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# Geology and Mineral Resources of Okfuskee County, Oklahoma

By

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# GEOLOGY AND MINERAL RESOURCES OF OKFUSKEE COUNTY, OKLAHOMA

By Edward Richard Ries

## ABSTRACT

Okfuskee County is in central eastern Oklahoma and covers an area of approximately 625 square miles. The consolidated bedrock that crops out is of Middle and Upper Pennsylvanian age, and consists principally of shales and sandstones, together with a few thin limestones and conglomerates. These are locally covered by surficial deposits of Quaternary age, including flood-plain deposits, higher terrace sands, residual high-level gravels, and eolian sand deposits. Volcanic ash is associated with the higher terrace sands.

*Stratigraphy.* The outcropping Pennsylvanian rocks are of the Des Moines, Missouri, and Virgil series, and have a composite thickness of about 3,865 feet. They are divided into 17 formations, which are further subdivided into 71 mapped units.

The oldest rocks exposed are in the upper part of the Des Moines series. They crop out in southeastern Okfuskee County and include, in ascending order, strata of the Senora formation, Calvin sandstone, Wetumka shale, Wewoka formation, and Holdenville shale. All are in the Marmaton group except the Senora, which is the highest formation in the Cabaniss group. A regional unconformity is present at the top of the Des Moines series, between the Holdenville shale and the overlying Seminole formation, but in Okfuskee County there is no demonstrable truncation or overlap. That part of the Des Moines series exposed in the county has a composite thickness of about 1,580 feet.

Rocks of the overlying Missouri series crop out in the central part of the county, where they have a composite thickness of about 1,270 feet. These strata are placed in the Skiatook group below, consisting of the Seminole formation, Checkerboard limestone, Coffeyville formation, Hogshooter formation, Nellie Bly formation, and the Dewey formation; and the Ochelata group above, consisting of the Chanute, Tallant and Barnsdall formations. Rocks of the Missouri series are mostly thick grayish- to brownish-green shales, thin sandstones, and thin limestones, all of which are typically marine. Limestones of the Checkerboard and Hogshooter formations disappear southward, in the central part of the county, by grading into shale. A minor unconformity is present at the base of the Barnsdall formation.

The youngest bedrocks exposed are in the Virgil series of Upper Pennsylvanian age. The mapped units in ascending order are Vamoosa formation, "Pawhuska" formation, and the Ada and Vanoss formations, undifferentiated. These formations crop out in the western part of the county and have a total thickness of about 880 feet. The strata consist of red to reddish-brown shales, sandstones, chert conglomerates, and dolomitic limestone, mostly deposited in a deltaic environment.

The Vamoosa contains at its base a chert conglomerate about 50 feet thick which is here named the Boley conglomerate member of the Vamoosa formation. At the base of the Boley conglomerate is the most prominent unconformity in Okfuskee County. Below it, all the Tallant formation and the upper part of the Barnsdall formation are strike-overlapped, the magnitude of overlap increasing southward toward the Arbuckle Mountains. By making the base of the Boley conglomerate the base of the Vamoosa formation, the writer restricts the definition of Vamoosa as originally given by Morgan.

*Fossils.* Most of the shales and many limestones of the Des Moines and Missouri series in Okfuskee County are fossiliferous. Although many fossils are long-ranging, *"Marginifera" muricatina, Mesolobus mesolobus, Delocrinus granulosus,* and a few other species were found to be diagnostic of the Des Moines series, whereas *Chonetinella* and *Triticites irregularis* were found to be diagnostic of the Missouri series. Fossils from the Virgil rocks are scarce and are undiagnostic. Faunal evidence indicates paucity of life in post-Dewey time.

*Subsurface geology.* The outcropping formations of the areal geologic map were traced into subsurface through the use of the electric logs of wells drilled for oil and gas. Generally the sandstones of the surface change into shales westward in subsurface, and this change is accompanied by westward thinning. The following important correlations are made with subsurface units as used by petroleum geologists in Okfuskee County; (a) subsurface Checkerboard limestone is equivalent to a sandy limestone in the Seminole formation; (b) subsurface Oswego is equivalent to a calcareous sandstone in the middle of the Wetumka formation; (c) subsurface Prue sand is equivalent to the upper Calvin sandstone; (d) subsurface Verdigris limestone is equivalent to limestones in the middle shale of the Calvin formation; and (e) subsurface Skinner sand is equivalent to the lower sandstone of the Calvin formation.

*Structural geology.* The regional structure of Okfuskee County is a gently dipping homocline in which the strata generally strike N. to N. 28 E. and dip westward 0.5 to 1 degree. The homocline is locally modified by anticlinal folds, noses, and faults, some of which have served as traps for petroleum and natural gas.



Surface faults of the county are typically en echelon, occurring in belts that trend northeastward roughly parallel to the strike of the Pennsylvanian formations. Within these belts the faults are arranged in subparallel, overlapping alignment, mostly striking N. 17 W. to N. 45 W. and commonly making an angle of about 45° with the direction of the belt in which they lie. All of these faults appear to be normal. Displacement on the en echelon faults is generally less than 40 feet at the surface, and decreases downward, as few of the faults can be detected in deeper subsurface work.

*Drainage.* Detailed drainage study in Okfuskee County showed that the drainage area of Deep Fork Canadian River is much larger than the drainage area of North Canadian River. At places, Deep Fork drainage encroaches within 2 miles of North Canadian River. At the same longitude, in R. 8 E., North Canadian River flows at an elevation of 800 feet, whereas Deep Fork flows at an elevation of 700 feet. This study indicates that Deep Fork once played a much more important role that it does now.

*Economic geology.* Oil and gas are the most important mineral resources of the county. Nonmetallic mineral resources include sand and gravel, shales and clays, limestone, building stone, and volcanic ash, most of which have not been extensively used owing to lack of market. Ground water suitable for municipal and industrial use occurs principally in alluvium and in sandstones of the Calvin, Wewoka, Nellie Bly, and Vamoosa formations.

# INTRODUCTION

## Scope and Purpose of Report

This report represents a detailed study of the rocks of Pennsylvanian age that crop out in Okfuskee County.

The primary purposes of this investigation were: (1) to make a detailed areal geologic map of Okfuskee County; (2) to study the surface rocks and to describe in detail their thickness, character, and distribution; (3) to collect and study fossils; and (4) to map the faults of the area.

## Location of the Area

The county is irregular in outline and contains approximately 625 square miles. It is approximately within Latitudes 35° 17′ North and 35° 39′ North, and within Longitudes 95° 59′ West and 96° 38′ West. A series of three topographic maps [1, 2, 3] cover the county.

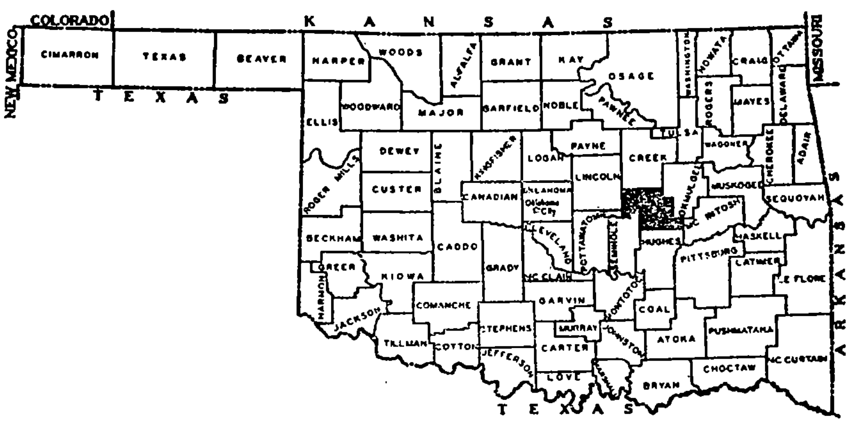


Figure 1. Index Map of Oklahoma, showing the location of Okfuskee County.

[1] "Wewoka Quadrangle topographic sheet," *United States Geological Survey* (1901).

[2] "Nuyaka Quadrangle topographic sheet," *United States Geological Survey* (1901).

[3] "Stroud Quadrangle topographic sheet," *United States Geological Survey* (1906).



## Accessibility of the Area

U. S. Highways No. 62 and 75 and Oklahoma Highways No. 1, 27, and 56 traverse the county. These roads are either paved or graveled. The primary road system is supplemented by many section-line roads which give access by automobile to almost every section, except a few in the more rugged parts of the county.

Okfuskee County is served by two railroads: the St. Louis and San Francisco Railroad and the Kansas, Oklahoma, and Gulf Railroad.

## Previous Investigations

In 1910, Gould, Ohern, and Hutchison[4] studied the groupings of the Pennsylvanian rocks of eastern Oklahoma. In the same year, Ohern[5] published his work on the stratigraphy of the older Pennsylvanian rocks of northeastern Oklahoma. In his studies of structural materials in 1911, Gould[6] mentioned some of the sandstones, limestones, clays, and shales of the county. The same year, Snider[7] worked on the clays and discussed the stratigraphy of Okfuskee County. In his preliminary report on road materials, Snider[8] included the road-building materials of the county.

In his study of the volcanic dust in Oklahoma, Frank Buttram[9] discussed the volcanic ash deposits in sec. 17, T. 10 N., R. 7 E. In 1917, Fath and Heald[10] completed their studies of the fault structure in the vicinity of Paden. The same year, L. C. Snider[11] included the geography of Okfuskee County in his "Geography of Oklahoma."

[4] Gould, C. N., Ohern, D. W. and Hutchison, L. L., 1910. *The State University of Oklahoma, Research Bulletin*, No. 3.

[5] Ohern, D. W., 1910. *The State University of Oklahoma, Research Bulletin*, No. 4.

[6] Gould, C. N., 1911. *Oklahoma Geological Survey, Bulletin* 5, p. 168.

[7] Snider, L. C., 1911. *Oklahoma Geological Survey, Bulletin* 7, p. 227.

[8] Snider, L. C., 1911. *Oklahoma Geological Survey, Bulletin* 7, p. 179.

[9] Buttram, Frank, 1914. *Oklahoma Geological Survey, Bulletin* 13, pp. 42-44.

[10] Fath, A. E., and Heald, K. C., 1917. *Oklahoma Geological Survey, Bulletin* 19, Part II, pp. 352-361.

[11] Snider, L. C., 1917. *Oklahoma Geological Survey, Bulletin* 27, pp. 302-303.

Investigations were stimulated by the finding of oil in Okfuskee County. In 1921, Kirwan and Schwarzenbek[12] wrote their report on the Deaner Oil Field. Three years later, Kirwan wrote two papers concerning the Quinn Dome[13] and on the effects of extraneous gas on the production of oil wells in the Lyons-Quinn field.[14] The same year, Lockwood wrote his paper on the Papoose Pool.[15] The year 1925 brought out the Gould and Decker stratigraphic review[16] in which they described lithology and listed fossils of many of the formations in Okfuskee County. In 1926, Bunn[17] wrote his petroleum engineering report on the Papoose oil field. Wilson's article on paleogeography[18] in 1927 shows Okfuskee County in relation to the paleogeography of Oklahoma. The "Digest of Oklahoma Oil Fields"[19] was published in 1928. This work contained a review of all the oil pools in Okfuskee County. Shead,[20] in his analyses of Oklahoma mineral raw materials report, included the analysis of such Okfuskee materials as volcanic ash, cupriferous sandstone, copper ores, gold and silver ores, gases, hydrocarbon complexes, and artesian water. In the same year, 1929, Moose and Searle[21] did a chemical study of Oklahoma coals. Their report included Okfuskee County in the area known to contain workable coals.

The beginning of the new decade brought a micropaleontological study of the Wetumka, Wewoka, and Holdenville formation by Warthin.[22] Many of the samples were collected in Okfuskee County. The most comprehensive geological study in Okfuskee County was published in 1930 when J. Phillip Boyle[23] discussed the surface and subsurface geology and included the first areal geologic map of the county. His work also included many surface and subsurface maps. A bibliography of Oklahoma oil and gas pools by Alan G. Skelton and Martha B. Skelton[24] contains a bibliography of the oil and gas pools in Okfuskee County.

12 Kirwan, M. J., and Schwarzenbek, F. X., 1921. *Department of Interior—Bureau of Mines*, in cooperation with the State of Oklahoma and the Bartlesville Chamber of Commerce, pp. 1-72.

13 Kirwan, M. J., 1924. *U. S. Bureau of Mines* in cooperation with the Office of Indian Affairs, pp. 1-53.

14 Kirwan, M. J., 1924. *U. S. Bureau of Mines, Report of Investigations* No. 2612, pp. 1-21.

15 Lockwood, C. D., 1924. *Oil and Gas Journal*, Vol. 23, No. 27, pp. 23, 110.

16 Gould, C. N., and Decker, C. E., 1925. *Oklahoma Geological Survey, Bulletin* 35.

17 Bunn, J. R., and Roark, Louis, 1926. *Oklahoma Geological Survey, Bulletin* 36.

18 Wilson, Roy A., 1927. *Oklahoma Geological Survey, Bulletin* 40, vol. 1, pp. 22-66.

19 "Digest of Oklahoma Oil Fields," 1928. *Oklahoma Geological Survey, Bulletin* 41, vol. 1, pp. 22-66.

20 Shead, A. C., 1929. *Oklahoma Geological Survey, Bulletin* 14, pp. 21, 27, 29, 31, 50, 57, 64, 73, 83, 87, 91, 110, 116, 126.

21 Moose, J. E., and Searle, V. C., 1929. *Oklahoma Geological Survey, Bulletin* 51, p. 7.



Within the last few years, the only significant work on Okfuskee County known to the writer has been a Master's Thesis by Neil Jackson[25] on the subsurface geology.

Throughout the years, much work, such as surface mapping and subsurface correlations, has been done by oil companies. Most of this information, however, is not available to the public.

## Present Investigations

### Preparation

Preparation for field work consisted of carefully making a base-map using the Agriculture Adjustment Administration aerial photographs, scale about 3.2 inches to the mile. Transparent cellulose acetate sheets were made for each photograph. These were attached by small cellulose tape hinges to the top of each photograph, so that the smooth side of the acetate was toward the picture. This placed the rough side of the acetate to the outside, making it possible to use pencil or ink for copying purposes. Aerial photographs in Okfuskee County are well suited for this type of mapping and for compilation of a base-map, as the photographs are of a nearly uniform scale and roads and fences clearly indicate the land survey lines.

Upon completion of the base-map, the aerial photographs were studied stereoscopically. During the stereoscopic study, all possible structural and stratigraphic data as well as drainage and

22 Warthin, A. S., 1930. *Oklahoma Geological Survey, Bulletin* 53.

23 Boyle, J. P., 1930. *Oklahoma Geological Survey, Bulletin* 40, Vol. III, pp. 431-450.

24 Skelton, A. G., and Skelton, M. B., 1942. *Oklahoma Geological Survey, Bulletin* 63.

25 Jackson, Neil, 1948. *Master of Science Thesis*, University of Oklahoma.

cultural features were traced directly onto the cellulose acetate sheets. Later these features were traced directly onto transparent township plats which had been used to make the base-map. Where the aerial photographs deviated from their average scale of three inches to the mile, the transfer of data onto the base map was completed by adjusting the data to every corner of the section. This gave rise to a slight distortion of features in the center of every section where an adjustment had been made.

### Field Procedure

Field investigation began in June, 1949, and was continued during the Summer and Fall of 1950. Township plats, with all the data that had been assembled from the aerial photographs, were taken into the field. Each township plat, when in use, was mounted on a piece of 20 by 22-inch fiber-board which had a transparent cellulose acetate cover. This cover gave the necessary protection while the mapping was in progress and changes were being made.

The mapping, which in part consisted of checking the data which were derived from aerial photographs, began in southeastern Okfuskee County. Each mappable unit was traced along the outcrop. Distances were checked from section-line corners with the aid of a speedometer. Lithology was noted and described and, in many places, detailed sections were measured by hand-level, alidale, transit, or aneroid. Where fossils were observed, collections were made.

### Laboratory Procedure

At most places it was difficult to obtain the true thickness of sections owing to slump, weathering, cover, and long distances between outcrops. Electric logs were obtained of wells drilled west of the outcrops and after positive identifications of the formations were established, true thicknesses were measured directly from the electric logs. Regional dips were also established.

Fossils that had been collected in the field were washed, cleaned, and sorted. Later they were identified and listed.




## Acknowledgments

The present report contains the essential results of a dissertation submitted in 1951 to the graduate faculty of the University of Oklahoma, in partial fulfillment of the requirements for the degree of Doctor of Philosophy. The dissertation was written under the able direction of Professor Charles E. Decker, who also checked the paleontology and read the manuscript. Mr. Malcolm C. Oakes of the Oklahoma Geological Survey checked the field work; recommended the stratigraphic nomenclature used for the Dewey, Chanute, Barnsdall, and Tallant formations; and read the manuscript. Mr. W. D. McBee of The Carter Oil Company carefully checked the electric log cross-section and supplied the nomenclature used for the pre-Senora strata. The following men on the faculty of the School of Geology in the University of Oklahoma read the dissertation and gave constructive criticism: Professor O. F. Evans, Professor A. J. Williams, and Associate Professor George G. Huffman.

Above all others, the writer is indebted to his wife, Amelia, for encouragement, help in the field, and in the final preparation of the dissertation.

The writer wishes to acknowledge the generosity of The Carter Oil Company who made their electric logs available, and the Oklahoma Geological Survey who loaned the aerial photographs.

Able assistance was rendered in the field during the summer of 1948 by Robert Donald Schneider of the University of Oklahoma.

Numerous improvements in the present text and geologic map have been made by Dr. William E. Ham of the Oklahoma Geological Survey. Final drafting of the colored geologic map was done in the drafting department of the Oklahoma Geological Survey by Dwight H. Ford and Mrs. Ramona Bloss.

# GEOGRAPHY

## Topographic Features

Regionally, Okfuskee County is in the area which Fenneman[26] has designated as the Central Lowland physiographic province. Locally, Snider[27] has included Okfuskee County in the Sandstone Hills region of the physiographic provinces of Oklahoma.

The surface rocks in this area are of Pennsylvanian age. They consist almost entirely of shales and sandstones with an occasional limestone and conglomerate. The shales are mostly thick, soft, and more easily eroded than the sandstones, and so became carved into low valleys. The sandstones have various thicknesses, but in general are thinner than the shales. Insofar as sandstones are harder and much more resistant to erosion, they support long, high ridges. The limestones are generally thin, and except at one locality none is thicker than 7 feet in the county. Many of the limestones are arenaceous and argillaceous, and in general crop out in shale slopes that are capped by resistant sandstones. The conglomerates, where well cemented, form high ridges.

The beds in Okfuskee County dip to the northwest at a rate of about one degree. Differential erosion has produced the prevailing topographic features in Okfuskee County.

There are numerous cuestas, some buttes, and a few hogbacks, formed by the more resistant sandstones.

The cuestas are characterized by eastward-facing steep escarpments, and long, gentle dip slopes that descend gradually from the crest of the cuesta to the level of the valley or plain to the west. In eastern Okfuskee County the trend of the cuestas is north 20° to 30° east, but in the western part of the county they trend more nearly north. The greatest relief of a single escarpment is in the SW¼ sec. 21, T. 10 N., R. 12 E., where the basal Calvin sandstone stands 300 feet above the valley floor. Most of the cuesta escarpments range between 50 and 100 feet in height.

26 Fenneman, Nevin M., 1938. *Physiography of Eastern United States* (McGraw-Hill Book Co., 1938), p. 616.

27 Snider, L. C., 1917. *Oklahoma Geological Survey, Bulletin* 27, pp. 80-81.



Many of the escarpments are modified by reentrants and promontories. Headward cutting by tributary streams has completely severed some promontories from the rest of the escarpment, thus producing buttes.

The lower Calvin sandstones cap a butte in sec. 14, T. 10 N., R. 12 E. Buttes capped by upper Calvin sandstones are found in secs. 23, and 26, and sec. 34, T. 10 N., R. 11 E. Buttes capped by sandstones and limestones of the Hogshooter or Nellie Bly formations are most common in Okfuskee County. Many smaller buttes are associated with rocks of every formation. Some of these buttes are as much as 1.5 miles from the cuestas with which they were once connected.

Hogbacks are rare in Okfuskee County, and are mostly the result of faulting. They have lower escarpments and shorter and steeper dip slopes. The most prominent hogback in the county is in the west half of sec. 31, T. 13 N., R. 9 E.

The height of the cuestas depends primarily upon the thickness of the shales that underlie the sandstone and limestone caps. The amount of dip and the resistances of the cap rocks are also important factors. Although the cap rocks are subject to normal weathering and erosion, the principal cause of removal of these resistant beds is undercutting of the underlying shale and slumping of the overlying resistant beds. Escarpments migrate in the direction of dip as this process continues.

Major valleys are present in Okfuskee County along 2 rivers: North Canadian and Deep Fork. These rivers are nearly parallel to each other and cut across escarpments almost at right angles. The larger tributaries form valleys of lesser magnitude.

According to topographic maps[28, 29, 30] of the United States Geological Survey, the lowest elevation is between 600 and 650 feet where the North Canadian River leaves the county in sec. 25, T. 10

28 "Wewoka Quadrangle topographic sheet," *United States Geological Survey*, (1901).

29 "Stroud Quadrangle topographic sheet," *United States Geological Survey*, (1906).

30 "Nuyaka Quadrangle topographic sheet," *United States Geological Survey*, (1906).

N., R. 12 E. The highest point in the county is in the center of sec. 1, T. 12 N., R. 11 E., where the altitude is between 1,050 and 1,100 feet above sea level. The average elevation of Okfuskee County is between 850 and 900 feet above sea level. The maximum relief is 400 to 500 feet.

### Drainage

Okfuskee County is drained by the North Canadian River, the Deep Fork Canadian River, and their tributaries. The North Canadian River flows across Oklahoma in an east-southeast direction. It forms the southern boundary of Okfuskee County in R. 7 E. and the western two-thirds of R. 8 E. According to the United States Geological Survey topographic map,[31] the river has a drop of 150 feet from a point in sec. 2. T. 11 N., R. 8 E. to a point in sec. 27, T. 10 N., R. 11 E. This is a stream gradient of less than 2.43 feet per mile. The valley ranges in width from about 0.25 mile in sec. 18, T. 11 N., R. 8 E. to almost 2 miles in secs., 10, 11, 14, and 15, T. 10 N., R. 10 E.

The Deep Fork Canadian River is in the northern part of the county. According to the United States Geological Survey topographic maps[32, 33] the river has a drop of 90 feet from a point in sec. 23, T. 14 N., R. 6 E. to a point in sec. 30, T. 14 N., R. 11 E. This is a stream gradient of less than 1.95 feet per mile.

An interesting problem, but beyond the scope of this paper, is the history of the Deep Fork Canadian River. Near Okfuskee County, the Deep Fork Canadian River flows at a much lower elevation than does the North Canadian River. In the longitude of R. 8 E., the Deep Fork Canadian River flows at an elevation of 700 feet and the North Canadian River at an elevation of 800 feet. The watershed of the Deep Fork Canadian River is much greater than that of the North Canadian River. In the SE¼ sec. 23, T. 12 N., R. 8 E., the watershed of the Deep Fork Canadian River encroaches to within 2 miles of that of the North Canadian

31 "Wewoka Quadrangle topographic sheet," *United States Geological Survey*, (1901).

32 "Stroud Quadrangle topographic sheet," *United States Geological Survey*, (1906).

33 "Nuyaka Quadrangle topographic sheet," *United States Geological Survey*, (1901).



River, whereas the Deep Fork Canadian River is almost 10 miles away. The Deep Fork Canadian River has, generally speaking, a wider valley and a wider alluvial deposit. The North Canadian River, however, has a greater water flow. These facts seem to indicate that the Deep Fork Canadian River once played a much more important role than it does at the present time.

Most of the larger tributaries are strike streams, that is, the streams follow the strike of the formations. The major tributaries of the North Canadian River are: Little Wewoka Creek, Battle Creek, Flat Rock Creek, Alabama Creek, Rock Creek, Stidham Creek, and Bad Creek. The tributaries of the Deep Fork Canadian River are: Pettiquah Creek, Hilliby Creek, Buckeye Creek, Nuyaka Creek, Philadelphia Creek, and Salt Creek.

Many of the sandstones and all of the limestones in Okfuskee County are thin. These thin beds are of such a nature that even the smaller streams and gullies greatly influence the topographic features. Because of this, drainage is shown in detail in the hope that it will be of aid in geologic interpretations.

### Vegetation

The higher areas are covered with blackjack (*Quercus marylandica* Muench), post oak (*Quercus stellata* Wang), and hickory (*Carya cordiformis* Koch). The shale valleys constitute the grasslands. The alluvial bottoms are covered with cottonwood (*Populus sargentii* Dode), black willow (*Salix nigra* Marsh), pecan (*Carya pecan* English and Graben), and black walnut (*Juglans nigra* Linnaeus).

### Climate

The climate of Okfuskee County is typical of the climate in east-central Oklahoma.

#### Temperature

Statistics taken over a period of 26 years at Okemah, in the center of Okfuskee County, show that the average annual temperature[34] is 60 degrees. The average temperature for January is 39.2

34 "Climate and Man," 1941. 1941 *Yearbook of Agriculture*, United States Department of Agriculture, p. 1067.

degrees and the average temperature for July is 82.6 degrees. The absolute maximum temperature throughout these years was 115 degrees, and the absolute minimum temperature was 10 degrees below zero. The average date for the last killing frost in spring is March 30. November 8 is the average date for the first killing frost in fall. The average growing season is 223 days.

### RAINFALL

The average annual precipitation,[35] as measured at the Okemah, Okfuskee County, station over a period of 27 years, is 36.77 inches. Table I gives the average monthly precipitation in Okfuskee County as taken over the same period.

TABLE I

AVERAGE MONTHLY PRECIPITATION OF OKFUSKEE COUNTY

| Month | Inches |
|---|---|
| January | 2.22 |
| February | 1.67 |
| March | 3.13 |
| April | 3.95 |
| May | 4.31 |
| June | 3.82 |
| July | 2.35 |
| August | 2.86 |
| September | 4.09 |
| October | 3.89 |
| November | 2.61 |
| December | 1.87 |

### POPULATION

In 1920, according to the Bureau of the Census,[36] Okfuskee County had a population of 25,051, or 39.2 persons per square mile. By 1930, the population had risen to 29,016, or 47 persons per square mile. This rise was probably due to the oil boom in the county. Since then, the county has had a steady decline of population. In 1940,[37] the county had a population of 26,279, or

35 "Climate and Man," 1941. 1941 *Yearbook of Agriculture*, United States Department of Agriculture, p. 1067.

36 "Number of Inhabitants," 1940. *Population*, Vol. 1, Sixteenth Census of the United States, p. 863.

37 "Number of Inhabitants," 1940. *Population*, Vol. 1, Sixteenth Census of the United States, p. 863.



41.2 persons per square mile. Because of the war in the years that followed, many persons left the county to seek employment in the large cities, and by 1950,[38] the census showed that the population had declined to 16,968, or 26.5 persons per square mile. The latest figures available show that in 1940, 85.5 percent of the population of the county was rural, and 14.5 percent was urban.

38 Letter from the Department of Commerce, Bureau of Census (April 27, 1951).

# SURFACE STRATIGRAPHY

## Introduction

Outcrops in Okfuskee County involve rocks of Pennsylvanian and Quaternary age. Indurated Paleozoic rocks include beds ranging in age from the upper part of the Senora formation of the Des Moines series through beds of the Vamoosa and Ada formations of the Virgil series. In Okfuskee County, the composite thickness of these rocks is about 3,865 feet. In the electric log of the H. Waggoner and Company No. 1 Miracle well in the NE¼NE¼SW¼ sec. 30, T. 13 N., R. 7 E., these rocks have a thickness of about 3,030 feet.

Much geologic surface work has been done in Okfuskee County owing to the great amount of oil activity. Even more subsurface work has been done. Literally thousands of wells have been drilled for oil, and drillers logs have been made for almost every well. As of June, 1950, at least 671 electric logs had been listed for Okfuskee County in Riley's catalogue[39] of electric logs. Recently many radioactive logs have been made. Only a relatively small amount of the stratigraphic work that has been done in Okfuskee County has been published.

# PENNSYLVANIAN SYSTEM

## Des Moines Series

The oldest rocks exposed in Okfuskee County are in the upper part of the Des Moines series. They include strata in the Senora formation, Calvin sandstone, Wetumka shale, Wewoka formation, and Holdenville formation.

The Des Moines series rests unconformably on the earlier series of Pennsylvanian age. Evidence that an unconformity exists below the Des Moines include discordance of beds, a sedimentary hiatus, a lithologic change, and well-established paleontologic relations.

[39] Riley Reproduction Co., Riley's Second Edition Log Catalogue (Oklahoma City, Oklahoma, 1950).



Many geologists believe that the Des Moines series is unconformable with the overlying Missouri series. The writer has come to the conclusion that in Okfuskee County an unconformity is present but that no truncation of the Des Moines series is evident from the field mapping. The strongest evidence for unconformity is paleontologic. Many fossils that have been found in the Des Moines rocks in Okfuskee County are such diagnostic Desmoinesian fossils as *Wedekindellina, Fusulina girtyi, Fusulina eximia, "Marginifera" muricatina, Mesolobus mesolobus, Delocrinus granulosus, Plaxocrinus moorei, Owenoceras,* and *Wellerites,* which have not been found in the overlying Missouri series either in Okfuskee County or in other areas. In many areas, the faunal change between the Des Moines and Missouri series is also accompanied by structural discordance, sedimentary hiatus, and lithologic change, but in Okfuskee County these non-faunal evidences for unconformity were not observed.

In Okfuskee County the Des Moines series contains rocks of two groups, the Cabaniss group below and the Marmaton group above. The Cabaniss group, named by Oakes (1953, pp. 1523-1526), includes in ascending order the Thurman sandstone, Stuart shale, and Senora formation. Only the Senora formation of this group crops out in Okfuskee County. The Marmaton is the highest group of the Des Moines series, and in the area between the Arbuckle Mountains and Arkansas River (Oakes, 1952, p. 19), including Okfuskee County, consists in ascending order of the Calvin sandstone, Wetumka shale, Wewoka formation, and Holdenville shale.

### Cabaniss Group

#### Senora Formation

*First Reference*: J. A. Taff, 1901.
*Nomenclator*: J. A. Taff.
*Type Locality*: Old postoffice of Senora, southern Okmulgee County, Oklahoma.

*Stratigraphic Position*: In the type area, the Senora formation lies conformably above the Stuart shale and below the Calvin sandstone. In Okfuskee County the relationships are the same as at the type locality.

*Original Description*: In describing the Senora formation, J. A. Taff[40] gave the following description:

> This formation is composed of interstratified sandstones and shaly beds having a thickness of nearly 500 feet in the northeastern corner of the quadrangle. The thickness of the formation decreases toward the southwest chiefly by the thinning of the sandstone beds, until at the western border of the quadrangle, it does not exceed 150 feet. The outcrop of the formation in the northern part of the quadrangle averages about 10 miles in width. The lower 320 feet of the formation there is composed almost entirely of sandstone which forms a very rugged and stoney highland with sandstone bluffs, in places nearly 100 feet high, along the eastern side. This sandstone grades upward through thin sandy beds into shale strata which are approximately 160 feet in thickness.
>
> Near the middle of the quadrangle, the lower massive sandstone becomes divided and shale beds 20 to 75 feet in thickness appear. With this change in character, the surface becomes less rugged and stony. In the western part of the quadrangle, the sandstone beds become quite variable in thickness and their position in the formation. The outcrop of the formation here varies in width from 1 to 4 miles depending chiefly upon the erosion of the streams which cross it. The upper and more shaly members have a variable thickness from 100 to 120 feet in the western part.
>
> In texture, the sandstones are generally fine-grained and are gray or reddish brown in color. The shales, which occupy the more level land in the western and northern parts of the outcrop, are rarely well exposed and their original physical characteristics were not satisfactorily determined. Bluish clay shales and brownish sandy shales belonging in the upper part of the series, however, are exposed in the deeper cuttings of the streams which flow from the higher land of the succeeding Calvin sandstone.

*Distribution*: In eastern Oklahoma the Senora formation crops out in a belt that extends from an area north of the Arbuckle Mountains, in central Pontotoc County, northeastward to the Kansas state line. This belt of outcrop passes through the southeastern corner of Okfuskee County.

In Okfuskee County, the Senora formation crops out in parts of T. 10 N., Rs. 11 and 12 E., but its base is nowhere exposed.

[40] Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas*, Folio No. 74, p. 4.



The strike of the formation is N. 29° E. and the beds dip N. 61° W. at about 30 feet per mile. The low dip in this area is local, however, and the regional dip of the Senora formation, as determined from electric well logs in Okfuskee County, is about 94 feet per mile.

The uppermost beds of the Senora formation are predominantly shales, and so most of the outcrops are in valleys. A considerable part of the formation is covered by terrace materials and the alluvial deposits of the North Canadian River.

*Thickness and Character*: Only the uppermost 190 feet of the Senora formation crops out in Okfuskee County. Most of this section consists of brown and greenish brown shales, but contains a thin fossiliferous limestone and a few thin sandstones. The uppermost shales of the Senora formation are generally exposed in the escarpment below the massive sandstone at the base of the Calvin formation. At the foot of the hill, in the west ditch of the road going north up the lower Calvin sandstone escarpment in the center of sec. 11, T. 10 N., R. 12 E., a fossiliferous, sandy limestone 1 to 2 feet thick is about 83 feet below the base of the lower Calvin sandstone. It is the only place where this limestone was seen. In the SE cor. sec. 34, and in the SW cor. sec. 35, T. 10 N., R. 12 E., a 4-foot, light-brown, medium-grained sandstone was observed. The base of this sandstone is about 82 feet below the aforementioned limestone. About 24 feet below the base of this sandstone, the top of a massive sandstone is exposed. This sandstone crops out in secs. 35 and 36, T. 10 N., R. 12 E., but the thickness was not determined because of incomplete exposure.

*Paleontology*: Owing to the lack of good exposures, fossils were observed and collected only at the limestone outcrop in the center of sec. 11, T. 10 N., R. 12 E. Nineteen species were identified, of which ten are brachiopods. The absence of a pelecypod fauna is of special interest. The following species were identified:

FOSSILS COLLECTED AND IDENTIFIED

Crinoidea
- Aatocrinus patulus (Girty)
- Delocrinus granulosus Moore and Plummer
- Ethelocrinus verrucosus (White and St. John)

Bryozoa
- Rhombopora lepidodendroides Meek

Brachiopoda
- Chonetes granulifer Owen
- Composita subtilita (Hall)
- Derbyia crassa (Meek and Hayden)
- "Dictyoclostus" americanus Dunbar and Condra
- Hustedia mormoni (Marcou)
- Juresania nebrascensis (Owen)
- Linoproductus prattenianus (Norwood and Pratten)
- "Marginifera" muricatina Dunbar and Condra
- Neospirifer cameratus (Morton)
- Punctospirifer kentuckiensis (Shumard)

Gastropoda
- Bucanopsis meekiana Swallow
- Euphemites vittatus (McChesney)
- Worthenia tabulata (Conrad)

Nautiloidea
- Liroceras liratum (Girty)
- Metacoceras sangamonense (Meek and Worthen)

*Age and Correlation*: The Senora formation is of middle Des Moines age.

The Senora formation of northeastern Oklahoma includes the Tiawah, Chelsea, Verdigris, and Breezy Hill members.

It is continuous across Okfuskee County from Hughes County to the south and from McIntosh and Okmulgee Counties to the east and north.

## Marmaton Group

### Calvin Sandstone

*First Reference*: J. A. Taff, 1901.

*Nomenclator*: J. A. Taff.

*Type Locality*: The town of Calvin, Hughes County, Oklahoma.

*Stratigraphic Position*: In the type area, the Calvin sandstone lies conformably above the Senora formation and below the Wetumka shale. In Okfuskee County, the Calvin occupies the same stratigraphic position, and is conformable with the beds directly below and above.

*Original Description*: In describing the Calvin formation, J. A. Taff[41] gave the following description:

[41] Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas,* Folio No. 74, p. 4.



> Above the Senora formation there is a deposit of massive and thin-bedded sandstone with some shaly beds in the upper part having a thickness of 140 to 240 feet. For nearly 140 feet upward from the base, the rock is a massive but not a very hard sandstone. . . . In the southern part of its outcrop the lower sandy member becomes shaly, and even the massive beds which occur are more friable than the same deposits in the northern part of the quadrangle. Near the middle of this lower sandstone member, west of Sand Creek, there is a shaly and slightly calcareous bed which contains iron in the form of hematite. On account of the bright-red color of the iron upon weathering this bed is a marked feature of the formation.
>
> The upper part of the Calvin sandstone is least shaly in the northern part of the area, and many of the beds are hard and weather into slabs and hard plates. The upper 90 to 100 feet of the formation here contains two, and in places more, shaly beds 10 to 20 feet in thickness. The sandstone beds of the upper portion decrease southwestward from 40 feet in thickness to thin layers interstratified with shales.

*Distribution*: The outcrop of the Calvin formation in eastern Oklahoma extends from eastern Pontotoc County northeastward almost to the Arkansas River near Stone Bluff in Wagoner County. Northward across the Arkansas River the formation is not recognized, but according to Oakes (1953, p. 1525) its base is approximately equivalent to the base of the Fort Scott limestone.

In Okfuskee County, the Calvin formation crops out in parts of Tps. 10 and 11 N., Rs. 11 and 12 E. The base of this formation forms a high escarpment which extends from sec. 1, T. 10 N., R. 12 E. to the SW¼ sec. 32, T. 10 N., R. 12 E. The top of the formation, which is the top of the sandstone directly below the Wetumka shale, extends from the NE¼ sec. 24, T. 11 N., R. 11 E., to the SW¼ sec. 33, T. 10 N., R. 11 E. The width of the Calvin outcrop is about 4 to 6 miles and the strike is N. 28° E. The beds dip N. 62° W. at 20 to 30 feet per mile. This low dip is due to local structure in the northern part of T. 10 N., R. 12 E. The regional dip of the Calvin formation in Okfuskee County as determined from electric logs is about 92 feet per mile.

*Thickness and Character*: The thickness of the Calvin formation was originally determined by aneroid barometer, but because of the many variations in dip the measurements were found to be unreliable and were discarded in favor of measurements taken directly from electric logs. As determined from electric logs, the Calvin sandstone in Okfuskee County appears to have a rather uniform thickness of 245 feet. Representative wells in which this thickness was found are the McIntyre and Cummings No. 1 Wells in the NW¼NW¼SW¼ sec. 8, T. 10 N., R. 11 E., and the Amerada Petroleum Corporation No. 1 Murray Barton, in the SE¼NE¼SE¼ sec. 7, T. 11 N., R. 11 E.

The Calvin sandstone in Okfuskee County is divided into three unnamed members: a basal sandstone member (IPcv-1 of map), a thick middle shale member (IPcv-2 of map), and an upper sandstone member (IPcv-3 of map).

The basal sandstone member (IPcv-1 of map) consists of a sequence of two to eight sandstones with thin, intervening shales. This sequence seems to have a rather uniform thickness regardless of the number of sandstones. In the McIntyre and Cummings No. 1 Wells this lower member has a thickness of 60 feet. In the Amerada Petroleum Corporation No. 1 Murray Barton, the member is 70 feet thick. At the outcrop, the sandstone is light brown, well cemented, and caps high escarpments. Of interest are the many yellow-brown limonitic spherules which are disseminated throughout most of the sandstone beds. These spherules range from 1 to 5 mm. in diameter. (See Figure 2).

The middle shale member (IPcv-2 of map) consists mostly of brown to greenish brown shales. A black shale was observed occasionally. In the McIntyre and Cummings No. 1 Wells, this middle shale member is 135 feet thick. In the Amerada Petroleum Corporation's No. 1 Murray Barton, this member has a thickness of 125 feet. It appears that the middle shale member thickens slightly toward the south at the expense of the lower sandstone member. (See Figures 3 and 4.)

The upper member of the Calvin formation (IPcv-3 of map) consists of soft, friable sandstones with a hard, 11-foot sandstone at the top. In the McIntyre and Cummings No. 1 Wells, this upper member is 50 feet thick. It appears to have a uniform thickness from north to south. Two outliers in secs. 22, 23, and 26,



Figure 2. Sandstone strata in the lower Calvin sandstone in roadcut, C. SE¼ sec. 13, T. 10 N., R. 11 E. (Looking northwest).

Figure 3. View showing thin sandy layers at the top of the middle shale of the Calvin formation as seen in the west-central part of sec. 14, T. 10 N., R. 11 E. (Looking north).

T. 10 N., R. 11 E., and in sec. 34, T. 10 N., R. 11 E., are capped by this sandstone.

*Paleontology*: In their discussion of the Calvin formation, neither Taff[42] nor Morgan[43] gave any mention of fossils. The following 32 species were found in the Calvin formation in Okfuskee County.

FOSSILS COLLECTED AND IDENTIFIED

Brachiopoda
- Chonetes granulifer armatus Girty
- Cleiothyridina orbicularis (McChesney)
- Composita subtilita (Hall)
- Condrathyris perplexa (Shumard)
- Crurithyris planoconvexa (Shumard)
- Derbyia crassa (Meek and Hayden)
- Hustedia mormoni (Marcou)
- Juresania nebrascensis (Owen)
- Linoproductus insinuatus (Girty)
- 'Marginifera" muricatina Dunbar and Condra
- Mesolobus mesolobus (Norwood and Pratten)
- Mesolobus mesolobus decipiens (Girty)
- Neospirifer cameratus (Morton)
- Punctospirifer kentuckiensis (Shumard)

Pelecypoda
- Acanthopecten carboniferus (Stevens)
- Allorisma terminale Hall
- Anthraconeilo taffiana Girty
- Aviculopinna americana Meek
- Edmondia nebrascensis (Geinitz)
- Lima retifera Shumard
- Nuculana bellistriata (Stevens)
- Nuculana bellistriata attenuata (Meek)
- Parallelodon kansasensis Sayre
- Pleurophorus tropidophorus Meek
- Promytilus swallovi (McChesney)
- Schizodus affinis Herrick
- Schizodus alpinus (Hall)
- Yoldia glabra Beede and Rogers

Gastropoda
- Baylea perhumerosa (Meek)
- Bellerophon crassus wewokanus Girty
- Strobeus brevis (White)

Plantae
- Calamites sp.

*Age and Correlation*: The Calvin formation is of middle Desmoinesian age.

In Oklahoma, the Calvin formation is approximately the same age as part of the upper Deese group of the Ardmore Basin in

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42 Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas*, Folio No. 74, p. 4.

43 Morgan, G. D., 1924. *Oklahoma Bureau of Geology, Bulletin* 2, p. 90.

southern Oklahoma, and of the Fort Scott limestone in northeastern Oklahoma.

## Wetumka Shale

*First Reference*: J. A. Taff,[44] 1901.
*Nomenclator*: J. A. Taff.[45]

*Type Locality*: At the town of Wetumka, Hughes County, Oklahoma.

*Stratigraphic Position*: In the type area, the Wetumka shale lies above the Calvin sandstone and below the Wewoka formation. The beds are conformable. In Okfuskee County, the Wetumka formation occupies the same stratigraphic position, and is conformable with the beds directly below and above.

*Original Description*: In describing the Wetumka formation, J. A. Taff[46] gave the following description.

> The shaly beds of the Calvin sandstone grade into succeeding Wetumka shale, so that the division line between the formations cannot be easily determined stratigraphically nor very accurately mapped.
>
> With the exception of thin shaly sandstone layers near the center, the Wetumka shale is composed of friable, laminated clay shales. It is estimated to be about 120 feet thick throughout its occurrence in the Coalgate quadrangle.

*Other Description*: George D. Morgan has given the following description of the Wetumka formation in the Stonewall quadrangle area[47] to the south:

> In sec. 24, T. 4 N., R. 7 E., the Wetumka shale has a thickness of between 150 and 175 feet, while a section measured in sec. 3, T. 3 N., R. 7 E., shows a total of 250 feet. As pointed out in the discussion of the Calvin formation this apparent difference in thickness is probably due to the fact that in section 3, some of the upper shaly strata of the Calvin have been mapped as basal Wetumka. The contact between the two formations is graditional and, at least in the Stonewall quadrangle, it would probably be more advisable to map the formations together. They extend only a short distance into the area, however, and in an endeavor to preserve the stratigraphic subdivisions used in the Coalgate folio a separation of the formations has been attempted.
>
> There are a few thin sandstones near the top and bottom, but for the most part the formation consists of almost unbroken shale.
>
> The slight resistance offered to erosion by this shale results in its being undercut from beneath the resistant sandstone in the base of the overlying Wewoka formation, and in the formation of a prominent southeastward-facing escarpment.
>
> The top of the Wetumka is especially fossiliferous, some 35 species were collected from the formation . . . .

[44] Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas*, Folio No. 74, p. 4.
[45] Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas*, Folio No. 74, p. 4.
[46] Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas*, Folio No. 74, p. 4.
[47] Morgan, G. D., 1924. *Oklahoma Bureau of Geology, Bulletin* 2, p. 91.



*History of Usage*: The name Wetumka appears to have been used always in the present sense.

*Distribution, Thickness, and Character*: The Wetumka formation is shown on the "Geologic Map of Oklahoma"[48] as extending northeastward from Pontotoc County through Hughes, Okfuskee, Okmulgee, and Tulsa Counties to near the Arkansas River.

In Okfuskee County, the Wetumka shale extends from the SE¼ sec. 13, T. 11 N., R. 11 E. to the SW¼ sec. 32, T. 10 N., R. 11 E. The width of the Wetumka outcrop ranges from less than 600 feet in the NW¼ sec. 28, T. 10 N., R. 11 E., to almost 2 miles in secs. 9, 10, and 11, T. 10 N., R. 11 E. The strike of the Wetumka formation in Okfuskee County is N. 28° E. and its regional dip is N. 62° W. at about 94 feet per mile.

At most places the entire Wetumka formation crops out in the high escarpment directly below the basal sandstone of the Wewoka formation. The base of the Wetumka is a transitional zone of thin sandy shales which grade downward into a massive 11-foot sandstone, which was mapped as the top of the Calvin formation. The formation consists of gray and yellowish silty shale which contains a thin friable sandstone in the middle.

[48] Miser, H. D., 1954. "Geological Map of Oklahoma," *United States Geological Survey*, color copy.

A section was measured in the NW¼ sec. 28, T. 10 N., R. 11 E. from the massive sandstone in the west ditch of the road to the base of the massive sandstone at the top of the hill to the north. This gave the Wetumka shale a total thickness of 146 feet. A section measured in the northeastern part of sec. 24, T. 11 N., R. 11 E. showed the Wetumka formation to have a total thickness of 120 feet.

In the McIntyre et al, Thompson No. 1, C. NE¼SW¼ sec. 32, T. 11 N., R. 11 E., the Wetumka formation is 148 feet thick. In this well the middle sandstone unit is well developed.

*Paleontology*: No fossils were observed in the Wetumka formation in Okfuskee County.

*Age and Correlation*: The Wetumka formation is of middle upper Desmoinesian age.

In Oklahoma, the Wetumka formation is the same age as part of the Labette shale formation in northeastern Oklahoma, and as the beds below the Rocky Point formation down almost to the top of the Arnold limestone of the upper Deese group in the Ardmore Basin of southern Oklahoma.

### Wewoka Formation

*First Reference*: J. A. Taff,[49] 1901.
*Nomenclator*: J. A. Taff,[50] 1901.
*Type Locality*: Wewoka Creek, near the town of Wewoka[51] in Seminole County, Oklahoma.

*Stratigraphic Position*: In the type area, the Wewoka formation lies above the Wetumka formation and below the Holdenville formation. The beds are conformable. In Okfuskee County, the Wewoka formation occupies the same stratigraphic position and is conformable with the beds directly below and above.

*Original Description*: In describing the Wewoka formation, J. A. Taff[52] gave the following description:

49 Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas*, Folio No. 74, p. 4.
50 Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas*, Folio No. 74, p. 4.
51 Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas*, Folio No. 74, p. 4.
52 Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas*, Folio No. 74, p. 4.



Above the Wetumka shale there is a succession of massive and, for the most part, friable sandstones and shales, seven in number, in alternating beds 40 to 130 feet thick. These beds together are about 700 feet thick and named the Wewoka formation, from the town of the same name in the Wewoka Quadrangle to the north. The separate massive beds composing the formation are of sufficient thickness to be mapped, but on account of the obscurity of the contact lines, due to the friable nature of the beds, it is not possible to accurately distinguish them.

The lowest of the four sandstone divisions of the Wewoka formations is thinner, though generally harder, than the succeeding ones. At its base there are local indurated beds of sandy chert conglomerate. These conglomerates are most prominent near the western border of the quadrangle where they form bluffs facing Boggy Creek Valley. This group of sandstones and conglomerates become thinner eastward and northward, so that its outcrop is hardly perceptible on the border of the Canadian River Valley.

Above this sandstone and conglomerate there is fossiliferous friable blue clay shale 120 feet, ending locally in thin white fossiliferous limestone.

The succeeding sandstone member is about 110 feet thick. It caps the high land near the western border of the quadrangle, south of the Canadian River and forms high bluffs surmounting the escarpments, facing eastward upon the north of the river. Its beds are massive and friable, breaking down readily into loose sand and weathering into rounded ledges.

Above this sandstone, and near the middle of the formation, there is a soft fossiliferous blue clay shale nearly 130 feet thick. This shale is remarkable for the abundant and perfectly preserved fossil shells which it contains. Above this thick shale there is a sandstone 60 feet thick, which is succeeded by 45 feet of shale. Next above comes the highest sandstone member of the formation, which is estimated to be about 100 feet in thickness. The uppermost beds of this sandstone are shaly and culminate in a shelly sandy limestone.

*Other Description*: George D. Morgan[53] gave the following description of the Wewoka formation in the Stonewall quadrangle to the southeast.

53 Morgan, G. D., 1924. *Oklahoma Bureau of Geology, Bulletin* 2, p. 94.

Several sections measured in the Stonewall quadrangle show a total average thickness of 400 feet for the Wewoka. The top and bottom of the formation are marked by definite sandstone ledges that were mapped without difficulty. The basal sandstone, as well as several other members, locally grades into chert conglomerate.

In the upper part of the formation there are several very characteristic beds among which there is a thin limestone that is rich in specimens of *Fusulina*.

The top of the sandstone bed, which marks the top of the formation, locally grades into limestone.

In the northern part of T. 3 N., R. 6 E., limestone conglomerates are quite common in the upper part of the Wewoka formation. That these conglomerates were derived from the Arbuckle Mountains is indicated by the contained fragments, many of which closely resemble the Hunton and Viola limestones.

Just east of the center of sec, 32, T. 5 N., R. 8 E., southwest of Allen and beyond the limits of the Stonewall quadrangle, there is a conglomerate that is very unusual. It differs from the sediments below the Pontotoc terrain in that it carries pebbles of igneous material. The bed could be traced for only a few hundred yards. The igneous material contained is darker and more fine-grained than the average arkosic material which is so common in the Pontotoc beds and it seems improbable that the two were derived from the same source. The nature of the igneous material in the Pontotoc strata and the fossiliferous limestone fragments associated with it clearly indicates that it was derived from the Arbuckle Mountains. The source of the igneous pebbles in the Wewoka occurrence, however, is unknown. The pebbles are mostly small and well rounded and may have been brought in from a distant region.

*History of Usage*: The term Wewoka appears always to have been used in its present sense.

*Distribution*: The Wewoka formation is shown on the "Geologic Map of Oklahoma"[54] as extending northeastward from the east-central part of Pontotoc County, through Hughes, Okfuskee, Okmulgee, and Tulsa Counties to the Arkansas River.

54 Miser, H. D., 1954. "Geologic Map of Oklahoma", *United States Geological Survey*, in press.



Figure 4. Upper part of the middle shale of the Calvin formation unconformably overlain by alluvial deposits of Quaternary age at station 32, sec. 32, T. 10 N., R. 11 E. Hammer rests on shale-alluvium contact.

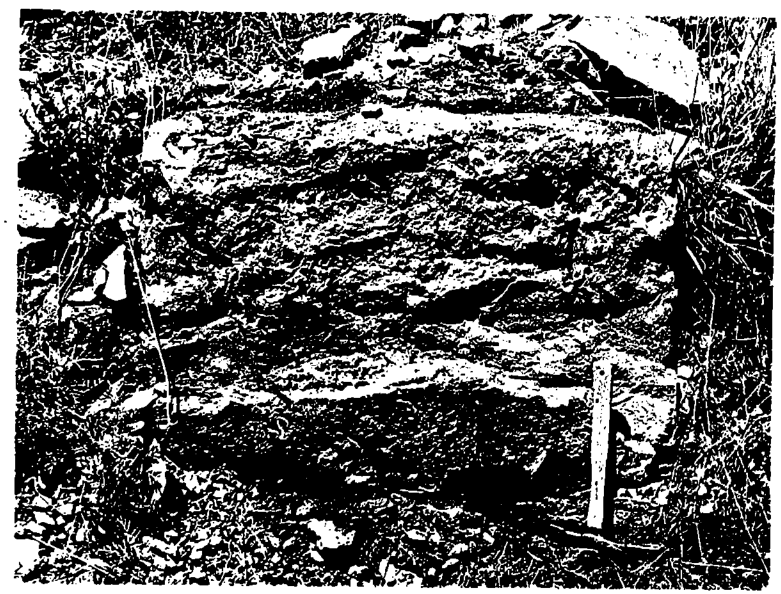

Figure 5. View of a 26-inch fossiliferous limestone found at the horizon of IPw-7, Wewoka formation, at station 64, in sec. 13, T. 12 N., R. 11 E.

In Okfuskee County, the base of the Wewoka formation extends from the southeastern part of sec. 13, T. 11 N., R. 11 E. to the SE¼ sec. 31, T. 10 N., R. 11 E. The top of the formation extends from the northwestern part of sec. 4, T. 12 N., R. 11 E. to the SW¼ sec. 35, T. 10 N., R. 9 E. The average width of the outcrop is about 7 miles. The Wewoka formation has a strike of N. 28° E. and a regional dip of N. 62° W. at about 90 feet per mile.

*Thickness and Character*: The Wewoka formation is a succession of thick shales containing interstratified friable sandstones and a few local limestones. Five sandstone units and 4 shale units were mapped across Okfuskee County; and 4 sandstone tongues or lenses were mapped in parts of the County. These units generally crop out in 4 distinct escarpments.

The Wewoka formation has a composite thickness ranging from 780 feet in the southern part of the county to 730 feet along the northern boundary. A typical electric log in which the Wewoka formation may be identified is that of the Wilcox Oil Company, Wynne No. 1, NW¼SE¼SW¼ sec. 16, T. 11 N., R. 10 E. In this well the Wewoka formation has a corrected thickness of about 780 feet, the top and base being picked at 230 feet and 1,030 feet, respectively.

*Units of the lower escarpment*: The sandstone capping the lower escarpment is the base of the formation, and consists in the south of a single sandstone unit (IPw-1), which is divided by a middle shale unit northward into a lower sandstone bed (IPw-1a) and an upper sandstone tongue (IPw-1b).

Unit IPw-1 is a resistant yellowish-brown sandstone 10.5 feet thick in the north-central part of sec. 32, T. 10 N., R. 11 E. (Station 29). Traced northward beyond the point where it is split by shale, the basal sandstone of the Wewoka is mapped as unit IPw-1a, which is 4 feet thick in the SW¼ sec. 23, T. 11 N., R. 11 E. (Station 50). It is overlain by a yellowish-brown shale which is about 56 feet thick in the SE¼ sec. 27, T. 11 N., R. 11 E. Overlying the shale is sandstone unit IPw-1b, which is 2 to 8 feet thick. This sandstone was traced from the south-central part of sec. 29, T. 10 N., R. 11 E. to the east-central part of sec. 27, T. 11 N., R. 11 E. A thin, poorly developed sandstone which appears to occur at this horizon, crops out in the northwest part of sec. 14, T. 11 N., R. 11 E. The shale interval between IPw-1a and IPw-1b appears to increase northward. Beds found in this lower Wewoka escarpment may be clearly identified in subsurface in the electric log of the W. M. Dunn, Crawley Morgan No. 1 in the NW¼NW¼SE¼ sec. 36, T. 11 N., R. 10 E. (See Well No. 5 of the Electric Log Cross-Section, Plate II.) In this well, the base of IPw-1a was picked at 565 feet and the base of IPw-1b at 503 feet.

*Units of the second escarpment*: The second large escarpment contains a thick shale, IPw-2, and a supporting cap of 2 continuous sandstones, of which the lower is mapped as IPw-3 and the upper as IPw-5. A local thin lens of sandstone above IPw-5 is mapped as IPw-6a. The shale cropping out in the escarpment below IPw-3 and above IPw-1b is fossiliferous, friable, yellowish-brown to bluish gray, and is 180 feet thick in the SE¼ sec. 5, T. 10 N., R. 11 E.

The sequence in the capping rocks of the second escarpment consists in ascending order of sandstone IPw-3, shale IPw-4, and sandstone IPw-5. These units were mapped continuously across Okfuskee County. IPw-3 ranges in thickness from 40 feet in the NE¼ sec. 22, T. 11 N., R. 11 E. (Station 54) to 2.5 feet in the west-central part of sec. 11 T. 11 N., R. 11 E. (Station 57). It is 55 feet thick in the W. M. Dunn, Crawley Morgan No. 1 well. IPw-4 is yellowish-brown shale that is 11 feet thick in the NW¼ sec. 16, T. 11 N., R. 11 E. (Station 53), and is rather uniform in thickness along the strike. In this same area, IPw-5 consists of a six-inch highly fossiliferous, ferruginous, and somewhat calcareous sandstone; a 5-foot sandy shale; and a massive 8-foot brownish-gray sandstone. A local, highly fossiliferous, 3-foot limestone was observed at the horizon of IPw-5 in the SW¼ sec. 16, T. 11 N., R. 11 E. (Station 38). Unit IPw-5 is 13 feet thick in the W. M. Dunn, Crawley Morgan No. 1 well.

Unit IPw-6a is a sandstone lens that crops out locally in secs. 31 and 32, T. 11 N., R. 11 E. and secs. 5, 6, and 7, T. 10 N., R. 11 E. This sandstone is 5 to 10 feet thick and lies about 45 feet above the base of IPw-5. These horizons, which are found in the second



Wewoka escarpment, may be clearly identified in subsurface in the electric log of W. M. Dunn, Crawley Morgan No. 1 in the NW¼NW¼SE¼ sec. 36, T. 11 N., R. 10 E. (See well no. 5 of Plate II.) In this well, the base of IPw-3 was picked at 305 feet, the base of IPw-5 at 247, and the base of IPw-6a at 200 feet.

*Units of the third escarpment*: Units that crop out in the third Wewoka escarpment include a thick shale at the base, IPw-6, and three sandstones near the top which are mapped as IPw-7, IPw-8b, and IPw-8d. Shale IPw-6 crops out in the scarp face and can be traced across the county. It is fossiliferous, yellowish brown to brownish gray, and is 130 feet thick. A local sandstone lens, IPw-6a, is present in the lower part of this unit south of Clearview, chiefly in sec. 31, T. 11 N., R. 11 E., and sec. 6, T. 10 N., R. 11 E., where it supports the top of the second escarpment of the Wewoka formation.

The principal sandstone supporting the third escarpment is IPw-7, which was mapped across the county and is 30 feet thick in the east-central part of sec. 3, T. 11 N., R. 11 E. (Station 53). This unit contains a 2.5 foot limestone in the west-central part of sec. 13, T. 12 N., R. 11 E. (Station 64). In subsurface, unit IPw-7 may be identified in the electric log of Vierson and Cochran, Fox No. 1 in the NE¼SE¼NW¼ sec. 26, T. 11 N., R. 10 E., where it is 45 feet thick. (See well no. 6 of Plate II). In this well the base of IPw-7 was picked at 285 feet. In the electric logs of well nos. 7, 8, and 9 of Plate II the base was picked at 315, 580, and 724 feet respectively.

In the northern part of the county there are two mappable sandstone beds that lie above IPw-7, each of which grades into shale southward near Clearview in the east-central part of Okfuskee County. The lower of these is IPw-8b (See Figure 15). It extends from the NE¼ sec. 12, T. 12 N., R. 11 E. to the NE¼ sec. 24, T. 11 N., R. 10 E. where it ends against a fault. It was not observed on the south side of the fault. This bed ranges in thickness from 2 feet in its southern extremity at the fault, to more than 10 feet in the NW¼ sec. 23, T. 12 N., R. 11 E. (Station 61). The upper sandstone is IPw-8d, which is 16 feet thick and whose base lies about 20 feet above the top of IPw-8b in the southwestern part of sec. 23, T. 12 N., R. 11 E. It extends from the NE¼ sec. 12, T. 12 N., R. 11 E. to the central part of sec. 7, T. 11 N., R. 11 E. where it becomes so thin that it could not be traced to the south. The southward extensions of sandstones IPw-8b and IPw-8d are not clearly established, as the outcrops in the critical areas are mostly covered.

*Units of the fourth escarpment*: The fourth Wewoka escarpment contains a thick shale, IPw-8, and a capping sandstone, IPw-9. Shale unit IPw-8 is a fossiliferous friable, yellowish-brown to bluish-gray shale which is 140 thick in areas where it directly overlies sandstone IPw-7. In certain areas it is highly concretionary. Above this thick shale is sandstone IPw-9, which can be traced across the entire county. The top of this sandstone is the most massive of all the Wewoka sandstones. It extends from sec. 4, T. 12 N., R. 11 E. to sec. 36, T. 10 N., R. 9 E. The sandstone is soft, friable, fine-grained, and reddish brown. On weathering, it becomes reddish orange. It is 42 feet thick in the southeastern part of sec. 27, T. 11 N., R. 10 E., (Station 85), and thins northward to 7 feet in the east-central part of sec. 10, T. 12 N., R. 11 E. (Station 71).

*Paleontology*: The Wewoka formation has a prolific fauna. It has been described and figured by Girty.[55] Of special interest, is the prolific bryozoan fauna found at Station 51 (see Registry of Localities).

FOSSILS COLLECTED AND IDENTIFIED

Anthozoa
- Lophophyllidium sp.

Conularida
- Paraconularia crustula (White)

Crinoidea
- Aatocrinus patulus (Girty)
- Delocrinus granulosus Moore and Plummer

Echinoidea
- Echinocrinus megastylus (Shumard)

Annelida
- Sepulopsis insita White

55 Girty, G. H., *United States Geological Survey, Bulletin* 544.



Figure 6. Outcrop of sandstone IPw-7 in the Wewoka formation in the southwestern part of sec. 27, T. 10 N., R. 10 E. (Looking east).

Figure 7. Escarpment capped by Wewoka sandstones IPw-7 and IPw-8b in the southeastern part of sec. 26, T. 12 N., R. 11 E. (Looking northeast).

Bryozoa
Fenestrellina mimica (Ulrich)
Fistulipora carbonaria Ulrich
Pinnatopora bellula Ulrich
Polypora crassa Ulrich
Polypora elliptica Rogers
Polypora nodocarinata Ulrich
Polypora whitei Ulrich
Prismopora lobata Warthin
Rhombopora crassa Ulrich
Rhombopora lepidodendroides Meek
Rhombopora pilula Moore
Septopora blanda Moore
Septopora elliptica Warthin
Tabulipora carbonaria (Worthen)
Tabulipora cabonaria conferta Ulrich
Thamniscus tenuiramus Rogers

Brachiopoda
Lindstroemella patula (Girty)
Chonetes granulifer Owen
Cleiothyridina orbicularis (McChesney)
Composita ovata Mather
Composita subtilita (Hall)
Condrathyris perplexa (McChesney)
Crurithyris planoconvexa (Shumard)
Derbyia crassa (Meek and Hayden)
"Dictyoclostus" americanus Dunbar and Condra
"Dictyoclostus" portlockianus (Norwood and Pratten)
Hustedia mormoni (Marcou)
Juresania nebrascensis (Owen)
Leptalosia ovalis Dunbar and Condra
Linoproductus insinuatus (Girty)
Linoproductus prattenianus (Norwood and Pratten)
"Marginifera" muricatina Dunbar and Condra
Marginifera splendens (Norwood and Pratten)
Meekella striatocostata (Cox)
Mesolobus mesolobus euampygus (Girty)
Neospirifer cameratus (Morton)
Nudirostra rockymontanum (Marcou)
Punctospirifer kentuckiensis (Shumard)
Rhipidomella carbonaria (Swallow)

Pelecypoda
Acanthopecten carboniferus (Stevens)
Allorisma terminale Hall
Astartella concentrica Conrad
Aviculopinna americana Meek
Aviculopinna peracuta (Shumard)
Fasciculiconcha providencis (Cox)
Limipecten texanus (Girty)
Nucula anodontoides Meek
Nuculana bellistriata (Stevens)
Nuculopsis girtyi Schenck
Pleurophorus tropidophorus Meek
Promytilus swallovi (McChesney)
Schizodus affinis Herrick
Schizodus alpinus (Hall)
*Schizodus insignis Drake
Yoldia glabra Beede and Rogers

* *Schizodus insignis* Drake was described as from Permian sandstone 5 miles east of McDermitt. The single internal mold resembles *Schizodus wheeleri* Swallow. The locality is probably in sec. 21, T. 11 N., R. 11 E. and is in Wewoka Bed No. 5.

Gastropoda
- Amphiscapha catilloide (Conrad)
- Bellerophon crassus wewokanus Girty
- Euphemites vittatus (McChesney)
- Glabrocingulum grayvillense (Norwood and Pratten)
- Meekospira peracuta (Meek and Worthen)
- Meekospira peracuta choctawensis Girty
- Pharkidonotus percarinatus (Conrad)
- Soleniscus typicus Meek and Worthen
- Strobeus brevis (White)
- Trepospira depressa (Cox)
- Worthenia tabulata (Conrad)

Scaphopoda
- Plagioglypta meekiana (Geinitz)

Nautiloidea
- Brachycycloceras normale Miller, Dunbar, and Condra
- Liroceras liratum (Girty)
- Metacoceras perelegans Girty
- Metacoceras sangamonense (Meek and Worthen)
- Mooreoceras normale Miller, Dunbar, and Condra
- Pseudorthoceras knoxense (McChesney)

Ammonoidea
- Euloxoceras greenei Miller, Dunbar, and Condra
- Gastrioceras excelsum (Meek)

Trilobita
- Ameura sangamonensis (Meek and Worthen)

Chondrichthyes
- Petrodus occidentalis (Newberry and Worthen)

Plantae
- Calamites sp.

*Age and Correlation*: The Wewoka formation is upper Desmoinesian age. In Oklahoma, the Wewoka formation is approximately of the same age as the Labette shale, the Pawnee and Altamont limestones, the Nowata shale, and the Lenapah limestone of the Marmaton group of northeastern Oklahoma, and as the beds above the Rocky Point formation to below the base of the Confederate limestone of the upper part of the Deese group of the Ardmore Basin of southern Oklahoma.

## Holdenville Shale

*First Reference*: J. A. Taff,[56] 1901.

*Nomenclator*: J. A. Taff,[57] 1901.

*Type Locality*: City of Holdenville, Hughes County, Oklahoma.

*Stratigraphic Position*: In the type area, the Holdenville lies

[56] Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas,* Folio No. 74, p. 4.

[57] Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas,* Folio No. 74, p. 4.



above the Wewoka formation and below the Seminole formation. It is conformable with the Wewoka formation below and is overlapped[58] by the Seminole formation above. In Okfuskee County, the Holdenville formation occupies the same stratigraphic position. It is conformable with the Wewoka formation below. From paleontologic discontinuities and from unconformable relations observed elsewhere, it is believed that an unconformity is present at the top of the Holdenville shale in Okfuskee County, although field mapping in the county revealed no truncation at this boundary.

*Original Description*: J. A. Taff[59] gave the following description of the Holdenville formation:

> This shale, 250 feet in thickness, rests upon the Wewoka formation, and its crop in this quadrangle is limited to a small triangular area in the northwestern corner. The surface of the formation becomes broader northward in the more level country about Holdenville, 3 miles north of the border of the quadrangle.
>
> The formation is composed of friable blue clay shale, with local thin beds of shelly limestone and shaly calcareous sandstone in the upper part. The sandstone ledges outcrop in terraces around the slopes of hills bordering the north side of Little River. The thin limestone occurs about 35 feet below the top of the formation, and its outcrop is usually covered by the sandstone and conglomerate debris from the overlying formation. In its usual exposure 1 to 2 feet only of shaly limestone may be seen. At other places a bed of shell breccia loosely cemented is found, representing the thin hard plates of the shelly rock. The shales are rarely exposed. The smooth grass-covered prairie soil, however, even in the steep slopes, bears evidence of the friable shale beneath.

*Other Description*: Morgan[60] gave the following description of the Holdenville formation in the Stonewall quadrangle to the south:

> The Holdenville formation consists largely of shale, but also contains numerous sandstone beds and two mappable limestone members. Some of the sandstones locally develop into massive chert conglomerates that are lithologically identical with the conglomerate at the base of the Seminole in the type area of that formation.

[58] Morgan, G. D., 1924. *Oklahoma Bureau of Geology, Bulletin* 2, p. 103.

[59] Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas,* Folio No. 74, p. 4.

[60] Morgan, G. D., 1924. *Oklahoma Bureau of Geology, Bulletin* 2, p. 103.

In the northeastern part of the quadrangle the Holdenville is approximately 235 feet thick. It thins southward, however, and at its southern extremity, where it is overlapped by the Seminole, does not exceed 100 feet.

*History of Usage*: The name appears to have always been used in its present sense.

*Distribution*: The Holdenville formation is shown on the Geologic Map of Oklahoma[61] as extending from near Lawrence, on the north flank of the Arbuckle Mountains in the central part of Pontotoc County northeastward through Seminole, Hughes, Okfuskee, Okmulgee, and Tulsa Counties. In Okfuskee County, the base of the Holdenville formation extends from the NE¼ sec. 5, T. 12 N., R. 11 E. to the SW¼ sec. 35, T. 10 N., R. 9 E. The top of the formation extends from the SE¼ sec. 13, T. 13 N., R. 10 E. to the south-central part of sec. 32, T. 10 N., R. 9 E. The average width of the outcrop is about two miles. The Holdenville formation in Okfuskee County has a strike of N. 27° E., and the direction of its regional dip is N. 63° W. at about 90 feet per mile.

*Thickness and Character*: The Holdenville formation consists of a succession of shales, sandstones, and a few local limestones. Generally speaking, the shales are thick and the sandstones are thin. The limestones are as much as 2 feet thick.

The shales are yellowish brown to grayish green. Locally they contain small concretions and carry a prolific fauna.

The sandstones are erratically developed and thus are difficultly mappable. They thicken and thin within short distances, and at many places they are friable and poorly developed.

The limestones are thin, fossiliferous, and on weathering become yellow-brown owing to the high iron content.

The thickness of the Holdenville formation ranges from 280 feet in the southern part of the county to 200 feet in the northern part. It is 210 feet thick in T. 11 N., R. 10 E.

The entire Holdenville formation can be identified in subsurface in the electric log of the Big Chief Drilling Company's

[61] Miser, H. D., 1954. "Geologic map of Oklahoma", *United States Geological Survey*, in press.



Kirby No. 1 in the SW¼NE¼NE¼ sec. 20, T. 10 N., R. 9 E. In this well the base of the Holdenville formation was picked at 360 feet and the top at 75 feet, giving the formation a total uncorrected thickness of 285 feet or a corrected thickness of about 280 feet.

In the electric log of the British American Church Community A-1 in the SW¼NW¼SW¼ sec. 12, T. 11 N., R. 9 E. (well No. 10 of Plate II) the base of the Holdenville formation was picked at 585 feet and the top at 365 feet. This gave the formation a total uncorrected thickness of 220 feet or a corrected thickness of about 215 feet.

Three sandstones were mapped in the Holdenville formation in Okfuskee County. The lowermost of these sandstones, IPhd-1b, lies 15 to 60 feet above the top of the Wewoka formation. This variation is due to the thickening of the underlying shale to the south. The lower sandstone is poorly developed in the northernmost part of the county, and in the area south of the northeastern part of sec. 11, T. 11 N., R. 10 E. to the eastern part of sec. 28, T. 11 N., R. 11 E. It is also poorly developed south of the eastern part of sec. 5, T. 10 N., R. 11 E., and could not be mapped south of North Canadian River. This sandstone ranges in thickness from 2 feet at Station 88 in sec. 33, T. 11 N., R. 10 E., to 12 feet at Station 76 in sec. 19, T. 12 N., R. 11 E. There is a local limestone at the horizon of this sandstone in secs. 35 and 36, T. 12 N., R. 10 E. and secs. 1, 2, 11, and 12, T. 11 N., R. 10 E. This limestone is well exposed in the roadcut at Stations 96, 95, and 93.

A one-foot local limestone conglomerate containing shale pebbles was observed at Station 148 in sec. 4, T. 10 N., R. 10 E. This limestone was estimated to be 10 to 15 feet above IPhd-1b.

The middle sandstone of the Holdenville formation, IPhd-2, is more uniform in thickness and lateral extent, and could be traced across the county. In the northern part of the county this sandstone is well developed and forms large escarpments. In the southern portion the sandstone is more friable and therefore forms lower escarpments. (See Figure 17.) The sandstone ranges from 3 to 12 feet in thickness, and, generally speaking, thickens southward.

The uppermost sandstone of the Holdenville formation, mapped as ℙhd-3b, is present only in the area around Lake Papoose, south of North Canadian River in secs. 22, 26, 27, 33, and 34, T. 10 N., R. 9 E. Evidently in the central and northern parts of Okfuskee County this sandstone grades into shale of map unit ℙhd-3.

*Paleontology*: The Holdenville formation is very fossiliferous. It carries a typical Desmoinesian fauna. The following 80 species were identified:

FOSSILS COLLECTED AND IDENTIFIED

Anthozoa
- Lophophyllidium sp.
- Pleurodictyum eugeneae White

Conularida
- Paraconularia crustula (White)

Crinoidea
- Ethelocrinus magister (Miller and Gurley)

Bryozoa
- Tabulipora carbonaria (Worthen)

Brachiopoda
- Lindstroemella patula (Girty)
- Lingula carbonaria Shumard
- Petrocrania modesta (White and St. John)
- Chonetes granulifer Owen
- Chonetes granulifer armatus Girty
- Cleiothyridina orbicularis (McChesney)
- Composita subtilita (Hall)
- Composita trilobata Dunbar and Condra
- Condrathyris perplexa (McChesney)
- Crurithyris planoconvexa (Shumard)
- "Dictyoclostus" americanus Dunbar and Condra
- "Dictyoclostus" portlockianus (Norwood and Pratten)
- Echinoconchus semipunctatus (Shephard)
- Hustedia mormoni (Marcou)
- Juresania nebrascensis (Owen)
- Juresania symmetrica (McChesney)
- Linoproductus pertenuis (Meek)
- Linoproductus prattenianus (Norwood and Pratten)
- "Marginifera" muricatina Dunbar and Condra
- Marginifera splendens (Norwood and Pratten)
- Mesolobus mesolobus decipiens (Girty)
- Mesolobus mesolobus euampygus (Girty)
- Mesolobus mesolobus lioderma Dunbar and Condra
- Neospirifer cameratus (Morton)
- Nudirostra rockymontanum (Marcou)

Pelecypoda
- Acanthopecten carboniferus (Stevens)
- Allorisma terminale Hall
- Astartella concentrica Conrad
- Astartella vera Hall
- Aviculopinna americana Meek
- Conocardium obliquum Meek
- Edmondia gibbosa McCoy
- Edmondia ovata Meek and Worthen



- Fasciculoconcha providencis (Cox)
- Limipecten texanus (Girty)
- Modiola subelliptica Meek
- Nucula anodontoides Meek
- Nuculana bellistriata (Stevens)
- Nuculana bellistriata attenuata (Meek)
- Nuculopsis girtyi Schenck
- Orthomyalina subquadrata (Shumard)
- Parallelodon obsoletus (Meek)
- Pleurophorus tropidophorus Meek
- Promytilus swallovi (McChesney)
- Schizodus affinis Herrick
- Schizodus wheeleri (Swallow)
- Yoldia glabra Beede and Rogers

Gastropoda
- Amphiscapha catilloide (Conrad)
- Bellerophon crassus wewokanus Girty
- Bucanopsis meekiana Swallow
- Cymatospira montfortiana (Norwood and Pratten)
- Euconospira turbiniformis (Meek and Worthen)
- Euphemites vittatus (McChesney)
- Glabrocingulum grayvillense (Norwood and Pratten)
- Meekospira peracuta (Meek and Worthen)
- Meekospira peracuta choctawensis Girty
- Pharkidonotus percarinatus (Conrad)
- Strobeus brevis (White)
- Trepospira depressa (Cox)
- Trepospira discoidalis Newell
- Trepospira sphaerulata (Conrad)
- Worthenia tabulata (Conrad)

Nautiloidea
- Brachycycloceras normale Miller, Dunbar, and Condra
- Liroceras liratum (Girty)
- Metacoceras cornutum Girty
- Pseudometacoceras sculptile (Girty)
- Pseudorthoceras knoxense (McChesney)

Ammonoidea
- Eoasianites angulatus Miller and Furnish
- Gastrioceras hyattianum Girty
- Gastrioceras venatum Girty
- Goniolobоceras goniolobus (Meek)
- Peritrochia ganti (Smith)

Trilobita
- Ameura sangamonensis (Meek and Worthen)

Plantae
- Calamites sp.

*Age and Correlation*: The Holdenville formation is of uppermost Desmoinesian age. In Oklahoma, it is the same age as the Confederate limestone of the uppermost part of the Deese group of the Ardmore Basin of southern Oklahoma, and extends northeastward into Kansas and Missouri.

## Missouri Series

Rocks of the Missouri series crop out in the central part of Okfuskee County, having an outcrop width of about 13 miles.

They overlie, with probable unconformity, rocks of the Des Moines series, and are overlain with pronounced overlap by rocks of the Virgil series.

In this county the Missouri series includes, in ascending order, the Seminole, Checkerboard, Coffeyville, Hogshooter, Nellie Bly, Dewey, Chanute, Barnsdall, and Tallant formations. The strike of this series trends northeast, and the beds dip northwest at about one degree. These beds consist mostly of grayish-green to brownish-green shales, together with thin sandstones and a few limestones and conglomerates. No coals were observed.

From field work in Okfuskee County, the writer accepts the unconformity at the base of the Seminole formation and base of the Missouri series, based principally on fossil studies, although in the county no evidence for structural discontinuity could be found.

The unconformity at the top of the Missouri series in Okfuskee County, however, is prominent and is evidenced by (1) structural discordance, (2) a striking color and lithologic change, and (3) well-established paleontologic evidence.

In Okfuskee County, the Missouri series is strike-overlapped by the Virgil series. At least two shales and two sandstones are overlapped. The amount of strike-overlap, however, could not be determined because of inability to measure the thickness of the Tallant formation.

There is a pronounced color and lithologic change between the Missouri and Virgil series. The beds of the Missouri series consist mostly of thick shales and thin sandstones which are typically grayish green to brownish green. The Barnsdall and Tallant formations, however, contain some red beds. The basal beds of the Virgil series in Okfuskee County consist almost entirely of sandstones, conglomeratic sandstones, and thin shales. Most of these beds are red. These lower Virgil beds, as represented by the Vamoosa formation, were probably deposited in a deltaic environment, whereas the beds of the Missouri series are typical marine deposits.

The disappearance of the brachiopod *Chonetinella* and the appearance of *Lissochonetes* and *Chonetes transversalis* marks a



faunal break between the Missouri and Virgil series. Diagnostic fossils of the Missouri series include such genera as *Chonetinella, Eothallassoceras,* and *Prouddenites. Triticites irregularis* and *Apographiocrinus* are diagnostic Missourian forms.

To the north, in northern Oklahoma and southern Kansas, the Missouri series has been subdivided by Moore, Newell, Dott, and Borden[62] into the Skiatook and Ochelata groups. The lower is Skiatook group, which includes those beds from the base of the Seminole formation to the top of the Dewey formation. The beds from the base of the Chanute formation to the base of the Virgil series comprise the Ochelata group. These subdivisions have been made on the basis of a disconformity at the base of the Chanute formation which was discovered in work by N. D. Newell. The unconformity at the base of the Chanute formation, however, has not been established with certainty in Okfuskee County.

In the electric log of the J. M. Davidson, Lehmer No. 1 well in the NE¼SW¼NW¼ sec. 17, T. 12 N., R. 8 E., the base of the Missouri series (base of the Seminole formation) was picked at 1,540 feet. The top of the series was picked at the base of the Vamoosa formation at 245 feet. This gives the Missouri series a total uncorrected thickness of 1,295 feet. A correction factor for a one-degree dip makes the true thickness of the Missouri series 1,270 feet. (See electric log No. 16 in the Electric Log Cross-Section, Plate II.)

## Skiatook Group

### Seminole Formation

*First Reference*: J. A. Taff,[63] 1901.

*Nomenclator*: J. A. Taff,[64] 1901.

*Type Locality*: Seminole Nation, now Seminole County, Oklahoma.

[62] Moore, R. C., Newell, N. D., Dott, R. H., and Borden, J. L., 1937. *The Kansas Geological Society,* Eleventh Annual Field Conference, p. 39.

[63] Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas,* Folio No. 74, p. 4.

[64] Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas,* Folio No. 74, p. 4.

*Stratigraphic Position*: In the type area, the Seminole formation lies above the Holdenville formation and below the Francis formation. According to Morgan,[65] there are local unconformities between the Holdenville and Seminole formations. The Seminole formation is conformable with the Francis formation above. However, Morgan[66] has found that north of the town of Fitzhugh, Pontotoc County, the Seminole is overlapped by the Ada formation, which normally occurs about 800 feet higher in the section.

In Okfuskee County as in Tulsa County and northward, the Seminole formation lies above the Holdenville formation and below the Checkerboard limestone. On the basis of regional mapping, many geologists believe there is an unconformity at the base of the Seminole formation, but in Okfuskee County the writer could find little evidence of truncation. The Seminole formation is conformable with the overlying Checkerboard limestone. To the south, however, the Checkerboard limestone grades into shale and is not mappable beyond sec. 23, T. 11 N., R. 9 E. From there to the southern limits of the county the shale equivalent to the Checkerboard limestone, about 5 feet thick, and the overlying shale about 12 feet thick, which in the north is the basal shale member of the Coffeyville formation, are mapped with the Seminole formation.

*Original Description*: In describing the Seminole formation, J. A. Taff[67] gave the following 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. This part of the formation is composed of laminated or stratified subangular chert, with a sprinkling of quartz pebbles from 3 inches in diameter to small grains in a cement of fine brown and usually ferruginous sand. The coarser conglomerate in the beds at the base is loosely cemented and on weathered surfaces breaks down into rounded boulders and loose gravel. 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.

[65] Morgan, G. D., 1924. *Oklahoma Bureau of Geology, Bulletin* 2, p. 103.
[66] Morgan, G. D., 1924. *Oklahoma Bureau of Geology, Bulletin* 2, p. 103.
[67] Taff, J. A., 1901. *United States Geological Survey, Geol. Atlas,* Folio No. 74.



*Other Description*: Morgan[68] has described the Seminole formation and has defined its upper limits. He says:

> East and north of Fitzhugh the Seminole is overlapped by the Ada formation which normally occurs about 800 feet higher in the section. . . . The presence of Seminole strata in the Franks graben is not clearly established. On the basis of evidence which indicates the outcrop there of the underlying Holdenville and the overlying Francis formation, however, it seems probable that it is there represented in some part of the interval between the upper Wewoka and the lower Francis formation.
>
> Although defined by Taff the upper limit of the Seminole was not mapped by him. . . . . By definition then, the Seminole of the type area has a thickness of "about" 150 feet. Since no definite bed is named as marking the top of the formation there can be no question as to the original measurement and the definition must be taken literally.
>
> In measuring upward and westward from the bottom of the 50 foot chert member, that occurs at the base of the type-section, it was found that in the extreme northeastern part of the Stonewall quadrangle is a thin limestone that is separated from the base of the Seminole by an interval which in that area averages 150 feet. This is a definite and persistent limestone and in the present work its base is taken as the top of the Seminole. This is the DeNay limestone.

*History of Usage*: Except as noted under Stratigraphic Position, usage has followed Morgan.

*Distribution*: The Seminole formation is shown on the "Geologic Map of Oklahoma",[69] as extending northeastward from central Pontotoc County through Seminole, Hughes, and Okfuskee Counties, and northward to the Kansas state line. In Okfuskee County, the base of the Seminole formation extends from the SE¼ sec. 13, T. 13 N., R. 10 E. to the south-central part of sec. 32, T. 10 N., R. 9 E. The top of the Seminole formation extends from the northern part of sec. 3, T. 13 N., R. 10 E. to the southwestern corner of sec. 31, T. 10 N., R. 9 E. The average width of the outcrop is about 2½ miles. The Seminole formation has a strike of N. 26° E.

[68] Morgan, G. D., *Oklahoma Bureau of Geology, Bulletin* 2, pp. 109-110.
[69] Miser, H. D., 1954. "Gelogic map of Oklahoma", *United States Geological Survey,* in press.

and the regional dip in Okfuskee County is N. 64° W. at about one degree.

*Thickness and Character*: The Seminole formation contains a succession of thick shales with thinner sandstones, a conglomerate, and a thin local limestone.

The basal unit of the Seminole formation, traceable across the entire county, is conglomerate, conglomeratic sandstone, or sandstone. It ranges in thickness from 4 feet at Station 170 in sec. 36, T. 11 N., R. 9 E. to 21 feet at Station 107 in sec. 36, T. 13 N., R. 10 E. In the southern part of the county, this unit consists mostly of a medium- to coarse-grained yellowish-brown sandstone. At station 84 in the SE¼ sec. 3, T. 11 N., R. 10 E., there is an extremely abrupt change to a coarse conglomerate about 17 feet thick that contains chert fragments as large as two inches in diameter. (See Figure 18.) The thickness of the bed and the size of these chert particles becomes progressively smaller northward; and at Station 139 in sec. 13, T. 13 N., R. 10 E., no chert particles were observed, this unit consisting of a coarse- to medium-grained sandstone.

In the northern part of Okfuskee County, the Seminole formation consists of this basal sandstone or conglomerate unit (IPsl-1) and an upper shale unit (IPsl-3). Southward from the central part of T. 10 N., R. 12 E., however, IPsl-1 is split by shale into sandstone sub-units IPsl-1a at the base, IPsl-1b in the middle, and IPsl-1c at the top. Unit IPsl-1b is a southward-wedging tongue which could not be traced beyond North Canadian River, but IPsl-1a and IPsl-1c were mapped to the southern boundary of the county. The medial shale is map unit IPsl-2, which is divided into lower and upper tongues, IPsl-2a and IPsl-2b, where sandstone IPsl-1b is present.

Shale IPsl-2a, between IPsl-1a and IPsl-1b, is yellowish brown, 50 to 60 feet thick, and is very fossiliferous locally. Sandstone tongue IPsl-1b was mapped from the north-central part of sec. 35, T. 11 N., R. 9 E. to about sec. 28, T. 12 N., R. 10 E. (See Figure 19.) It is sandy limestone in the area between the NE¼ sec. 19, T. 11 N., R. 10 E. and sec. 4, T. 11 N., R. 10 E. This bed is 1 to 5 feet thick, and is overlain by 30 to 45 feet of yellowish shale (IPsl-2b).



Figure 8. Small fault in Wewoka sandstone IPw-9 in roadcut at station 79, in the northern part of sec. 18, T. 11 N., R. 11 E. (Looking south).

Figure 9. Cuesta capped by basal Seminole conglomerate, IPsl-1, at station 84 in the SE¼ sec. 3, T. 11 N., R. 10 E. (Looking north).

Overlying this shale is IPsl-1c, the highest mappable sandstone of the Seminole formation in the county, which has been traced from the SE¼ sec. 3, T. 12 N., R. 10 E. to the NW¼ sec. 3, T. 10 N., R. 9 E. South of this point, the sandstone is friable and poorly developed. It reappears again in the south-central part of sec. 20, T. 10 N., R. 9 E. and extends southward to the Hughes County line.

The top unit of the formation is shale IPsl-3. It is grayish green to yellowish brown, fossiliferous, and 100 to 140 feet thick. In the area south of sec. 23, T. 11 N., R. 9 E., shale equivalent to the Checkerboard limestone, about 5 feet thick, and the overlying shale about 12 feet thick, are mapped in this unit.

The Seminole formation can be clearly identified in subsurface in the electric log of British American, Church Community A-1 in the SW¼NW¼SW¼ sec. 12, T. 11 N., R. 9 E. (See Well No. 10 of Plate II.) In this well the base of the Seminole formation was picked at 370 feet, the base of the middle Seminole sandstone (IPsl-1b) was picked at 250 feet, and the base of the upper Seminole sandstone (IPsl-1c) was picked at 210 feet. The top of the Seminole formation was estimated at about 97 feet. This gives the Seminole formation an uncorrected thickness of 270 feet, or a corrected thickness of 264 feet.

Elsewhere in the county, composite surface measurements show the Seminole formation to have a total thickness of 250 to 330 feet.

*Paleontology*: The Seminole formation is very fossiliferous. It carries a fauna typical of the Missouri series.

FOSSILS COLLECTED AND IDENTIFIED

Anthozoa
- Lophophyllidium sp.

Conularida
- Paraconularia crustula (White)

Bryozoa
- Rhombopora lepidodendroides Meek

Brachiopoda
- Lindstroemella patula (Girty)
- Chonetes granulifer Owen
- Composita subtilita (Hall)
- Crurithyris planoconvexa (Shumard)
- Derbyia crassa (Meek and Worthen)
- "Dictyoclostus" americanus Dunbar and Condra

Juresania nebrascensis (Owen)
Linoproductus inflatus coloradoensis (Girty)
Linoproductus insinuatus (Girty)
Linoproductus prattenianus (Norwood and Pratten)
Marginifera lasallensis (Worthen)
Marginifera splendens (Norwood and Pratten)
Neospirifer cameratus (Morton)
Neospirifer texanus (Meek)
Nudirostra rockymontanum (Marcou)
Punctospirifer kentuckiensis (Shumard)

Pelecypoda
Allorisma terminale Hall
Astartella concentrica Conrad
Aviculopecten occidentalis (Shumard)
Aviculopinna americana Meek
Aviculopinna peracuta (Shumard)
Edmondia ovata Meek and Worthen
Nuculana bellistriata (Stevens)
Nuculopsis girtyi Schenck
Paralleloden kansasensis Sayre
Pleurophorus tropidophorus Meek
Promytilus swallovi (McChesney)
Schizodus wheeleri Swallow
Yoldia glabra Beede and Rogers

Gastropoda
Amphiscapha catilloide (Conrad)
Glabrocingulum grayvillense (Norwood and Pratten)
Meekospira peracuta choctawensis Girty
Pharkidonotus percarinatus (Conrad)
Strobeus brevis (White)
Strobeus regularis (Cox)
Trepospira depressa (Conrad)
Worthenia tabulata (Conrad)

Plantae
Calamites sp.

*Age and Correlation*: The Seminole formation is of early Missourian age. In Oklahoma, the Seminole formation is approximately of the same age as the lowermost part of the Hoxbar group in the Ardmore Basin of southern Oklahoma.

## Checkerboard Limestone

*First Reference*: The first published recognition of the bed which is now known as the Checkerboard limestone, was made by Gould, Ohern, and Hutchison[70] in 1910. On a map of eastern Oklahoma, they showed its outcrop extending as far south as the North Fork Canadian River. Erroneously, however, they considered it the southward extension of the Lenapah limestone.

[70] Gould, C. N., Ohern, D. W., and Hutchison, L. L., 1910. *The State University of Oklahoma, Research Bulletin* No. 3, Map.



*Nomenclator*: The name appears to have come into usage without formal definition. As early as 1911, Hutchison[71] made reference to it by name. In 1914, Carl D. Smith[72] described it by name.

> 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 bridge over the Arkansas River, at a number of places between Red Fork and Jenks, 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 Checkboard lime.

In 1917, the Checkerboard limestone was mentioned by Fath and Emery.[73]

> Two outcrops of the Checkerboard lime, a bed which is about two feet thick, where 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.

*Type Locality*: In 1925, Gould[74] designated the type locality of the Checkerboard limestone as the exposures on Checkerboard Creek in T. 15 N., R. 11 E.

*Stratigraphic Position*: In the type area, the Checkerboard formation lies above the Seminole formation and below the Coffeyville formation. The beds are conformable. In Okfuskee County, the Checkerboard formation occupies the same stratigraphic position. The formation is also conformable with the beds directly below and above.

[71] Hutchison, L. L., 1911. *Oklahoma Geological Survey, Bulletin* 2, p. 157.
[72] Smith, C. D., 1912. *United States Geological Survey, Bulletin* 541, p. 41.
[73] Fath, A. E., and Emery, W. B., 1917. *Oklahoma Geological Survey, Bulletin* 19, part 2, p. 370.
[74] Gould, C. N., 1925. *Oklahoma Geological Survey, Bulletin* 35, p. 72.

*Original Description*: The first actual description was given by Gould[75] in 1925.

> 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 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. 13 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.

*History of Usage*: The term Checkerboard appears always to have been used in its present sense. The Checkerboard limestone was, however, a member of the Coffeyville formation until it was raised to the rank of a formation in 1937 by Moore, Newell, Dott, and Borden.[76]

*Distribution*: The Checkerboard formation is shown on the "Geologic Map of Oklahoma",[77] as extending from the latitude of Okmulgee to the Kansas state line.

In Okfuskee County, the Checkerboard limestone extends from the northern part of sec. 3, T. 13 N., R. 10 E. to the NE¼ sec. 23, T. 11 N., R. 9 E., (Station 10). South of this locality, shale equivalent to the Checkerboard formation is mapped with the Seminole formation. The Checkerboard formation has a strike of N. 22° E., and dips N. 68° W. at about one degree.

*Thickness and Character*: The Checkerboard formation in Okfuskee County consists of a single unit—a limestone 2 to 7 feet thick. It overlies the uppermost shales of the Seminole formation and is overlain by the lower shales of the Coffeyville formation. Normally, the Checkerboard limestone is found 12 to 18 feet below the base of the lowest Coffeyville sandstone.

[75] Gould, C. N., 1925. *Oklahoma Geological Survey, Bulletin* 35, p. 72.
[76] Moore, R. C., Newell, N. D., Dott, R. H., and Borden, J. L., 1937. *The Kansas Geological Society*, Eleventh Annual Field Conference, p. 40.
[77] Miser, H. D., 1954. "Geologic Map of Oklahoma," *United States Geological Survey*, in press.



Figure 10. Thin-bedded Checkerboard limestone at station 240, in the south-central part of sec. 11, T. 11 N., R. 9 E. (Looking west).

Figure 11. Lower sandstone of Coffeyville formation, IPcf-2a, at station 10 in the northeastern part of sec. 23, T. 11 N., R. 9 E. (Looking west).

In the SE¼ sec. 27, T. 13 N., R. 10 E., (Station 136), a limestone crops out in an open field and not in the same escarpment as the lower sand of the Coffeyville. This may be the Checkerboard limestone brought to this position as the result of a large fault. The exact throw of this fault could not be determined, and if the throw is less than an estimated 120 feet, this 17-inch limestone could be a limestone in the Seminole formation at about the stratigraphic horizon of the middle Seminole sandstone member, Psl-1c. (See Geologic Map, Plate I.)

In the northern part of the county, the Checkerboard limestone consists of a massive bed which ranges in thickness from 8 inches to 2 feet. This limestone thickens southward. In the western part of sec. 27, T. 13 N., R. 10 E. (Station 134), the limestone is 2.5 feet thick and is very fossiliferous. In the southwestern part of sec. 4, T. 12 N., R. 10 E. (Station 131), the Checkerboard is 4 feet thick. The upper 2 feet is sandy and the lower 2 feet is a dense blue-colored limestone. In the southeastern part of sec. 5, T. 12 N., R. 10 E. (Station 130), the Checkerboard consists of a massive and dense 3.5-foot limestone. Capping an outlier in the south-central part of sec. 8, T. 12 N., R. 10 E., (Station 122), the Checkerboard limestone is 4.5 feet thick. From this point southward, the Checkerboard limestone changes abruptly into a series of thin (1 to 3 inch) limestone flags that are interstratified with shale. This zone is 7 feet thick at Station 118, sec. 6, T. 11 N., R. 10 E. (See Figure 21.) The Checkerboard limestone extends southward to its southern extremity where it maintains its flaggy nature but is somewhat thinner, being only 4 feet thick at Station 240, in sec. 11, T. 11 N., R. 9 E. (See Figure 10.)

The Checkerboard limestone could not be traced south of the NW¼ sec. 23, T. 11 N., R. 9 E.

*Paleontology*: The Checkerboard limestone is very fossiliferous. At many places, the limestone consists almost entirely of crinoid stem ossicles. It carries the typical fauna of the Missouri series.

FOSSILS COLLECTED AND IDENTIFIED

Brachiopoda
- Chonetes granulifer Owen
- Composita subtilita (Hall)
- Crurithyris planoconvexa (Shumard)
- Derbyia crassa (Meek and Hayden)

"Dictyoclostus" americanus Dunbar and Condra
Juresania nebrascensis (Owen)
Linoproductus insinuatus (Girty)
Linoproductus prattenianus (Norwood and Pratten)
Marginifera lasallensis (Worthen)
Neospirifer cameratus (Morton)

Pelecypoda

Astartella concentrica Conrad
Aviculopecten occidentalis (Shumard)
Nuculana bellistriata (Stevens)
Pleurophorus tropidophorus Meek
Promytilus swallovi (McChesney)

Gastropoda

Amphiscapha catilloide (Conrad)
Glabrocingulum grayvillense (Norwood and Pratten)

Nautiloidea

Metacoceras cornutum Girty
Pseudorthoceras knoxense (McChesney)

*Age and Correlation*: The Checkerboard limestone lies near the base of the Missouri series. In Oklahoma, it is approximately of the same age as DeNay limestone of central Oklahoma and beds of the lower part of the Hoxbar group of the Ardmore Basin in southern Oklahoma.

## Coffeyville Formation

*First Reference*: Schrader and Haworth,[78] 1905.

*Nomenclators*: Schrader and Haworth,[79] 1906.

*Type Locality*: In the vicinity of Coffeyville, Kansas.

*Stratigraphic Position*: In the type area the Coffeyville formation lies conformably above the Checkerboard limestone and conformably below the Hogshooter (Dennis) limestone.

In central Okfuskee County the base and top of the Coffeyville formation are the Checkerboard and Hogshooter limestones, respectively. However, the Checkerboard limestone grades into shale southward and is not mappable between sec. 23, T. 11 N., R. 9 E. and the southern boundary of the county. In this area the base of the Coffeyville formation is mapped at the base of its lowest sandstone unit, IPcf-2, which is 5 to 20 feet above the Checkerboard limestone. The Hogshooter limestone, which marks the upper boundary of the Coffeyville formation, also grades into shale southward and is not mappable beyond sec. 35, T. 12 N., R. 9 E.

[78] Schrader, F. C., and Haworth, Erasmus, 1905. *United States Geological Survey, Bulletin* 260, p. 446.

[79] Schrader, F. C., and Haworth, Erasmus, 1906. *United States Geological Survey, Bulletin* 296, p. 14.



From there to the southern boundary of the county the shale equivalent to the Hogshooter formation, approximately 2 feet thick, and the overlying shale approximately 5 feet thick, are mapped as the top unit of the Coffeyville formation. The upper 5-foot shale is the base of the Nellie Bly formation in Okfuskee County where the Hogshooter is present.

*Original Description*: Schrader and Haworth[80] gave the original description of the Coffeyville formation as follows:

> 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).

*History of Usage*: The use of the term Coffeyville as a formation name has varied greatly since its inception in 1905. At that time, Schrader and Haworth[81] included, in ascending order, the Ladore-Dudley shale, the Mound Valley limestone, the Galesburg shale, the Dennis limestone, and the Cherryvale shale, in the Coffeyville formation. This involved a section about 250 feet in thickness. Since then the term Coffeyville as a formation name has been redefined many times. In 1937, Moore, Newell, Dott, and Borden[82] restricted the term Coffeyville to the strata between the Checkerboard limestone below and the Dennis (Hogshooter) limestone above. In this paper, the term Coffeyville is used in the latter sense.

*Distribution*: The Coffeyville formation is shown on the "Geologic Map of Oklahoma"[83] as extending from one mile south of Okemah northward into Kansas. Actually, beds in the lower part of the Francis formation to the south are of the same age and are a continuation of the Coffeyville formation. This would make the southern extension of the Coffeyville formation at Fitzhugh, Pontotoc County, on the north side of the Arbuckle Mountains. In Okfuskee County, the base of the Coffeyville formation extends from the NE¼ sec. 3, T. 13 N., R. 10 E. to the SW¼ sec. 31, T.

[80] Schrader, F. C., and Haworth, Erasmus, 1906. *United States Geological Survey, Bulletin* 296, p. 14.

[81] Schrader, F. C., and Haworth, Erasmus, 1906. *United States Geological Survey, Bulletin* 296, p. 14.

[82] Moore, R. C., Newell, N. D., Dott, R. H., and Borden, J. L., 1937. *The Kansas Geological Society*, Eleventh Annual Field Conference, p. 41.

[83] Miser, H. D., 1954. "Geologic Map of Oklahoma," *United States Geological Survey*, in press.

10 N., R. 9 E. The top of the Coffeyville formation extends from the western part of sec. 5, T. 13 N., R. 10 E. to the west-central part of sec. 35, T. 10 N., R. 8 E. The average width of the outcrop is about 2.5 miles. The Coffeyville formation in Okfuskee County has a strike of N. 22° E. and a regional dip of about one degree in the direction N. 68° W.

*Thickness and Character*: The Coffeyville formation in Okfuskee County is about 245 feet thick and consists of a succession of shales and sandstones. Generally the shales are thick and the sandstones are thin. The shales are yellowish brown to grayish green, contain small concretions at many places, and carry a prolific fauna locally. The sandstones are well indurated, resistant to erosion, and form long dip slopes that cap steep escarpments. The sandstones are generally yellowish brown.

The basal shale of the Coffeyville formation (IPcf-1 of map) lies directly above the Checkerboard limestone. It ranges in thickness from 5 to 20 feet. It is yellowish brown and fossiliferous. The shale is well exposed at Station 230 in sec. 7, T. 11 N., R. 10 E., and at Station 10 in sec. 23, T. 11 N., R. 9 E. (See Figure 11.) South of sec. 23, T. 11 N., R. 9 E., where the underlying Checkerboard limestone grades into shale, this unit is mapped with the Seminole formation.

Overlying this shale is a well-indurated, yellowish-brown sandstone 2 to 20 feet thick (IPcf-2a). South of sec. 8, T. 12 N., R. 10 E., this sandstone is overlain by shale (IPcf-2b) and forms long dip slopes. In the vicinity of Okemah, secs. 11, 12, 13 and 14, T. 11 N., R. 9 E., the dip slope is more than 2 miles wide. Near its base this sandstone contains a ubiquitous *Linoproductus prattenianus* fauna. North of sec. 8, T. 12 N., R. 10 E., shale IPcf-2b disappears and sandstone IPcf-2a unites with sandstone IPcf-2c to form a single sandstone unit, IPcf-2.

Shale IPcf-2b is extremely fossiliferous in the western part of sec. 31, T. 12 N., R. 10 E. It is thickest in the southern part of the county where it is 80 feet thick, becoming progressively thinner northward and finally disappearing in sec. 8, T. 12 N., R. 10 E.

Where shale IPcf-2b is present it is overlain by sandstone IPcf-2c, which is 10 to 30 feet thick and extends northeastward



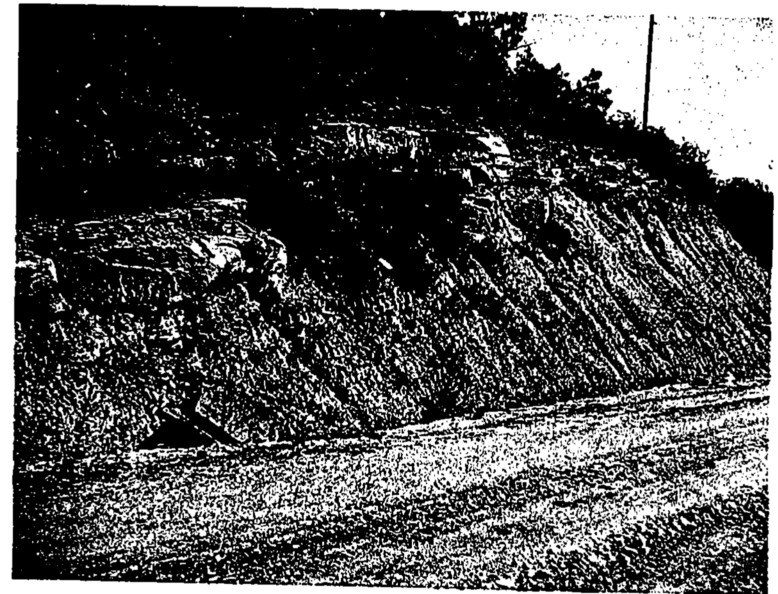

Figure 12. Upper sandstone of Coffeyville formation, IPcf-2c, at station 320, in the NW¼ sec. 36, T. 10 N., R. 8 E. (Looking north).

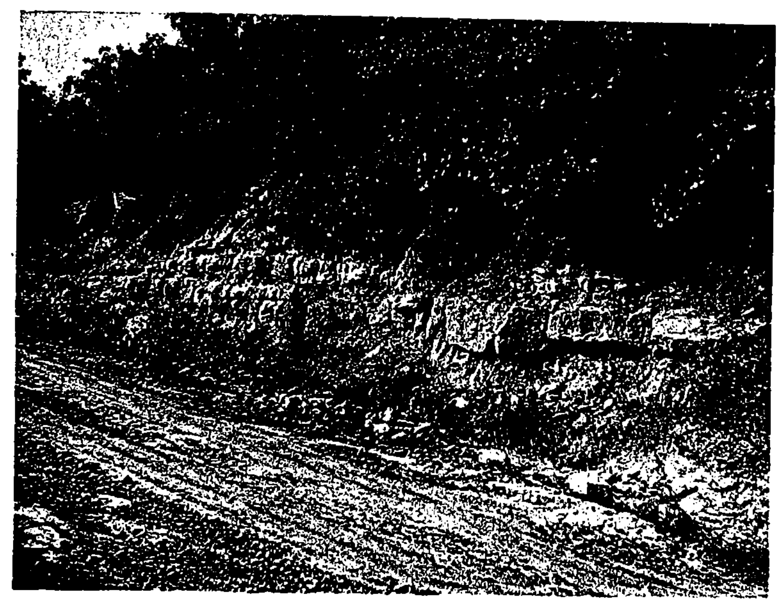

Figure 13. Sandstone IPnb-6 in the lower part of the Nellie Bly formation at station 276 in the east-central part of sec. 28, T. 13 N., R. 9 E. (Looking west).

from the south-central part of sec. 35, T. 10 N., R. 8 E., to sec. 8, T. 12 N., R. 10 E., where it and sandstone IPcf-2a unite to form a single sandstone unit, IPcf-2 (See Figure 12).

A 135-foot shale (IPcf-3) is the top unit of the Coffeyville formation. It is fossiliferous, soft, and yellowish brown. It is overlain by the Hogshooter limestone north of sec. 35, T. 12 N., R. 9 E., but southward from this locality the Hogshooter disappears and the shale unit as mapped includes shale equivalent to the Hogshooter formation, about 2 feet thick, as well as an overlying shale about 5 feet thick that farther north is the basal shale unit of the Nellie Bly formation.

The Coffeyville formation may be clearly identified in subsurface in the electric log of the Davidor and Davidor, McKernan No. 1 well in the SE¼SE¼SW¼ sec. 20, T. 12 N., R. 9 E. (See Plate II.) In this well, the base of the Checkerboard limestone was picked at 675 feet and the top of the Coffeyville formation was picked at 420 feet. This gives the Coffeyville formation an uncorrected thickness of 255 feet, or a corrected thickness of 245 feet.

*Paleontology*: Many of the shales of the Coffeyville formation are fossiliferous and afford excellent collecting. The fauna is typical of the Missouri series.

FOSSILS COLLECTED AND IDENTIFIED

Anthozoa
- Lophophyllidium sp.
- Pleurodictyum eugeneae White
- Stereostylus ? radicosus (Girty)

Conularida
- Paraconularia crustula (White)

Bryozoa
- Rhombopora lepidodendroides Meek

Brachiopoda
- Lindstroemella patula (Girty)
- Lingula carbonaria Shumard
- Chonetes granulifer Owen
- Composita subtilita (Hall)
- Crurithyris planoconvexa (Shumard)
- Derbyia crassa (Meek and Hayden)
- "Dictyoclostus" americanus Dunbar and Condra
- "Dictyoclostus" portlockianus (Norwood and Pratten)
- Echinoconchus semipunctatus (Shepard)
- Juresania nebrascensis (Owen)
- Linoproductus inflatus coloradoensis (Girty)
- Linoproductus insinatus (Girty)
- Linoproductus prattenianus (Norwood and Pratten)
- Marginifera lasallensis (Worthen)

Marginifera splendens (Norwood and Pratten)
Neospirifer cameratus (Morton)
Nudirostra rockymontanum (Marcou)

Pelecypoda
Allorisma terminale Hall
Astartella concentrica Conrad
Aviculopecten occidentalis (Shumard)
Aviculopinna americana Meek
Edmondia gibbosa McCoy
Nucula anodontoides Meek
Nucula wewokana Girty
Nuculana bellistriata (Stevens)
Nuculopsis girtyi Schenck
Parallelodon obsoletus (Meek)
Pleurophorus tropidophorus Meek
Promytilus swallovi (McChesney)
Schizodus wheeleri Swallow
Yoldia glabra Beede and Rogers

Gastropoda
Amphiscapha catilloide (Conrad)
Euphemites vittatus (McChesney)
Glabrocingulum grayvillense (Norwood and Pratten)
Meekospira bella Walcott
Meekospira peracuta (Meek and Worthen)
Meekospira peracuta choctawensis Girty
Pharkidonotus percarinatus (Conrad)
Strobeus brevis (White)
Strobeus primogenius (Conrad)
Trepospira depressa (Conrad)
Worthenia tabulata (Conrad)

Nautiloidea
Brachycycloceras normale Miller, Dunbar, and Condra
Metacoceras cornutum Girty
Pseudorthoceras knoxense (McChesney)

Ammonoidea
Dimorphoceras lenticulare Girty
Gastrioceras hyattianum Girty

Trilobita
Ameura major (Shumard)

Plantae
Calamites sp.

*Age and Correlation*: The Coffeyville formation is of lower Missourian age. In Oklahoma, it is approximately of the same age as the lower part of the Francis formation of central Oklahoma and beds in the lower part of the Hoxbar group in the Ardmore Basin of southern Oklahoma.

## Hogshooter Formation

*First Reference*: Adams,[84] 1903. First mapped as the lower Drum limestone.

*Nomenclator*: Ohern,[85] 1910.

84 Adams, G. I., Girty, G. H., and White, David, 1903. *United States Geological Survey, Bulletin* 211, pp. 62-63.
85 Ohern, D. W., 1910. *The State University of Oklahoma, Research Bulletin* 4, p. 28.



*Type Locality*: Along Hogshooter Creek in T. 26 N., R. 14 E.

*Stratigraphic Position*: In the type area, the Hogshooter limestone lies above the Coffeyville formation and below the Nellie Bly formation. The Hogshooter is conformable with beds above and below. In Okfuskee County, the Hogshooter occupies the same stratigraphic position and is conformable with beds above and below.

*Original Description*: D. W. Ohern[86] gave the following 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.
>
> 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.

*Other Description*: M. C. Oakes[87, 88] has described the formation in Washington County and Tulsa County. He noted several members and reported thicknesses ranging from 1 to 60 feet.

*History of Usage*: Ohern[89] originally used the term Hogshooter as synonymous with the lower Drum. This usage is now known to be erroneous as the Hogshooter of Ohern has been traced into the Winterset member of the Dennis formation of Kansas.

The Hogshooter as used by M. C. Oakes is essentially equivalent to the Dennis formation of Kansas as redefined by Jewett[90] in 1932. Oakes,[91] however, deemed it advisable to retain the name Hog-

86 Ohern, D. W., 1910. *The State University of Oklahoma, Research Bulletin* 4, p. 28.
87 Oakes, M. C., 1940. *Oklahoma Geological Survey, Bulletin* 62, pp. 42-43.
88 Oakes, M. C., 1952. *Oklahoma Geological Survey, Bulletin* 69, pp. 59-67. 4, p. 28.
89 Ohern, D. W., 1910. *The State University of Oklahoma, Research Bulletin*
90 Jewett, J. M., 1932. *Kansas Geological Society*, Guide Book, Sixth Annual Field Conference, p. 102.
91 Oakes, M. C., 1940. *Oklahoma Geological Survey, Bulletin* 62, p. 41.

shooter. He writes:

> 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. 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.

In this paper, the term Hogshooter shall be used in the above sense.

*Distribution*: The Hogshooter formation is shown on the "Geologic Map of Oklahoma,"[92] as extending from the latitude of Okemah in Okfuskee County, Oklahoma, northward into Kansas.

In Okfuskee County, the Hogshooter formation extends from the eastern part of sec. 6, T. 13 N., R. 10 E. to the northeastern part of sec. 35, T. 12 N., R. 9 E. South of this point, the Hogshooter limestone grades into shale which is mapped with the Coffeyville formation. The Hogshooter formation has a strike of N. 21° E. and the regional dip in Okfuskee County is N. 69° W. at one degree.

*Thickness and Character*: The Hogshooter formation is mapped as a single unit in Okfuskee County.

The lithology of the Hogshooter formation is not uniform. At most places it is a limestone, but at many places it becomes arenaceous and grades into a calcareous sandstone. The limestone ranges from 1 to 6 feet in thickness. Excellent exposures may be observed at Station 179 in the southwestern part of sec. 6, T. 12 N., R. 10 E. and at Station 175 in the northeastern part of sec. 24, T. 12

[92] Miser, H. D., 1954. "Geologic Map of Oklahoma," *United States Geological Survey*, in press.



N., R. 9 E. Of special interest is the outcrop of the Hogshooter limestone in a quarry at Station 185 in the center of sec. 20, T. 13 N., R. 10 E. Here the Hogshooter formation, ranging in color from yellow to dark bluish black, is 20 feet thick and very fossiliferous. It is conglomeratic and contains pebbles of sandstone, shale, and coal. The limestone conglomerate is quarried for road material.

It should be mentioned that a limestone 3 to 6 inches thick was observed at Station 321 in sec. 35, T. 10 N., R. 8 E., where it is 12 feet below the base of the lowermost Nellie Bly sandstone (IPnb-2). A limestone of the same thickness was also observed at this horizon at Station 325 in sec. 12, T. 10 N., R. 8 E., and again in the SE¼ sec. 1, T. 10 N., R. 9 E. It is entirely conceivable that these limestone outcrops may represent the Hogshooter limestone, although more detailed work is needed to confirm this correlation.

The Hogshooter formation may be identified in subsurface in the electric log of the Davidor and Davidor, McKernan No. 1 well in the SE¼SE¼SW¼ sec. 20, T. 12 N., R. 9 E. (See Well No. 13 in the Electric Log Cross-Section, Plate II.) In this well the base and top of the Hogshooter were picked at 278 and 272 feet, respectively.

*Paleontology*: The Hogshooter formation in Okfuskee County has yielded the fauna listed below.

FOSSILS COLLECTED AND IDENTIFIED

Brachiopoda
- Derbyia crassa (Meek and Hayden)
- "Dictyoclostus" americanus Dunbar and Condra
- Juresania nebrascensis (Owen)
- Linoproductus prattenianus (Norwood and Pratten)

Pelecypoda
- Aviculopecten occidentalis (Shumard)
- Nuculana bellistriata (Stevens)
- Nuculopsis girtyi Schenck
- Pleurophorus tropidophorus Meek
- Schizodus wheeleri Swallow

Gastropoda
- Euphemites vittatus (McChesney)
- Meekospira peracuta (Meek and Worthen)

Nautiloidea
- Brachycycloceras normale Miller, Dunbar, and Condra
- Pseudorthoceras knoxense (McChesney)

*Age and Correlation*: The Hogshooter formation is of lower Missourian age. In Oklahoma, it is approximately of the same age as parts of the Francis formation of central Oklahoma and the Crinerville limestone of the Hoxbar group in the Ardmore Basin of southern Oklahoma.

## Nellie Bly Formation

*First Reference*: Charles N. Gould,[93] 1925.

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

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

*Stratigraphic Position*: In the type area, the name Nellie Bly is applied to sandstones and shales that lie conformably above the Hogshooter formation and conformably below the Dewey formation, or below the unconformity at the base of the Chanute formation where the Dewey is absent. M. C. Oakes[94] and others have found the Dewey and part of the Nellie Bly to be cut out by pre-Chanute erosion and 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.

In Okfuskee County, the Nellie Bly formation overlies the Hogshooter formation conformably and is conformably overlain by the Dewey formation.

*Original Description*: Charles N. Gould[95] has given the following 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. Middle formation of the Drum Group. Rests on the Hogshooter limestone and is overlain by the Dewey limestone.

*History of Usage*: The name Nellie Bly appears always to have been used in the present sense.

93 Gould, C. N., "Index to the Stratigraphy of Oklahoma," *Oklahoma Geological Survey, Bulletin* 35, p. 74.
94 Oakes, M. C., 1940. *Oklahoma Geological Survey, Bulletin* 62, p. 47.
95 Gould, C. N., 1925. *Oklahoma Geological Survey, Bulletin* 35, p. 74.



*Distribution*: The Nellie Bly formation is shown on the "Geologic Map of Oklahoma"[96] as extending from the latitude of Okemah in Okfuskee County, northward into Kansas. Beds in the upper part of the Francis formation to the south are of the same age and a continuation of the Nellie Bly formation. This would extend the equivalents of the Nellie Bly formation to an area near Fitzhugh, Pontotoc County, on the north flank of the Arbuckle Mountains.

In Okfuskee County, the base of the Nellie Bly formation extends from the NE¼ sec. 6, T. 13 N., R. 10 E. to the NW¼ sec. 35, T. 10 N., R. 8 E. The top of the Nellie Bly formation extends from sec. 5, T. 13 N., R. 9 E. to the NW¼ sec. 14, T. 11 N., R. 8 E. The average width of the outcrop is about 5 miles. The Nellie Bly formation in Okfuskee County has a strike of N. 20° E. and a regional dip westward of about one degree.

*Thickness and Character*: The Nellie Bly formation consists of 6 mappable sandstones and 7 mappable shales, all of which are traceable across Okfuskee County. One thin limestone was observed. The thickness of the formation in Okfuskee County ranges from 440 to 460 feet. Generally the sandstones of the Nellie Bly are thick and well developed, although a few are friable and do not form pronounced escarpments. The shales are generally thin

TABLE 2

LITHOLOGY AND THICKNESS OF MAPPED UNITS OF THE NELLIE BLY FORMATION IN OKFUSKEE COUNTY

| Map Unit | Lithology | Thickness (feet) | Interval above base of Hogshooter (feet) |
|---|---|---|---|
| IPnb-13 | shale | 60-90 | |
| IPnb-12 | sandstone | 20-50 | |
| IPnb-11 | shale | 5-25 | |
| IPnb-10 | sandstone | 3-15 | 306 |
| IPnb-9 | shale | 30-90 | |
| IPnb-8 | sandstone | 5-10 | 296 |
| IPnb-7 | shale | 20-80 | |
| IPnb-6 | sandstone | 18-80 | 196 |
| IPnb-5 | shale | 60-90 | |
| IPnb-4 | sandstone | 3-10 | 111 |
| IPnb-3 | shale | 70-90 | |
| IPnb-2 | sandstone | 4-12 | |
| IPnb-1 | shale | 16 | |
| Normal thickness of formation | | 440-460 | |

96 Miser, H. D., 1954. "Geologic Map of Oklahoma," *United States Geological Survey*, in press.

and yellowish brown. Small concretions are found in places. There is a marked decrease in the abundance and distribution of the fauna as compared with the fauna of the underlying beds.

Table 2 summarizes the lithology and thickness of the mapped units in the county.

The basal unit of the Nellie Bly formation is a thin shale (IPnb-1). This shale is yellowish brown, it contains few fossils, and normally is about 16 feet thick. South of sec. 35, T. 12 N., R. 9 E. where the underlying Hogshooter formation disappears, this shale is mapped with the Coffeyville formation.

Overlying the lowermost shale of the Nellie Bly is a light-brown sandstone (IPnb-2), which ranges in thickness from 4 to 12 feet. This sandstone contains few fossils.

A greenish-yellow to yellowish-brown shale (IPnb-3) overlies the above sandstone. It ranges from 70 to 90 feet in thickness and contains few fossils.

The overlying unit is a thin sandstone (IPnb-4), the base of which is 111 feet above the base of the Hogshooter formation. It is light brown but weathers dark brown. It ranges in thickness from 3 to 10 feet. In the north it forms low-lying scarps, and in the south it may be found in the middle of an escarpment formed by an overlying sandstone. Few fossils were observed in this sandstone.

Overlying sandstone IPnb-4 is a thick shale, IPnb-5. It is yellowish brown, relatively unfossiliferous, and ranges in thickness from 60 to 90 feet.

The next unit above is sandstone IPnb-6. (See Figure 29) It is light brown but becomes deep red on weathering. This sandstone is very massive and forms high escarpments across the county. In a few places the sandstone is friable and forms only low-lying ridges. The base of the sandstone is about 196 feet above the base of the Hogshooter formation. This sandstone ranges in thickness from 18 to 80 feet. An exposure of this sandstone at Station 228 in the NW¼ sec. 8, T. 11 N., R. 9 E. is of special interest. Near its base, bedding planes show a dip of 16 degrees. About 75 feet higher, near the top of the sandstone, the dip is only 1 or 2 degrees.



Overlying this sandstone is a yellowish-brown shale (IPnb-7). It contains few fossils and ranges in thickness from 20 to 80 feet.

A thin, virtually unfossiliferous sandstone (IPnb-8) overlies shale IPnb-7. It is light brown but weathers reddish orange. Although this sandstone was mapped across the entire county, it forms few high escarpments. The thickness of sandstone IPnb-8 is about 5-10 feet, and its base is 296 feet above the base of the Hogshooter formation.

Overlying this sandstone is a yellowish-brown shale, IPnb-9, which ranges in thickness from 30 to 90 feet and is fossiliferous in places.

A thin sandstone (IPnb-10) overlies the above shale. This sandstone is light brown, weathering deep brown. Its base is 306 feet above the base of the Hogshooter formation. The thickness ranges from 3 to 15 feet. It is generally found in the escarpment which is capped by the more massive sandstone above.

Overlying the above sandstone is a thin shale (IPnb-11). This shale is yellowish brown and contains few fossils. It ranges in thickness from 5 to 25 feet.

A massive light-brown, sparsely fossiliferous sandstone (IPnb-12) overlies shale IPnb-11. Its base is 406 feet above the base of the Hogshooter formation, and its thickness ranges from 20 to 50 feet. This sandstone generally forms high escarpments throughout the county. Of special interest is a limestone 6 inches to 2 feet thick which occurs persistently at the base of this sandstone and can be found at most places (See Figures 14 and 15).

The uppermost unit of the Nellie Bly formation is a greenish-yellow fossiliferous shale (IPnb-13). It overlies sandstone IPnb-12 and is overlain by the Dewey limestone. This shale ranges in thickness from 60 to 90 feet.

The Nellie Bly formation ranges in thickness from 440 to 460 feet. In the southern part of the county, it can be clearly identified in the electric log of the Wood Oil Company, Sanders No. 1 well in the NE¼SW¼SW¼ sec. 25, T. 11 N., R. 7 E., where the base of the formation was picked at 1,090 feet and the top at about 650 feet, giving a thickness of 440 feet.

In the central part of the county, the Nellie Bly can be clearly identified in the electric log of the Hernstadt Oil Company, Davis Reed No. 1 well in the SE¼SE¼NW¼ sec. 12, T. 12 N., R. 7 E. (See Well No. 17 in the Electric Log Cross-Section, Plate II.) In this well, the base of the Nellie Bly formation was picked at 1,170 feet and the top at 710 feet, giving a thickness of 460 feet.

In the northern part of the county, the Nellie Bly can be identified in the electric log of the B. C. Deardorf, Gentner No. 1 well in the SW¼SE¼SW¼ sec. 17, T. 13 N., R. 8 E. In this well, the base of the Nellie Bly was picked at 1,110 feet and the top at 650 feet, giving a thickness of 460 feet.

*Paleontology*: The following 15 species were identified:

FOSSILS COLLECTED AND IDENTIFIED

Brachiopoda
- Derbyia crassa (Meek and Hayden)
- Linoproductus insinuatus (Girty)
- Linoproductus prattenianus (Norwood and Pratten)

Pelecypoda
- Aviculopecten occidentalis (Shumard)
- Aviculopinna americana Meek
- Aviculopinna peracuta (Shumard)
- Nucula anodontoides Meek
- Nuculana bellistriata (Stevens)
- Nuculopsis girtyi Schenck
- Pleurophorus tropidophorus Meek
- Promytilus swallovi (McChesney)
- Schizodus wheeleri Swallow
- Yoldia glabra Beede and Rogers

Gastropoda
- Strobeus primogenius (Conrad)

Plantae
- Calamites sp.

*Age and Correlation*: The Nellie Bly formation is of middle Missourian age. In Oklahoma, it is approximately of the same age as the upper part of the Francis formation of central Oklahoma and those beds between the Crinerville limestone and the Anadarche limestone of the Ardmore Basin in southern Oklahoma.

## Dewey Formation

*First Reference*: George I. Adams,[97] 1903.
*Nomenclator*: D. W. Ohern,[98] 1910.

[97] Adams, G. I., Girty, G. H., and White, David, 1903. *United States Geological Survey, Bulletin* 211, pp. 62-63.

[98] Ohern, D. W., 1910. *The State University of Oklahoma, Research Bulletin* 4, p. 30.



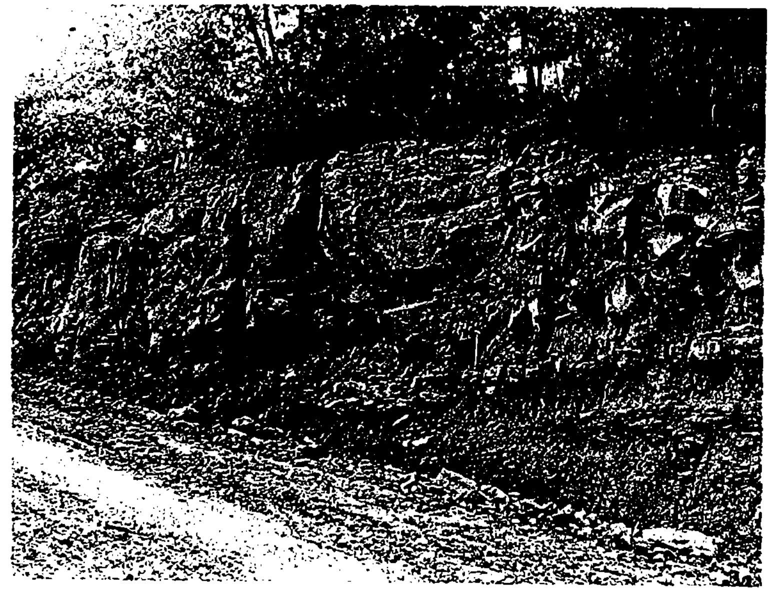

Figure 14. Sandstone IPnb-12 in the upper part of the Nellie Bly formation at station 284 in the SW¼ sec. 28, T. 13 N., R. 9 E. (Looking north).

Figure 15. Scarp-slope view of sandstone IPnb-12 in the upper part of the Nellie Bly formation. Station 260 in the southwestern part of sec. 8, T. 12 N., R. 9 E. (Looking west).

*Type Locality*: The old quarry of the Dewey Portland Cement Company in sec. 26, T. 27 N., R. 13 E.

*Stratigraphic Position*: In the type area, the name Dewey is applied to beds that lie above the Nellie Bly formation and below the Chanute formation. The beds appear to be conformable. However, a few miles to the north from the center of sec. 13, T. 28 N., R. 14 E. to the Kansas border, the Dewey limestone was removed by pre-Chanute erosion. In Okfuskee County, the Dewey formation overlies the Nellie Bly formation below and is overlain by the Chanute formation above. The beds appear to be conformable.

*Original Description*: D. W. Ohern[99] gave the following 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 from the town of Dewey where the limestone is admirable 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, *Campophyllum torquium* being especially abundant.

*Other Description*: M. C. Oakes[100] has given the following description of the Dewey formation in Washington County, Oklahoma:

> 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. affords 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

99 *Ibid.*

100 Oakes, Malcolm C., 1950. *Oklahoma Geological Survey, Bulletin* 62, p. 55.

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.

*History of Usage*: The name appears to have always been used in its present sense, except in that area from the Kansas border south to sec. 13, T. 28 N., R. 14 E. where it was erroneously applied to a sandstone and limestone conglomerate at the base of the Chanute formation.

*Distribution*: The Dewey formation extends from Okfuskee County northward into Kansas. In Okfuskee County, the base of the Dewey formation extends from the southern part of sec. 5, T. 13 N., R. 9 E. to the NW¼ sec. 14, T. 11 N., R. 8 E. The top of the Dewey formation extends from the south-central part of sec. 6, T. 13 N., R. 9 E. to the east-central part of sec. 34, T. 12 N., R. 8 E. The average width of the outcrop is about three-fourths of a mile. The Dewey formation has a strike of N. 15° E. and the regional dip in Okfuskee County is N. 75° W. at about one degree.

*Thickness and Character*: The Dewey formation consists of a lower limestone or arenaceous limestone member (IPd-1 of map) and an overlying shale member (IPd-2 of map).

The lower member is generally bluish-gray limestone that weathers brownish yellow, and ranges in thickness from 16 inches to 12 feet. In the north-central part of the county its base is about 40 feet above the top of the uppermost Nellie Bly sandstone (IPnb-12). At some places it is a dense and massive limestone, but elsewhere it is so sandy that it could be classed as a calcareous sandstone. Where this member is a limestone it is very fossiliferous. (See Figure 16).

The upper member (IPd-2 of map) is a brownish-yellow, relatively unfossiliferous shale. It ranges in thickness from 25 to 52 feet and is overlain by the basal sandstone of the Chanute formation.



Figure 16. Calcareous sandstone IPd-1 in the lower part of the Dewey formation, about 0.35 mile east of the SW cor. sec. 8, T. 13 N., R. 9 E. (Looking north).

Figure 17. Sandstone IPbd-1 at the base of Barnsdall formation at station 301 in sec. 34, T. 12 N., R. 8 E. (Looking northwest).

The Dewey formation can be clearly identified in the electric log of the B. C. Deardorf, Gentner No. 1 well in the SW¼SE¼ SE¼ sec. 19, T. 13 N., R. 8 E. In this well the base of the Dewey formation was picked at 650 feet and the top at 615 feet. The lower sandstone member is 4 feet thick and the overlying shale member is 34 feet thick.

*Paleontology*: The Dewey formation is very fossiliferous. The following 32 species were collected and identified:

FOSSILS COLLECTED AND IDENTIFIED

Anthozoa
- Lophophyllidium sp.
- Pleurodictyum eugeneae White

Conularida
- Paraconularia crustula (White)

Bryozoa
- Tabulipora carbonaria (Worthen)
- Rhombopora lepidodendroides Meek

Brachiopoda
- Lindstroemella patula Girty
- Lingula carbonaria Shumard
- Trigonoglossa nebrascensis (Meek)
- Chonetes granulifer Owen
- Chonetinella flemingi (Norwood and Pratten)
- Chonetinella flemingi plebeia (Dunbar and Condra)
- Chonetinella verneuiliana (Norwood and Pratten)
- Composita subtilita (Hall)
- Condrathyris perplexa (McChesney)
- Derbyia crassa (Meek and Hayden)
- "Dictyoclostus" americanus (Dunbar and Condra)
- Juresania nebrascensis (Owen)
- Linoproductus pertenuis (Meek)
- Marginifera lasallensis (Worthen)
- Neospirifer cameratus (Morton)

Pelecypoda
- Allorisma terminale Hall
- Astartella concentrica Conrad
- Aviculopecten occidentalis (Shumard)
- Nucula anodontoides Meek
- Yoldia glabra Beede and Rogers

Gastropoda
- Glabrocingulum grayvillense (Norwood and Pratten)
- Trepospira depressa (Conrad)
- Worthenia tabulata (Conrad)

Nautiloidea
- Brachycycloceras normale Miller, Dunbar, and Condra
- Pseudorthoceras knoxense (McChesney)

Ammonoidea
- Euloxoceras greenei (Miller, Dunbar, and Condra)

Trilobita
- Griffithides parvulus Girty

*Age and Correlation*: The Dewey formation is of middle Missourian age.

In the neighboring states of the Midcontinent Region, the Dewey formation is approximately of the same age as the Drum formation of Iowa, Kansas, and Nebraska.

In Oklahoma, the Dewey formation is approximately the same age as the Anadarche limestone of the Hoxbar group of the Ardmore Basin of southern Oklahoma.

### Ochelata Group

#### Chanute Formation

*First Reference*: Haworth and Kirk,[101] 1894.

*Nomenclator*: Haworth and Kirk,[102] 1894.

*Type Locality*: Vicinity of Chanute, Kansas.

*Stratigraphic Position*: In the type area, the Chanute formation lies above the Corbin City limestone of the Dewey formation and below the Iola formation. There is a disconformity at the base of the Chanute formation. At some places, the Chanute formation rests on eroded beds of the Dewey formation. In other places, the Dewey formation is absent and the Chanute rests on the eroded beds of the upper Nellie Bly formation. The Chanute formation appears to be conformable with the overlying Iola formation.

In Okfuskee County, the Chanute formation lies conformably on the Dewey formation and is unconformably overlain by the Barnsdall formation. From Washington County, Oklahoma, southward to Okfuskee County,[103] the Barnsdall formation has cut out, in descending order, the Birch Creek limestone; an unnamed shale; the Torpedo sandstone; the Wann formation; and the Avant limestone, Muncie Creek shale, and Paola limestone members of the Iola formation.

*Original Description*: Haworth and Kirk[104] gave the following description of the Chanute formation:

[101] Haworth, Erasmus. and Kirk, Z. M., 1894. *Kansas University Quarterly*, vol. 2, No. 3, p. 109.
[102] Haworth, Erasmus. and Kirk, Z. M., 1894. *Kansas University Quarterly*, vol. 2, No. 3, p. 109.
[103] Oakes, Malcolm C., 1951. Personal Communication. (Mr. Oakes mapped "The Okesa" to northern Okfuskee County.)
[104] Haworth, Erasmus, and Kirk, Z. M., 1894. *Kansas University Quarterly*, Vol. 2, No. 3, p. 109.



> Above the Erie limestone, 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 possibly does not exceed 100 feet. It reaches its maximum thickness in the vicinity of Thayer, where it is estimated to be 150 feet thick. It extends from below Osage mission to above Chanute, 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.

*History of Usage*: R. C. Moore[105] has given the following discussion of the early usage of the term Chanute:

> 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 Drum limestone and the base of the Iola limestone. . . . application of Chanute in the restricted sense has come to be accepted generally.

In Oklahoma, Ohern[106] had included the rocks, which are now the Chanute formation, 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 limestones of his Copan member of the Wann formation (northern area).

[105] Moore, R. C., 1935. *Kansas Geological Survey, Bulletin* 22, p. 109.
[106] Ohern, D. W., 1910. *The State University of Oklahoma, Research Bulletin* 4.

*Distribution*: The Chanute formation has been mapped from Kansas to southern Okfuskee County. Mapping in Seminole County may show that the Chanute formation extends even farther south. Malcolm C. Oakes[107] mapped the Chanute formation as far south as the northern part of Okfuskee County. From this point, the writer mapped the formation southward to Seminole County.

In Okfuskee County, the base of the Chanute formation extends from the northern part of sec. 7, T. 13 N., R. 9 E. to the east-center of sec. 34, T. 12 N., R. 8 E. The average width of the outcrop is about three-fourths mile. The Chanute formation has a strike of N. 12° E. The direction of regional dip in Okfuskee County is N. 78° W. at about one degree.

*Thickness and Character*: The Chanute formation consists of a lower sandstone member (IPch-1 of map) and an overlying shale member (IPch-2 of map).

The lower member is light-brown to chocolate-brown sandstone which commonly weathers dark rust-brown. The base of this member lies about 37 to 46 feet above the base of the Dewey limestone. It ranges in thickness from 3 to 8 feet. Although the sandstone thickens toward the south, it also becomes more friable in that direction and as a result does not form as high escarpments as it does to the north. This member contains few fossils.

The upper member is a brownish-yellow, relatively unfossiliferous shale. It ranges in thickness from about 20 feet in the south to 50 feet in the north. This member is overlain unconformably by the basal sandstone of the Barnsdall formation, and its southward thinning is the result of pre-Barnsdall erosion.

*Paleontology*: The paucity of fossils in the Chanute formation is striking as compared with the prolific fauna of the underlying Dewey formation. Not a single animal species was found. A few *Calamites* were observed.

*Age and Correlation*: The Chanute formation is of upper Missourian age. In Oklahoma, the Chanute formation is the same age as the rocks between the Dewey and the Iola formations of northern Oklahoma. It is approximately the same age as the rocks between the Anadarche limestone and the Daube limestone of the Ardmore Basin in southern Oklahoma.

107 Oakes, M .C., 1951. Personal Communication.



### Barnsdall Formation

*First Reference*: Malcolm C. Oakes.

*Nomenclator*: Malcolm C. Oakes,[108] 1951.

*Type Locality*: At the town of Barnsdall in T. 24 N., R. 11 E., in Osage County, Oklahoma.

*Stratigraphic Position*: In the type area, the Barnsdall formation lies above the base of the Birch Creek limestone and below the base of the Bigheart sandstone member of the Tallant formation. In the type area, the Barnsdall formation lies unconformably on the Wann formation, below, and is overlain conformably by the Tallant formation above.

In Okfuskee County, the Barnsdall formation is conformable below the Tallant formation to a point as far south as sec. 28, T. 13 N., R. 8 E. South of this point, the Tallant formation is removed by erosion and the Barnsdall is unconformably overlain by the Vamoosa formation at the base of the Virgil series. The Barnsdall formation lies unconformably on the Chanute formation below. The beds above and below the base of the Barnsdall appear from the field work to be parallel, yet northward from the county Oakes has demonstrated truncation of all the Wann formation by the Barnsdall, and from his work it appears that the original thickness of beds truncated increases southward toward Okfuskee County.

*Original Description*: Malcolm C. Oakes[109] has given the following description of the Barnsdall formation.

> It was found expedient to set up a new geologic unit of formation rank to include the rocks that crop out between the base of the Birch Creek limestone of Bowen, below, and the base of the Bigheart sandstone member of the Tallant formation, above. The name Barnsdall formation is here applied to these rocks.

*History of Usage*: The term Barnsdall appears now to have the same meaning as the term Okesa[110] as originally defined by Clark.

108 Oakes, M. C., 1951. *Tulsa Geol. Soc., Digest*, vol. 19, p. 120.

109 Oakes, M. C., 1951. *Tulsa Geol. Soc., Digest*, vol. 19, p. 120.

*Distribution*: The Barnsdall formation extends from the Kansas-Oklahoma line southward through western Washington County, eastern Osage County, western Tulsa County, Creek County, and into Okfuskee County, where it is overlapped by the Vamoosa formation. Its southern limit in subsurface is not definitely known. If it is not truncated by the unconformity at the base of the Virgil series, it may extend to the northern flank of the Arbuckle Mountains.

Malcolm C. Oakes[111] had mapped the Barnsdall formation as far south as the northern part of Okfuskee County. From this point, the writer mapped the formation southward to Seminole County.

In Okfuskee County, the base of the Barnsdall formation extends from the northwestern part of sec. 1, T. 13 N., R. 8 E. to the central part of sec. 34, T. 12 N., R. 8 E. The top of the Barnsdall formation extends from the northwestern corner of sec. 2, T. 13 N., R. 8 E. to the southern part of sec. 7, T. 11 N., R. 8 E. The Barnsdall formation has a strike of N. 11° E. The direction of regional dip in Okfuskee County is N. 79° W. at about one degree. The average width of the outcrop is about two miles.

*Thickness and Character*: The Barnsdall formation consists of two sandstone and two shale members.

The lowermost member (IPbd-1 of map) is a unit that ranges from massive sandstone to thin sandstones containing thin shale partings. The deep-red color of this sandstone is in sharp contrast to the color of the sandstones of the underlying beds, which are normally light to dark brown. At many places, there are concretions and thin zones of pure hematite that are generally purple to black. This sandstone ranges in thickness from 5 to 20 feet, and is so friable that it does not form high escarpments. There are few fossils in this sandstone. (See Figure 17).

Overlying this sandstone is a deep-red to reddish-brown shale (IPbd-2 of map). At some places it contains thin ferruginous and calcareous concretions.

110 White, David and others, 1922. *United States Geological Survey, Bulletin* 686, p. 95.
111 Oakes, M. C., 1951. Personal Communication.



A thin pure-white sandstone unit (IPbd-3 of map) lies next above. It ranges in thickness from 4 to 10 feet. An excellent exposure may be seen in the roadcut at Station 289 about 0.2 mile east of the NW cor. sec. 11, T. 13 N., R. 8 E., where the sandstone is 5 feet thick. This unit extends from the north-central part of sec. 2, T. 13 N,. R. 8 E. to the western part of sec. 34, T. 13 N., R. 8 E. where it is strike-overlapped by the basal beds of the Virgil series.

The uppermost member of the Barnsdall formation is a bright-red shale (IPbd-4 of map). Near the top, there are thin zones of pure-white shales. This shale ranges from 25 to 40 feet in thickness. It is overlain by the basal sandstone of the Tallant formation as far south as the eastern part of sec. 28, T. 13 N., R. 8 E., where it is strike-overlapped by the basal beds of the Virgil series.

The total thickness of the Barnsdall formation in the latitude of T. 12 N. is 80 feet. No accurate measurement could be obtained in the extreme northern part of the county.

*Paleontology*: Ecological conditions appear to have been unsuitable for the development of a prolific fauna. Fossils are extremely rare. A few crinoid stems were the only fossils observed in the entire Barnsdall formation.

*Age and Correlation*: The Barnsdall formation is of upper Missourian age. In Oklahoma, it is approximately equivalent to beds of middle Hoxbar age in the Ardmore Basin of southern Oklahoma.

### Tallant Formation

*First Reference*: Malcolm C. Oakes.

*Nomenclator*: Malcolm C. Oakes,[112] 1951.

*Type Locality*: At the town of Tallant, in the southeast corner of sec. 35, T. 25 N., R. 10 E., Osage County, Oklahoma.

*Stratigraphic Position*: In the type area, the Tallant formation is conformably underlain by the Barnsdall formation and unconformably overlain by basal Virgil rocks. In Osage County, the Tallant formation is overlain by the Cheshewalla sandstone—the basal member of the Vamoosa formation.

112 Oakes, M. C., 1951. *Tulsa Geol. Soc., Digest*, vol. 19, p. 121.

In Okfuskee County, the Tallant formation overlies the Barnsdall formation conformably. It is strike-overlapped by the basal beds of the Virgil series—the Boley conglomerate member of the Vamoosa formation.

*Original Description*: Malcolm C. Oakes[113] has given the following description of the Tallant formation.

> The base of the Virgil series lies at the base of the Tonganoxie sandstone in southern Kansas, and it was formerly thought to be marked by the base of the Bigheart sandstone in northern Oklahoma and by the base of conglomeratic sandstone beds in the Vamoosa formation in the area north of the Arbuckle Mountains. The author . . . . found that the Tonganoxie-Cheshewalla sandstone of northern Osage County, Oklahoma is equivalent to the Cheshewalla sandstone of the type locality, in the vicinity of Tallant, Osage County; and the lowermost conglomeratic sandstone beds of the Vamoosa formation mentioned above. Thus these beds mark the base of the Virgil series in Oklahoma north of the Arbuckle Mountains. The sandstone units between the base of the Bigheart sandstone and the Virgil-Missouri contact are thin and lenticular in northern Osage County and are represented by the sandstone lenses in the upper Missourian Weston shale in southern Kansas.
>
> It was found expedient to set up a new geologic unit of formation rank to include the rocks that crop out between the base of the Bigheart sandstone, below, and the Missouri-Virgil boundary, above. The name Tallant formation is here applied to these rocks.

*History of Usage*: Rocks that are now included in the Tallant formation were originally included in the basal beds of the Nelagoney formation by Ohern.[114]

*Distribution*: The Tallant formation extends, in a strip only a few miles wide, from the Kansas-Oklahoma line southward across eastern Osage County, southeastern Pawnee County, Creek County, and into Okfuskee County. Malcolm C. Oakes[115] has mapped the Tallant formation as far south as the northern part of Okfuskee County. From this point, the writer mapped the formation southward to sec. 28, T. 13 N., R. 8 E. where the Tallant formation is strike-overlapped by the Vamoosa formation of the Virgil series.

113 Oakes, M. C., 1952. *Oklahoma Geol. Survey, Bulletin* 69, p. 92-93.
114 Ohern, D. W., (In an unpublished manuscript.)
115 Oakes, M. C., 1951. Personal Communication.



In Okfuskee County, the Tallant formation has an average outcrop width of about one-half mile. The formation has a strike of N. 11° E. The direction of regional dip in Okfuskee County is N. 79° W. at about one degree.

*Thickness and Character*: The Tallant formation consists of a basal sandstone (IPtl-1 of map), probably the equivalent of the Bigheart sandstone of northern Oklahoma, and an upper shale member (IPtl-2 of map).

The basal sandstone member is a massive red to brownish-red sandstone. It is friable and does not form high escarpments. No accurate measurement of this sandstone could be obtained in the northern part of the county, but its thickness is estimated at about 25 feet. No fossils were observed in this sandstone.

The unnamed shale member (IPtl-2 of map) is red except for thin zones of white shale near the base that occasionally contain concretions. The entire thickness of this shale is not known as it is already partly overlapped at the northern boundary of the county. This shale is entirely strike-overlapped by the Boley conglomerate member of the Vamoosa formation in the northeastern part of sec. 28, T. 13 N., R. 8 E.

*Paleontology*: No fossils of any kind were observed in the Tallant formation.

*Age and Correlation*: In Oklahoma, the Tallant formation is approximately of the same age as the upper beds of the Hoxbar group of the Ardmore Basin in southern Oklahoma.

## Virgil Series

Only the lower part of the Virgil series, comprising the Vamoosa, "Pawhuska," and Ada and Vanoss formations, is exposed in Okfuskee County. These beds have a total thickness of about 880 feet.

There is an unconformity at the base of the Virgil series. The criteria for the recognition of this unconformity have been previously discussed in detail. This unconformity is clearly displayed in the Electric Log Cross-Section (Plate II), which shows uppermost Missourian beds being strike-overlapped by the basal conglomerate of the Vamoosa formation. Whereas all Pennsylvanian formations in Okfuskee County become thinner toward the west, the section between the base of the Barnsdall formation and the base of the Vamoosa formation increases in subsurface toward the northwest at the rate of 120 feet in the 9 miles between wells 16 and 21 of the Electric Log Cross-Section. This increase of the section to the west is not due to thickening of beds, but to the addition of new beds stratigraphically higher than those beds which are visible on the surface at the Barnsdall-Vamoosa contact. These uppermost Missourian beds have been strike-overlapped in a southeastern direction by the Vamoosa formation at the rate of 13.3 feet per mile.

### Vamoosa Formation

*First Reference*: George D. Morgan,[116] 1923.

*Nomenclator*: George D. Morgan,[117] 1924.

*Type Locality*: About one-half mile east of the village of Vamoosa, Seminole County, Oklahoma. The formation is typically developed on the main road between Sasakwa and Konawa.

*Stratigraphic Position*: In the type area, the Vamoosa formation conformably overlies the Belle City limestone. It is overlapped by the overlying Ada formation so that only the lower shale and about 30 feet of the clastic portion of the formation are exposed near the town of Byng.

In Okfuskee County, the Vamoosa formation strike-overlaps the Tallant and Barnsdall formations. It is conformably overlain by the "Pawhuska" formation.

The discovery of an unconformity at the base of the lowermost conglomerate of the Vamoosa formation necessitates redefinition of the formation. Heretofore, the Vamoosa formation as originally defined by Morgan,[116] had at its base a dark shale which is about 30 feet thick. This shale rests on the Belle City formation. Morgan made no mention of an unconformity at either the base of this shale or at the base of the conglomerate which overlies this shale.

116 Morgan, G. D., 1923. *Oklahoma Geological Survey, Circular 12*, p. 15.
117 Morgan, G D., 1924. *Bureau of Geology, Bulletin* 2, p. 125.
118 Morgan, G. D., 1924. *Bureau of Geology, Bulletin* 2, p. 125.



The presence of an unconformity at the base of the lowermost Vamoosa conglomerate is manifest in the strike-overlapping relations of the conglomerate with the underlying beds. In Okfuskee County alone, the entire Tallant formation and the upper two units (IPbd-3 and -4) of the Barnsdall formation have been strike-overlapped by the lowermost conglomerate of the Vamoosa formation. This unconformity makes it possible to establish a natural boundary for the base of the Vamoosa formation and, therefore, also establishes a natural Missouri-Virgil series boundary. The writer therefore here redefines the Vamoosa formation (as used by Morgan) and restricts it, so that its lower boundary is extended upward to the unconformity at the base of the lowermost conglomerate (Boley conglomerate member) in the formation.

*Original Description*: George D. Morgan[119] gave the following description of the Vamoosa formation:

> In the Stonewall quadrangle the formation is exposed over an area of approximately 20 square miles. The lateral extent of its outcrop is similar to that of the underlying Belle City limestone. . .
>
> Where all of the formation is exposed the entire section has an average thickness of 260 feet. At the base is about 30 feet of dark shale that might easily be mapped as a separate formation. No collections were made from this member, but it is very probably fossiliferous. The main mass of the formation is above this shale and has a maximum thickness of about 230 feet. It consists in large part of chert conglomerates, of massive, coarse, red and brown sandstones, and red shales. The clastic material is finer near the top and the red coloration is there also less pronounced.
>
> The chert conglomerates of the Vamoosa formation closely resemble those of the Wewoka, Holdenville, Seminole, and Francis formations, but may be distinguished from somewhat similar beds in the Pontotoc terrane because of arkosic material contained in the latter. The Vamoosa formation contains a greater thickness of chert conglomerates than does any other formation of the area. It is probably to the beds of this formation that McCoy referred as 'the main horizon in a series of conglomerates.' The chert fragments which make up the conglomerates are mostly angular and range is size from a fraction of an inch to as much as three inches in length. The average length, however, is less than an inch.

119 Morgan, G. D., 1924. *Bureau of Geology, Bulletin* 2, p. 125.

Overlap of the Vamoosa formation, by the succeeding Ada formation, is progressive southward. For this reason only the lower shale and about 30 feet of the clastic portion of the formation are exposed near Byng.

No fossils were found nor is it highly probable that any are present in the clastic beds of the Vamoosa.

*History of Usage*: The name appears to have always been used in its present sense.

*Distribution*: The Vamoosa formation extends from the northern flanks of the Arbuckle Mountains in Pontotoc County through Seminole and Okfuskee Counties, and into Kansas.

In Okfuskee County, the base of the Vamoosa formation extends from the NE¼ sec. 5, T. 13 N., R. 8 E. to the SE¼ sec. 7, T. 11 N., R. 8 E. The top of the Vamoosa formation extends from the west-central part of sec. 6, T. 13 N., R. 7 E. to the eastern part of sec. 19, T. 11 N., R. 7 E. The average width of the outcrop is about 7 miles. The Vamoosa formation has a strike of N. 4° E. The direction of regional dip in Okfuskee County is N. 86° W. at about three-fourths of one degree.

*Thickness and Character*: The Vamoosa formation consists of a succession of conglomerates, sandstones, conglomeratic sandstones, and red shales. At the base lies a conglomerate, 50 to 60 feet thick, whose base can be clearly mapped across the county. The upper limits of this member are not always as definite and locally grade into sandstone lenses of the overlying undifferentiated beds, which appear to consist of a sequence of deltaic facies which are so erratic in distribution and thicknesses that the writer could not trace any of the individual sandstones for any great distance. This lowermost conglomerate of the Vamoosa formation is here named the Boley conglomerate member, after its type locality, the town of Boley, Oklahoma, which is situated on this member in sec. 20, T. 12 N., R. 8 E. There is an excellent exposure capping the promontory in the northeastern part of sec. 21, T. 12 N., R. 8 E.

The Boley conglomerate consists mostly of sub-angular to well-rounded white chert pebbles and cobbles, some of which are as large as 6 inches in diameter. (See Figures 18 and 19). The fragments become progressively smaller toward the top. Interspaced among



Figure 18. Boley conglomerate member of the Vamoosa formation at station 299 in sec. 34, T. 13 N., R. 8 E.

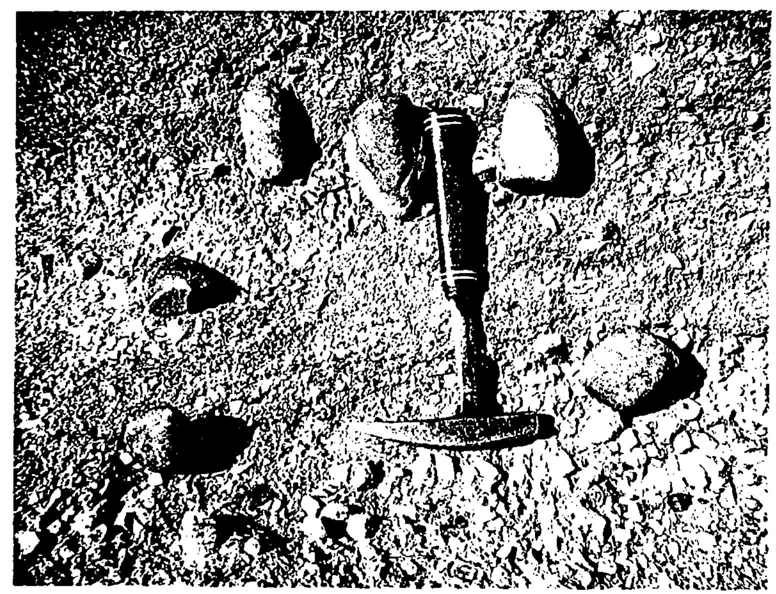

Figure 19. Boley conglomerate member of the Vamoosa formation at station 299, showing the size of some of the larger pebbles in the conglomerate.

these chert fragments are finer sands and pebbles of fossiliferous limestone that have been replaced by silica. Crinoid stems, fenestrate bryozoans, and other bryozoans that are in these pebbles are entirely replaced by silica. Many rock fragments are of chalcedony, quartz, or quartzite, the largest of which are about 6 inches in diameter. Rarer, but still present in significant numbers, are exotic pebbles such as silicified tectonic breccias and second and even third generation conglomerates. The origin of these pebbles in the Boley conglomerate member of the Vamoosa formation would form an intriguing study.

Lying above the Boley conglomerate member of the Vamoosa formation are about 600 feet of undifferentiated sandstones, conglomeratic sandstones, and red shales. These beds, as already mentioned, probably represent a deltaic facies. The beds are extremely erratic and could not be traced laterally for any great distance. The top of this undifferentiated zone is a massive conglomeratic sandstone. (See Figure 20). Its base appears to be a soft, friable sandstone which is nowhere exposed well enough to be studied. The top of this sandstone is more resistant and uniform. It can easily be traced across the entire county.

Overlying this sandstone is a red to brown shale. It is rather uniform in thickness and ranges from 12 to 16 feet across Okfuskee County. Owing to lack of reliable information and detailed mapping from both north and south, the actual position of this shale is questionable. More study is needed. The writer hereby tentatively considers this shale the uppermost member of the Vamoosa formation.

The Vamoosa formation ranges in thickness from 650 to 690 feet in Okfuskee County.

The Vamoosa formation may be identified in subsurface in the electric log of the H. Waggoner and Company, Miracle No. 1 well in the NE¼NE¼SW¼ sec. 30, T. 13 N., R. 7 E. (See well No. 21 in the Electric Log Cross-Section, Plate II). In this well, the base of the Vamoosa formation was picked at 730 feet.

*Paleontology*: The paucity of fossils in the Vamoosa formation is striking. Only a few *Calamites* and crinoid stems were observed.

*Age and Correlation*: The Vamoosa formation is of lowermost Virgilian age. In Oklahoma, the Vamoosa formation is approximately of the same age as beds immediately below the Zuckerman sandstone of the Hoxbar group of the Ardmore Basin in southern Oklahoma.

"Pawhuska" Formation

*First Reference*: Herbert C. Hoover, 1892.[120]

*Nomenclator*: J. P. Smith,[121] 1894.

*Type Locality*: Quarry 3 miles west of Pawhuska, Oklahoma.

*Stratigraphic Position*: In the type area, the Pawhuska formation is conformable with the Vamoosa formation below and with the Buck Creek formation above.

In Okfuskee County, the "Pawhuska" formation is conformable below with the Vamoosa formation and above with the Ada and Vanoss formations, undifferentiated.

*Original Description*: James Perrin Smith[122] gave the following original description of the Pawhuska[123] formation.

> In the eastern part of the Indian Territory are found large deposits of coal in the Upper Coal Measures, but further west the same horizon is represented by marine limestone. In 1892, Mr. H. C. Hoover, of the Geological Survey of Arkansas, found at the government lime-kiln, three miles northwest of Pawhuski, Oklahoma Territory, Osage Agency, a bed of massive limestone about 100 feet thick, lying horizontally on heavily bedded sandstones. The limestone is fossiliferous, but the sandstones are not.

*History of Usage*: The term Pawhuska has been used for a group of limestones and intervening shales, and for the limestone member (Lecompton) which is traceable farther south than the other members.

*Distribution*: The "Pawhuska" formation was known to extend from the Kansas-Oklahoma border to northern Okfuskee County. From this point, it was traced southward through Okfuskee County by the writer.

120 Smith, J. P., *Journal of Geology*, Vol. 2, p. 189.
121 Smith, J. P., *Journal of Geology*, Vol. 2, p. 189.
122 Smith, J. P., *Journal of Geology*, vol. 2, p. 189.
123 (Originally spelled "Pawhuski".)



Figure 20. View of the uppermost sandstone in the Vamoosa formation at station 235 in the southwestern part of sec. 19, T. 13 N., R. 7 E. (Looking east).

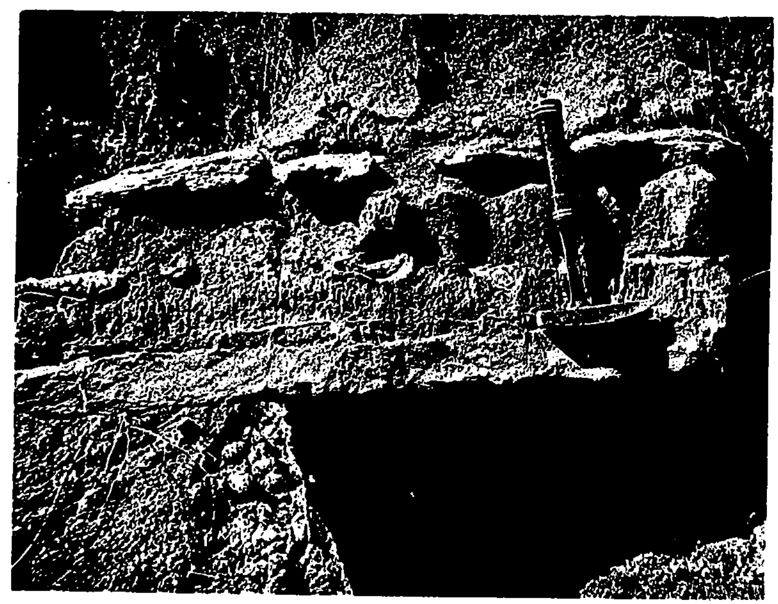

Figure 21. Lower dolomite bed of the "Pawhuska" formation showing vugs lined with calcite. Station 345 in the northwestern part of sec. 32, T. 12 N., R. 7 E. (Looking west).

The base of the "Pawhuska" formation in Okfuskee County extends from the west-central part of sec. 6, T. 13 N., R. 7 E. to sec. 19, T. 11 N., R. 7 E. The average outcrop width of the formation is only a few hundred feet, as the thin dolomite beds normally crop out under escarpments capped by resistant sandstones of the overlying formation. The rocks strike north and dip west at about three-fourths of one degree.

*Thickness and Character*: The "Pawhuska" formation in Okfuskee County consists of three members—a thin dolomitic limestone at the base, a thin middle shale, and a thin dolomitic limestone at the top.

The basal dolomitic limestone ranges in thickness from 8 inches at Station 334 in the south-central part of sec. 19, T. 13 N., R. 7 E., to 22 inches at Station 349 in the northwest part of sec. 20, T. 11 N., R. 7 E. This member is uniform and distinctive across the county except in the southernmost part, at Station 349, where it is soft, highly fossiliferous, dark brown, and carbonaceous. At Station 349 this unit is 11 feet above the highest sandstone of the Vamoosa formation. In normal lithology the basal dolomitic limestone consists of two distinct parts—a lower pink to red highly fossiliferous dolomite 3-5 inches thick, and an upper white to yellow limestone 5-12 inches thick. The more resistant dolomitic part on weathering forms distinctive lobate protuberances, whereas the upper white limestone is less resistant and is weathered into a niche.

The middle member of the "Pawhuska" formation is a thin shale which is gray to greenish brown. It ranges in thickness from 3 to 7 feet.

Overlying this shale is the uppermost member of the "Pawhuska" formation—a reddish-pink dolomitic limestone which appears to crumble when weathered. It is extremely uniform in thickness, being only 12 to 15 inches across the entire county. (See Figure 22). At places, it is very fossiliferous. There is an excellent exposure of the "Pawhuska" formation at Station 338 in the east-central part of sec. 30, T. 13 N., R. 7 E. The thickness of the "Pawhuska" formation in Okfuskee County ranges from 5 to 10 feet.

*Paleontology*: The "Pawhuska" formation contains a large quantity of crinoid remains. The only other fossils observed were a few large unidentified gastropods.

*Age and Correlation*: The Pawhuska formation is of middle Virgilian age. In Oklahoma, the Pawhuska formation is approximately the same age as Pennsylvanian beds above the Zuckerman sandstone in the Ardmore Basin of southern Oklahoma.

### Ada and Vanoss formations, undifferentiated

The Ada and Vanoss formations were differentiated and named by Morgan in the Stonewall quadrangle. Rocks at the same stratigraphic position in Okfuskee County have not been subdivided and are mapped as one unit.

*Distribution*: In Okfuskee County, the base of the Ada and Vanoss formations extends from the west-central part of sec. 6, T. 13 N., R. 7 E. to the SE¼ sec. 19, T. 11 N., R. 7 E. In the county this outcrop belt is about 2 miles wide. The formations have a north strike and a west regional dip of about three-fourths of one degree.

*Thickness and Character*: Probably all the Ada formation and the lowermost part of the Vanoss formation crop out in Okfuskee County. As mapped, this unit is about 125-200 feet thick and consists almost entirely of brown to reddish-brown shales and a few thin sandstones. None of these sandstones was traced across the entire county. Fossils are extremely scarce.

## Quaternary System

### Flood-plain Deposits

Most important of the post-Pennsylvanian strata in Okfuskee County are the flood-plain deposits. All the rivers and their larger tributaries in Okfuskee County deposit sediments in their valleys during times of flood. With the exception of the North Canadian and the Deep Fork Canadian Rivers, these streams collect their sediments from the soil of the region. Where laid down, these sediments are in the form of fine sands, clays, and silts—very similar to the bed-rock from which they have been derived. Toward its source, the North Canadian River flows across Permian



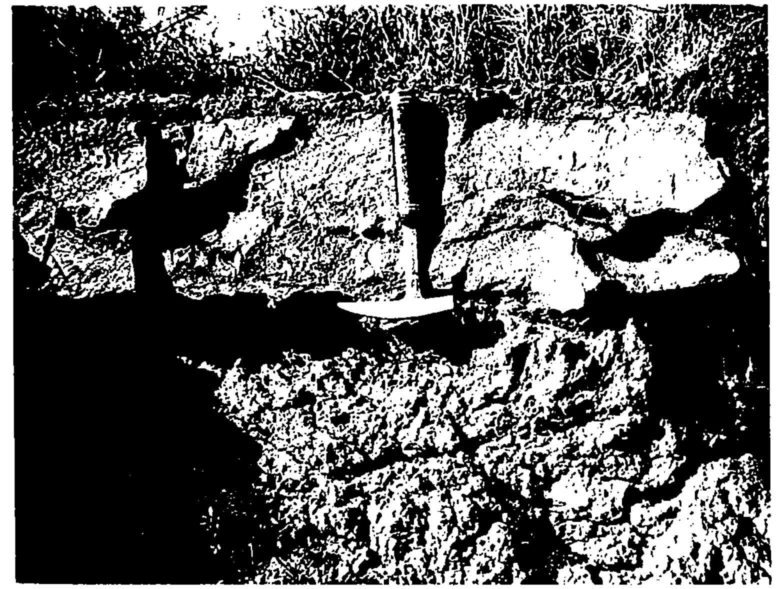

Figure 22. Upper dolomite bed of the "Pawhuska" formation at station 334 in the northeastern part of sec. 30, T. 13 N., R. 7 E. (Looking east).

Figure 23. Higher terrace deposits in the northeastern part of sec. 21, T. 11 N., R. 9 E. (Looking west).

and younger formations, from which it derives large quantities of fine sand. The amount of this sand brought down has been more than it could carry, and as a result, its channel has become choked at places.

In mapping the river alluvium, the writer observed at least two low-lying terrace levels along the North Canadian and the Deep Fork Canadian Rivers. These terraces were not differentiated but were mapped as river alluvium (Qal of map).

The exact age of these alluvial deposits is not known. It is, however, believed that the deposits of all the smaller streams as well as of most of the larger streams, and some, if not all, of the deposits of the North Canadian and the Deep Fork Canadian Rivers are probably of Recent age.

### Higher Terrace Sands

Situated near, and in places well above the lowermost alluvial flood-plain deposits (Qal of map) of the North Canadian and Deep Fork Canadian Rivers, are fine red to reddish-orange sands, silts, and clays (Qt of map). These deposits are remnants of older deposits which now occupy the terraces and slopes of abandoned channels of the present drainage. The deposits are soft and unconsolidated, and as a result, they are easily eroded. (See Figures 23, 24, and 25.) Generally these deposits border the alluvium of the river flood-plain deposits. At some places, as in T. 10 N., R. 12 E., these deposits (Qt of map) extend as far as 3 miles away from the present flood-plain deposits (Qal of map). Of special interest is the fact that these terraces are not always found at a definite elevation. In secs. 11, 12, 13 and 14, T. 10 N., R. 11 E., these higher terrace sands extend vertically from near the river level up to the top of the cuesta, which is capped by upper Calvin sandstone. The boundaries of these higher terrace deposits are very indefinite, because the unconsolidated sands give rise to eolian sands which are blown onto Pennsylvanian bedrock in the neighboring areas.

The age of the higher terrace deposits (Qt of map) is not definitely known. They are, however, older than the alluvial flood-plain deposits (Qal of map) and therefore probably are Recent and late Pleistocene in age.

### Residual High Level Gravels

In Okfuskee County there are scattered high-level gravels that cap even the highest hills. Remnants of these gravels are also found at various elevations, even down to some of the present stream valleys. They are patchy, thin, and widely scattered over the hilltops, and nowhere were they found in thick concentrated deposits. This, and the fact that they are found at various elevations, appears to indicate that these gravels are not in place, but are of a residual nature. These high level gravels are too thinly spread over the surface to be mapped.

An excellent place to observe the gravels is on the hilltop in the SE¼ sec. 5, T. 12 N., R. 9 E. They consist of coarse, hard, and in many instances well-rounded pebbles and cobbles 1 to 5 inches in diameter. They are chiefly quartz and quartzites, although some igneous rocks were observed.

The age of these high level gravels in problematic. They are, however, older than either the flood-plain deposits (Qal of map) or the terrace sands (Qt of map). They appear to be Pleistocene or even Tertiary in age.

### Eolian Sand Deposits

Eolian sand deposits are found in Okfuskee County, generally in close proximity to the alluvial flood-plain deposits (Qal of map). They are also developed on the terrace sands (Qt of map), both of which are soft and unconsolidated, and therefore are an excellent source for wind-blown sands. Typical dune sands derived from alluvial flood-plain deposits (Qal of map) may be observed just southwest of the Dustin river bridge over the North Canadian River in the east-central part of sec. 28, T. 10 N., R. 12 E. Many of these dunes are 6 feet high. Typical dune sand derived from higher terrace sands may be observed in sec. 29, T. 11 N., R. 9 E.

Eolian sands that have been derived from bedrock and deposited on bedrock occur to a lesser extent. Such sands and sand dunes may be seen on the Seminole formation in the western part of sec. 14, T. 12 N., R. 10 E.

The presence of eolian sands in the vicinity of alluvial flood-plain and terrace sand deposits (Qal and Qt of map), causes great difficulty in the precise mapping of these deposits because wind-blown sands mask the boundaries of these deposits.

## SUBSURFACE GEOLOGY

In order to amplify and expand the concepts of stratigraphy gained from surface mapping and study, an investigation was made of the corresponding formations in the subsurface of Okmulgee County, chiefly through the use of electric logs of wells drilled for oil and gas.

Several hundred wells have been drilled in the county, and well casing conditions are optimum for obtaining electric logs almost to the surface, as the casings are ordinarily set no lower than 50 to 200 feet. With electric log recordings almost to the surface, it is necessary to go only a short distance down dip from the outcrop to the well, to encounter the formation in the electric log. With beds dipping only 1 degree, as they do in most of Okfuskee County, one need never go more than three miles down dip from the outcrop to encounter the formation in subsurface as recorded by the elcetric log in wells with even the deepest casing.

After considerable electric log study, the writer has found the beds in Okfuskee County to be so uniform in thickness that the thickness as measured in electric logs one to three miles down dip from the outcrop is probably of greater accuracy than thickness measurements by hand-level and aneroid along the outcrop. In furthering this study the writer made a subsurface structural map on the top of the upper Calvin sandstone member (IPcv-3 of map). This horizon was selected because it was clearly visible on all electric logs and because it was the oldest formation cropping out in Okfuskee County that had been mapped in detail.

Upon completion of a structural subsurface map made on the top of the Calvin formation, the direction and true dip of the Calvin were determined. An arbitrary line was then drawn in the direction of the true regional dip of the Calvin formation in Okfuskee County. Later Riley's Catalogue of Electric Logs was consulted and the best wells that lay in close proximity of this line were selected. An attempt was made to space the wells as closely as possible so that chances of miscorrelation would be minimized. Wells were plotted in relation to their position with the line of section. In adjusting the horizontal distance of the wells, all were shifted parallel to the strike of the beds so that the position of the wells for the cross-section was not adjusted to lay on the selected direction of dip. The electric logs were then plotted and correlated.

After the wells had been correlated, the top of the cross-section was placed along a line in the identical direction of the true dip of the top of the Calvin formation which had been placed on a surface map of the same scale. Small "tick marks" were then placed at the top of the cross-section where the direction of dip crossed the strike at the base of a mappable resistant unit. Later, the subsurface beds in the cross-section were projected upward to the surface where they intersected the "tick marks". This point was taken as the theoretical base of the unit forming an escarpment. A cross-section uniting surface and subsurface geology was thus constructed by using electric logs in conjunction with detailed surface mapping (Plate II).

### Stratigraphy

Analysis of the cross-section gave important information on (1) correlations of well-known subsurface horizons with surface formations, (2) stratigraphic thicknesses, (3) facies changes, and (4) unconformities. Each is briefly discussed below.

(1) The electric log cross-section shows that the following subsurface horizons in Okfuskee County are approximate equivalents of the following surface units.

a. the subsurface Hogshooter is the same as the surface Hogshooter (IPh-1 of map).

b. The subsurface Layton sand is the same as a sandstone in the Coffeyville formation of the surface (IPcf-2c of map).

c. The subsurface Checkerboard limestone is not the same as what has been mapped as the surface Checkerboard limestone (IPcb of map) in Okfuskee County. It is the same age as a sandy limestone in the Seminole formation of the surface (IPsl-1b of map).

d. The subsurface Cleveland sand appears to be equivalent to the basal sandstone of the Seminole formation of the surface (IPsl-1a of map).



e. The subsurface Oswego zone is of the same age as a calcareous sandstone in the middle of the Wetumka formation of the surface.

f. The subsurface Prue sand is equivalent to the upper Calvin sandstone of the surface (IPcv-3 of map).

g. The subsurface Verdigris limestone is of the same age as limestones in the middle shale unit of the Calvin formation of the surface (IPcv-2 of map).

h. The subsurface Skinner sand is equivalent to the lower sandstone of the Calvin formation of the surface (IPcv-1 of map).

(2) The following thicknesses of the Des Moines and Missouri series were determined from the electric log cross section:

The Des Moines series is 3,120 feet thick in well No. 8. Farther west, at well No. 21, it is 1,670 feet thick. This is a thinning of 1,450 feet in 22 miles or 65.9 feet per mile. The Missouri series is 1,410 feet thick in well No. 16. Farther west, at well No. 21, it is 1,400 feet thick. The Missouri series in well No. 21, however, contains younger beds in addition to the beds that are found in both wells No. 16 and 21. The actual rate of thinning is, therefore, more than it appears to be but cannot be definitely measured owing to the strike-overlap by the Virgil series. Table 3 shows thicknesses of the various formations.

(3) Facies changes may be clearly traced in the electric log cross-section. The following are of special interest:

a. The development of a thick sandy facies at the expense of the overlying shale may be seen above the Cromwell sandstone in wells No. 3, 4, and 5.

b. The abrupt change in the development of the Booch sand may be observed in well No. 3.

c. On the surface, the Wewoka formation contains 9 mappable sandstones. A facies change occurs to the west in subsurface so that in the western part of the county all the sands have changed to shale. This change from a sandstone to a shale facies in a westerly direction is typical of most of the surface formations of Okfuskee County.

TABLE 3

THICKNESS AS DETERMINED FROM ELECTRIC LOG CROSS-SECTION

| Stratigraphic Unit | Uncorrected Thickness in Feet (To obtain corrected thickness subtract 1.74 feet per hundred feet) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of well in cross-section (Plate II) | | | | | | | | | | |
| | 21 | 19 | 17 | 15 | 14 | 12 | 11 | 9 | 8 | 4 | 3 |
| Vamoosa formation | 680 | | | | | | | | | | |
| Virgil series | 735+ | | | | | | | | | | |
| Tallant formation | 275 | 270 | 175 | 100 | | | | | | | |
| Barnsdall formation | 42 | 60 | 85 | 215 | | | | | | | |
| Chanute formation | 100 | 85 | 90 | 80 | | | | | | | |
| Dewey formation | 50 | 50 | 55 | 60 | | | | | | | |
| Nellie Bly formation | 430 | 460 | 420 | 485 | 490 | | | | | | |
| Hogshooter formation | 18 | 20 | 15 | 10 | 10 | | | | | | |
| Coffeyville formation | 220 | 220 | 250 | 250 | 240 | 280 | | | | | |
| Checkerboard formation | 5 | 5 | 5 | 5 | 5 | 5 | | | | | |
| Seminole formation | 260 | 280 | 290 | 295 | 310 | 325 | 330 | | | | |
| Missouri series | 1,400 | 1,450 | 1,385 | | | 1,570 | Composite thickness near outcrop = | | | | |
| Holdenville formation | 150 | 150 | 155 | 190 | 200 | 210 | 225 | 210 | | | |
| Wewoka formation | 660 | 680 | 660 | 660 | 645 | 645 | 670 | 720 | 750 | | |
| Wetumka formation | 15 | 25 | 50 | 50 | 50 | 70 | 70 | 100 | 105 | 148 | |
| Calvin formation | 90 | 95 | 125 | 155 | 220 | 230 | 235 | 240 | 240 | 265 | 280 |
| Cabaniss and Krebs groups | 745 | 895 | 985 | 1,105 | 1,105 | 1,325 | 1,370 | 1,550 | 1,605 | 1,840 | 1,870 |
| Des Moines series | 1,660 | 1,845 | 1,975 | 2,160 | 2,220 | 2,480 | 2,570 | 2,820 | | | |



(4) Unconformities may be clearly identified in the electric log cross-section. In Okfuskee County at least 5 unconformities were observed. They are the unconformities at the base of (1) the Virgil series, (2) the Hartshorne formation, (3) the Atoka formation, (4) the Pennsylvanian system, and (5) the Woodford shale.

The unconformity at the base of the Virgil series is clearly indicated by the stratigraphic increase in a westerly direction of beds in the upper part of the Missouri series below the unconformity.

In Okfuskee County the unconformity at the base of the Hartshorne formation truncates both the unconformity at the base of the Atoka formation and the unconformity at the base of the Pennsylvanian system. The unconformity at the base of the Hartshorne cuts out 950 feet of section from well No. 1 to well No. 18. This is a distance of 35 miles or a truncation rate of 27.1 feet per mile.

The unconformity at the base of the Atoka formation truncates 460 feet of pre-Atoka beds between well No. 3 and well No. 20. This is a distance of 27 miles or a truncation rate of 17.0 feet per mile.

The unconformity at the base of the Pennsylvanian system along this line of section shows that there is truncation toward the east. The interval between the base of the Pennsylvanian and the unconformity at the base of the Woodford shale is 425 feet in well No. 21. In well No. 3 this interval is 360 feet. This shows a truncation toward the southeast at the rate of 2.1 feet per mile.

The unconformity at the base of the Woodford shale shows the Hunton formation thinning northwestward along the line of the cross-section.

## Structural Features

Regional Structure: The regional structure in Okfuskee County is a broad, gently dipping homocline. The beds have a regional strike ranging from north to N. 28° E. The beds dip westward at the rate of one-half to one degree.

Folds: Many types of surface structures may be found in Okfuskee County. These structures include all gradations from anticlinal domes to slight noses. The folds are generally small and may be detected only by plane table work. Their closure is generally measured only in tens of feet.

The East Mountain anticline is the only large anticline that may be clearly seen without the aid of plane table work. Its axis trends N. 7° E. and lies roughly along the east line of secs. 16, 9, and 4, T. 10 N., R. 12 E. It extends northward into T. 11 N., R. 12 E. It has an estimated closure of 100 to 125 feet.

Faults: There are many surface faults in Okfuskee County. These faults may be divided into two general groups: (1) those faults which have an orderly arrangement—the en echelon faults and (2) those faults whose axes have a random orientation.

En Echelon Faults: Most of the faults of Okfuskee County lie in belts whose alinements are roughly parallel to the strike of the formations. The strike of these belts ranges from almost due north to N. 28° E. Within these belts, the faults are arranged in an en echelon manner so that they trend in a northwest direction, striking N. 17° W. to N. 45° W. In many instances they make an angle of about 45° with the direction of the belt in which they lie. All these faults appear to be normal. There appears to be very little difference between the number of faults that have their downthrown side on the northeast and the number with their downthrown side on the southwest. Generally the faults are small, ranging in length from one to four miles and averaging 1.5 miles. The throw of these en echelon faults ranges from 10 to 150 feet, most of them being less than 40 feet. The throw appears to decrease downward, as very few of the faults can be detected in deeper subsurface work.

Faults with Random Orientation: Faults other than those that lie in the en echelon pattern are very rare in Okfuskee County. One such fault may be found in T. 12 N., R. 9 E. where it extends from the NE¼ sec. 20 to the NE¼ sec. 11. This fault trends N. 52° E. and is approximately three miles long.



Another northeast-trending fault may be found in the southwestern part of sec. 21, T. 10 N., R. 11 E. This fault has a throw of 10 to 20 feet. It trends N. 8° E. and is from 0.5 to 1 mile in length.

In the western part of sec. 28, T. 12 N., R. 11 E. another northeast-trending fault may be observed. This fault is only one-half to three-fourths mile in length. It trends N. 23° E.

Surface phenomena that accompany faulting may manifest themselves in shearing and veining of sandstone and limestone in the zone of faulting; slickensiding of sandstone and limestone beds where they have been cut by faults; buckling ledges into sharp ridges that follow the fault trace; and in the formation of abnormal dips that are probably due to slumping toward the fault plane which may take place on either or both sides of the fault.

# ECONOMIC GEOLOGY

## Water Resources

### Surface Waters

Aerial photographs made in 1943 show that Okfuskee County had over 650 bodies of standing surface water. Most of these were small ponds that were made by damming ephemeral watercourses. Only 12 of these were larger than 40 acres. The largest, Lake Cohee, in sec. 19, T. 10 N., R. 9 E., covers an area of about 110 acres. The North Canadian River, the Deep Fork Canadian River, and their major tributaries are sources of surface water which are available in all but periods of greatest drought.

### Subsurface Water

A systemic study of subsurface waters is beyond the scope of this paper. Generally, it is not difficult to secure small amounts of water from underground sources. Large wells have been reported from the alluvium of the North Canadian River, the Deep Fork Canadian River, and their major tributaries. There are many large wells in aquifers other than alluvial sands. This is especially true in the Calvin, Wewoka, Nellie Bly, and Vamoosa formations.

In 1936-37 the Works Progress Administration in conjunction with the Oklahoma Mineral Survey, made a water survey in various counties. Investigators were sent to each farm and a questionnaire was filled out. The data, which are not all that might be desired for a scientific underground water study, were assembled by untrained workers who depended on the opinions and memories of the tenants and owners. These data are in the files of the Oklahoma Geological Survey and may be consulted by those interested.

## Oil and Gas Resources

Okfuskee County is an important producer of oil and gas. Oil has been found in every township and as of June, 1951, at least 92 pools have been reported in the county. Most wells are shallow—the deepest being less than 5,000 feet deep. There are many pro-



ducing horizons in the county. Among these are the Cleveland, Prue, Skinner, Red Fork, Earlsboro, Bartlesville, Booch, Dutcher, Deaner, Gilcrease, Cromwell, Hunton, Misener, Wilcox, and Arbuckle. The Cromwell, Hunton, Wilcox, Gilcrease, and Booch are the biggest producers. Although production is on the decline, new pools are still being found. In the last few years there has been much exploration in the western part of the County. Although most surface structures have already been found, geophysical methods will no doubt reveal many new subsurface structures.

## Sand and Gravel

The alluvial zones of the North Canadian River, the Deep Fork Canadian River, and their major tributaries are adequate sources for sand. They also furnish some gravel. At some places, as in the southeastern part of sec. 3, T. 11 N., R. 10 E., the Seminole conglomerate is sufficiently unconsolidated so that it may be used as a source of gravel. Gravel pits may be found at many places along the outcrop of the Vamoosa formation. Its basal member, the Boley conglomerate, is the best source of gravel in the county. The pebbles are subangular to round. They are generally loosely cemented and are therefore easily worked.

## Shales and Clays

There is no clay-products industry in Okfuskee County. This, however, is probably due to factors other than the lack of suitable materials. Future investigation will probably reveal clays and shales suitable for making brick and tile.

## Limestone

Okfuskee County has numerous limestones. All, however, are thin, none normally being thicker than 7 feet. These limestones range from the arenaceous limestones of the Dewey formation to the dolomitic limestones of the Pawhuska formation. The following is a brief list of the limestones in the county.

1. A 2- to 3-foot ferruginous limestone in the Wewoka formation is exposed in the southwestern part of sec. 16, T. 11 N., R. 11 E. It appears to be of local extent.

2. A 1- to 2-foot arenaceous and ferruginous limestone in the Holdenville formation is best developed in sec. 35 and 36, T. 12 N., R. 11 E. and in secs. 1, 2, 11, and 12, T. 11 N., R. 11 E.

3. A thin 1- to 2-foot limestone in the Seminole formation (IPsl-3 of map) is well exposed in secs. 4, 9, 17, and 20, of T. 11 N., R. 10 E. This appears to be the subsurface Checkerboard limestone of western Okfuskee County.

4. The Checkerboard limestone is generally 3 to 5 feet thick. In its southern extremity it changes from a single massive limestone to thin limestone slabs interbedded with shales. It is 5 to 7 feet thick in the latitude of Okemah.

5. The Hogshooter limestone ranges from 3 to 5 feet in thickness. In places it becomes very sandy. Locally, at Station 185, it is conglomeratic and 20 feet thick. It is being quarried for road graveling material.

6. At many places there is a thin 1- to 2-foot limestone at the base of a bed in the Nellie Bly formation (IPnb-12 of map).

7. The Dewey limestone (IPd-1 of map) consists of a ferruginous to arenaceous limestone. It ranges in thickness from 2 to 4 feet.

8. There are several thin dolomitic limestones near the top of the Vamoosa formation. They are normally purple to reddish purple.

9. There are two thin 8- to 24-inch dolomitic limestones in the Pawhuska formation. They extend across the entire county.

### Building Stone

Okfuskee County has an adequate supply of building stone. Most of the building stone that is now being quarried is sandstone, little or no limestone having been quarried for this purpose. The Nellie Bly formation (IPnb-4 of map), in secs. 11, 12, 13, and 14, T. 10 N., R. 8 E. contains thin 6- to 14-inch beds of hard sandstones which are ideal for building stone. Sandstones of building stone quality are quite common throughout the county.



In the northern part of the county, the Hogshooter and the Checkerboard limestones are relatively thin—10 to 24 inches at places. These thinner limestones might be suitable for building stone.

Probably the best sources of building stone in the county are the two Pawhuska limestones. They range in thickness from 8 to 24 inches and fracture in such a way that they require a minimum of dressing for building stone. These limestones are not pure white but range from yellow to pink.

All known quarries are located on the Geologic Map of Okfuskee County. (see Plate I).

### Coal

No coal deposits of any size were found cropping out in Okfuskee County. Wells in the eastern part of the County show the presence of the Henryetta coal. Its exact western extent in the county is not known.

### Volcanic Ash

There are at least three volcanic ash deposits in Okfuskee County. All are associated with the higher terrace deposits. (Qt of map).

The largest of these deposits is in secs. 34 and 35, T. 11 N., R. 10 E. and in secs. 2 and 3, T. 10 N., R. 10 E. This deposit covers an estimated 80 to 100 acres. The ash is white. The individual shards are subangular. This deposit ranges in thickness up to 5.5 feet, and the red sandy-clay overburden ranges in thickness from 2 to 10 feet. This volcanic ash deposit is of suitable quality for commercial abrasives. (See Figure 24)

Another volcanic ash deposit is in the SE¼ sec. 19, and in the NE¼ sec. 30, T. 10 N., R. 10 E. At Station 167 only 6 feet of the volcanic ash deposit was exposed. Its entire thickness and extent are not known. The ash is similar to the deposit at Station 145 but is gray to brownish-pink in color. (See Figure 25)

There is a volcanic ash deposit of unknown thickness exposed in the roadcut about 0.2 mile west of the NE cor. sec. 28, T. 10 N., R. 9 E. The ash ranges in color from light brown to pinkish cream. The overburden consists of 5 to 7 feet of yellowish-brown clay.

## Miscellaneous

There is a cupriferous sandstone deposit in sec. 31, T. 12 N., R. 7 E. This deposit is believed to have been formed along a fault trace. Associated with the copper are minute traces of gold and silver. Neither the copper nor the gold or silver is present in economic quantities.

Of interest, but not of economic importance are the iron-bearing sands in the lower part of the Vamoosa formation. These sands are best developed in the northeastern part of sec. 20, T. 13 N., R. 8 E. Concretions of almost pure hematite are locally associated with these sands.



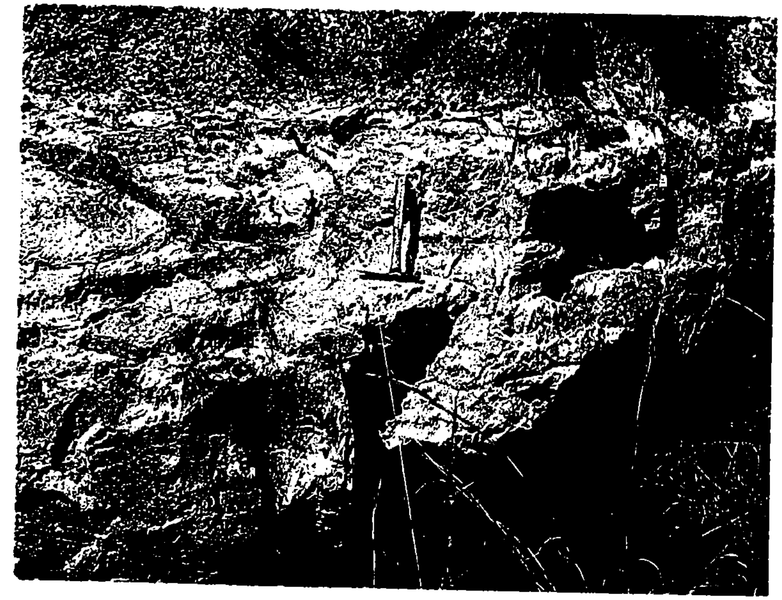

Figure 24. Volcanic ash bed in the higher terrace deposits at station 145 in sec. 34, T. 11 N., R. 10 E. (Looking northeast).

Figure 25. Volcanic ash bed in the higher terrace deposits at station 167 in sec. 19, T. 10 N., R. 10 E. (Looking north).

## GENERAL SUMMARY AND CONCLUSIONS

1. Shown on Geologic Map (Plate I) are 71 units of sandstones, shales, limestones, and conglomerates that have been mapped by the writer.

2. The unconformity at the base of the Missouri series in Okfuskee County is indicated principally by faunal evidence, no structural discordance being found during the course of the field mapping.

3. There is an unconformity at the base of the Barnsdall formation. In Washington County the Iola formation, Wann formation, Torpedo sandstone, and an unnamed shale lie between the top of the Chanute and the base of the Barnsdall formation. In Okfuskee County, the Barnsdall formation overlies the Chanute formation unconformably.

4. There is a definite unconformity at the base of the Virgil series. The Vamoosa formation strike-overlaps the upper beds of the Missouri series. The strike-overlapping relationship in Okfuskee County manifests itself in the over-lapping of the entire Tallant formation (IPtl-1 and -2 of map) and of the upper two members of the Barnsdall formation (IPbd-3 and -4 of map).

5. The deposits of volcanic ash are invariably associated with higher terrace deposits (Qt of map). They are probably of Quaternary age.

6. Study of the electric log cross-section indicates that the Pennsylvanian beds of Okfuskee County thin to the west. The cross-section also shows that the sandstones of the outcrop grade into shale westward in subsurface. The subsurface Checkerboard of the western Okfuskee County is not the Checkerboard of the surface, but is a limestone (IPsl-1b of map) in the Seminole formation.

7. Most of the Pennsylvanian fossils in Okfuskee County have long stratigraphic ranges. Only a few are limited to the stratigraphic range of a single series. *"Marginifera" muricatina, Mesolobus mesolobus*, and *Delocrinus granulosus* were found to be diag-

nostic Desmoinesian fossils. The presence of *Chonetinella* and *Triticites irregularis* indicates beds of Missourian age. No diagnostic Virgilian fossils were observed. Faunal evidence indicates paucity of life in post-Dewey time.

8. Most of the faults of Okfuskee County are of the en echelon type. They lie in belts that trend north to N. 28° E. These belts are roughly parallel to the strike of the formations. Within these belts, the faults are arranged in an en echelon manner so that they trend northwestward, from N. 17° W, to N. 45° W. In many places they make an angle of 45° with the direction of the belts in which they lie. All appear to be normal faults.

9. The drainage of the county, mapped by the writer, is shown on the Geologic Map.

10. Detailed drainage study in Okfuskee County showed that the watershed of the Deep Fork Canadian River is much larger than the watershed of the North Canadian River. In places the watershed of the Deep Fork Canadian River encroaches to within two miles of the North Canadian River. At the same longitude, in R. 8 E., the North Canadian River flows at an elevation of 800 feet while the Deep Fork Canadian River flows at an elevation of 700 feet. The results of this study seem to indicate that the Deep Fork Canadian River once played a much more important role than it does now.

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# APPENDIX

## REGISTER OF LOCALITIES

Station 6. Checkerboard limestone (IPcb-1 of map) exposed in the west ditch of the road about 0.4 mile south of the NE corner of sec. 10, T. 13 N., R. 10 E.

Station 8. Fossiliferous upper Seminole shale (IPsl-3 of map) exposed in the roadcut and just east of the road about 0.35 mile north of the SE corner of sec. 27, T. 13 N., R. 10 E.

Station 9. Checkerboard limestone (IPcb of map) and overlying beds of the Coffeyville formation exposed in the roadcut, near the top of the hill, about 0.2 mile north of SW corner of sec. 7, T. 11 N., R. 9 E.

Station 10. Checkerboard limestone (IPcb of map) and overlying Coffeyville sandstone (IPcf-2a of map) exposed in the west ditch of the road about 0.25 mile south of the NE corner of sec. 23, T. 11 N., R. 9 E.

Station 11. Checkerboard limestone (IPcb of map) and Coffeyville beds (IPcf-1 and 2a of map) exposed in the east ditch of the road about 0.4 mile north of the SW corner of sec. 13, T. 11 N., R. 9 E.

Station 12. Checkerboard limestone (IPcb of map) exposed in the north ditch of the road about 150 feet north of the Okemah High School Gymnasium. This is located about 0.5 mile north and 0.1 mile west of the SE corner of sec. 13, T. 11 N., R. 9 E.

Station 20. Lower Calvin sandstone (IPcv-1 of map) exposed in the roadcut just west of the creek about 0.25 mile east of the SW corner of sec. 5, T. 10 N., R. 12 E.

Station 21. Lower Calvin sandstone (IPcv-1 of map) exposed in the roadcut just north of the creek about 0.1 mile south of the NW corner of sec. 8, T. 10 N., R. 12 E.

Station 28. Lower Calvin sandstone (IPcv-1 of map) exposed in the creek, just east of the bridge 0.45 mile south of the NE corner of sec. 36, T. 11 N., R. 11 E.

Station 29. Upper part of Wetumka shale (IPwt of map) and the lowermost sandstone of the Wewoka (IPw-1 of map) exposed in the escarpment just west of the highway 0.15 mile south and 0.5 mile east of the NW corner of sec. 32, T. 10 N., R. 11 E.

Station 31. Upper Calvin Sandstone (IPcv-3 of map) exposed in the roadcut on the hill 0.05 mile north of the SE corner of sec. 32, T. 10 N., R. 11 E.

Station 32. Upper Calvin Sandstone (IPcv-3 of map) exposed in the creek, just west of the bridge, about 0.4 mile north of the SE corner of sec. 32, T. 10 N., R. 11 E.

Station 34. Wewoka (IPw-2 of map) exposed in the north ditch of the road about 0.05 mile west of the SE corner of sec. 5, T. 10 N., R. 11 E.

Station 35. Wewoka (IPw-1a of map) exposed in the creek bed just northwest of the bridge across Alabama Creek about 0.45 mile west of the SE corner of sec. 4, T. 10 N., R. 11 E.

Station 36. Wewoka (IPw-2 and -3 of map) exposed in an east-facing escarpment about 0.25 mile north and 0.35 mile east of the SW corner of sec. 27, T. 11 N., R. 11 E.

Station 38. Wewoka (IPw-4 and -5 of map) exposed in the roadcut about 0.1 mile north of the SW corner of sec. 16, T. 11 N., R. 11 E.

Station 39. Wewoka (IPw-4 and -5 of map) exposed in the east ditch of the road about 0.45 mile west and 0.05 mile north of the SE corner of sec. 30, T. 11 N., R. 11 E.

Station 40. Wewoka (IPw-4 and -5 of map) exposed in the roadcut, just south of the creek, about 0.15 mile south and 0.25 mile west of the NE corner of sec. 31, T. 11 N., R. 11 E.

Station 41. Wewoka (IPw-4 and -5 of map) exposed in the east ditch of the road, south of the creek about 0.15 mile west and 0.2 mile north of the SE corner of sec. 31, T. 11 N., R. 11 E.

Station 42. Wewoka (IPw-2, -3, -4 and -5 of map) exposed in an east-facing escarpment about 0.1 mile west of the NE corner of sec. 5, T. 10 N., R. 11 E.

Station 43. Wewoka (IPw-2 and -3 of map) exposed in the roadcut in the escarpment 0.35 mile west of the SE corner of sec. 5, T. 10 N., R. 11 E.

Station 44. Wewoka (IPw-5 of map) exposed in the east ditch of the road about 0.2 mile north of the SE corner of sec. 6, T. 10 N., R. 11 E.

Station 46. Wewoka (IPw-6 and -7 of map) exposed about 0.05 mile north and 0.3 mile west of the SE corner of sec. 1, T. 10 N., R. 10 E.

Station 48. Wewoka (IPw-3, -4, and -5 of map) exposed in the escarpment just north of the road about 0.3 mile east and 0.45 mile north of the SW corner of sec. 18, T. 10 N., R. 11 E.

Station 49. Wewoka (IPw-2, -3, -4, -5, -6, and -7 of map) exposed in the escarpment north of the road about 0.25 mile west and 0.4 mile north of the SE corner of sec. 13, T. 10 N., R. 10 E.

Station 50. Wewoka (IPw-1a of map) exposed in the roadcut in the escarpment 0.2 mile north of the SE corner of sec. 23, T. 11 N., R. 11 E.

Station 51. Wewoka (IPw-1a of map) exposed in the east ditch of the road 0.45 mile south of the NW corner of sec. 13, T. 11 N., R. 11 E.

Station 52. Wewoka (IPw-6 and -7 of map) exposed on the north side of the road about 0.25 mile south and 0.5 mile east of the NW corner of sec. 17, T. 11 N., R. 11 E.

Station 53. Wewoka (IPw-2, -3, -4, and -5 of map) exposed in the old roadcut about 0.2 mile south and 0.25 mile east of the NW corner of sec. 16, T. 11 N., R. 11 E.

Station 54. Wewoka (IPw-2 and -3 of map) exposed in road ditch about 0.05 mile east and 0.15 mile south of the NW corner of Sec. 22, T. 11 N., R. 11 E.

Station 55. Wewoka (IPw-2, -3, -4, and -5 of map) exposed in roadcut about 0.1 mile south and 0.5 mile west of the NE corner of sec. 16, T. 11 N., R. 11 E.

Station 56. Wewoka (IPw-2, -3, -4, and -5 of map) exposed along the old section-line about 0.15 mile east of the NW corner of sec. 15, T. 11 N., R. 11 E.

Station 57. Wewoka (IPw-2, -3, -4 and -5 of map) exposed in the roadcut about 0.35 mile south of the NW corner of sec. 11 T. 11 N., R. 11 E.

Station 58. Wewoka (IPw-6 and -7 of map) exposed in the roadcut about 0.45 mile south of the NE corner of sec. 3, T. 11 N., R. 11 E.

Station 61. Wewoka (IPw-8a and -8b of map) exposed in the roadcut about 0.05 mile south of the NW corner of sec. 26, T. 12 N., R. 11 E.

Station 62. Wewoka (IPw-8c and -8d of map) exposed in the roadcut about 0.15 mile south of the NW corner of sec. 23, T. 12 N., R. 11 E.

Station 64. Wewoka (IPw-6 and -7 of map) exposed in the roadcut about 0.5 mile north and 0.3 mile east of the SW corner of sec. 13, T. 12 N., R. 11 E.

Station 65. Wewoka (IPw-4 and -5 of map) exposed where the trail crosses the creek about 0.1 mile west and 0.2 mile south of the NE corner of sec. 13, T. 12 N., R. 11 E.

Station 70. Wewoka (IPw-8c and -9 of map) exposed in the roadcut 0.3 mile west and 0.5 mile south of the NE corner of sec. 32, T. 12 N., R. 11 E.

Station 71. Wewoka (IPw-8c and -9 of map) exposed in the roadcut 0.45 mile north of the SE corner of sec. 10, T. 12 N.. R. 11 E.

Station 72. Wewoka (IPw-8c and -9 of map) exposed in the roadcut about 0.25 mile west of the NE corner of sec. 15, T. 12 N., R. 11 E.

Station 74. Wewoka (IPw-8 and -9 of map) exposed in the roadcut about 0.05 mile south and 0.3 mile east of the NW corner of sec. 18, T. 11 N., R. 11 E.

Station 76. Fossiliferous lower Holdenville shale (IPhd-1a of map) exposed directly below a massive 12-foot sandstone which is exposed about 0.2 mile north of the SE corner of sec. 19, T. 12 N., R. 11 E.

Station 77. Fossiliferous Holdenville shale (IPhd-1c of map) exposed in the west ditch of the road about 0.1 mile north of the SE corner of sec. 18, T. 12 N., R. 11 E.

Station 79. Wewoka (IPw-5, -6, and -6a of map) exposed in the roadcut about 0.45 mile west of the SE corner of sec. 6, T. 10 N., R. 11 E.



Station 80. Wewoka (IPw-8 and -9 of map) exposed in the roadcut about 0.3 mile south of the NE corner of sec. 26, T. 11 N., R. 10 E.

Station 81. Wewoka (IPw-6 and -7 of map) exposed in the south ditch of the road about 0.45 mile west of the NE corner of sec. 11, T. 10 N., R. 10 E.

Station 84. Basal Seminole conglomerate (IPsl-1a of map) exposed in the roadcut about 0.5 mile north of the SE corner of sec. 3, T. 11 N., R. 10 E.

Station 85. Wewoka (IPw-9 of map) exposed in the roadcut about 0.2 mile west of the SE corner of sec. 27, T. 11 N., R. 10 E.

Station 87. Fossiliferous Holdenville shale (IPhd-1c of map) exposed directly below a massive 6-foot sandstone about 0.25 mile east of the NW corner of sec. 33, T. 11 N., R. 10 E.

Station 88. Fossiliferous lower Holdenville sandstone (IPhd-1b of map) exposed on the road about 0.1 mile north of the SE corner of sec. 32, T. 11 N., R. 10 E.

Station 92. Fossiliferous Holdenville shale (IPhd-1c of map) exposed directly below a massive 5.2-foot sandstone which is exposed about 0.45 mile west of the SE corner of sec. 2, T. 11 N., R. 10 E.

Station 93. Fossiliferous Holdenville sandstone (IPhd-1b of map) exposed in the south ditch of the road about 0.2 mile west of the NE corner of sec. 11, T. 11 N., R. 10 E.

Station 94. Fossiliferous Holdenville shale (IPhd-1a of map) exposed just west of the road about 0.2 mile south of the NE corner of sec. 11, T. 11 N., R. 10 E.

Station 95. Lower Holdenville shale (IPhd-1c of map) exposed in the roadcut about 0.3 mile east of the SW corner of sec. 1, T. 11 N., R. 10 E.

Station 96. Lower Holdenville sandstone (IPhd-1b of map) exposed in the roadcut about 0.3 mile south of the NW corner of sec. 1, T. 11 N., R. 11 E.

Station 97. Holdenville sandstone (IPhd-1b of map) exposed about 0.3 mile north of the SW corner of sec. 36, T. 12 N., R. 10 E.

Station 98. Holdenville sandstone (IPhd-1b of map) exposed about 50 feet south of the road about 0.35 mile east of the corner of sec. 1, T. 11 N., R. 10 E.

Station 99. Basal Seminole conglomerate (IPsl-1a of map) exposed in the roadcut about 0.2 mile south of the NE corner of sec. 3, T. 11 N., R. 10 E.

Station 104. Basal Seminole conglomerate (IPsl-1 of map) exposed on the north side of the road about 0.45 mile west of the SE corner of sec. 23, T. 12 N., R. 10 E. Fossils are found in the Holdenville shale directly below.

Station 110. Basal Seminole sandstone (IPsl-1a of map) exposed in the escarpment about 0.4 mile south of the NE corner of sec. 9, T. 11 N., R. 10 E.

Station 112. Fossiliferous Holdenville shale (IPhd-1b of map) exposed directly below a massive 5 foot sandstone about 0.25 mile west of the SE corner of sec. 16, T. 11 N., R. 10 E.

Station 113. Basal Seminole sandstone (IPsl-1a of map) exposed in the escarpment about 0.1 mile north and 0.45 mile east of the SW corner of sec. 20, T. 11 N., R. 10 E.

Station 114. Basal Seminole sandstone (IPsl-1a of map) exposed in the roadcut about 0.5 mile south of the NE corner of sec. 19, T. 11 N., R. 10 E.

Station 115. Basal Seminole sandstone (IPsl-1a of map) exposed in the east ditch of the road about 0.5 mile north of the SW corner of sec. 3, T. 11 N., R. 10 E.

Station 116. Seminole (IPsl-1c of map) exposed in the roadcut about 0.5 mile south of the NE corner of sec. 29, T. 11 N., R. 10 E.

Station 117. Checkerboard limestone (IPcb of map) and overlying Coffeyville beds (IPcf-1 and -2 of map) exposed in the roadcut about 0.25 mile east of the NW corner of sec. 7, T. 11 N., R. 10 E.

Station 118. Checkerboard limestone (IPcb of map) exposed in the east ditch of the roadcut near the top of the hill just south of the creek about 0.4 mile south of the NW corner of sec. 6, T. 11 N., R. 10 E.

Station 119. Coffeyville beds (IPcf-2b of map) exposed about 0.15 mile north and 0.05 mile west of the SE corner of sec. 36, T. 12 N., R. 9 E.

Station 120. Checkerboard (IPcb of map) and overlying Coffeyville beds (IPcf-1 and -2 of map) exposed in the roadcut about 0.3 mile west of the SE corner of sec. 30, T. 12 N., R. 10 E.

Station 121. Checkerboard limestone (IPcb of map) and overlying Coffeyville beds (IPcf-1 and 2 of map) exposed in the roadcut about 0.3 mile west of the SE corner of sec. 30, T. 12 N., R. 10 E.

Station 122. Checkerboard limestone (IPcb of map) capping the outlier 0.4 mile west of the SE corner of sec. 8, T. 12 N., R. 10. E.

Station 123. Coffeyville beds. (IPcf-2a, -2b, and 2c of map) exposed about 0.05 mile west of the SE corner of sec. 7, T. 12 N., R. 10 E .

Station 126. Coffeyville beds (IPcf-2a, -2b, and -2c of map) exposed in the roadcut about 0.35 mile north of the SW corner of sec. 8, T. 12 N., R. 10 E.

Station 129. Checkerboard limestone (IPcb of map) exposed in the north ditch of the road about 0.4 mile west of the SE corner of sec. 5, T. 12 N., R. 10 E.

Station 130. Checkerboard limestone (IPcb of map) and overlying Coffeyville beds (IPcf-1 and -2 of map) exposed in the north ditch of the road about 0.35 mile west of the SE corner of sec. 5, T. 12 N., R. 10 E.

Station 131. Checkerboard limestone (IPcb of map) and overlying Coffeyville beds (IPcf-1 and -2 of map) exposed in the roadcut about 0.15 mile north of the SE corner of sec. 5, T. 12 N., R. 10 E.

Station 132. Checkerboard limestone (IPcb of map) and overlying Coffeyville beds (IPcf-1 and -2 of map) exposed in the roadcut about 0.45 mile west of the SE corner of sec. 33, T. 13 N., R. 10 E.

Station 133. Fossiliferous upper Seminole shale (IPsl-3 of map) exposed in the roadcut and in the field directly south of the road and just west of the creek about 0.24 mile east of the NW corner of sec. 3, T. 12 N., R. 10 E.

Station 134. Checkerboard limestone (IPcb of map) and overlying Coffeyville beds (IPcf-1 and -2 of map) exposed in an old roadcut about 0.3 mile east of the SW corner of sec. 27, T. 13 N., R. 10 E.

Station 136. This is believed to be an outcrop of the Checkerboard limestone (IPcb of map) on the east or downthrown side of a large fault. It is possible that this could be IPsl-1b of map. This outcrop is exposed 0.2 mile west of the SE corner of sec. 27, T. 13 N., R. 10 E.

Station 138. Checkerboard limestone (IPcb of map) exposed in the creek bank where the two creeks join about 0.25 mile south and 0.35 mile east of the NW corner of sec. 22, T. 13 N., R. 10 E.

Station 139. Seminole (IPsl-1 of map) exposed in the roadcut about 0.1 mile west of the SE corner of sec. 13, T. 13 N., R. 10 E.

Station 141. Checkerboard limestone (IPcb of map) and overlying Coffeyville beds (IPcf-1 and -2 of map) exposed in the roadcut about 0.15 mile north of the SE corner of sec. 10, T. 13 N., R. 10 E.

Station 144. Basal Seminole sandstone (IPsl-1a of map) exposed just north of the road about 0.35 mile west of the SE corner of sec. 20, T. 11 N., R. 10 E.

Station 145. Volcanic ash in the higher terrace sands (Qt of map) exposed in the roadcut about 0.4 mile west of the SE corner of sec. 34, T. 11 N., R. 10 E.

Station 147. Fossiliferous Holdenville shale (IPhd-1c of map) is found directly below a 6-foot sandstone which is exposed in the roadcut 0.4 mile north of the SE corner of sec. 5, T. 10 N., R. 10 E.

Station 148. Fossiliferous Holdenville limestone (IPhd-1c of map) exposed in the roadcut about 0.15 mile south of the NW corner of sec. 4, T. 10 N., R. 10 E.

Station 149. Holdenville beds (IPhd-1a and -1b of map) exposed in an old roadcut about 0.3 mile east of the SW corner of sec. 33, T. 11 N., R. 10 E.

Station 151. Fossiliferous Holdenville sandstone (IPhd-1b of map) exposed in the roadcut about 0.4 mile north of the SE corner of sec. 32, T. 11 N., R. 10 E.

Station 153. Fossiliferous Holdenville shale (IPhd-3a of map) exposed in the east ditch of the road about 0.25 mile north of the SE corner of sec. 31, T. 11 N., R. 10 E.

Station 158. Fossiliferous Holdenville shale (IPhd-3a of map) is found below a 5-foot sandstone which is exposed about 0.35 mile east of the SW corner of sec. 6, T. 10 N., R. 10 E.

Station 161. Wewoka (IPw-3, -4, and -5 of map) exposed in the roadcut in the escarpment about 0.1 mile west of the SE corner of sec. 26, T. 10 N., R. 10 E.

Station 165. Wewoka (IPw-6 and -7 of map) exposed in the roadcut about 0.65 mile south and 0.15 mile west of the NE corner of sec. 33, T. 10 N., R. 10 E.



Station 167. Volcanic ash in the high terrace sands (Qt of map) exposed in the roadcut about 0.15 mile west of the SE corner of sec. 19, T. 10 N., R. 10 E.

Station 170. Basal Seminole sandstone (IPsl-1a of map) exposed in the roadcut about 0.3 mile south of the NE corner of sec. 36, T. 11 N., R. 9 E. Fossils are found in the brownish gray Holdenville shale directly below.

Station 171. Fossiliferous upper Holdenville shale (IPhd-3a of map) exposed in roadcut about 0.1 mile west of the SE corner of sec. 36, T. 11 N., R. 9 E. This was the most fossiliferous zone observed in Okfuskee County.

Station 175. Hogshooter (IPh of map) and Nellie Bly beds (IPnb-1 and -2 of map) exposed in the roadcut about 0.35 mile west of the NE corner of sec. 24, T. 12 N., R. 9 E.

Station 176. Coffeyville (IPcf-3 of map) and overlying Hogshooter beds (IPh of map) exposed in the roadcut about 0.1 mile south of the NE corner of sec. 14, T. 12 N., R. 9 E.

Station 179. Hogshooter (IPh of map) and Nellie Bly (IPnb-1 and -2 of map) exposed in the roadcut about 0.2 mile east of the SW corner of sec. 6, T. 12 N., R. 10 E.

Station 182. Hogshooter limestone (IPh of map) and overlying Nellie Bly beds (IPnb-1 and -2 of map) exposed about 0.45 mile north of the SW corner of sec. 19, T. 13 N., R. 10 E.

Station 184. Coffeyville bed (IPcf-3 of map) and overlying Hogshooter limestone (IPh of map) exposed just south of the road 0.15 mile east of the SW corner of sec. 17, T. 13 N., R. 10 E.

Station 185. Hogshooter limestone (IPh of map) and overlying Nellie Bly beds (IPnb-1 and -2 of map) exposed in the quarry about 0.35 mile north and 0.45 mile west of the SE corner of sec. 20, T. 13 N., R. 10 E.

Station 189. Hogshooter limestone (IPh of map) and overlying Nellie Bly beds (IPnb-1 and -2 of map) exposed in the roadcut about 0.3 mile north of the SE corner of sec. 22, T. 12 N., R. 9 E.

Station 190. Lower Calvin sandstone (IPcv-1 of map) exposed in the west ditch of the road about 0.35 mile east and 0.35 mile north of the SW corner of sec. 11, T. 10 N., R. 12 E.

Station 191. Senora limestone exposure at the foot of the hill, in the west ditch of the road, about 0.3 mile east and 0.3 mile north of the southwestern corner of sec. 11, T. 10 N., R. 12 E.

Station 194. Lower Calvin sandstone (IPcv-1 of map) exposed in the roadcut at the top of the escarpment 0.45 mile east of the SW corner of sec. 7, T. 10 N., R. 12 E.

Station 202. Fossiliferous Holdenville shale (IPhd-3a of map) exposed directly below a fossiliferous sandstone which crops out in the roadcut about 0.35 mile south of the NW corner of sec. 34, T. 10 N., R. 9 E.

Station 206. Fossiliferous upper Holdenville sandstone (IPhd-2 of map) exposed in the south ditch of the road about 0.35 mile west of the SE corner of sec. 33, T. 10 N., R. 9 E.

Station 207. Holdenville (IPhd-3b of map) exposed in the roadcut about 0.4 mile east of the SW corner of sec. 33, T. 10 N., R. 9 E.

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