation. | |
| Sandstone, base not exposed | 3.0 |

### 44. SEC. 5, T. 25 N., R. 15 E. ¼ MILE WEST OF CENTER

| | |
|---|---|
| Coffeyville formation (lower part). | |
| Shale, gray, top not exposed, not measured. | |
| Limestone, gray to brown, conglomeratic | 1.0 |
| Shale, gray | 12.0 |
| Shale, black, fissile | 12.0 |
| Limestone, conglomeratic | 1.0 |
| Shale, black, fissile | 4.0 |
| Shale, black fissile, abundant phosphatic concretions | 2.0 |
| Covered, not measured, probably consists of 2 feet of black, fissile shale succeeded by the Checkerboard limestone, which is usually 1 foot thick. | |

### 45. SEC. 30, T. 25 N., R. 15 E., NW NW

| | |
|---|---|
| Coffeyville formation. | |
| Sandstone, caps hill top, top eroded, about | 2.0 |
| Covered slope, probably sandy shale | 23.0 |
| Bench, probably a soft sandstone about | 2.0 |
| Covered slope, probably shale | 33.0 |
| Bench, probably a soft sandstone, about | 2.0 |
| Covered slope, probably shale | 28.0 |
| Checkerboard formation. | |
| Member 1. | |
| Limestone, gray, splits into thin flakes in weathering | 3.0 |
| Seminole formation. | |
| Shale | 2.0 |
| Sandstone | 6.0 |
| Sandstone, shaly | 3.0 |
| Sandstone | 1.0 |
| Shale, sandy | 4.5 |
| Shale, gray, fissile | 4.5 |
| Flag bed, limonitic | 0.1 |
| Shale, dark, fissile, base not exposed | 4.0 |

46. T. 25 N., R. 15 E. FROM THE BASE OF THE LENAPAH LIMESTONE TO THE TOP OF THE CHECKERBOARD LIMESTONE, BEGINNING AT THE NE CORNER OF SEC. 27, GOING WEST ALONG ROAD TO NW CORNER OF SEC. 28, THENCE ¼ MILE NORTH TO BASE OF THE UPPER SANDSTONE OF THE SEMINOLE FORMATION. FROM THE BASE OF THIS SANDSTONE TO THE TOP OF THE CHECKERBOARD LIMESTONE WAS MEASURED IN SEC. 25, T. 25 N., R. 14 E.

| | Feet |
|---|---|
| Missouri subseries. | |
| Checkerboard formation. | |
| Member 1. | |
| Limestone, gray, fossiliferous | 1.0 |
| Seminole formation. | |
| Shale, sandy | 1.0 |
| Sandstone | 6.0 |
| Shale | 20.0 |
| Sandstone, thin-bedded | 15.0 |
| Shale, somewhat sandy | 5.2 |
| Sandstone, brown, thin-bedded | 4.5 |
| Covered, probably all shale | 8.9 |
| Coal, Dawson | 0.1 |
| Covered, probably shale | 2.5 |
| Des Moines subseries. | |
| Lenapah limestone. | |
| Limestone, gray, marly, very fossiliferous | 3.0 |
| (Fossils from this bed and from the roadside ditch are *Chonetes granulifera* abundant, *Mesolobus* common, *Prismopora*, *Composita*, *Pustula*, *Spirifer*, and crinoids.) | |
| Covered, a few exposures of calcareous shale | 5.7 |
| (Upper 2 feet exposed and crammed with fossils, mostly *Chonetes granulifera.*) | |
| Limestone, gray to reddish, siliceous, hard, even-bedded, crinoidal | 0.6 |
| Limestone, gray to brown, siliceous, rough-pitted surface, crumbly on extreme weathering | 1.2 |
| Nowata shale, not measured. | |

## TOWNSHIP 26 NORTH

47. SEC. 14, T. 26 N., R. 11 E., IN THE CLIFF ON THE NORTH BANK OF SAND CREEK ABOUT ¼ MILE EAST OF THE W¼ CORNER

| | |
|---|---|
| Weston shale. | |
| "The Okesa". | |
| Sandstone, massive, gray, medium-grained, some red streaks near the base, caps ridge, top eroded | 10.0 |
| Covered, probably thin sandstones and sandy shale | 45.0 |
| Birch Creek limestone. | |
| Limestone, rests on uneven, eroded surface of underlying Torpedo sandstone, filling hollows and covering high points, gray on fresh surfaces, weathers rusty-red, heavy, sparingly fossiliferous except in upper 1 foot | 10.0 |
| Torpedo sandstone and overlying shale. | |
| Overlying shale. | |
| Absent, removed by pre-Birch Creek erosion. | |

### 48. VICINITY OF THE MOUND, BARTLESVILLE. SEC. 3, T. 26 N., R. 12 E.

(From the end of the sandstone outcrop at the white house ¼ mile southwest of The Mound to top of The Mound)

| | Feet |
|---|---|
| Weston shale. | |
| "The Okesa". | |
| Sandstone, brown, fine-grained, massive; caps Mound | 10.0 |
| Covered, steep slope, probably shale | 65.0 |
| Birch Creek limestone. | |
| Limestone, brown, extremely sandy | 2.0 |
| Marl, fossiliferous | 3.0 |
| Torpedo sandstone and overlying shale. | |
| Overlying shale. | |
| Covered, steep slope, probably all shale, upper part fossiliferous | 50.0 |
| Sandstone, brown, about | 2.0 |
| Covered, probably shale | 30.0 |
| Torpedo sandstone. | |
| Sandstone, not measured, faulted off at this point and in contact with the Cottage Grove sandstone member of Chanute formation. | |

### 49. SEC. 19, T. 26 N., R. 12 E. IN THE NORTH BANK OF THE ROAD UP THE HILL 500 FEET SOUTH OF THE NW CORNER

| | |
|---|---|
| Torpedo sandstone and overlying shale. | |
| Overlying shale. | |
| Shale, top eroded | 10.0 |
| Torpedo sandstone. | |
| Sandstone, thin-bedded to massive, reddish-brown, medium-grained | 60.0 |
| Wann formation. | |
| Shale, thin sandstone beds in the upper 10 feet | 25.0 |
| Shale, gray, thin sandstone beds in upper 10 feet, base not exposed | 55.0 |

### 50. SECTION MEASURED BY JOSEPH L. BORDEN ON CIRCLE MOUNTAIN, SEC. 36, T. 26 N., R. 12 E.

(Formation names by M. C. Oakes)

| | |
|---|---|
| Torpedo sandstone and overlying shale. | |
| Overlying shale. | |
| Not present. | |
| Torpedo sandstone. Top eroded. | |
| Sand, massive, blocky, caps hill, more than | 3.0 |
| Covered, probably shale | 9.0 |
| Sand, reddish, massive, blocky | 4.0 |
| Wann formation. | |
| Shale, blue-gray, fossiliferous, limonitic | 46.0 |
| Lime, rusty, blue-gray on fresh breaks, platy, very fossiliferous, abundant fusulinids | 2.0 |
| Shale, blue-gray, fossiliferous | 10.0 |
| Limestone, red, sandy, fossiliferous, grades into gray, massive, very fossiliferous limestone ¼ mile to the north | 4.0 |
| Covered, probably shale | 13.0 |
| Sand, grades into 15 feet of massive sand ¼ mile to north; Clem Creek sandstone of Emery | 8.5 |
| Shale, badly covered with slump, where seen in gulleys exposures are gray to drab, probably some thin sands. Saw slump of red, fossiliferous sand but did not find in place | 200.0 |

| | Feet |
|---|---|
| Torpedo sandstone. | |
| Sandstone, massive, medium-grained, reddish-brown, contains a few limy lenses 1 to 2 feet in length, lower half in beds 1 to 3 feet thick, upper half in beds 3 to 10 feet thick | 60.0 |
| Wann formation. | |
| Covered, steep bank down to bed of Sand Creek, probably shale | 30.0 |
| Iola formation. | |
| Limestone and shale, see No. 33 for continuation of this section to Dewey limestone. | |

51. SEC. 11, T. 26 N., R. 13 E., 1/8 MILE NORTH OF THE SE CORNER

| | |
|---|---|
| Chanute formation. | |
| Cottage Grove sandstone member. | |
| Sandstone, buff to reddish-brown, thin-bedded to massive, fine-grained, top eroded | 10.0 |
| Thayer coal member. | |
| Coal | 0.1 |
| Shale, dark, a mass of plant fossils, good collecting | 2.7 |
| Coal | 0.1 |
| Shale, light buff color | 2.9 |
| Coal | 0.1 |
| Shale member. | |
| Clay shale, somewhat sandy | 9.0 |
| Dewey limestone, not measured. | |

52. SEC. 14, T. 26 N., R. 12 E. ¼ MILE SOUTH OF NE CORNER

| | |
|---|---|
| Chanute formation. | |
| Cottage Grove sandstone member. | |
| Sandstone, reddish brown, thin-bedded to massive, top eroded | 10.0 |
| Shale, sandy | 6.0 |
| Thayer coal member, does not crop out. | |
| Shale member. | |
| Shale, poorly exposed | 22.0 |
| Dewey limestone, not measured. | |

53. SEC. 19, T. 26 N., R. 13 E., E¼ CORNER

| | |
|---|---|
| Chanute formation. | |
| Cottage Grove sandstone member. | |
| Sandstone, light-yellow, soft, thin-bedded, top eroded | 5.0 |
| Thayer coal member. | |
| Coal | 0.1 |
| Shale member. | |
| Shale, very sandy, micaceous | 5.0 |
| Shale, poorly exposed | 15.0 |
| Dewey limestone. | |
| Limestone, light colored, relatively massive with minor shale partings, fossils do not weather out | 15.0 |
| Limestone and calcareous shale in alternating thin beds, fossiliferous | 14.0 |
| Limestone, dark, calcareous, fossiliferous | 1.0 |
| Limestone, sandy and shaly, very fossiliferous | 2.5 |
| Nellie Bly formation, not measured. | |

54. SEC. 19, T. 26 N., R. 13 E., ¼ MILE SOUTH OF NE CORNER

| | |
|---|---|
| Dewey limestone, top eroded | 3.0 |
| Nellie Bly formation. | |
| Sandstone, fine-grained, cross-bedded | 6.0 |
| Shale, micaceous, carbonaceous, calcareous | 6.0 |
| Sandstone, fine-grained, thin-bedded, silty, base not exposed | 15.0 |

55. SEC. 20, T. 26 N., R. 13 E., ¼ MILE SOUTH OF NW CORNER

| | Feet |
|---|---|
| Dewey limestone. | |
| Limestone, top eroded, not measured. | |
| Nellie Bly formation. | |
| Sandstone, thin-bedded, fine-grained, cross-bedded | 6.0 |
| Shale, thinly laminated, carbonaceous, micaceous, calcareous | 6.0 |
| Sandstone, thin-bedded, fine-grained, silty, base not exposed | 15.0 |

56. SEC. 25, T. 26 N., R. 13 E., NEAR SE CORNER

| | |
|---|---|
| Dewey limestone. | |
| Limestone, not measured. | |
| Nellie Bly formation. | |
| Clay shale, silty shale, thin-bedded, fine-grained, silty sandstone, total thickness | 100.0 |
| Hogshooter limestone. | |
| Not measured. | |

57. SEC. 13, T. 26 N., R. 13 E., AND SEC. 18, T. 26 N., R. 14 E. FROM ¼ MILE NORTH OF THE SE CORNER OF SEC. 13 TO ¼ MILE WEST OF THE SE CORNER OF SEC. 18

| | |
|---|---|
| Dewey limestone. | |
| Limestone, not measured. | |
| Nellie Bly formation. | |
| Clay shale, silty shale, thin-bedded, fine-grained, silty sandstones, total thickness | 100.0 |
| Hogshooter limestone. | |
| Limestone, not measured. | |

58. SECS. 4 and 5, T. 26 N., R. 14 E., ALONG WINDING ROAD FROM CENTER OF SE¼ OF SEC. 5 TO TOP OF THE HOGSHOOTER LIMESTONE IN SEC. 4

| | |
|---|---|
| Dewey limestone. | |
| Limestone, not measured. | |
| Nellie Bly formation. | |
| Clay shale, silty shale, thin-bedded, fine-grained, silty sandstones, total thickness | 140.0 |
| Hogshooter limestone. | |
| Limestone, not measured. | |

59. SEC. 9, T. 26 N., R. 14 E., 1,500 FEET EAST OF SW CORNER. THICKEST KNOWN SECTION OF THE HOGSHOOTER LIMESTONE

| | |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, gray, rough, platy, forms weed-covered slope to the top of the Hogshooter limestone | 7.0 |
| Limestone, gray, massive, sparingly fossiliferous, shatters in weathering | 5.0 |
| Limestone, gray, massive, sparingly fossiliferous, shatters in weathering | 2.0 |
| Limestone, buff colored | 2.0 |
| Limestone, buff colored | 3.6 |
| Limestone, massive, fossiliferous | 1.4 |
| Limestone, rough, platy, very fossiliferous | 3.0 |
| Limestone, dark, badly weathered, contains phosphatic nodules, believed to be the dark, crinoidal, nodular, basal bed of other areas | 0.3 |
| Lost City limestone member. | |
| Limestone, gray, soft, platy, occurs in the bed of the creek, not present in any other locality visited, base not exposed | 1.7 |

### 60. SEC. 14, T. 26 N., R. 14 E., EAST ¼ CORNER

| | Feet |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, gray, fossiliferous, top eroded | 4.0 |
| Coffeyville formation. | |
| Shale, gray | 1.5 |
| Coal | 0.2 |
| Shale, gray, base not exposed, not measured. | |

### 61. SEC. 14, T. 26 N., R. 14 E., WEST ¼ CORNER

| | |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, gray, fossiliferous, top eroded | 3.0 |
| Coffeyville formation. | |
| Shale, gray, sandy | 11.0 |
| Coal | 0.4 |
| Shale, gray, sandy, base not exposed | 2.0 |

### 62. SEC. 15, T. 26 N., R. 14 E., NORTHWEST CORNER

| | |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, gray, fossiliferous, top eroded | 5.0 |
| Coffeyville formation. | |
| Shale, weathers yellow, poorly exposed | 9.0 |
| Sandstone | 0.3 |
| Shale, sandy | 5.0 |
| Sandstone | 0.7 |
| Shale, light-colored, sandy | 5.0 |
| Sandstone, light-colored, fine-grained, thin-bedded to massive | 10.0 |
| Coal | 0.2 |
| Shale, light-colored, thin-bedded, sandy, base not exposed | 2.0 |

### 63. SEC. 27, T. 26 N., R. 14 E., BEGINS 150 YARDS SOUTH OF SW CORNER, EXTENDS ¼ MILE NORTH OF THAT CORNER

| | |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone top eroded, not measured. | |
| Coffeyville formation. | |
| Sandstone, thin-bedded, shaly | 4.0 |
| Shale, silty, micaceous | 9.0 |
| Sandstone, thin-bedded, micaceous | 2.0 |
| Shale, very sandy, silty, micaceous | 7.0 |
| Sandstone, thin-bedded, micaceous, ferruginous | 4.0 |
| Shale, very sandy, and sandstone, thin-bedded, micaceous | 13.0 |
| Shale, light-colored | 4.0 |
| Sandstone, light-colored, thin-bedded | 11.0 |
| Shale, sandy, base not exposed. | |

### 64. SEC. 31, T. 26 N., R. 14 E., 0.1 MILE SOUTH OF CENTER

| | |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone | 17.0 |
| Stark shale member. | |
| Shale, black, fissile, contains large sideritic concretions | 4.0 |
| Canville limestone member. | |
| Limestone, light-colored, siliceous | 1.0 |
| Coffeyville formation. | |
| Shale, sandy, light-colored | 6.0 |
| Sandstone, shaly, base not exposed | 2.0 |

65. SEC. 7, T. 26 N., R. 15 E., ¼ MILE EAST OF SW CORNER

| | Feet |
|---|---|
| **Hogshooter limestone.** | |
| Limestone, gray, fossiliferous, top eroded | 5.0 |
| **Coffeyville formation.** | |
| Shale, thin-bedded, sandy | 20.0 |
| Sandstone, light-colored, thin-bedded, fine-grained to shaly | 40.0 |
| Shale, sandy, not measured. | |

66. SECS. 3, 4, 5, T. 26 N., R. 15 E., FROM A POINT 200 FEET EAST OF THE NW CORNER OF SEC. 3 TO THE N¼ CORNER OF SEC. 5. (Dip allowed, 25 feet per mile.)

| | |
|---|---|
| **Missouri** subseries. | |
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, gray, fossiliferous, top eroded | 10.0 |
| Coffeyville formation. | |
| Sandstone and sandy shale, poorly exposed | 30.0 |
| Shale, poorly exposed | 40.0 |
| Sandstone and sandy shale, poorly exposed | 15.0 |
| Covered, grassy slope, probably shale | 80.0 |
| Sandstone with about 4 feet of limy sandstone at the base | 15.0 |
| Shale, dark, poorly exposed, phosphatic nodules in base | 55.0 |
| Checkerboard limestone, should occur at this horizon, does not crop out at this place | 1.0 |
| Seminole formation. | |
| Sandstone and sandy shale, poorly exposed | 20.0 |
| **Des Moines** subseries. | |
| Lenapah limestone. | |
| Limestone, base not exposed, not measured. | |

67. SEC. 11, T. 26 N., R. 14 E., 900 FEET NORTH OF THE SW CORNER

| | |
|---|---|
| **Coffeyville** formation (in upper part). | |
| Shale, sandy, forming slope of hill, not measured. | |
| Sandstone, light-colored, fine-grained, massive to thin-bedded | 12.0 |
| Coal, probably about 40 feet below top of Coffeyville formation | 0.4 |
| Shale, light-colored, thin-bedded, sandy, not measured. | |

68. SEC. 21, T. 26 N., R. 14 E., NORTH ¼ CORNER

| | |
|---|---|
| **Coffeyville** formation (in upper part). | |
| Shale, sandy, top eroded | 2.0 |
| Sandstone, massive | 3.0 |
| Shale, sandy | 7.0 |
| Coal, shale parting 0.2 ft. thick, probably 40 feet below top of Coffeyville formation, Cedar Bluff coal | 0.5 |
| Shale, sandy, base not exposed, not measured. | |

69. SEC. 15, T. 26 N., R. 14 E., CENTER OF SECTION

| | |
|---|---|
| **Coffeyville** formation (in upper part). | |
| Sandstone, light-colored, massive, fine-grained, top eroded | 12.0 |
| Shale, light-colored, thin-bedded | 2.0 |
| Coal, probably 40 ft. below top of Coffeyville formation, Cedar Bluff coal | 0.1 |
| Shale, base not exposed. | |

70. SEC. 35, T. 26 N., R. 14 E., FROM SE CORNER ¼ MILE NORTH

| | |
|---|---|
| **Coffeyville** formation (in middle part). | |
| Shale, sandy, top eroded | 3.0 |
| Shale and sandstone in alternating thin beds | 7.0 |
| Sandstone, massive | 2.0 |
| Shale, sandy, with a few very thin sandstone beds | 22.0 |

| | Feet |
|---|---|
| Shale, silty, with thin sandstone beds | 2.0 |
| Shale, silty | 2.0 |
| Sandstone, thin-bedded | 4.0 |
| Shale, silty | 1.5 |
| Sandstone, massive | 1.5 |
| Shale, dark, silty | 5.0 |
| Sandstone, thin-bedded | 6.0 |
| Shale, sandy | 6.0 |
| Covered, talus slope, not measured. | |

71. SECS. 32, 33, 34, 35, T. 26 N., R. 15 E., FROM POINT ¼ MILE WEST OF SE CORNER OF SEC. 32 TO OUTCROP OF LENAPAH LIMESTONE IN SEC. 35

| | |
|---|---|
| Coffeyville formation (lower part). | |
| Sandstone, gray to reddish-brown, medium- to fine-grained, thin-bedded, top eroded | 6.0 |
| Shale, buff, sandy | 25.0 |
| Sandstone, thin-bedded | 20.0 |
| Shale, dark | 20.0 |
| Limestone, sandy, phosphatic, hematitic, glauconitic | 2.0 |
| Shale, dark, phosphatic concretions in base | 60.0 |
| Checkerboard limestone, does not crop out along road but does so at this horizon near by | 1.0 |
| Seminole formation. | |
| Sandstone, weathers brown, thin-bedded, medium-grained | 4.0 |
| Shale, dark, not well exposed | 50.0 |
| Sandstone, reddish-brown, thin-bedded, medium-grained | 4.0 |
| Shale, dark, not well exposed, no coal observed, base of Seminole | 6.0 |

## TOWNSHIP 27 NORTH

72. SEC. 12, T. 27 N., R. 12 E., NW¼
(Go northwest from school house past two silos, take trail to top of hill, poor exposures.)

| | |
|---|---|
| Weston shale. | |
| "The Okesa". | |
| Sandstone and shale in alternating beds 1 to 4 feet thick | 10.0 |
| Covered, steep rocky slope, seems to be shale | 80.0 |
| Birch Creek limestone. | |
| Limestone, fossiliferous, marly | 1.0 |
| Torpedo sandstone and overlying shale. | |
| Overlying shale. | |
| Covered, steep rocky slope, probably shale | 30.0 |
| Torpedo sandstone. | |
| Sandstone bench, exposed | 10.0 |
| Wann formation. | |
| Covered slope, probably shale | 105.0 |
| (Base of formation covered by alluvium) | |

73. SEC. 26, T. 27 N., R. 12 E. SW SW

| | |
|---|---|
| Weston shale. | |
| "The Okesa". | |
| Sandstone, top eroded | 5.0 |
| Shale | 3.0 |
| Birch Creek limestone. | |
| Limestone, bluish white, dense, fossiliferous, poorly exposed | 2.0 |
| Torpedo sandstone and overlying shale. | |
| Overlying shale. | |
| Covered, grassy slope, probably shale | 45.0 |

| | Feet |
|---|---|
| Torpedo sandstone. | |
| Sandstone, a poor outcrop | 15.0 |
| Wann formation. | |
| Covered, grassy slope, probably shale | 140.0 |
| (Base of formation covered by alluvium) | |

74. SEC. 12, T. 27 N., R. 12 E. SW¼. SCHOOL HOUSE TO TOP OF HILL

(Rubble strewn slope with very poor exposures)

| | |
|---|---|
| Torpedo sandstone and overlying shale. | |
| Torpedo sandstone. | |
| Sandstone, reddish brown, medium grained, massive but weathers thin-bedded, exposed | 10.0 |
| Wann formation. | |
| Covered, probably shale | 115.0 |
| (Base of formation covered by alluvium) | |

75. SEC. 13, T. 27 N., R. 12 E. NEAR CENTER OF SW¼

| | |
|---|---|
| Torpedo sandstone and overlying shale. | |
| Overlying shale, not measured. | |
| Torpedo sandstone. | |
| Sandstone, reddish-brown, massive, medium-grained | 25.0 |
| Wann formation. | |
| Covered, steep, grassy, tree-covered slope, probably shale | 118.0 |
| Shale, dark, exposed in sides of pit, a few weathered phosphatic nodules, not in place | 12.0 |
| Limestone, rusty brown, nodular, *Leiorhynchus* and associated fossils common to this member | 0.5 |
| A short distance west is an exposure of another thin limestone somewhat higher. | |
| (Base of formation covered by alluvium) | |

76. SEC. 16, T. 27 N., R. 14 E. MEASURED UP THE NORTHEAST FLANK OF BLUE MOUND

| | |
|---|---|
| Torpedo sandstone and overlying shale. | |
| Overlying shale not present. | |
| Torpedo sandstone. | |
| Rubble covered slope, probably sandy shale | 9.0 |
| Sandstone, weathers brownish red, massive | 12.0 |
| Covered, probably sandy shale | 17.0 |
| Sandstone, massive | 2.5 |
| Wann formation. | |
| Covered, probably shale | 49.0 |
| (Typical Wann Fossils in saddle east of gulley at the base of this interval.) | |
| Covered, probably shale | 53.0 |
| (Gulley is choked with rubble but blue shale is exposed in many places. Found one unidentified pelecypod, one *Trepospira depressa*, and several thin plates of limestone, none of the material being in place.) | |
| Iola formation. | |
| Not exposed, probably | 2.5 |
| Chanute formation. | |
| Carbonaceous shale member, does not crop out. | |
| Cottage Grove sandstone member. | |
| Massive sandstone blocks thought to indicate a bed at this horizon | 1.5 |
| Thayer coal member, does not crop out. | |
| Shale member. | |
| Covered, probably shale, possibly sandstone in the upper part | 26.0 |

| | Feet |
|---|---|
| Dewey limestone. | |
| Limestone, white, fossiliferous, platy, interbedded with shale at base, more massive at top | 24.0 |
| (J. L. Borden reports presence of black fissile shale below the Dewey limestone down the draw north of Blue Mound.) | |

77. SEC. 9, T. 27 N., R. 13 E. FROM SE CORNER TO W¼ CORNER ALONG CREEK

| | |
|---|---|
| Iola formation. | |
| Muncie Creek shale member. | |
| Shale with phosphatic nodules in the base, not measured. | |
| Paola limestone member. | |
| Occasional patches of limestone resting on and grading into sandstone below | 0.5 |
| Sandstone, massive, weathers with a pitted upper surface, considered equivalent to Paola limestone | 6.0 |
| Chanute formation. | |
| Carbonaceous shale member, not observed. | |
| Cottage Grove sandstone member. | |
| Covered, probably sandstone | 4.0 |
| Sandstone, gray, thin-bedded, fine-grained | 2.0 |
| Thayer coal member. | |
| Coal | 0.8 |
| Shale member. | |
| Shale, gray | 2.5 |
| Covered, probably shale | 3.0 |
| Dewey limestone. | |
| Does not crop out but is indicated by large pieces washed from a deep scour in the bottom of Post Oak Creek just east of the W¼ corner of the section. | |

78. SEC. 6, T. 27 N., R. 14 E., 1/8 MILE EAST OF SOUTHWEST CORNER

| | |
|---|---|
| Chanute formation. | |
| Carbonaceous shale member, not observed. | |
| Cottage Grove sandstone member. | |
| Sandstone, light-yellow color, soft, thin-bedded | 6.0 |
| Thayer coal member, not exposed. | |
| Shale member. | |
| Shale, weathers blue to yellow, no coal observed | 10.0 |
| Dewey limestone. | |
| Limestone, base not exposed | 10.0 |

79. SEC. 30, T. 27 N., R. 14 E., 300 FEET EAST OF SW CORNER

| | |
|---|---|
| Chanute formation. | |
| Carbonaceous shale member, does not crop out. | |
| Cottage Grove sandstone member. | |
| Sandstone, weathers reddish-brown, thin-bedded, fine-grained, top eroded | 10.0 |
| Thayer coal member. | |
| Coal | 0.1 |
| Shale member. | |
| Shale, dark, weathers yellow | 11.0 |
| Dewey limestone. | |
| Limestone | 17.0 |
| Nellie Bly formation, not measured. | |

80. SEC. 22, T. 27 N., R. 13 E., SE SW NW

| | |
|---|---|
| Dewey limestone. | |
| Limestone, granular with an abundance of phosphatic nodules | 0.2 |

| | Feet |
|---|---|
| (This phosphatic bed is found at no other locality visited and is probably a remnant of a phase of the Dewey limestone removed in other places by pre-Chanute erosion.) | |
| Shale | 4.0 |
| Limestone, massive, not measured. | |

81. SEC. 26, T. 27 N., R. 13 E., CENTER OF SE NW IN THE OLD QUARRY OF THE DEWEY PORTLAND CEMENT COMPANY

| | |
|---|---|
| Dewey limestone. | |
| Limestone, blue-gray to red, massive, honey-combed with small solution cavities | 4.0 |
| Limestone, blue-gray, dense, massive, fossiliferous | 14.0 |
| Limestone, below floor of quarry, probably shaly and possibly siliceous, about | 3.0 |

82. SEC. 25, T. 27 N., R. 14 E. FROM CENTER OF SECTION TO SW CORNER. (Dip Allowed 15 Feet)

| | |
|---|---|
| Dewey limestone. | |
| Limestone, top eroded | 5.0 |
| Nellie Bly formation. | |
| Sandstone, reddish-brown, fine-grained, thin-bedded, poorly exposed | 10.0 |
| Shale, sandy, poorly exposed | 30.0 |
| Sandstone, reddish-brown, thin-bedded, fine-grained | 10.0 |
| Covered, grassy slope, probably shale | 55.0 |
| Hogshooter limestone. | |
| Limestone, not measured. | |

(Interval from Dewey to Hogshooter measured by barometer, subdivisions are approximate.)

83. SEC. 12, T. 27 N., R. 14 E., FROM OUTLIER OF DEWEY LIMESTONE IN NE¼ TO TOP OF HOGSHOOTER LIMESTONE SOUTHEAST OF SE CORNER

| | |
|---|---|
| Dewey limestone, top eroded, not measured. | |
| Nellie Bly formation. | |
| Shale, estimated | 10.0 |
| Sandstone, about | 15.0 |
| Shale, sandy with occasional thin, dense, fine-grained, reddish-brown sandstones | 80.0 |
| Hogshooter limestone, not measured. | |

84. SEC. 18, T. 27 N., R. 15 E., SW NW NW

| | |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone | 6.0 |
| Limestone, dark, crinoidal, phosphatic nodules | 1.0 |
| Stark Shale member. | |
| Shale, black, fissile | 2.0 |
| Canville limestone member. | |
| Limestone, dark, slightly siliceous | 0.5 |
| Coffeyville formation. | |
| Shale, gray, calcareous | 0.2 |
| Sandstone, not measured. | |

85. SEC. 30, T. 27 N., R. 15 E., ¼ MILE WEST OF NORTHEAST CORNER

| | |
|---|---|
| Hogshooter limestone. | |
| Limestone, eroded, not measured. | |
| Coffeyville formation. | |
| Shale, gray | 12.0 |
| Coal | 1.5 |
| Shale, not measured. | |

86. SEC. 22, T. 27 N., R. 15 E., 1,000 FEET NORTH OF SOUTH ¼ CORNER (A very poor exposure, measurements are approximate only.)

| | Feet |
|---|---|
| Coffeyville formation. | |
| Shale, black, fissile, contains phosphatic nodules in base | 2.5 |
| Checkerboard limestone. | |
| Member 3. | |
| Limestone, gray, marly, fossiliferous | 1.0 |
| Member 2. | |
| Shale, gray, calcareous, fossiliferous | 6.0 |
| Member 1. | |
| Limestone, gray, fossiliferous, splits into thin plates in weathering | 1.0 |

## TOWNSHIP 28 NORTH

87. SEC. 2, T. 28 N., R. 12 E., MEASURED ON BIG HILL SOUTH OF OSAGE GAP THROUGH WHICH RAILROAD PASSES

| | |
|---|---|
| Weston shale. | |
| Unnamed sandstone. | |
| Sandstone, top eroded | 5.0 |
| Unnamed shale. | |
| Covered, probably shale | 20.0 |
| Gap sandstone. | |
| Sandstone, brown, fine-grained | 1.5 |
| Unnamed shale. | |
| Covered, probably shale | 14.0 |
| Hulah sandstone. | |
| Sandstone, brown | 5.0 |

88. SEC. 13, T. 28 N., R. 12 E., FROM HORIZON OF THE BIRCH CREEK LIMESTONE AT THE CENTER OF SECTION TO TOP OF HILL TO NORTH

| | |
|---|---|
| Weston shale. | |
| Unnamed sandstone and shale. | |
| Sandstone, weathers brown, dense, fine-grained, makes large slabs | 1.0 |
| Covered, grassy slope, probably shale | 8.0 |
| Hulah sandstone. | |
| Sandstone, weathers brown, massive, medium-grained, dense | 6.0 |
| Unnamed shale. | |
| Covered, grassy slope, steep, probably sandy shale and thin sandstones | 74.0 |
| "The Okesa". | |
| Sandstone, poorly exposed, tree-covered | 20.0 |
| Covered, grassy slope, probably shale | 25.0 |
| Birch Creek limestone. | |
| Limestone or fossiliferous zone in clay shale, badly weathered | 3.0 |

89. SEC. 22, T. 28 N., R. 12 E., ACROSS THE CREEK WEST FROM THE SOUTHWEST CORNER, WEST TO TOP OF HILL

| | |
|---|---|
| Weston shale. | |
| Gap? sandstone. | |
| Sandstone, reddish-brown, medium-grained, massive to thin-bedded | 2.0 |
| Unnamed shale. | |
| Covered, grassy slope, probably shale | 18.0 |
| Hulah sandstone. | |
| Sandstone, reddish-brown, medium-grained, massive to thin-bedded | 10.0 |

| | Feet |
|---|---|
| Unnamed shale. | |
| Covered, grassy slope, probably shale | 70.0 |
| "The Okesa". | |
| Sandstone, base not exposed. | |

90. SEC. 11, T. 28 N., R. 12 E., FROM THE SANDSTONE AT THE NORTHEAST CORNER TO THE BASE OF SANDSTONE AT TOP OF HILL ALONG ROAD WESTWARD

| | |
|---|---|
| Weston shale. | |
| Hulah sandstone. | |
| Sandstone, top not exposed. | |
| Unnamed shale. | |
| Shale, covered for most part, contains several sandstone beds | 70.0 |
| "The Okesa". | |
| Sandstone, base not exposed. | |

91. SECS. 1 AND 12, T. 28 N., R. 12 E., FROM TOP OF TORPEDO SANDSTONE BY BRIDGE 1/8 MILE NORTH OF NE COR. SEC. 12, TO TOP OF HILL SOUTH OF SAME CORNER

| | |
|---|---|
| Weston shale. | |
| "The Okesa". | |
| Sandstone in beds 0.1 to 0.4 foot thick, weathers reddish-brown, medium- to fine-grained, (thickness measured ½ mile west) | 40.0 |
| Shale, buff colored | 12.0 |
| Birch Creek limestone. | |
| Limestone, weathers brown, sandy, fossiliferous | 1.0 |
| Torpedo sandstone and overlying shale. | |
| Overlying shale. | |
| Shale, sandy | 2.0 |
| Shale, gray, calcareous, fossiliferous | 4.0 |
| Covered, probably shale | 64.0 |
| Torpedo sandstone. | |
| Sandstone, base not exposed. | |

92. SEC. 23, T. 28 N., R. 12 E., FROM EDGE OF THE ALLUVIUM EAST OF THE SOUTHWEST CORNER NORTHEAST TO THE SHALE PIT NEAR THE CENTER SW SE

| | |
|---|---|
| Weston shale. | |
| "The Okesa". | |
| Shale at the base grading upward through sandy shale into sandstone at the top | 40.0 |
| Birch Creek limestone. | |
| Limestone, bluish-white, fossiliferous | 2.0 |
| Torpedo sandstone and overlying shale. | |
| Overlying shale. | |
| Shale | 3.0 |
| Sandstone | 2.0 |
| Covered, seems to be sandy shale | 10.0 |
| Limestone apparently less than 1 foot thick, fossiliferous, exposed at the edge of the alluvium in south road ditch, base not exposed. | |

### 93. SEC. 8, T. 28 N., R. 13 E., FROM TOP OF TORPEDO SANDSTONE AT NE AND SE CORNERS TO TOP OF HILL AT E¼ CORNER

| | Feet |
|---|---|
| Weston shale. | |
| "The Okesa". | |
| Sandstone, top eroded, not measured. | |
| Shale, gray to buff | 12.0 |
| Birch Creek limestone. | |
| Limestone, coquinoid | 0.5 |
| Torpedo sandstone and overlying shale. | |
| Overlying shale. | |
| Covered, grassy slope, probably shale | 24.0 |
| Torpedo sandstone. | |
| Sandstone, base not exposed, not measured. | |

### 94. SEC. 15, T. 28 N., R. 13 E., FROM DRAW SOUTH OF NE CORNER TO TOP OF HILL SOUTH OF E¼ CORNER

| | |
|---|---|
| Birch Creek limestone. | |
| Limestone, brown and sandy with a minor amount of white limestone, caps mound as fragmental layer | 1.0 |
| Torpedo sandstone and overlying shale. | |
| Overlying shale. | |
| Shale, gray, calcareous, very fossiliferous, good collecting | 6.0 |
| Shale, gray calcareous, fossiliferous | 23.0 |
| Sandstone | 1.0 |
| Covered, roadside ditch shows clay and fragments of sandstone, probably dark shale, base not exposed | 40.0 |

### 95. SEC. 6, T. 28 N., R. 14 E. BEGINNING AT THE FOOT OF THE HILL AT THE HOUSE ON THE EAST SIDE OF THE ROAD ¼ MILE NORTH OF SE CORNER, FOLLOWING ROAD SOUTH AND WEST TO TOP OF HILL

| | |
|---|---|
| Torpedo sandstone and overlying shale. | |
| Torpedo sandstone. | |
| Shale, gray, sandy, top eroded | 6.0 |
| Sandstone, gray to brown, thin-bedded to massive, soft, micaceous | 25.0 |
| Shale, weathers light yellow | 15.0 |
| Sandstone, light gray to brown, soft, thin-bedded to massive | 15.0 |
| Wann formation. | |
| Covered, roadside ditch shows shale and clay, probably all dark shale, weathers yellow, base not exposed | 40.0 |

### 96. SEC. 8, T. 28 N., R. 14 E., FROM SW CORNER EASTWARD 0.3 MILES

| | |
|---|---|
| Torpedo sandstone and overlying shale. | |
| Torpedo sandstone. | |
| Sandstone, gray, thin-bedded, soft, micaceous, top eroded | 10.0 |
| Shale, dark, sandy | 5.0 |
| Sandstone, shaly | 1.0 |
| Wann formation. | |
| Shale, dark, weathers brown to gray | 50.0 |
| Limestone, weathers yellow, platy, shaly, fossiliferous | 3.0 |
| Shale, gray, base not exposed, not measured. | |

### 97. SEC. 9, T. 28 N., R. 14 E., FROM ¼ MILE EAST OF SW CORNER UP HILL TO NORTHWEST

| | |
|---|---|
| Torpedo sandstone and overlying shale. | |
| Torpedo sandstone. | |
| Sandy shale and thin beds of sandstone, top eroded | 30.0 |

| | Feet |
|---|---|
| Sandstone, thin-bedded, limy | 8.0 |
| Wann formation. | |
| Shale, dark, weathers gray | 35.0 |
| Limestone, unfossiliferous, shaly, platy, weathers yellow | 3.0 |
| Shale, dark, base not exposed, not measured. | |

### 98. SECS. 9 AND 10, T. 28 N., R. 14 E., FROM 0.1 MILE EAST OF SE CORNER SEC. 9 TO TOP OF HILL 0.1 MILE NORTH OF SW CORNER SEC. 10

| | |
|---|---|
| Torpedo sandstone and overlying shale. | |
| Torpedo sandstone. | |
| Covered, grassy sandy slope, probably very sandy shale, top eroded | 10.0 |
| Sandstone, light gray, soft to hard, thin-bedded to massive | 15.0 |
| Wann formation. | |
| Covered, grassy side of hill, probably shale | 57.0 |
| Limestone, weathers yellow, platy, shaly, unfossiliferous | 3.0 |
| Covered, probably dark shale | 40.0 |
| Iola formation. | |
| Avant limestone member. | |
| Limestone, gray, fossiliferous, top only exposed. | |

### 99. SECS. 19 AND 29, T. 28 N., R. 14 E., FROM TOP OF IOLA LIMESTONE IN DRAW BACK OF HOUSE BY RAILROAD TRACK ½ MILE EAST OF NW CORNER SEC. 29 TO BASE OF TORPEDO SANDSTONE BELOW HOUSE ON HILL ¼ MILE NORTHWEST OF SE CORNER SEC. 19

| | |
|---|---|
| Torpedo sandstone not measured. | |
| Wann formation. | |
| Covered, grassy slope, probably dark shale | 75.0 |
| Limestone, yellow, platy, shaly | 3.0 |
| Covered, probably shale | 25.0 |
| Iola formation. | |
| Not measured. | |

### 100. SEC. 10, T. 28 N., R. 14 E., CENTER OF NW¼ SOUTH SIDE OF OLD RAILROAD GRADE

| | |
|---|---|
| Iola formation. | |
| Avant limestone member. | |
| Limestone, blue, hard, crinoidal | 1.0 |
| Muncie Creek shale member. | |
| Shale, calcareous, phosphatic nodules observed but not in place | 3.0 |
| Paola limestone member. | |
| Limestone, marly, fossiliferous, soft | 1.0 |
| Marl, grades into limy sandstone | 1.0 |
| Chanute formation. | |
| Carbonaceous shale member. | |
| Shale, soft, sandy, carbonized wood, plant remains | 0.2 |
| Coal | 0.1 |
| Cottage Grove sandstone member. | |
| Sandstone, thin-bedded, fine-grained, soft, base not exposed. | |

### 101. SECS. 10, 11, 12, T. 28 N., R. 14 E., FROM 1/8 MILE EAST OF S¼ CORNER OF SEC. 12 TO SW CORNER OF SEC. 10. (Dip allowed 39 feet per mile.)

Iola formation.
Paola limestone member.
Limy sandstone, top eroded.

| | Feet |
|---|---|
| Chanute formation. | |
| Carbonaceous shale member not recognized. | |
| Cottage Grove sandstone member. | |
| Sandstone, cream to buff in color, thin- and even-bedded, micaceous, shaly, in this locality there is 10 feet of very sandy shale in the top | 50.0 |

102. SEC. 33, T. 28 N., R. 14 E., SOUTHWEST CORNER

| | |
|---|---|
| Chanute formation. | |
| Cottage Grove sandstone member. | |
| Sandstone, top eroded | 10.0 |
| Thayer coal member, not recognized. | |
| Shale member. | |
| Shale, weathers yellow | 6.0 |
| Dewey limestone, not measured. | |

103. SEC. 34, T. 28 N., R. 14 E., FROM NORTH ¼ CORNER EASTWARD ¼ MILE

| | |
|---|---|
| Chanute formation. | |
| Shale member. | |
| Clay shale, weathered | 18.0 |
| Dewey limestone. | |
| Not measured. | |

104. SEC. 18, T. 28 N., R. 15 E., WEST OF N¼ CORNER

| | |
|---|---|
| Chanute formation. | |
| Cottage Grove sandstone member. | |
| Sandstone, light yellow, thin-bedded, fine-grained, micaceous, top eroded | 5.0 |
| Thayer coal member. | |
| Coal | 0.2 |
| Shale member. | |
| Shale, sandy | 8.0 |
| Shale, poorly exposed | 30.0 |
| Noxie sandstone member. | |
| Sandstone, coarse, cross-bedded, not measured. | |

105. SEC. 7, T. 28 N., R. 15 E., WEST OF NORTH ¼ CORNER

| | |
|---|---|
| Chanute formation. | |
| Thayer coal member. | |
| Coal | 0.3 |
| Shale member. | |
| Clay shale, gray, weathers buff, plant fossils | 7.5 |
| Coal | 0.3 |
| Shale, under clay? | 0.2 |
| Shale, dark, weathers bluish | 6.0 |
| Coal, very shaly | 0.8 |
| Clay shale, dark, weathers bluish | 27.0 |
| Noxie sandstone member. | |
| Sandstone, coarse, cross-bedded, not measured. | |

106. SEC. 13, T. 28 N., R. 14 E., NEAR CENTER

| | |
|---|---|
| Chanute formation. | |
| Thayer coal member. | |
| Coal | 0.1 |
| Shale member. | |
| Shale, weathers light blue | 15.0 |
| Dewey limestone. | |
| Limestone, gray, fossiliferous | 6.0 |
| Nellie Bly formation. | |
| Shale, gray, calcareous | 4.0 |
| Sandstone, thin-bedded, base not exposed, not measured. | |

### 107. SEC. 19, T. 28 N., R. 15 E., FROM THE SOUTH ¼ CORNER TO THE SW CORNER

| | Feet |
|---|---|
| Dewey limestone. | |
| Limestone, top eroded, not measured. | |
| Nellie Bly formation. | |
| Upper third, sandstone at the top, reddish-brown, soft, fine- to medium-grained, grades downward into very sandy shale. | |
| Middle third, top very sandy shale, grades downward into shale with little grit. | |
| Lower third, clay shale with little grit. | |
| Total thickness | 80.0 |
| Hogshooter limestone, not measured. | |

### 108. SECS. 3, 4, T. 28 N., R. 15 E. ALONG SOUTH SIDE, CONTINUING ¼ MILE WEST OF SOUTHWEST CORNER

| | |
|---|---|
| Nellie Bly formation. | |
| Sandstone and sandy shale, top removed by pre-Chanute erosion | 45.0 |
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, gray, estimated | 5.0 |
| Coffeyville formation. | |
| Covered along this line but in this vicinity there is usually at the top 10 feet of sandy shale with one or more thin coal veins. The remainder consists of thin-bedded lenses of buff to reddish-brown sandstone and sandy shale. There is usually a thin coal 40 feet from the top | 45.0 |
| Shale, base not exposed. | |

### 109. SECS. 20, 21, 22, 23, T. 28 N., R. 15 E. FROM 200 FEET EAST OF SW CORNER OF SEC. 22 TO 200 FEET W OF N¼ CORNER OF SEC. 20, CHECKED FROM S¼ CORNER OF SEC. 20 TO SW CORNER OF SEC. 20

| | |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, top eroded, not measured. | |
| Coffeyville formation. | |
| Shale, gray | 10.0 |
| Sandstone, buff-colored, thin-bedded, fine-grained | 20.0 |
| Coal | 0.1 |
| Sandstone, buff-colored, thin-bedded, fine-grained | 5.0 |
| Shale, sandy | 55.0 |
| Covered, probably shale | 60.0 |
| Thin-bedded, sandy shale and fine-grained sandstone | 8.0 |
| Shale, base not exposed. | |

### 110. SEC. 23, T. 28 N., R. 15 E., 1200 FEET SOUTH OF W¼ CORNER

| | |
|---|---|
| Coffeyville formation (in middle part). | |
| Shale, not measured. | |
| Sandstone, brown, thin-bedded | 4.0 |
| Shale, gray, micaceous, sandy | 9.0 |
| Sandstone, gray, micaceous | 2.5 |
| Shale, gray, micaceous, base not exposed | 11.0 |

### 111. SEC. 12, T. 28 N., R. 15 E. ALONG WEST SIDE OF NW¼

| | |
|---|---|
| Coffeyville formation (in middle part). | |
| Sandstone, top eroded, not measured. | |
| Covered, topography and ditches in the vicinity indicate shale with a few thin sandstones | 75.0 |
| Sandstone, base not exposed. | |

### 112. SEC. 31, T. 28 N., R. 16 E., FROM ESTIMATED HORIZON OF CHECKERBOARD LIMESTONE 1/8 MILE EAST OF SW CORNER TO THAT CORNER

| | Feet |
|---|---|
| Coffeyville formation (lower part). | |
| Sandstone, top eroded, buff to reddish-brown, beds 0.2 foot thick, moderately hard, fine-grained | 2.0 |
| Shale, sandy | 5.0 |
| Sandstone, buff to reddish-brown, thin-bedded, moderately hard, fine-grained | 6.0 |
| Covered, probably shale with a few sandy streaks | 50.0 |
| Checkerboard limestone. | |
| Does not crop out, horizon indicated by change in soil from the sticky clay soil of the Coffeyville formation to the sandy soil of the Seminole formation. | |

### 113. SEC. 6, T. 28 N., R. 16 E., NEAR E¼ CORNER, FROM BLACK SHALE IN DRAW WEST OF HIGHWAY TO SANDSTONE AT TOP OF RIDGE TO WEST

| | |
|---|---|
| Coffeyville formation (lower part). | |
| Sandstone, top eroded, not measured. | |
| Clay shale, dark | 55.0 |
| Sandstone | 4.0 |
| Shale, gray | 6.0 |
| Shale, black, fissile, contains phosphatic nodules, base not exposed | 2.0 |

### 114. SEC. 25, T. 28 N., R. 15 E., 300 FEET UP THE STREAM NORTH OF THE E¼ CORNER

| | |
|---|---|
| Coffeyville formation. | |
| Black fissile shale with phosphatic nodules | 2.0 |
| Checkerboard formation. | |
| Member 3. | |
| Limestone, blue, hard, nodular | 0.5 |
| Member 2. | |
| Shale, gray, calcareous, fossiliferous | 5.5 |
| Member 1. | |
| Limestone, granular to flaky | 1.0 |
| Seminole formation. | |
| Shale, sandy, about | 3.0 |
| Sandstone, base not exposed, not measured. | |

### 115. SEC. 18, T. 28 N., R. 16 E., FROM ¼ MILE EAST OF S¼ CORNER UP STREAM TO POINT NEAR CENTER OF SECTION

| | |
|---|---|
| Missouri subseries. | |
| Checkerboard formation. | |
| Member 1. | |
| Limestone, gray, platy, fossiliferous | 1.0 |
| Seminole formation. | |
| Thin-bedded, sandy shale or shaly sandstone, a few thin beds of fine-grained, hard sandstone | 10.0 |
| Coal, Dawson | 0.1 |
| Clay shale, yellow | 2.5 |
| Des Moines subseries | |
| Lenapah limestone. | |
| Limestone, weathers red brown or yellow, fossiliferous | 0.5 |
| Shale, light-colored, calcareous | 0.5 |
| Shale, black fissile, contains phosphatic nodules | 1.0 |
| Shale, gray, weathers yellow | 2.0 |
| Limestone, gray to white, base poorly exposed, estimated | 15.0 |

## TOWNSHIP 29 NORTH

### 116. SEC. 22, T. 29 N., R. 12 E., NEAR THE CENTER OF THE WEST LINE

| | Feet |
|---|---|
| Missouri subseries? | |
| Ochelata group? | |
| Weston shale? | |
| Cheshewalla sandstone. | |
| Sandstone, reddish-brown, coarse-grained, top eroded, about | 15.0 |
| Missouri subseries. | |
| Ochelata group. | |
| Weston shale. | |
| Unnamed shale. | |
| Shale, probably contains a few thin sandstone beds | 160.0 |
| Hulah sandstone. | |
| Sandstone, base not exposed, not measured. | |

### 117. SEC. 17, T. 29 N., R. 13 E., FROM BRANCH ROAD ¼ MILE NORTH OF SE COR. TO TOP OF HILL TO NORTH

| | |
|---|---|
| Weston shale. | |
| "The Okesa". | |
| Limestone, gray, sandy | 10.0 |
| Covered, probably sandy shale and sandstone | 55.0 |
| Birch Creek limestone. | |
| Limestone, gray to brown, sandy | 2.0 |

### 118. SEC. 21, T. 29 N., R. 13 E., CENTER OF SW NE BELOW OLD RAILROAD GRADE IN SPILLWAY OF POND

| | |
|---|---|
| Birch Creek limestone. | |
| Limestone, brown, weathers yellow, extremely sandy, fossiliferous, oolitic | 2.0 |
| Shale, blue-gray, calcareous | 2.0 |
| Limestone, brown, sandy, fossiliferous | 2.5 |
| Torpedo sandstone and overlying shale. | |
| Overlying shale. | |
| Shale, sandy, trace of phosphate | 2.0 |
| Shale, extremely granular, trace of phosphate | 0.4 |
| Shale, thin-bedded, very sandy, slight trace of phosphate | 3.0 |
| Shale, dark, semifissile | 7.0 |
| Shale, sandy, brown, micaceous | 0.4 |
| Sandstone, limy, micaceous | 1.0 |

### 119. SEC. 36, T. 29 N., R. 12 E., AT W¼ COR. SOUTH SIDE OF STREAM, NEAR HOUSE

| | |
|---|---|
| Torpedo sandstone and overlying shale. | |
| Torpedo sandstone (in middle part). | |
| Sandstone, limy, massive to thin-bedded | 8.0 |
| Limestone, gray, sandy, crinoidal, base not exposed | 6.0 |

### 120. SECS. 20, 28, T. 29 N., R. 14 E. FROM OUTCROP OF LIMESTONE IN ROAD 3/8 MILE NORTH OF SE CORNER OF SEC. 20 TO LIMESTONE ON TOP OF HILL IN NW¼ OF SEC. 28

| | |
|---|---|
| Birch Creek limestone. | |
| Limestone, gray to brown, sandy, fossiliferous, many crinoid stems | 1.0 |
| Torpedo sandstone and overlying shale. | |
| Overlying shale, absent. | |
| Torpedo sandstone. | |
| Sandstone, brown, thin-bedded | 5.0 |

| | Feet |
|---|---|
| Wann formation. | |
| Shale, covered, probably clay shale with a few sandy streaks .. | 95.0 |
| Limestone, weathers yellow, shaly and platy, fossiliferous .... | 1.0 |
| Shale, base not exposed not measured. | |

121. SECS. 22, 23, T. 29 N., R. 13 E., ALONG SOUTH SIDE, FROM ¼ MILE EAST OF SE CORNER OF SEC. 23 TO ¼ MILE WEST OF SW CORNER OF SEC. 22

| | |
|---|---|
| Birch Creek limestone. | |
| Limestone, buff to brown, sandy, fossiliferous | 4.0 |
| Torpedo sandstone and overlying shale. | |
| Overlying shale. | |
| Shale covered, material from post holes indicates clay shale | 15.0 |
| Torpedo sandstone. | |
| Sandstone, reddish-brown, thin-bedded to massive, medium grained | 30.0 |
| Wann formation. | |
| Shale covered, regionally this interval is clay shale, a calcareous zone 70 to 80 feet from the base carries *Leiorhynchus*, *Trepospira* and other fossils making an assemblage typical of the member | 95.0 |
| Iola formation, not measured. | |

122. SECS. 22, 27, T. 29 N., R. 14 E., ALONG WEST SIDE

| | |
|---|---|
| Birch Creek limestone. | |
| Limestone, gray, sandy, fossiliferous | 2.0 |
| Torpedo sandstone and overlying shale. | |
| Overlying shale, absent. | |
| Torpedo sandstone. | |
| Sandstone, locally absent | 1.0 |
| Wann formation. | |
| Shale, covered, probably clay shale | 145.0 |
| Iola formation. | |
| Does not crop out but position is indicated by change from sticky clay soil of lower Wann formation to sandy soil of Cottage Grove sandstone. | |

123. SEC. 25, T. 29 N., R. 13 E., ¼ MILE SOUTH OF N¼ CORNER

| | |
|---|---|
| Iola formation. | |
| Avant limestone member. | |
| Limestone, yellowish, argillaceous, crinoidal slightly sandy | 1.0 |
| Shale, gray, calcareous, fossiliferous | 2.0 |
| Limestone, yellow, crinoidal | 1.0 |
| Muncie Creek shale member. | |
| Shale, gray calcareous, sandy, fossiliferous, phosphatic nodules in the base | 3.0 |
| Paola limestone member. | |
| Limestone and limy sandstone, surface pitted | 1.0 |

124. SEC. 22, T. 29 N., R. 14 E., 1/8 MILE NORTH OF SOUTH ¼ CORNER IN MAIN DRAW

| | |
|---|---|
| Iola formation. | |
| Avant limestone member. | |
| Limestone, gray to buff, crinoidal | 1.0 |
| Muncie Creek shale member. | |
| Shale, dark, weathers yellow, gray phosphatic nodules in the base | 3.0 |
| Paola limestone member. | |
| Marl, yellow, soft, sandy, with residual fragments of crinoidal limestone, badly weathered | 0.3 |

| | Feet |
|---|---|
| Chanute formation. | |
| Carbonaceous shale member. | |
| Coal, no underclay | 0.1 |
| Cottage Grove sandstone member. | |
| Sandstone, gray, soft, fine-grained, thin-bedded, base not exposed, not measured. | |

125. SEC. 23, T. 29 N., R. 14 E., FROM N¼ CORNER TO 1/8 MILE NORTH OF SE CORNER

| | |
|---|---|
| Chanute formation. | |
| Cottage Grove sandstone member. | |
| Sandstone, buff-colored, thin- and even-bedded, fine-grained, micaceous | 40.0 |

126. SEC. 24, T. 29 N., R. 14 E., NEAR NE CORNER

| | |
|---|---|
| Chanute formation. | |
| Cottage Grove sandstone member. | |
| Sandstone, light buff, thin-bedded to massive, fine-grained, top eroded | 10.0 |
| Thayer coal member. | |
| Shale, dark, poorly exposed | 5.9 |
| Coal | 0.1 |
| Shale member. | |
| Shale, dark, incompletely exposed | 45.0 |
| Noxie sandstone member. | |
| Sandstone, not measured. | |

127. SEC. 25, T. 29 N., R. 14 E., 1/8 MILE NORTH OF SE CORNER

| | |
|---|---|
| Chanute formation. | |
| Thayer coal member. | |
| Coal | 0.1 |
| Shale member. | |
| Shale, dark | 9.0 |
| Coal | 0.1 |
| Shale, dark, bluish color | 1.0 |
| Coal | 0.1 |
| Shale, blue | 1.0 |
| Coal | 0.1 |
| Shale, light-colored, sandy | 2.0 |
| Shale, dark | 9.0 |
| Noxie sandstone member. | |
| Sandstone, coarse cross-bedded, not measured. | |

128. SEC. 24, T. 29 N., R. 14 E., ALONG EAST SIDE

| | |
|---|---|
| Chanute formation. | |
| Noxie sandstone member. | |
| Sandstone, buff to reddish-brown, massive, coarse, cross-bedded | 60.0 |
| Basal conglomerate member. | |
| Limestone conglomerate | 5.0 |

129. SEC. 15, T. 29 N., R. 15 E., NE NE NE

| | |
|---|---|
| Chanute formation. | |
| Basal conglomerate member. | |
| Limestone, gray, thin-bedded, fossiliferous, conglomeratic, contains a few phosphatic nodules in the base | 20.0 |
| (This conglomeratic limestone overlaps the calcareous flags in the lower part of the Nellie Bly formation in sec. 14.) | |

130. SEC. 28, T. 29 N., R. 15 E., WEST SIDE OF THE NW NW

| | |
|---|---|
| Chanute formation. | |
| Basal conglomerate member. | |
| Limestone conglomerate | 2.0 |
| Nellie Bly formation. | |
| Clay shale | 80.0 |

| | Feet |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, not measured. | |

131. SEC. 32, T. 29 N., R. 15 E., NORTH ¼ CORNER

| | Feet |
|---|---|
| Chanute formation. | |
| Noxie sandstone member. | |
| Sandstone, coarse, tree-bearing, not measured. | |
| Nellie Bly formation. | |
| Clay shale, upper part removed by pre-Chanute erosion | 55.0 |
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, not measured. | |

132. SEC. 14, T. 29 N., R. 15 E., ¼ MILE WEST OF SE CORNER

| | Feet |
|---|---|
| Hogshooter formation. | |
| Stark shale member. | |
| Shale, black, fissile | 2.0 |
| Limestone, dark, siliceous, much fractured | 1.0 |
| Shale, black, fissile, base not exposed | 4.0 |

133. SEC. 21, T. 29 N., R. 15 E. VICINITY OF SW CORNER

| | Feet |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, gray, contains crinoids and brachiopods | 5.0 |
| Shale, limy, crinoid stems and brachiopods | 1.0 |
| Limestone, dark, crinoidal, contains phosphatic nodules | 0.8 |
| Coffeyville formation. | |
| Shale, limy | 0.4 |
| Coal | 0.1 |
| Sandy shale and thin sandstones | 5.7 |
| Sandstone, light-colored, fine-grained, base not exposed | 5.0 |

134. SEC. 14, T. 29 N., R. 15 E., EAST ¼ CORNER

| | Feet |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, top eroded | 14.0 |
| Coffeyville formation. | |
| Sandstone, light-colored, micaceous | 1.8 |
| Coal | 0.4 |
| Shale, light-colored, sandy, micaceous | 5.0 |
| Coal | 0.1 |
| Sandstone, brown, thin-bedded | 6.0 |
| Sandstone, light-colored, shaly, thin-bedded, micaceous | 6.0 |
| Shale, sandy | 12.0 |
| Covered, probably sandy shale | 17.0 |
| Sandstone, thin-bedded | 1.0 |
| Shale, ferruginous, very sandy, micaceous, base not exposed | 4.0 |

135. SEC. 28, T. 29 N., R. 15 E., NEAR SW CORNER

| | Feet |
|---|---|
| Hogshooter formation. | |
| Winterset limestone member. | |
| Limestone, top eroded, not measured. | |
| Coffeyville formation. | |
| Shale, gray, a few thin sandstone beds | 15.0 |
| Sandstone, base not exposed, not measured. | |

136. SEC. 36, T. 29 N., R. 15 E., AT THE W¼ CORNER

| | Feet |
|---|---|
| Coffeyville formation (in lower part). | |
| Shale, top eroded. | |
| Sandstone, about | 4.0 |
| Shale, sandy | 6.0 |
| Sandstone, weathers gray to reddish-brown, thin-bedded, fine-grained | 4.0 |
| Clay shale, not measured. | |