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# GEOLOGY OF THE PEARSONIA AREA, OSAGE COUNTY, OKLAHOMA

A THESIS

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JAMES A. CARTER JR.

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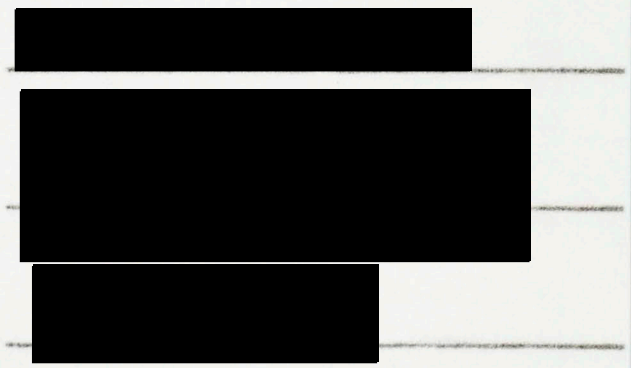
# THE GEOLOGY OF THE PEARSONIA AREA, OSAGE COUNTY, OKLAHOMA

A THESIS

APPROVED FOR THE SCHOOL OF GEOLOGY

BY



## ACKNOWLEDGMENTS

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The Oklahoma Geological Survey aided by financing the field work and by furnishing aerial photographs of the area. Mr. Malcolm C. Oakes, of the Oklahoma Geological Survey gave valuable instruction in the use of the photos.

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# OSAGE COUNTY, OKLAHOMA

## CHAPTER I

## INTRODUCTION

### Location and Description

The Pearsonia Area is located in north-central Osage County (see Fig. 1) in Tps. 27, 28, and 29 N., Rs. 8, 9, and 10 E. The northern boundary is the Kansas-Oklahoma State line and the eastern boundary is delineated by the outcrop of the Leavenworth limestone, which roughly parallels the eastern edge of R. 9 E.

Pearsonia, which is located in the southwest corner, includes a small school and a few near-by houses. Blackland, which also appears on maps of the area, is a railroad siding for shipping cattle from the surrounding countryside.

Only one county road crosses the entire area. Another runs parallel to and outside the eastern boundary, and both of these roads run north-south. No east-west roads are maintained across the area at the present time. State Highway 99 cuts across the extreme southeast corner and the only

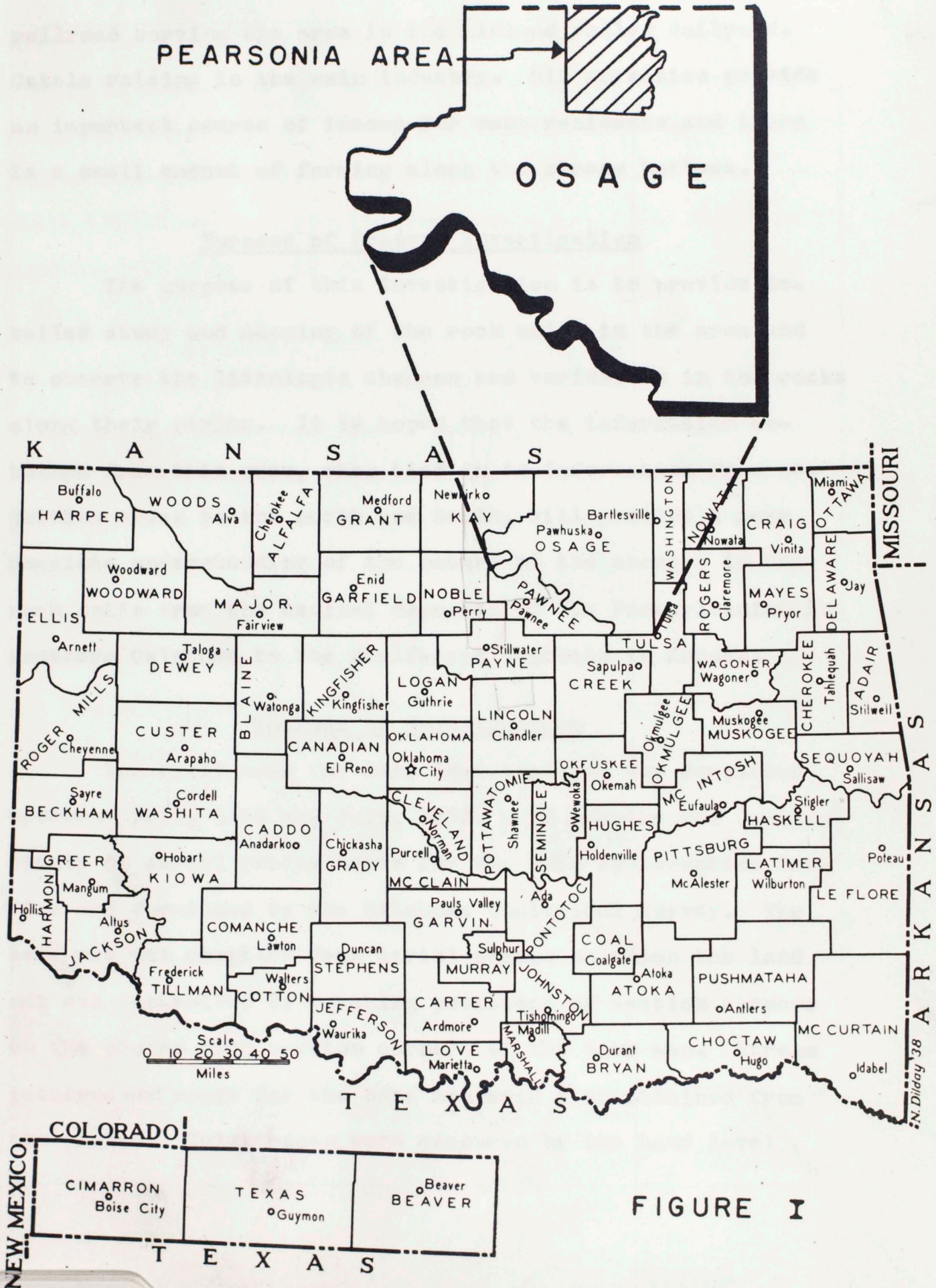
PEARSONIA AREA
OSAGE
KANSAS
MISSOURI
ARKANSAS
TEXAS
NEW MEXICO
COLORADO
HARPER
WOODS
Alva
ALFALFA
Cherokee
GRANT
Medford
KAY
Newkirko
Bartlesville
Pawhuska
OSAGE
WASHINGTON
NOWATA
CRAIG
Nowata
Vinita
OTTAWA
Miami
DELAWARE
Jay
MAYES
Pryor
ROGERS
Claremore
Tulsa
TULSA
WAGONER
Wagoner
CHEROKEE
Tahlequah
ADAIR
Stilwell
Muskogee
MUSKOGEE
OKMULGEE
SEQUOYAH
Sallisaw
MC INTOSH
Eufaula
Stigler
HASKELL
PITTSBURG
McAlester
LATIMER
Wilburton
Poteau
LE FLORE
Sapulpa
CREEK
Stillwater
PAYNE
PAWNEE
Pawnee
NOBLE
Perry
GARFIELD
Enid
MAJOR
Fairview
WOODWARD
Woodward
ELLIS
Arnett
DEWEY
Taloga
BLAINE
Watonga
KINGFISHER
Kingfisher
LOGAN
Guthrie
LINCOLN
Chandler
OKLAHOMA
Oklahoma City
CANADIAN
El Reno
ROGER MILLS
Cheyenne
CUSTER
Arapaho
BECKHAM
Sayre
WASHITA
Cordell
CADDO
Anadarko
Chickasha
GRADY
CLEVELAND
Norman
Purcell
POTTAWATOMIE
Shawnee
SEMINOLE
OKFUSKEE
Okemah
Wewoka
HUGHES
Holdenville
GREER
Hobart
KIOWA
Mangum
HARMON
Hollis
JACKSON
Altus
COMANCHE
Lawton
MC CLAIN
Pauls Valley
GARVIN
Ada
PONTOTOC
COAL
Coalgate
Sulphur
Duncan
STEPHENS
Frederick
TILLMAN
Walters
COTTON
MURRAY
JOHNSTON
Tishomingo
ATOKA
Atoka
PUSHMATAHA
Antlers
JEFFERSON
Waurika
CARTER
Ardmore
Madill
MARSHALL
LOVE
Marietta
Durant
BRYAN
CHOCTAW
Hugo
MC CURTAIN
Idabel
Scale
0 10 20 30 40 50
Miles
CIMARRON
Boise City
TEXAS
Guymon
Beaver
BEAVER
N. Dilday '38

FIGURE I

railroad serving the area is the Midland Valley Railroad. Cattle raising is the main industry. Oil royalties provide an important source of income for many residents and there is a small amount of farming along the stream bottoms.

## Purpose of Present Investigation

The purpose of this investigation is to provide detailed study and mapping of the rock units in the area and to observe the lithologic changes and variations in the rocks along their strike. It is hoped that the information obtained from this area, when tied in to information from adjoining areas to the north and south, will provide a more complete understanding of the nature of the changes in the rock units from the basinal deposits of the Pennsylvanian in southern Oklahoma to the shelf-type deposits in Kansas.

## Methods of Investigation

The field work for this investigation was completed between April, 1953 and July, 1953. The mapping was done entirely on aerial photos taken for the Soil Conservation Service and furnished by the Oklahoma Geological Survey. The base map was compiled from aerial photos on which the land net was controlled by matching positions of section corners on the photos with section corners of the base map. Stream patterns and roads for the base map were also obtained from the photos. Thicknesses were measured by the hand level

method and by the use of a six foot folding rule marked in tenths of feet. The accuracy of the rule was rarely fully realized, however, due to the type of exposures in the area. Formations were studied in the field with the use of a ten-power hand lens, and samples were taken of all of the formations that were to be studied more closely.

## History of Previous Investigations

Publications dealing specifically with the area were practically non-existent until Heald[1], in 1918, mapped the structures and described surface and sub-surface geology with its relation to oil possibilities. In 1922, Winchester[2], Bowen[3], and Heald[4] mapped areas that were partially covered by the work in this thesis. This was part of a large scale mapping project by the United States Geological Survey to map the Osage Indian Reservation and thus determine its oil possibilities. Beckwith[5], in 1928, combined information

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[1] K. C. Heald, "Geologic Structure of the Northwestern Part of the Pawhuska Quadrangle, Oklahoma," U. S. Geol. Survey Bull. 691-C, 1918.

[2] D. F. Winchester, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma," U. S. Geol. Survey Bull. 686-C, 1922.

[3] C. F. Bowen, Ibid., 686-F.

[4] K. C. Heald, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma," Ibid., 686-Q.

[5] H. T. Beckwith, "Geology of Osage County, Oklahoma," Oklahoma Geol. Survey Bull. 40-T, 1928.

obtained from the above work with information from various oil companies. Brown[6], Kitson[7], Kramer[8], and Millikan[9] have all published papers dealing with the local and regional structure of the region in which this thesis is a part. In 1940, Goodrich, Kennedy, and Leatherock[10] described the subsurface geology and oil and gas resources in the northeast part of this area and in the adjoining area.

The surface studies made by the United States Geological Survey were somewhat similar to the present study except that they were of a more general nature, were more limited by time, and were primarily concerned with structure.

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[6] R. W. Brown, "Origin of the Folds of Osage County, Oklahoma," Bull. Amer. Assoc. Petroleum Geologists, Vol. 12, 1928, pp. 501-513.

[7] H. W. Kitson, "Origin of the Folds of Osage County, Oklahoma," Bull. Amer. Assoc. Petroleum Geologists, Vol. 12, 1928, pp. 1026-1028.

[8] W. B. Kramer, "En Echelon Faults in Oklahoma," Bull. Amer. Assoc. Petroleum Geologists, Vol. 18, 1934, pp. 243-250.

[9] C. V. Millikan, "Inter-Relation of the Folds of Osage County, Oklahoma," Bull. Amer. Petroleum Geologists, Vol. 4, 1920, pp. 151-158.

[10] H. B. Goodrich, L. E. Kennedy, Otto Leatherock, "Subsurface Geology and Oil and Gas Resources of Osage, County, Oklahoma," U. S. Geol. Survey Bull. 900-F, 1940, pp. 209-236.

# CHAPTER II

## PHYSIOGRAPHY

The surface of the western two-thirds of this area is characterized by rolling, grass covered hills, while the eastern third presents a more rugged landscape with oak-covered hills. The maximum local relief in the area is approximately 200 feet. The highest elevation (1350') is along the northwestern side and the lowest elevations (750') are in the northeast and southeast corners. Buck, Pond, Sand, and North Bird Creeks, the major streams of the area, from north to south respectively, head at the base of the prominent escarpment formed by the Foraker limestone just outside the western boundary of the area. Sand Creek is a slight exception to this in that its head waters start in the south-central part of the area. Buck Creek and Pond Creek drain to the northeast whereas Sand Creek and North Bird Creek drain to the southeast. A loop of the Caney River cuts the extreme northeast corner of the area.

The gentle, westward dip of the rocks combined with the eastern slope of the surface produces several north-northeast trending cuestas with eastward facing escarpments.

Figure 2. Typical view of the topography in the western two-thirds of the area showing the low, rolling, grass covered hills.

These cuestas are capped by thick sandstones or limestones.

Different stages of erosion in relatively recent times are suggested by several different facts. These are: (1) the persistance of hilltops at the same elevation; (2) the remains of gravel beds at elevations 20 to 30 feet above the present stream beds; and (3) thick deposits of alluvium only recently dissected by streams.

Concordant summit levels are more noticeable in the region east and south where practically all of the hilltops are at an elevation of 1000 feet. The elevations of the hilltops increase as they approach the prominent escarpment formed by the Foraker limestone. This suggests that the escarpment was an obstacle to the ancient river system that peneplaned the region to the east.[11]

A few patches of gravel composed mostly of Foraker chert are present at a few localities. These are approximately 20 to 30 feet above the level of the present streams. Although chert is found in the gravel deposits within the stream beds, it is not as highly concentrated there as in the gravel beds at the higher elevations.

Thick deposits of alluvium occur in the lower parts of the valleys of Buck, Pond, and Sand Creeks. These deposits average 20 feet in thickness. The present streams

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[11] W. E. Ham, "Origin and Age of the Pawhuska Rock Plain of Oklahoma and Kansas," Unpublished Master of Science Thesis, University of Oklahoma, 1939, pp. 35-37.

and their lower tributaries have cut through this alluvium and now flow on bed rock. This cutting is recent, as the stream banks are practically vertical and show very little lateral erosion. This suggests recent rejuvenation in the area. Downcutting following this rejuvenation has exposed bed rock that otherwise would have been obscured.

The streams of the area flow generally to the east, while the beds dip, at most places, to the west. It is possible, at several localities, to start at the eastern edge of the area in a stream bed and follow the stream to its head at the base of the Foraker escarpment at the western edge of the area. This allows measurement of the complete section from the Leavenworth limestone to the Foraker limestone. The thicker limestones, such as the Deer Creek limestone, Little Hominy limestone, and the Lecompton limestone in the northern part of the area, are fairly well exposed. The thinner limestones, such as the Pearsonia, Turkey Run, Bird Creek, Wakarusa, and other thin named and un-named beds, are, at most places, covered by a soil mantle up to six feet thick on the hillsides and by alluvium up to 30 feet thick in the valleys.

Many shales and thin limestones had to be traced, at places by noticing the differences in the vegetation on them from that on the formations above and below. This was of particular help in finding faults and in tracing the Wakarusa, Bird Creek, Leavenworth, and Stonebreaker limestones.

# CHAPTER III

# STRATIGRAPHY

## General Statement

The stratigraphic sequence exposed in the Pearsonia Area consists almost entirely of Pennsylvanian units of Virgilian age. There is one small exposure of the lower part of the Foraker limestone on the north-western boundary of basal Permian age. The Leavenworth limestone which occurs along the eastern boundary, is the oldest unit which crops out.

## Pennsylvanian System

The Pennsylvanian units in this region are marginal in character and demonstrate the transition from the deposits of a stable foreland into the deposits of the geosyncline adjacent to the foreland. The hinge zone of the foreland in upper Pennsylvanian time appears to be in extreme southern Kansas and northern Oklahoma for it is in this area that the thin persistent limestones of Kansas, Missouri, Nebraska, and Iowa abruptly change facies into sands and shales towards southern Oklahoma. The different lithologic units of the

region are characteristic of deposition at shallow depths and it is quite common to observe alternations of marine and non-marine units in short vertical distances.

## Virgil Series

The Virgil series derived its name from the town of Virgil in eastern Greenwood County, Kansas. There, the Virgil is defined as the upper Pennsylvanian strata between the unconformity at the top of the Brownville, which also marks the top of the Pennsylvanian system, and the unconformity at the base of the Stranger formation. The Virgil series is represented, in Oklahoma, by beds from the base of the Vamoosa formation to the unconformity that is believed to be at the top of the Brownville.

The Virgil has been divided into three groups. These subdivisions are the Wabaunsee, Shawnee, and Douglas groups. The Wabaunsee and Shawnee groups are the only Pennsylvanian groups that crop out in the area and are distinguished by their differences in lithologic features.

## Shawnee Group

The Shawnee group, named for exposures in Shawnee County, Kansas, is defined as the beds from the base of the Oread limestone to the top of the Topeka limestone. In Oklahoma, this definition would include beds from the top of the Turkey Run limestone to the base of the Vamoosa formation. ???

The Shawnee group, in the Oklahoma classification, includes the Vamoosa formation and the Pawhuska formation. The Vamoosa formation contains the Oread limestone and Kanwaka shale in the upper part. The Pawhuska formation consists of the following named units in ascending order: Lecompton limestone, Plummer limestone, Deer Creek limestone, Little Hominy limestone, Pearsonia limestone (Red lime), and Turkey Run limestone.

The Shawnee is distinguished from the Wabaunsee group, in Kansas, by the presence of thick escarpment forming limestones arranged in cycles of cyclothems called megacycles. In Oklahoma, these cyclothems are not as distinct, due to facies changes and thickening of the units to the south; however, these thick escarpment-forming limestones are characteristic of the Shawnee in this area.

### Oread Limestone

The Oread limestone was named by Hayworth[12], in 1894, for exposures on Mount Oread, Lawrence, Kansas. The Oread there is 45 feet in thickness, and contains the following members in ascending order: Toronto limestone, Snyderville shale, Leavenworth limestone, Heebner shale, Plattsmouth limestone, Heumader shale, and Kereford limestone. The

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[12] Erasmus Hayworth, "A Geologic Section Along the A.T. and S.F.R.R. From Cherryvale to Lawrence, and From Ottawa to Holliday," Kan. Univ. Quart., Vol. 2, 1894, p. 123.

Leavenworth (Middle Oread), and Plattsmouth (Upper Oread) are the only limestone members of the Oread that are recognized in the Pearsonia Area.

Leavenworth Limestone Member

History of Nomenclature: The Leavenworth limestone was named by Condra, in 1927[13], for outcrops a short distance west of Leavenworth, Kansas.

Distribution: The Leavenworth is an extremely persistent thin limestone, and has been traced from central Iowa into northern Oklahoma. It is believed to be continuous throughout the Pearsonia Area with possibly the exception of a short distance in the southeast corner of section 25, T. 27 N., R. 9 E. A shaly limestone, 0.2 of a foot thick, occurs here at approximately the horizon of the Leavenworth but was not identified definitely. The thick sandstones of the Elgin, which occur directly above the Leavenworth, give rise to much sandstone float which covers it up. Practically all of the better exposures of this limestone are found at places where the overlying sandstones have been stripped off entirely, or are poorly developed.

Character and Thickness: The thickness of the Leavenworth, with the exception of the above mentioned instance, varies from one to two feet and has an average thickness of

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[13] G. E. Condra, "The Stratigraphy of the Pennsylvanian System in Nebraska," Neb. Geol. Survey Bull. 1, 2d Series, 1927, p. 38.

1.8 feet. At most places, the Leavenworth is a fine-grained, dense, brittle, blocky, dark gray-brown limestone which weathers to a grayish-yellow; however, both the lithology and fossil content of this unit vary along the strike at places. In the extreme northern end of the area, the top 0.3 of a foot consists of a coquinoid limestone composed of brachiopods and Triticites, whereas a few miles south of this exposure, this top zone is not found, but the lower half of the limestone is packed with Triticites. At several places, a pellet limestone comes in at the base and, at two exposures, makes up the entire Leavenworth. This facies appears to be of intraformational origin and is composed of small, light blue-gray limestone pellets of algal origin (Girvanella?) in a matrix of calcite and limonite which contains fine, subangular to sub-rounded sand grains. At a few places, the Leavenworth is so sandy and silty that it could be classified as a calcareous sandstone and, where weathered, resembles the sandstones above and below.

Correlations: The Leavenworth, commonly termed Middle Oread limestone by Oklahoma geologists, is the direct continuation of the Leavenworth limestone of Kansas and Iowa. It is placed in the lower Shawnee of Kansas and in the Vamoosa formation of Oklahoma.

Plattsmouth Limestone Member

History of Nomenclature: Keyes[14], in 1899, originally used the name Plattsmouth to indicate rocks, at the type locality, of about 30 feet in thickness. Condra[15], in 1927, restricted the name to apply only to the "upper Oread" and is used in this sense at the present. The type locality is near Plattsmouth, Nebraska.

Distribution and Thickness: The Plattsmouth, or as it is commonly called in Oklahoma, the Upper Oread, occurs only in the northern part of the area. Its northernmost exposure is in the center of sec. 15, T. 29 N., R. 9 E. where the line of crop crosses the Caney River. The Plattsmouth lies 40 feet above the Leavenworth here and is approximately 23 feet thick. One mile south of this exposure it is only 14 feet thick. From this point, it thins abruptly to the east, south, and west. In the SW 1/4 sec. 19, T. 29 N., R. 10 E., it is approximately 3 feet thick and lies 60 feet above the Leavenworth limestone. Here, it increases rapidly in thickness, to the east, and is closer in the section above the Leavenworth. In the SW 1/4 sec. 21, T. 29 N., R. 10 E., it is approximately 19 feet thick and lies 15 feet above the Leavenworth limestone. At this locality, the Plattsmouth

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[14] C. R. Keyes, "The Missourian Series of the Carboniferous," Am. Geologist, Vol. 23, 1899, p. 306.

[15] C. E. Condra, "The Stratigraphy of the Pennsylvanian System in Nebraska," Neb. Geol. Survey Bull. 1, 2d Series, 1927, p. 37.

forms a steep escarpment and caps the hills. At most places in the area, the Plattsmouth is covered up by slumping of slabs of the Elgin sandstone which occurs directly above it. The Plattsmouth is erratically higher and lower in the section for in sec. 36, T. 29 N., R. 9 E., it occurs 85 feet above the Leavenworth. Although exposures of the Plattsmouth were found as far south as the NE 1/4 sec. 23, T. 28 N., R. 9 E., it was not traced, as a continuous bed, past sec. 2, T. 28 N., R. 9 E., where it disappears in the sandstone and shale of the Kanwaka.

Character: The lithologic character of the Plattsmouth limestone varies more than any other unit in the Pearsonia area. In the extreme northern part of the area, it resembles the Deer Creek closely. At the Caney River exposure, the Plattsmouth consists of approximately 23 feet of moderately crystalline to finely crystalline, dense, gray, wavy bedded limestone with dark shale stringers coming in between the beds at the base. The exposures in T. 29 N., R. 10 E. become increasingly sandier towards the top and, many places near the upper part, there is a distinct calcareous sandstone which weathers to a bright brick-red. Corals are numerous in both individuals and species in the basal part of the limestone and many Meekella striatocostata with highly convex ventral valves occur here. At places where the Plattsmouth is only a few feet in thickness, it is characterized by being

Figure 3. Plattsmouth limestone exposure in road cut with the Elgin sandstone directly overlying it. SE 1/4 sec. 22, T. 29 N., R. 9 E.

Figure 4. Exposure of the Plattsmouth limestone in the SW 1/4 sec. 21, T. 29 N., R. 10 E.

packed with a slender Triticites about the size of a wheat grain. The southern-most exposure of the Plattsmouth consists of a sandy limestone packed with horn corals and Triticites.

Correlation: The Plattsmouth limestone, which is called the Upper Oread in Oklahoma, is a direct continuation of the Plattsmouth limestone of Nebraska. It is placed in the lower part of the Shawnee group of Kansas, and in the Vamoosa formation of Oklahoma.

## Kanwaka Shale

History of Nomenclature: The name Kanwaka was proposed by G. I. Adams in an unpublished manuscript. Beede[16], in 1902, used this name to refer to the shale that overlies the Oread limestone and underlies the Lecompton limestone. At the type locality, which is about 9 miles due west of Lawrence, Kansas, it consists entirely of shale that is sandy at the top. In extreme southern Kansas, and in northern Oklahoma, the Kanwaka is very sandy. Adams[17], in 1898, suggested that this sandstone in the Kanwaka be called the Elgin sandstone for its exposures near Elgin, Kansas.

Distribution: The sandstones of the Kanwaka form a

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[16] J. W. Beede, "Coal Measures Faunal Studies, II," Kan. Univ. Science Bull., Vol. I, 1902, p. 163.

[17] G. I. Adams, "Stratigraphy of the Kansas Coal Measures," Kan. Univ. Geol. Survey Bull., Vol. 3, 1898, p. 64.

continuous series of steep escarpments and benches throughout the Pearsonia area from north to south, and the east-west flowing streams of the area cause large salients of the sandstones to extend to the east. Although many large, sheer escarpments are formed by the individual sand and shale beds, at few places can a complete section of the Kanwaka be taken. In the southeast part of T. 28 N., R. 9 E., and the lower two-thirds of the eastern part of T. 27 N., R. 9 E., the Kanwaka underlies a broad belt from three to four miles wide. Fairly good exposures of the entire Kanwaka occur along the steep escarpment formed by the Caney River in the northern part of sec. 14, T. 29 N., R. 9 E., along the road in the western part of sec. 22, T. 29 N., R. 9 E., along a ranch road in the SE 1/4 sec. 15, T. 28 N., R. 9 E., and in the NW 1/4 sec. 12, T. 27 N., R. 9 E.

Character and Thickness: The Kanwaka shale is defined in Kansas as the beds between the top of the Kereford limestone or, where the Kereford is absent, the top of the Plattsmouth limestone member, and the base of the Lecompton limestone. This definition can be applied only in the northern part of this area where the Plattsmouth is present. Where the Plattsmouth is absent and the only remaining unit of the Oread is the Leavenworth, the Kanwaka is considered, in this thesis, to have its base at the top of the Leavenworth limestone. The interval between the base of the Lecompton and

the top of the Leavenworth along Caney River in the extreme northern end of the area, where the Plattsmouth member is present, is approximately 220 feet. This interval is larger than average, for the average interval between the base of the Lecompton and the top of the Leavenworth south of this exposure is about 175 feet. The exposure of the Kanwaka in the northern part of sec. 14, T. 29 N., R. 9 E. shows the presence of four thick, brown, medium grained, cross-bedded sandstones that have an average thickness of 20 feet each. These beds are separated by shale intervals of about the same thickness as the sandstones above and below them. The shales, which are, at most places, covered by slump from the sandstones above, consist of sandy, yellow-gray shales that grade, at places, into maroon shales. A thin, fossiliferous, buff limestone about 0.5 of a foot thick occurs here about 35 feet below the Lecompton limestone and between two sandstone beds. A limestone occurs at this horizon in sec. 5, T. 28 N., R. 9 E., in sec. 29, T. 27 N., R. 9 E., and at an exposure one mile north of Elgin, Kansas. It therefore appears that, at this horizon, there was a definite tendency towards limestone deposition. The four thick sandstone beds mentioned above appear to be either lenticular in nature or to occur erratically in the section, for one mile south of this exposure, a measured section showed only three beds. These beds are at different horizons and are of completely

different thicknesses than the four previously mentioned sandstone beds a mile to the north. Southward, along the strike, the sandstones in the Kanwaka appear to be concentrated in the center of the formation. A fairly persistent sandy shale unit which contains plant remains, and is 40 to 60 feet in thickness, is above the Leavenworth limestone throughout part of the area. Sandstone beds, from one to ten feet in thickness, are common in the shale immediately below the Lecompton limestone; however, in the southern part of the Pearsonia area, these beds increase abruptly in thickness and form a single bed 35 to 45 feet in thickness which lies approximately 30 feet below the Lecompton. At an exposure of the Kanwaka in the NW 1/4 sec. 12, T. 27 N., R. 9 E., a thick bed of sandstone approximately 70 feet thick occurs near the middle of the formation. The basal 15 feet consists of a thin-bedded sandstone divided at places by dark gray shale. The remaining sandstone above is tan, medium grained, cross-bedded, and friable at places. This upper part forms only a low, broad bench where the Lecompton, which is about 60 feet above, caps the hills.

Correlation: The Kanwaka shale forms the upper part of the Vamoosa formation and contains the Elgin sandstone member. The base of the Kanwaka is at a lower horizon in the Pearsonia area than in Kansas, as the upper limestone members of the Oread are not present except in the northern part of the area.

## Lecompton Limestone

The name Lecompton was first used by Bennett[18], in 1896, to apply to the three limestones which cap hills around Lecompton, Kansas. Condra[19], in 1927, includes four closely associated limestones, which, with the intervening shales, have a total thickness of 35 to 40 feet in the vicinity of Lecompton. This is the same as the present day description except that the Beil limestone was called the Cullom limestone. The above description includes all of the rock units that are underlain by the Kanwaka shale and overlain by the Tecumseh shale. The Lecompton, in Kansas, contains the following members, named in ascending order: Spring Branch limestone, Doniphan shale, Big Springs limestone, Queen Hill shale, Beil limestone, King Hill shale, and Avoca limestone. The only members of the Lecompton present in the Pearsonia area are the Beil limestone, King Hill shale, and Avoca limestone.

### Beil Limestone Member

History of Nomenclature: The name Beil was first

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[18] John Bennett, "A Geologic Section Along the Kansas River and Its Tributary, Mill Creek. From Kansas City to McFarland," Kan. Univ. Geol. Survey Bull., Vol. 1, 1896, p. 116.

[19] C. E. Condra, "The Stratigraphy of the Pennsylvanian System in Nebraska," Neb. Geol. Survey Bull. 1, 2d Series, 1927, p. 45.

used by Condra, in 1930[20], for its exposures on the Beil farm south of Rock Bluff, Nebraska.

Distribution: This limestone is fairly well exposed in the northern part of the area, where it has its greatest thickness. Where the overlying Deer Creek limestone has been stripped off, the Beil forms a prominent bench; however, where the Deer Creek is present directly above, the prominence of the bench or escarpment of the Beil is greatly reduced. Buck Creek, in the northern part of the area, provides many excellent exposures of this limestone. The approximate location of the Beil can generally be found by its position near the western edge of the Kanwaka sandstones which are commonly covered by scrub oak. Along the strike to the south, the Beil becomes thinner and changes into thin beds. At the southern end of the Pearsonia area, the only evidence of this limestone is its yellow slump blocks, as few exposures can be found here.

Character and Thickness: The Beil, although persistent, changes considerably in both facies and thickness from the northern boundary of the Pearsonia area to its southern edge. It is characterized by the presence of Caninia torquia, Syringopora multattenuata, and Triticites.

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[20] G. E. Condra, "Correlation of the Pennsylvanian Beds in the Platt and Jones Point Sections of Nebraska," Neb. Geol. Survey Bull. 3, 2d Series, 1930, p. 10.

In the southern and central parts of the area, different zones of the Bell weather to a bright yellow. In the northern part of the area, the Bell weathers to a light blue-gray. At places where the Bell is wavy bedded, it resembles the overlying Deer Creek and Little Hominy limestones closely. As a rule, however, the thicker exposures of the limestone are massively bedded and have a typically pitted surface. The Bell splits into two units south of T. 29 N. and, at places, has a third unit a few feet below the two upper units. The lower of the two previously mentioned beds thins faster, towards the south, than the upper one and attains a thickness of approximately 0.5 of a foot. It retains this thickness to practically the southern edge of the area where, possibly, it grades into a calcareous sandstone. Approximately three miles above the southern boundary of the area, the upper bed of the Bell is split by a thin sandy shale. A measured section of the Bell in the NW 1/4 sec. 29, T. 27 N., R. 9 E. shows, at the base, a thin, brown limestone which weathers yellow and contains numerous fusulinids and crinoid fragments. It is separated from an overlying limestone by five feet of grayish-yellow shale. This overlying limestone is divided into two beds by a thin shale stringer. The upper unit is a light blue-gray limestone which is splotched with yellow near the base, and contains a few scattered fusulinids. The lower unit is a brown limestone which weathers yellow and contains

many fusulinids and corals. These two units, which have a total thickness of 3.5 feet, are overlain by about four feet of maroon shale which has at the top a very thin, purple limestone full of fusulinids and crinoid fragments. A good exposure of the Beil, in the NE 1/4 sec. 36, T. 29 N., R. 8 E., shows a massive ten foot bed separated from an overlying two foot bed by approximately one foot of yellow-gray shale. Numerous corals occur at the base of the ten foot bed. The corals are less numerous upwards from the base, but fusulinids are more numerous. The upper part of this bed has few fossils and is slightly sandy. The entire bed weathers to a rough pitted surface. The two foot bed at the top is fossiliferous with the upper half containing numerous fusulinids and the lower half containing many fragments of fossils. It is possible that this bed, which is not found any farther to the south, is the southernmost extension of the Avoca limestone which is believed to be represented in the north-east part of T. 29 N., R. 9 E. Due to scarcity of exposures, however, this correlation could not be proven. The massive ten foot bed of the Beil at this locality appears to thin slightly towards the north, for a short distance north of Elgin, Kansas, it is only seven feet thick. A persistent maroon shale, from four to six feet thick, occurs above the Beil in the central and southern part of the area. It is possible that this correlates with the King Hill shale of Kansas and Nebraska.

Correlation: The Beil limestone is the direct continuation of the Beil limestone of Nebraska and Kansas, and is considered a member of the Lecompton formation. In Oklahoma, the Beil is called the Lecompton limestone and is placed at the base of the Pawhuska formation.

Avoca Limestone Member

History of Nomenclature: The Avoca was named by Condra[21], in 1927, for its exposures three miles east of Avoca, Otoe County, Nebraska.

Distribution: The Avoca occurs in the Pearsonia area in the northern half of T. 29 N., R. 9 E. A limestone one to two feet above the Beil in the southern part of the above township could not be identified as the Avoca definitely due to its unique lithology and lack of good exposures. The best exposure of the Avoca limestone in the Pearsonia area is in the NW 1/4 sec. 22, T. 29 N., R. 9 E. on the north side of the road. Approximately one mile north of Elgin, Kansas, this bed is eight feet above the Beil and has a thin, shaly, brown, pitted limestone four feet below it.

Character and Thickness: The only good exposure of the Avoca, in the NW 1/4 sec. 22, T. 29 N., R. 9 E., consists of a dull, dark-gray, dense, fossiliferous limestone

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[21] C. E. Condra, "The Stratigraphy of the Pennsylvanian System in Nebraska," Neb. Geol. Survey Bull. 1, 2d Series, 1927, p. 45.

that weathers to a grayish-yellow. Triticites, Caninia torquia, Amblysiphonella and fragments of fossils are present. No "cryptozoans" were found at this exposure, but a little farther north, "cryptozoans" are extremely abundant. The Avoca is about 0.8 of a foot thick at this exposure, and occurs four feet above the Beil.

Plummer Limestone

History of Nomenclature: The name Plummer was first used by Winchester[22], for exposures of the limestone northeast of the Plummer ranch house in sec. 8, T. 26 N., R. 9 E., Osage County, Oklahoma.

Distribution: The Plummer typically occurs at the base of the Deer Creek escarpment approximately 20 to 30 feet below the top. Its distinctive slump blocks can be found whenever its horizon is exposed. Good exposures of the Plummer can rarely be observed however, due to slumping of the Deer Creek directly above it. Its best exposures occur in stream beds. Exposures of this type are found in the NE 1/4 sec. 13, T. 27 N., R. 8 E., and the SE 1/4 sec. 26, T. 29 N., R. 8 E. At places along the southern edge of the area where the overlying Deer Creek has been stripped off by surface erosion, the Plummer forms a low, broad bench with the

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[22] D. E. Winchester, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma," U. S. Geol. Survey Bull. 686-C, 1922, p. 11.

Lecompton limestone and adjacent sandstones occurring at the base.

Character and Thickness: The Plummer limestone is one of the most persistent units in the area. Except for being slightly thicker in the northern part, its appearance is almost identical at the southern edge of the area and at the northern boundary on the Kansas-Oklahoma line. It is typically a thin, brittle, dense, dark gray, slightly fossiliferous, vertically-jointed limestone that weathers to a dirty yellow-gray. Its outcrop is characterized by the presence of large sharp-edged slabs with joint striations on the surface. Triticites occur at most exposures and, in the northern part of the area, "cryptozoans" occur in numbers. The thickness of the limestone varies from 0.8 of a foot in the southern part of the area to almost two feet in the northern part. The basal part of the shale interval separating the Plummer from the overlying Deer Creek consists of a dark-gray platy shale. The upper part is, at most places, a grayish-yellow to greenish-yellow, clayey shale. The interval between the Plummer and the Deer Creek varies from three to six feet throughout most of the area, but approximately three miles north of the southern edge of the area, this interval suddenly increases, and at the southern boundary is a little over ten feet in thickness. In the southern half of sec. 11, T. 26 T., R. 8 E., which is a mile and a half

south of the Pearsonia area, this interval is 16 feet. At this exposure, a thin, dense, dark gray limestone 0.5 of a foot thick which contains specimens of Crurithyris planoconvexa and Triticites occurs approximately six feet above the Plummer. It is possible that this unit correlates with the upper Plummer bed of Winchester's type locality.

A persistent calcareous sandstone was found from 8 to 12 feet below the Plummer throughout the entire Pearsonia area; however, at many places, both its composition and thickness vary greatly. The only characteristic feature that could be found in most of the exposures was its unusually weathered surface. This consists of a ragged, pitted surface caused by solution of the intermixed calcareous material. At places, the calcareous facies predominates and at other places the sandy facies predominates. The thickness of the bed varies from 1.5 to 6 feet, and the average thickness is two feet. In the northern part of the area, the bed is more calcareous and in sec. 26, T. 29 N., R. 8 E. consists of a shaly, lumpy, conglomeratic, gray limestone two feet thick which is approximately 12 feet below the Plummer.

Correlation: The Plummer limestone of the Pearsonia area is believed by the author to correlate directly with the basal limestone of Winchester's type section, which consists of two dark-gray limestones separated by 5 feet of shale. To the north, the Plummer is believed to be a direct

continuation of the Rock Bluff limestone of Kansas and Nebraska[23] as the description of the Rock Bluff fits exactly that of the Plummer in this area.

## Deer Creek Limestone

History of Nomenclature: The name Deer Creek was first used by Bennett[24], in 1896, for a system of three limestones and intervening shales on Deer Creek, in northeastern Shawnee County, Kansas. The Deer Creek formation in Kansas, contains the following members, named in ascending order: Ozawkie limestone, Oskaloosa shale, Rock Bluff limestone, Larsh-Mission Creek shale, and Ervine Creek limestone. In Oklahoma, the term Deer Creek is applied to the lower Ervine Creek limestone and this limestone is considered a member of the Pawhuska formation. This situation is due partially to a lack of detailed correlation between the Oklahoma and Kansas sections, partially to the absence of several of the Kansas Deer Creek members in northern Oklahoma, and partially to the precedence of the name Plummer over the Nebraska name Rock Bluff. For the sake of simplicity, the Oklahoma terminology of the Deer Creek interval will be used in this thesis.

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[23] R. C. Moore, "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas," State Geol. Survey of Kansas Bull. 22, 1935, p. 185.

[24] John Bennett, "A Geologic Section Along the Kansas River and Its Tributary, Mill Creek. From Kansas City to McFarland," Kan. Univ. Geol. Survey Bull., Vol. 1, 1896, p. 117.

Distribution: The Deer Creek forms a steep escarpment throughout the entire Pearsonia area and good exposures are common along its outcrop.

Character and Thickness: The thickness of the Deer Creek varies, but at few places is it thinner than 16 feet or thicker than 21 feet. Definite zones in the limestone can be seen in any single exposure but when traced any distance along the strike, develop characteristics found in some other zone of the unit. Typically, however, the Deer Creek has a soft, sandy, fossiliferous limestone at the top that is underlain by either a wavy bedded, light gray, dense limestone or a thick, platy, lithographic to finely crystalline, buff limestone which weathers to a pebbly surface. All three of the above types frequently occur at any single exposure of the Deer Creek, and at many places alternate several times. Fusulinids occur in zones which vary from place to place, but which are most frequent near the top of the wavy bedded limestone. Some exposures of the Deer Creek show numerous brachiopods, corals and "cryptozoans" at the base. Gastropods and pelecypods are numerous near the top and many are limonitic. The Deer Creek weathers to a slabby, light gray to off-white, rough, rust splotched surface. The base of the limestone is, at most places, covered by slump of higher beds and the top is frequently back a distance from the edge of the escarpment. A typical feature in the outcrops of the

Deer Creek and other thick, wavy bedded limestones in the area is the large scale rhombohedral jointing. This allows large, angular blocks to break off from the escarpment. At several places, complete sections of the Deer Creek occur upright 30 to 40 yards downslope from the outcrop.

Two thin limestones occur in the shale between the Deer Creek and the Little Hominy in the central and northern part of the Pearsonia area. Their presence was first noted in the NE 1/4 sec. 4, T. 27 N., R. 9 E. and were traced continuously to the northern edge of the area. The upper bed, which varies from 3 to 10 feet above the Deer Creek, closely resembles the Plummer limestone and contains numerous "cryptozoans" which have as their nucleus specimens of the sponge Amblysiphonella. This limestone was also identified a mile and a half south of Hewins, Kansas. The lower bed is separated from the underlying Deer Creek by a thin shale interval which thins to the north. This lower bed consists of a dense, dark, gray-brown, fossiliferous limestone which weathers to a light brown and contains numerous myalinas. It is possible that this limestone correlates with the upper Ervine Creek limestone of Kansas.

Correlation: The Deer Creek limestone, as conceived of in this thesis, correlates with the lower Ervine Creek limestone member of the Deer Creek formation of Kansas, and is the Deer Creek member of the Pawhuska formation in Oklahoma.

Figure 5. Exposure of the Deer Creek limestone in the south-central part of sec. 36, T. 27 N., R. 8 E.

Figure 6. Typical exposure of the Deer Creek limestone showing joint controlled slumping.

The possibility of the upper Ervine Creek limestone and the Ozawkie limestone being present cannot be determined until more definite information as to the geology of Chautauqua County, Kansas, which adjoins this area to the north, can be obtained. The other member of the Deer Creek, the Rock Bluff, is called the Plummer limestone and is discussed under that name.

## Little Hominy Limestone

History of Nomenclature: This limestone was named by Heald and Mather[25] for its outcrops on Little Hominy Creek in the southwestern part of T. 25 N., R. 8 E.

Distribution: The Little Hominy occurs throughout the Pearsonia area as a low bench just above the Deer Creek escarpment. In the northern part of the area, along Buck Creek, it forms a distinct escarpment that is similar to that of the Deer Creek. At some places where the interval between the Little Hominy and the Deer Creek is small, as the case is in the southeast part of T. 29 N., R. 8 E., the two limestones join in forming high bluffs. In the central part of the area, the Little Hominy forms two low benches just above the Deer Creek and in the southern part of the area, it forms one bench. A fairly good exposure of the Little Hominy

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[25] K. C. Heald, Kirtley F. Mather, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma," U. S. Geol. Survey Bull. 686-M, 1922, p. 152.

occurs in the road cut in the center of sec. 36, T. 27 N., R. 8 E.

Character and Thickness: The Little Hominy behavior is similar to that of the Bell limestone insofar as change in thickness along the strike is concerned. In sec. 36, T. 27 N., R. 8 E., the Little Hominy consists of a limestone six feet thick, underlain by a limestone two feet thick, ten feet below. Farther north in sec. 14, T. 27 N., R. 8 E., the interval between the upper and lower bed is six feet, and the upper bed, which is directly overlain by a thin sandstone, has thinned to approximately four feet. North of this exposure a mile, the upper bed is five feet thick and contains a thin shale bed about a foot from the top. This shale bed appears to thicken towards the north along with the overlying limestone, for in sec. 19, T. 28 N., R. 9 E. this upper thin limestone has increased in thickness to almost four feet, and six feet below is a limestone approximately eight feet thick. It appears that the lower bed, which has been moving up in the section towards the middle bed, joins it to form the thick basal bed, and that the thin shale bed, which is near the top of the main bed of the Little Hominy to the south, has increased rapidly in thickness to the north. The greatest development of the Little Hominy is in sec. 2, T. 28 N., R. 8 E. where a 25 foot section occurs. Here, a four foot shale bed occurs eight feet below the top of the limestone. From

Figure 7. Exposure of the Little Hominy in the sec. 2, T. 28 N., R. 8 E. where it attains its greatest thickness.

Figure 8. Exposure of the Little Hominy in the center of sec. 36, T. 27 N., R. 8 E.

this point northward, along the strike, the Little Hominy decreases in thickness. In sec. 26, T. 29 N., R. 8 E., the upper bed of the limestone has diminished in thickness to 3.5 feet and lies nine feet above the lower bed which has thinned to about seven feet. Three miles to the north, in Kansas, neither of these two beds could be identified definitely as only three thin limestones of completely different character occur at the Little Hominy horizon.

The Little Hominy is typically a wavy bedded, light blue-gray, sandy to shaly limestone. The upper part, which is, at most places, overlain by a sandstone bed, is commonly an algal limestone that contains small oolites and sub-angular to sub-rounded quartz grains. At many exposures, especially in the central and southern parts of the area, it weathers to a nodular, blue-gray and buff spotted surface. The lower part, except in the southern end of the area, is typically a dense, wavy bedded limestone that weathers into irregular shaped, rust splotched slabs. Triticites, "Cryptozoon", Amblysiphonella, sponge spicules, echinoid spines, crinoid stems, bryozoans, and many brachiopods such as Dictyoclostus americanus, Composita subtilita, Chonetes granulifer, Marginifera, and other species less common occur near the base of the Little Hominy.

Correlation: The Little Hominy limestone is believed

by Moore[26] and others to correlate with the Hartford limestone member of the Topeka formation of Kansas.

### Pearsonia Limestone

History of Nomenclature: Heald[27], in his original work in this area, gave the field term "red lime" to this limestone. This term has also been used to designate several other beds in Oklahoma and the multiple use has caused some confusion. Due to the fact that it is a very good marker bed in the Pearsonia area and possibly in the area to the north, and has been used as such in the past, it seems appropriate that it should have a geographical name applied to it. It is, therefore, here called the Pearsonia (new name) for the school of that name in the SE 1/4 sec. 21, T. 27 N., R. 8 E. Its type section is here designated as the exposure two and a half miles northeast of the Pearsonia School where the limestone crosses Dry Creek in the center of the SW 1/4 sec. 14, T. 27 N., R. 8 E.

Distribution: The Pearsonia limestone, although continuous throughout the area, is, at many places, covered by slump from the thick sand and shale beds higher up in the

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[26] R. C. Moore, "Divisions of the Pennsylvanian System in Kansas," State Geol. Survey of Kan. Bull. 83, 1949, fig. 22.

[27] K. C. Heald, "Geologic Structure of the Northwestern Part of the Pawhuska Quadrangle, Oklahoma," U. S. Geol. Survey Bull. 691-C, 1918, p. 67.

section. The better exposures of the limestone occur where the bed crosses small streams or where erosion is constantly taking place. Good exposures of the bed are those in the road cut in the center of sec. 36, T. 27 N., R. 8 E., at the previously mentioned type section, in the southern part of sec. 24, T. 28 N., R. 8 E., in the north-central part of sec. 11, T. 28 N., R. 8 E., and in the SW 1/4 sec. 26, T. 29 N., R. 8 E.

Character and Thickness: The Pearsonia varies from 2.5 to 3.5 feet in thickness and has an average thickness of three feet. At the type section, the Pearsonia has a thickness of 2.8 feet, and consists of a dense, dark gray-brown, silty, massively bedded limestone containing scattered fossils and fossil fragments. The bed, upon weathering, has a reddish-brown surface and becomes platy near the top. Vertical rhombohedral jointing is common in this limestone and permits large sharp-edged blocks to break off at the edge of the outcrop. The fossil content at the above exposure consists of a few large gastropods, numerous crinoid stems, sponge spicules, echinoid spines, and a few brachiopods of which Dictyoclostus americanus is the most common. The lithology at most of the other exposures of this limestone are similar to that at the above exposure and varies only in fossil content, the color of the weathered surface, and the presence of scattered fucoids at the base.

Figure 9. Exposure of the Pearsonia limestone in the center of sec. 36, T. 27 N., R. 8 E.

Figure 10. Exposure of the persistent fusulinid-bearing limestone that occurs approximately 10 feet below the Pearsonia limestone. Center sec. 36, T. 27 N., R. 8 E.

Underlying the Pearsonia from six to ten feet and separated from it by a grayish-yellow to buff, calcareous, sandy, fossiliferous shale, is a persistent, shaly, gray-brown limestone composed almost entirely of Triticites and split by numerous thin shale lenses. It varies from one to three feet in thickness and weathers to a dirty brown. This is one of the most useful marker beds occurring in the Pearsonia area, as no other unit was found that had all of the characteristics of this bed. This limestone is underlain, at most places, by a blue-gray shale that commonly is maroon at the base. This shale interval varies from a thickness of three feet in the northern part of sec. 2, T. 28 N., R. 8 E. to a thickness of 15 feet in the southern part of the area.

Correlation: The Pearsonia, commonly called the "Red lime" in Oklahoma, is considered by Moore[28] and others to correlate with the Curzon limestone member of the Topeka formation of Kansas. The correlation is uncertain due to the many facies changes in Chautauqua County, Kansas, which is just north of the Pearsonia area, and has not been mapped.

Turkey Run Limestone

History of Nomenclature: This limestone was named

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[28] R. C. Moore, "Divisions of the Pennsylvanian System in Kansas," State Geol. Survey of Kan. Bull. 83, 1949, fig. 22.

by Heald and Mather[29] for its exposures near the head of Turkey Run Creek in sections 9, 16, and 17, T. 24 N., R. 8 E. and was placed in the now obsolete Buck Creek formation of Oklahoma.

Distribution: The Turkey Run, which is thought to be present throughout the Pearsonia area, was the most difficult of the marker limestones to trace and, due to this difficulty, was not mapped. Exposures of the bed are almost nonexistent and only two good exposures were found in the area. These are in the SW 1/4 sec. 24, T. 28 N., R. 8 E., and in the east-central part of sec. 3, T. 28 N., R. 8 E. next to the road. The Turkey Run does not form a bench and normally occurs part way down the escarpment that is capped by the sandstones above and below the Bird Creek limestone.

Character and Thickness: This limestone, which is a good marker bed in the areas to the south, appears to change greatly in character and thickness just south of the point where it crosses the southern boundary of this area. South of the Pearsonia area, the Turkey Run is similar to the Pearsonia limestone and the Bird Creek limestone; however, at the above mentioned point, it changes into a pellet limestone which consists of small, light gray-blue balls of limestone, from one to five millimeters in diameter, in a dark gray,

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[29] K. C. Heald, K. F. Mather, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma," U. S. Geol. Survey Bull. 686-M, 1922, p. 153.

sandy limestone matrix. This facies is similar to that of the algal limestone that occurs in the lower part of the Leavenworth limestone in the southern part of the area, and is believed to be formed in the same way. Farther north, the limestone is more fossiliferous and consists of a dull, shaly, dark gray limestone which, on weathering, is platy and has a dirty yellow surface. This limestone is at no place thicker than one foot and, at the few exposures where a measured section could be taken, is approximately 0.8 of a foot thick.

The Turkey Run is underlain by a persistent 30 foot shale sequence which commonly consists of a dark gray to black, carbonaceous shale at the top which grades into a gray, calcareous, clayey shale near the middle. This shale grades downward into a maroon shale which is typical of the basal part. However, the basal layer, which is directly above the Pearsonia limestone, commonly consists of a yellow-gray, sandy, fossiliferous shale. Overlying the Turkey Run, at most places, is a clayey, yellow-gray, very fossiliferous shale that is increasingly sandy towards the top and grades into sandstone. In sec. 3, T. 28 N., R. 8 E., a conglomeratic limestone containing myalinas and algal remains occurs six feet below what is believed to be the Turkey Run limestone. At this exposure, the dark gray to black shale, present in other parts of the area, is absent.

Correlation: The Turkey Run, which marks the top of

the Pawhuska limestone in Oklahoma, is correlated with the Coal Creek limestone member of the Topeka formation in Kansas[30] and its top marks the boundary between the Shawnee and Wabaunsee groups.

## Wabaunsee Group

This group was originally defined by Prosser, in 1895[31], as a formation extending from the Nodaway coal in the Howard formation to the base of the Cottonwood limestone. Since that time, it has been repeatedly redefined and has been raised to the status of a group. Its present classification is the same as that given to it by Condra[32], in 1935, who defines it as the beds from the top of the Topeka formation to the unconformity at the top of the Brownville limestone.

The Wabaunsee group, which has its type locality in Wabaunsee County, Kansas, is distinguished from the Shawnee group by the presence of thick, sandy shale sections separated by thin, persistent limestone units which are commonly one

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[30] R. C. Moore, "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas," State Geol. Survey of Kan. Bull. 22, 1935, p. 195.

[31] C. S. Prosser, "The Classification of the Upper Paleozoic Rocks of Central Kansas," Journal of Geology, Vol. 3, 1895, p. 688.

[32] G. E. Condra, "Geologic Cross Section, Forest City, Missouri to Dubois, Nebraska," Neb. Geol. Survey Paper, 8, 1935, pp. 9-11.

to three feet in thickness. The cyclic arrangement appears to be quite different from that found in the Shawnee, as deposition occurred in regularly alternating marine and non-marine units. Another factor that separates the Wabaunsee from the Shawnee, especially in the Pearsonia area, is the presence of thick sandstones and numerous thin coal beds occurring throughout the section. The upper part of the Topeka formation in northern Oklahoma resembles more the type of deposition found in the Wabaunsee group than that in the Shawnee group in which it is placed in Kansas. This is due to the fact that the units from the top of the Little Hominy to the top of the Turkey Run consist mostly of shale with several thin, persistent limestone units.

## Bird Creek Limestone

History of Nomenclature: This limestone was first named by Heald[33] for its exposures on the sides of the valleys of Bird Creek and its tributaries in Osage County, Oklahoma.

Distribution: The Bird Creek limestone is persistent throughout the Pearsonia Area. In the central portion of the area, it occurs near the top of a large escarpment supported by the thick sandstones immediately below it. In the southern portion of the area, the limestone is characteristically found in a thin, treeless shale section which occurs between two thick sandstones that are, at most places, covered with

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[33] K. C. Heald, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma," U. S. Geol. Survey Bull. 686-Q, 1922, p. 216.

scrub oak. The northern exposures of the limestone are more difficult to find as the limestone is not associated with any topographical features that are easy to distinguish; however it still occurs between two sandstone units. Good exposures of the Bird Creek may be seen in the road cut in the north-central part of sec. 26, T. 27 N., R. 8 E., in the north-central part of sec. 21, T. 27 N., R. 8 E. where the line of crop crosses Hickory Creek, in the SW 1/4 sec. 23, T. 28 N., R. 8 E., in the SW 1/4 sec. 33, T. 29 N., R. 8 E. where the line of crop crosses Buck Creek, and in the road cut on the Kansas boundary line near the north-central part of sec. 14, T. 29 N., R. 8 E.

Character and Thickness: The Bird Creek limestone is a persistent unit in both character and thickness. It varies in thickness from 1.5 feet to 3 feet and is typically a dense, brittle, dark gray-brown, finely crystalline limestone, with rectangular vertical jointing. Its surface is, at most places, a dirty yellow to yellow-gray and its outcrop is marked by large rectangular blocks. Triticites, bryozoans, and brachiopod fragments occur in the limestone at places and the brachiopod Enteletes hemiplicata commonly occurs well preserved near the top part of this limestone in its southern exposures.

In the northern part of the area, a limestone closely resembling the Bird Creek occurs above it and is separated

from it by a thin dirty yellow shale. At the point where the Bird Creek enters the area from Kansas, this limestone occurs four feet above it and is 1.3 feet thick. Farther south, this limestone, together with the underlying shale, thins gradually until in the SW 1/4 sec. 23, T. 28 N., R. 8 E. it is only about 0.5 of a foot thick and the underlying shale is approximately one foot thick. This limestone was not found south of this exposure and is presumed to disappear completely. Sandstones of varying thicknesses occur, at most places, both above and below the Bird Creek limestone. These sandstones are commonly brown, slightly shaly, cross-bedded, medium to fine grained sandstones. The sandstone below the Bird Creek, at places, attains a thickness of 30 feet or more, as shown in the exposure in the SW 1/4 sec. 24, T. 28 N., R. 8 E. The sandstone bed directly above the Bird Creek attains its greatest thickness of almost 30 feet in the southern part of the area, where it forms steep bluffs along Bird Creek and its tributaries. In the northern part of the area, a thin coal seam, the Nodaway coal, and a thin underclay occurs a foot below the Bird Creek limestone. This coal, consisting mostly of carbonaceous shale, is persistent, to the south, several miles before becoming indistinguishable from the shale above and below.

Correlation: The Bird Creek is believed to be a direct continuation of the Church limestone member of the

Howard limestone of Kansas.[34] The shale between it and the underlying Turkey Run appears to be the same as the Severy shale of Kansas.

## Wakarusa Limestone

History of Nomenclature: The name Wakarusa was first used by Beede[35], in 1898, for a limestone which is now called the Reading. Condra[36], in 1927, described what he thought was Beede's Wakarusa; but when traced into Kansas, it turned out to be the upper member of Beede's "Stanton" limestone, which included all of the Burlingame and the overlying limestone now called the Wakarusa. The use of Condra's Wakarusa as the name of this upper limestone of the "Stanton" has continued to the present day.

Distribution: The Wakarusa is continuous throughout the Pearsonia area and is one of its better marker beds. Slump from its outcrop is the typical expression of its presence, for the limestone normally forms only a low bench. The general location of this bed, at some places, can be found by

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[34] R. C. Moore, "Stratigraphic Classification of the Pennsylvanian Rocks of Kansas," State Geol. Survey of Kan. Bull. 22, 1935, p. 208.

[35] J. W. Beede, "The Stratigraphy of Shawnee County, Kansas," Kan. Acad. Sci., Trans., Vol. 15, 1898, p. 30.

[36] G. E. Condra, "The Stratigraphy of the Pennsylvanian System in Nebraska," Neb. Geol. Survey Bull. 1, 2d Series, 1927, p. 66.

locating it from the base of the Stonebreaker escarpment. At other places, it occurs near the top of the low cuesta that extends outward from the base of the Stonebreaker escarpment a mile or more. In the southern part of the area, it commonly occurs directly below a thick escarpment-forming limestone. In the central and northern parts of the area, changes in vegetation can be used in tracing it from exposure to exposure. Good measurable exposures of the limestone and of its adjoining units are practically non-existent. Fair exposures of the bed can be found in the road cut in the north-central part of sec. 20, T. 27 N., R. 8 E., along the road cut in the south-central part of sec. 9, T. 27 N., R. 8 E., where it crosses Sand Creek in the NE 1/4 sec. 32, T. 28 N., R. 8 E., and along the road in the east-central part of sec. 9, T. 28 N., R. 8 E.

Character and Thickness: In the northern part of the area, the Wakarusa is approximately 22 feet thick and is composed of a lower fusulinid-bearing unit that is separated from two upper units by a thin shale. In the central and southern parts of the area, only one upper unit can be found. The two upper units in the northern part are separated by approximately seven feet of grayish-yellow, calcareous, clayey, fossiliferous shale. The upper bed is a brown, shaly, algal limestone which weathers to rust color. The lower bed is shaly, dark gray, and contains a few myalinas. This lower

bed is separated from the underlying fusulinid-bearing phase by about nine feet of shale in the northern part of the area. In the central and southern part, a gray to pinkish brown, fossiliferous calcarenite lies directly upon the fusulinid-bearing unit of the Wakarusa at places and commonly forms a small ledge. It ~~varies~~ ranges in thickness from 0.5 of a foot to three feet. However, in the railroad cut in the south-central part of sec. 18, T. 27 N., R. 8 E., the bed abruptly thickens to 12 feet and then abruptly thins again. This thickening occurs in a space of approximately 100 yards. Cross-bedding and pinching out of the lenses in the limestone is common in this exposure and the underlying fusulinid-bearing bed of the Wakarusa is warped downward as if from the weight of the thick limestone directly above. The fusulinid-bearing bed of the Wakarusa is a persistent unit in both character and thickness. It varies from one to three feet in thickness and is composed of a dark gray, dense, brittle, finely crystalline limestone which, upon being struck with a hammer, gives out a ringing sound and breaks with conchoidal fracture. Its surface is dirty yellow and is characteristically marked by dark blue-gray specimens of a "Cryptozoon" which stand out on the weathered surface. Triticites occurs in this bed along with fragments of brachiopods and bryozoans. Large blocks that break off at the outcrop of the limestone appear to be outlined by vertical joints which are characteristic in this bed.

In the NE 1/4 sec. 32, T. 28 N., R. 8 E., where the Wakarusa crosses Sand Creek, a dark gray, dense, brittle, fossiliferous limestone, 0.6 of a foot thick, but containing no "cryptozoans", overlies the Wakarusa and is separated from it by a thin shale bed. It appears to be a continuation of the fusulinid-bearing phase of deposition and is easily distinguished from the other limestones of the upper part of the Wakarusa. In the extreme northern part of the area, a dense, brittle, dark gray limestone two feet thick, containing numerous large Triticites, underlies the "Cryptozoon" and fusulinid-bearing phase of the Wakarusa and is separated from it by a thin shale interval. Although no "cryptozoans" were found in this unit either, it appears to be a result of the same type of deposition which formed the fusulinid phase of the Wakarusa. One foot below the Wakarusa, in the NE 1/4 sec. 32, T. 28 N., R. 8 E., a thin coal bed with no underclay was found. It is the only place in the area, at this horizon, that a definite coal bed was found; however, a dark gray, carbonaceous shale occurs in several other exposures at this same horizon. This appears to be the same coal bed that is locally found near the top of the Soldier Creek shale in Kansas.

Several named limestones are believed to have been identified in the section between the Wakarusa limestone and the Bird Creek limestone. These are, in ascending order: the Happy Hollow limestone, the Rulo limestone with the

Figure 11. Exposure of the thick, cross bedded calcarenite that occurs just above the fusulinid-bearing limestone of the Wakarusa. SE 1/4 sec. 18, T. 27 N., R. 8 E.

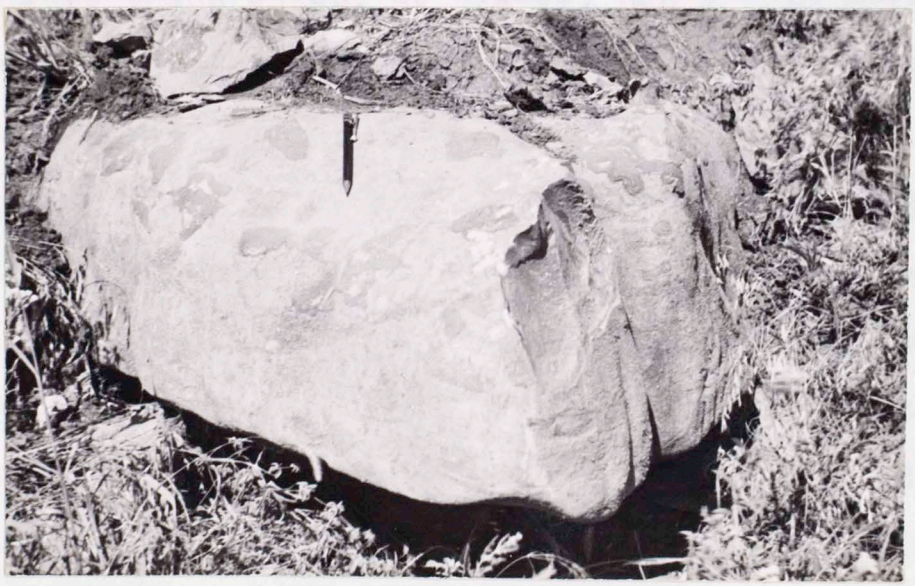

Figure 12. Exposure of the fusulinid-bearing limestone of the Wakarusa in the road cut in the SE 1/4 sec. 9, T. 27 N., R. 8 E.

underlying Elmo coal, and the Burlingame limestone.

The Burlingame, in the extreme northern end of the area, consists of three limestones which, with included shale, have a total thickness of approximately nine feet. It forms a distinctive ledge in the northern part of the area, and consists of a brown to gray limestone which weathers to a bright rust color. Pelecypods and gastropods are numerous, and a few brachiopods and cephalopods occur. This limestone is represented by one and, at places, two thin limestones in the southern part of the area.

Underlying the Burlingame, and separated from it by 20 to 25 feet of sandy shale to micaceous siltstone, is the Rulo limestone. At the point where the Rulo crosses the Kansas-Oklahoma line, it is a thin, shaly, platy limestone 0.6 of a foot thick which, at places, has a thin smutty shale immediately underlying it. Farther south along the strike, the limestone thickens, the smutty shale grades into coal, and the shale interval between the coal and the limestone is slightly greater. The Rulo is typically a dark brown to gray, dense, slightly impure limestone which contains a few myalinas at the base. Numerous brachiopod fragments were found near the top in the more southern exposures. The Rulo thickens to the south, and, in the railroad cut in the SE 1/4 sec. 18, T. 27 N., R. 8 E., is 3.5 feet thick. Three feet below, a smutty coal (Elmo) approximately one foot thick occurs.

The Happy Hollow limestone, where present, occurs slightly over 20 feet below the Rulo limestone. It is not a resistant limestone and is easily covered by slump from the overlying formations. In the northern part of the area, the limestone consists of one bed; however, farther south, it is gradually split into two units by a thin shale interval which thickens to the south. The upper bed has an olive-drab color, contains numerous blue spots (algal), and weathers to rust color. The lower bed is a light gray, medium to finely crystalline, shaly limestone that contains numerous fossil fragments. The Happy Hollow limestone, at many places, is underlain by a maroon shale that has sandstone beds near the base. This appears to fit in with the initial terrestrial deposits of the Happy Hollow cyclothem of Kansas, which occurs in the upper part of the White Cloud shale. The rest of the section on down to the top of the Bird Creek limestone consists of sandy shale and thick sandstone beds.

The geologic section between the Wakarusa limestone and the Bird Creek limestone is complicated and appears to contain several disconformities which are, at places, marked by sandstones. At many places, horizons at which limestones occur are occupied by thick cross-bedded sandstones. These sandstones disappear as suddenly as they appear and are then replaced by the limestones they had cut out at other places. The section is shortened or lengthened by these sandstone beds.

At places, the disconformity is marked by a conglomerate that commonly contains pieces of carbonized wood. Twenty or 30 feet of sediments are, at places, stripped off by erosion during the time of the conglomerate deposition. The most extensive disconformity in the Wakarusa-Bird Creek section appears to be the one a short distance below the Rulo limestone, as it is this interval between the Rulo and the Bird Creek that is commonly shortened.

Correlation: The Wakarusa limestone, in the Pearsonia area, is the same as the Wakarusa formation of Kansas, and the fusulinid-bearing phase of the limestone is a direct continuation of the "Cryptozoan" limestone of Oklahoma. The following units, present in the corresponding Kansas section, are also believed to be present in the interval between the Wakarusa limestone and the Bird Creek limestone in this area, and are, in ascending order: the White Cloud shale, the Happy Hollow limestone, the Cedar Vale shale, the Rulo limestone, the Silver Lake shale, the Burlingame limestone, and the Soldier Creek shale.

## Stonebreaker Limestone

History of Nomenclature: The Stonebreaker was named by Heald[37] for its exposures on the Stonebreaker Ranch in the

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[37] K. C. Heald, "Geologic Structure of the Northwestern Part of the Pawhuska Quadrangle, Oklahoma," U. S. Geol. Survey Bull. 691-C, 1918, p. 64.

the western part of T. 29 N., R. 8 E. His original description seems to indicate that he intended the name to apply to what is now called the Reading limestone; however, later geologists used this name for beds which correspond to the Emporia limestone of Kansas, which included what are now called the Reading limestone, the Harveyville shale, and the Elmont limestone. The name Emporia has since been discarded, as the old Reading and Elmont limestone members, and the shale interval between them, have now been raised to formation rank in Kansas.

Distribution: The Stonebreaker limestone forms a distinct escarpment along the western edge of the Pearsonia area. Although the limestone is easily seen at any point along its strike, measurable sections are difficult to find due to considerable slumping over the numerous included shale intervals. Good exposures of the entire Stonebreaker formation were found in the NW 1/4 sec. 12, T. 27 N., R. 7 E. where the limestone crosses North Bird Creek, in the NW 1/4 sec. 31, T. 28 N., R. 8 E. where it crosses Sand Creek, and in the center of sec. 18, T. 28 N., R. 8 E. where it crosses South Buck Creek.

Character and Thickness: The Stonebreaker formation, which has a total thickness of about 35 feet, can be divided into three parts. Named in ascending order, they are: the Reading limestone, the Harveyville shale, and the Elmont limestone.

The Reading limestone, which is the lower member of the Stonebreaker, is the thickest and most resistant unit. It can be divided into three limestone units and two shale units. The lower unit, which varies from one foot to approximately five feet in thickness, typically consists of a brown, shaly limestone that weathers to a yellow-brown, nodular surface which appears to be due to the presence of algal remains. In the NE 1/4 sec. 31, T. 28 N., R. 8 E., this lower unit is 2.5 feet thick and the upper half is a light gray-brown, medium crystalline, fossiliferous limestone which contains numerous specimens of Juresania nebrascensis and Myalina at its base. The lower half is the same as that in the typical exposure described above. In the NW 1/4 sec. 19, T. 27 N., R. 8 E., a brown, medium crystalline limestone, which weathers to a bright rust color and is about two feet in thickness, underlies the lower algal unit. The lower unit of the Reading is separated from the middle unit by a thin blue-gray shale which varies from one to four feet in thickness, and contains, near the middle, a thin smutty coal bed that commonly has an underclay at its base. The middle unit is the most resistant part of the Reading limestone, and it is the base of this unit that is mapped. It varies from slightly over four feet to six feet in thickness and is commonly divided into two and, at places, three parts. The lower part typically consists of a gray, dense, brittle limestone

containing numerous fusulinids which weather to a lighter color than the surrounding limestone. The lower part is separated from the overlying part by a thin gray shale interval. This overlying part is composed of dense, gray limestone which weathers to yellow-gray and contains many fusulinids and "cryptozoans". At places, the top portion of this part is separated from the lower portion by a thin shale interval. At these places, the top portion contains many "cryptozoans" and a few scattered fusulinids. The upper unit of the Reading is typically a gray and yellow, shaly, nodular, algal limestone which has an average thickness of slightly less than two feet, and represents the regressive part of the Reading cyclothem. This upper unit is overlain by the Harveyville shale.

The Harveyville has an average thickness of six feet in the Pearsonia area and, at most places, contains a thin, smutty coal bed near the middle. It is typically a gray, calcareous, clayey shale which grades into a dark gray to black shale near the top.

Directly overlying the Harveyville shale is the Elmont limestone member of the Stonebreaker. It consists of an upper and lower limestone separated by six to seven feet of yellow-gray, calcareous shale which grades into dark gray to black shale at the base. The lower limestone is a thin, dense, dark gray, shaly limestone which weathers to dirty yellow and,

at some places, contains numerous fusulinids and "crypto-zoans". The upper limestone is a brown, irregularly bedded, medium to finely crystalline limestone which weathers to yellow-brown. This bed is fossiliferous, at many places, and is believed to be of algal origin in part. The average thickness of the limestone is approximately two feet. Closely overlying this limestone and occurring at the base of the Willard shale, is a smutty coal bed 0.3 of a foot to one foot thick, underlain by a gray-blue clay.

The interval between the Stonebreaker and the Wakarusa varies from 35 feet in the northern part of the area, to over 55 feet in the southern part. In Kansas, the rocks of this interval are named the Auburn shale. The basal part of this shale, which immediately overlies the Wakarusa, consists of a yellow-gray, fossiliferous shale that grades upwards into maroon shale. This maroon shale, especially in the southern portion of the area, is, at many places, overlain by several sandstone beds. A thin, dense, brittle, dark gray limestone which weathers to a dirty yellow, and is full of myalinas, occurs throughout the entire area near the middle of the Auburn shale. In the northern part, several thin, persistent, gray limestones appear in the section a short distance above this limestone and are packed with many ramose bryzoans, and numerous Myalina and fossil fragments. Near the top of the Auburn shale, and a short interval below the Stonebreaker, is

a persistent, tan, fine grained, calcareous, micaceous, finely cross bedded sandstone that is easily recognized. To the south, the sandstone becomes thicker, less micaceous, medium grained, and darker.

Correlation: In Oklahoma, the Stonebreaker formation consists of three members: the Reading limestone, the Harveyville shale, and the Elmont limestone. In Kansas, the name Emporia limestone, which is the same as the Stonebreaker limestone of Oklahoma, has been discarded and the three members have been raised to the rank of formations. The Auburn shale is present throughout the Pearsonia area.

## Interval From the Stonebreaker Through the Middle Foraker

The beds in this interval, with the exception of the Willard-Langdon shale, are found only in the SW 1/4 sec. 6 and the NW 1/4 sec. 7, T. 28 N., R. 8 E. where a nose of the Foraker escarpment enters the Pearsonia area from the adjoining area to the west. These beds are well exposed at places in the adjoining area and were recently mapped in detail.[38] Since few measurable exposures of these units can be found in this area, their descriptions by Taylor[39] will be used in the

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[38] R. C. Taylor, "The Geology of the Foraker Area, Osage County, Oklahoma," Unpublished Master of Science Thesis, University of Oklahoma, 1953, pp. 19-50.

[39] R. C. Taylor, Ibid.

summary of this interval which follows.

The following named units, using Kansas terminology, are found in this interval and, named in ascending order, are: Willard-Langdon shale, Dover limestone, Dry shale, Grandhaven limestone, Friedrich shale, Jim Creek limestone, French Creek shale, Nebraska City limestone, Grayhorse limestone, Pony Creek shale, Brownville limestone, Five Point limestone, Hamlin shale, and the Foraker limestone.

The Willard-Langdon shale, which is the only unit of the above that is also present in sections 19, 30, and 31; T. 28 N., R. 8 E., is about 120 feet thick and is predominately shale and sandstone with two thin limestones near the top. The lower part, which contains a coal bed at the base, is composed of yellow, sandy shale, and the middle consists of three sandstone beds and included shale.

The Dover limestone, which has an average thickness of 18 feet, consists of two thin limestones separated by an interval of sandy micaceous shale and a soft, sandy, fossiliferous limestone that is 3.5 feet thick. The upper bed is 1.3 feet thick and consists of a brown-gray limestone that weathers brown and has numerous fusulinids.

No exposures of the Dry shale were found in the adjoining area or in the Pearsonia area. It forms a grass-covered slope near the base of the Foraker escarpment and has a thickness of about 20 feet.

The Grandhaven limestone is a thin, ferruginous, tan to gray, cross-bedded calcarenite which weathers red on the surface. Although fossils are mostly fragmental, a few specimens of large pelecypods may be found.

The Friedrich shale, which has an average thickness of about 16 feet, consists of gray, sandy, micaceous, shale with thin laminated beds of calcareous sandstone. Near the top is a thin coal bed.

The Jim Creek limestone is a characteristic bluish-gray to tan, fusulinid-bearing limestone which weathers to yellow-brown and is slightly over two feet in thickness.

The French Creek shale has an average thickness of 14 feet and consists of gray, calcareous shale with limestone concretions occurring near the middle, and, at places, grades into an impure limestone.

The Nebraska City limestone, which is approximately 3.5 feet thick, contains at its base a soft calcarenite that has a distinctive spotted weathered surface. The upper part of the bed is a massive, tan, ferruginous limestone which, at places, contains many gastropods and a few pelecypods.

The Grayhorse limestone is separated from the underlying Nebraska City limestone by a ten foot unnamed shale which contains a few thin limestone stringers. The Grayhorse is approximately three feet thick and at places, consists of two beds separated by one foot of greenish-gray shale with

intercalated beds of limestone. The upper bed is 0.6 of a foot thick, and is a dark gray, ferruginous limestone with thin shale partings. On weathering, it is slabby and takes on a grayish-brown hue. A few myalinas occur along with many fossil fragments. The lower bed is 1.3 feet thick and consists of a finely-crystalline, gray limestone that weathers tan. Many fossils are replaced by coarsely crystalline calcite and by limonite.

The Pony Creek shale is 42 feet thick near the Kansas-Oklahoma line and thickens slightly to the south. It consists of a yellow, sandy shale that contains a channel sandstone near the middle of the lower part and has a thin coal near the top.

The Brownville limestone is regarded as the uppermost stratigraphic unit of the Wabaunsee group and of the Pennsylvanian system in northern Oklahoma, Kansas, and Nebraska. It consists of an upper bed separated from a lower bed by two to three feet of yellow-drab shale. The upper bed is a massive, fossiliferous, ferruginous, slightly sandy limestone. The lower part of this bed is yellow-tan and grades upward into a darker reddish-brown near the top. Fusulinids are abundant near the top but diminish in number towards the base. This bed forms an abrupt bench and is easily traced. The lower bed is 1.9 feet thick, brittle, compact, and is filled with pelecypod remains.

The interval between the Brownville limestone and the Foraker limestone includes the Admire group of the Wolfcamp Series. The overlying Foraker is in the Council Grove Group.

The Five Point limestone occurs near the base of the Admire group and is separated from the underlying Brownville limestone by a 16 foot, gray and yellow shale which has a soft, porous, silty, yellow limestone near the middle and 2.5 feet of thin calcareous sandstone interbedded with silty calcareous shale near the bottom. The Five Point is two feet thick, and consists of a gray to reddish-brown, massive, dense, ferruginous and fossiliferous limestone. The upper 0.5 foot is a coquinite made up of small gastropods.

The Hamlin shale, which overlies the Five Point limestone, is divided into three members. These are, in descending order: the Oaks shale, the Houchen Creek limestone, and the Stine shale. The Stine is covered at most places, and is approximately 20 feet thick. The Houchen Creek is about five feet thick and consists, in the upper part, of thin limestones, limestone nodules, and shales. A dirty, soft, porous, yellow limestone, 2.1 feet thick, makes up the lower part. The limestones of the upper part are gray, clean, and finely-crystalline, and almost lithographic. The upper and lower beds of this division are fossiliferous and the shales are barren. The Oaks shale member is 2.7 feet thick and consists of a gray shale that weathers drab yellow.

The Foraker limestone is divided, in descending order, into the: Long Creek shale, Hughes Creek limestone, and the Americus limestone. The Foraker is easily recognized because of its topographical expression, chert content, and abundance of fusulinids.

The Americus limestone consists of two limestone beds separated by 6.5 feet of a gray, fossiliferous shale. The lower limestone, which is four feet thick, is a gray, massive, fusulinid-bearing limestone bed that is separated near the middle by a thin but consistent shale. The upper limestone is dark gray, shaly, sandy, and fossiliferous, and is slightly over one foot thick.

The Hughes Creek limestone (shale in Kansas) is 23.3 feet thick and over half of this thickness is made up of a resistant, cherty limestone. It is this member that forms the steep ledge at the top of the Foraker escarpment. The lower part of this member consists of a gray shale that is 5.5 feet thick. Overlying this unit is a massive, cherty, coarsely-crystalline, fusulinid-bearing limestone that is 12.8 feet in thickness. It is light bluish-gray and is spotted white by numerous fusulinids. The uppermost unit of the Hughes Creek is a two foot, gray, massive, ferruginous, fusulinid-bearing limestone. It is separated from the underlying massive, cherty bed by a 0.5 foot shale interval. This is the highest Permian bed found in the Pearsonia area, as the

upper member of the Foraker, the Long Creek, occurs back from the edge of the escarpment and is not present in the Pearsonia area.

# CHAPTER IV

## STRUCTURE

### Regional Structure

A good description of the folds and faults of Osage County is given by Milliken[40] and the following is a summary of his paper.

Osage County is divisible into a western and an eastern part in respect to the attitude of the strata. This line of division extends from the northwest corner of T. 22 N., R. 7 E. to the northwest corner of T. 27 N., R. 9 E. and thence N. 45° E. to the Oklahoma-Kansas state line. Western Osage County consists of a relatively even westward dipping monocline with little folding. The strike in R. 7 E. is about N. 5° E. To the west the strike approaches more closely to north. The average dip in this western part is about 38 feet per mile. In the eastern part, the folds are quite numerous and faulting is common. Thus the general strike or dip in any locality is hard to determine because of the numerous folds. The general strike in the eastern part is approximately

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[40] C. V. Millikan, "Inter-Relation of the Folds of Osage County, Oklahoma," Bull. Amer. Assoc. Petroleum Geologists, Vol. 4, 1920, pp. 151-158.

N. 10° E. except in the southwest corner where it changes to approximately N. 35° E. The average dip here is about 36 feet per mile. The upfolds consist mostly of slightly elongated or irregular domes from a few acres to seven square miles in area with the average being about one square mile. Basins are almost as numerous as the domes, but average a little smaller. Of the folds in which the axis can be determined, 84% trend N. 15° to 35° E. This shows that the axis of the folds is approximately perpendicular to the axis of the faults. The faults are en echelon and occur in north-south trending zones. The strike of the faults, with few exceptions, is northwest-southeast. Two directions are most frequently represented. These are N. 26 to 35° W. and a smaller group which strike N. 11 to 20° W. Faults with the upthrown side to the northeast and those with the upthrown side to the southwest are about equal in number and neither is notably predominant in a single area. Throw is, in most cases, quite small. The throw in 53% of the faults is 10 feet or less, in 70% of the faults 20 feet or less, and in 82% of the faults 30 feet or less. The faults and important folds appear not to be distributed at random but to lie in definite zones.

Brown[41], in his studies of this region, shows that if

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[41] R. W. Brown, "Origin of the Folds of Osage County, Oklahoma," Bull. Amer. Assoc. Petroleum Geologists, Vol. 12, 1928, pp. 1026-1028.

the area is tilted to the east to make up for the westward dipping Prairie Plains Homocline of which this area is a part, that many of the terraces that appear on structural maps of the area become domes and that the number of domes in the area is increased about 25%. He also points out that the heights of the domes vary from 15 to 20 feet and that

> the folds of Osage County are primarily the result of compressional forces acting with nearly equal intensity in all horizontal directions and are probably developed locally. Certain modifying factors, while not essential to the development of the folds of Osage County nor adequate to produce them may have exerted considerable influence such as (1) shearing movements producing the elongation and orientation and (2) differential compacting and settling over buried hills that localize the folds.

Kitson[42] states that shear and compressive forces occurred in the area at the same time and that the shearing stresses are the major cause of the domes and faults. He also points out that the granitic highs that occur under many of the domes may be due to flowage of the basement rocks to areas of less pressure as found under anticlines.

Kramer[43], in his studies on en echelon faults in Oklahoma, states that

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[42] H. S. Kitson, "Origin of the Folds of Osage County, Oklahoma," Bull. Amer. Assoc. Petroleum Geologists, Vol. 12, 1928, pp. 1026-1028.

[43] W. B. Kramer, "En Echelon Faults in Oklahoma," Bull. Amer. Assoc. Petroleum Geologists, Vol. 18, 1934, pp. 243-250.

A westward thrust from the Quachita Mountains is postulated as the force which created a shearing couple that caused elongation of the faulted area from northeast to southwest. This caused the development of the northwest trending, en echelon, tension faults in belts above north-northeast trending major shear planes produced in the basement rocks by forces of the couple.

## Local Structure

A zone of en echelon faults runs through the center of the Pearsonia area from the southeast corner of T. 27 N., R. 8 E. to the northwest corner of T. 29 N., R. 9 E. These faults vary from half of a mile to slightly over a mile in length and have an average strike of north 30 degrees west. The fault plane dips at a very high angle. This is proven by the fact that the strike of the fault trace never varies where crossing highly irregular terrain. The largest throw found in the faults was approximately 30 feet, with the average throw being about 15 feet. The width of the fault zones varies from 3 to 10 feet and these zones are marked by characteristic fault breccia where they cut across thick limestones. Up-thrown and down-thrown sides occur both to the northeast and southwest of the fault planes.

The largest structure in the area is the Pearsons Switch Anticline. It lies in sections 17, 18, 19, and 20, T. 27 N., R. 8 E. and has a closure of two contour lines (10 foot interval). Some of the other structures in the area that have been named are: the Round Top anticline, Triangle dome, Upper Dog Creek anticline, Ricerock anticline, Upper

Pond Creek dome, Drennan anticline, Stone House anticline, Lower Dog Creek dome, Lower Buck Creek anticlines, Benchmark anticline, and Limestone Flat terrace. All of these structures correspond roughly with the descriptions given by geologists in previous works.

# CHAPTER V

## GEOLOGIC HISTORY

The sediments exposed in the Pearsonia area are typical of the deposition that marks the upper Pennsylvanian in the northern mid-continent region. These sediments were deposited in an extensive shallow sea that covered a large, stable, flat shelf. It was during upper Pennsylvanian time that these seas advanced the fartherest to the north, into Nebraska and Iowa, and left one of the most extensive and complete records of this age that is found.

Although the sediments in the Pearsonia area are similar to the shelf sediments to the north, they represent the edge of this shelf where it grades gradually into the area to the south, which is affected by more profound disturbances of the earth's crust. This area accumulated sediment from the south at a much faster rate than the region to the north. This is the cause of many thick tongues of sandstones and shales, which are quite predominate south of the shelf region, to gradually thin and change facies into limestone on the shelf. Although not noticeable in such a small

area as the Pearsonia area, the facies changes along the strike, which is roughly north-south, is very noticeable in many cases.

The shallowness of this sea, its sensitiveness to any small movement of the crust or sea level, and the delicate balance between deposition and non-deposition seems to be one of the reasons why cyclic sedimentation is so obvious in this region, and is so well developed. Many of the key parts of these cyclothems, which are well developed to the north, disappear to the south or become masked by the large sands and shales that come into the section. These cyclothems, more than any other thing, demonstrate how easily these shallow seas could withdraw to be replaced by terrestrial conditions which, in turn, could be easily replaced again by the seas.

Most of the limestones, part of the shales, and an occasional sandstone were formed by marine deposition; the other lithic units, which consist of most of the sandstones, the coal beds, and part of the shales, are of non-marine deposition. The marine units have a greater thickness than the non-marine units, but comparison of the corresponding time that elapses during the marine and non-marine deposition, cannot be determined until more knowledge of rate of sedimentation and of the time represented by non-deposition is worked out more completely for this region.

In the Pearsonia area, the sandstones of the Kanwaka

seem to represent a fairly large predominantly non-marine interval. A predominantly marine interval is represented by the thick limestones of the Pawhuska formation of Oklahoma. This, in turn, appears to be followed by a time when marine and non-marine conditions alternated frequently, and considerable shale was deposited, along with an occasional thin, persistent limestone. This is fairly well represented by the Wabaunsee group. At many places, especially in the columnar section around the Stonebreaker and for some distance above it, this shale is non-marine (?) and, at many places, grades into a micaceous siltstone containing plant remains; however, in most of the other intervals, this shale is largely of marine origin. Thick sandstones which appear to be of littoral origin, occur abundantly in the Wabaunsee group and are, in many cases, separated by marine deposits. These sandstones, at most places, thicken to the south and thus appear to fit in with the regional character.

The Elgin sandstone, a member of the Kanwaka shale, abruptly thickens in the northern part of the Pearsonia area around Elgin, Kansas, and then thins to the south for a short distance. However, in the southern part of the area, it again appears to thicken slightly. The abrupt thickening of the Elgin in the northern part of the area, could, possibly, be due to a local disturbance causing increased erosion and deposition during Elgin time.

# CHAPTER VI

## ECONOMIC GEOLOGY

The economic resources of the Pearsonia area are, for all practical purposes, limited to the production of petroleum. Several thick limestone beds are present in the area, but they are impure and wavy bedded, thus making them undesirable for either the production of lime or for building stone. Most of the larger sections of shale are sandy and could not be used satisfactorily for clay products. Gravel commonly occurs along the larger streams, but is only in sufficient quantity for local use.

The oil-bearing horizons occur at shallow depths from less than a thousand feet to around 3,000 feet with an average depth of about 2,000 feet. The lowest producing horizon, at some places, is the top of the "Siliceous Lime"; however, the lowest prolific horizon is the top of the "Mississippi Lime". Several producing horizons occur in the sands above and below the Oswego and "Big Limes" and a few occur still higher up in the section. Often, multiple horizons that contain oil are encountered in one well and if production at one horizon is not found, several others can be tested before the well is

definitely abandoned.

The production in practically all of the wells is small but lasts a long time. Some of the wells that were drilled as far back as 1901, which is when the first production started in this area, are still producing oil.

Most of the oil seems to be associated in some way with the structures found in the area, but many of the wells are on the flank of the structure where the oil appears to be controlled by the varying porosity and lenticularity of the unit in which it is found.

Although many parts of the area have been extensively drilled, new pools are still being found and several producing wells were brought in during the field work on this thesis. This region seems to be ideal for small, independent oil companies as only light equipment is needed to drill a well and a comparatively small outlay of money is required.

# CHAPTER VII

## CONCLUSIONS

This study of the geology in the Pearsonia area, when tied into the adjoining areas, should bring to light many facts about this region that were not realized before.

The southern extension of many thin, persistent limestone units on the stable shelf of the northern mid-continent has not been known even though the extreme southern portions had been mapped in central and northern Oklahoma. Many of these limestones now appear to be much more persistent than formerly realized.

At certain geologic times, it appears that sedimentation in the Pearsonia area occurred under more stable marine conditions than during the corresponding time in the region to the north. This is suggested by such units as the Rulo limestone and the underlying coal bed, which are much thicker and well developed in the southern part of the area than in the northern part where they are both very thin and incomplete.

Many interesting facts should be obtained from this area by sedimentation studies on the source of sediments and nature of lentils; also, study in the areas now marked by

structures might determine if any unstable characteristics in the past existed in these same localities. Before paleontological evidence can be used to much advantage in this area, extensive collecting and study along this line will have to be made in order to ascertain the most effective ways of applying this type of evidence. Many interesting facts might also be obtained from a thorough study of the cyclic deposition in northern and central Oklahoma and the correlation of such units, if possible, with the well developed cyclothems in the northern part of the mid-continent region.

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# APPENDIX

## MEASURED STRATIGRAPHIC SECTIONS

## IN

## THE PEARSONIA AREA, OSAGE COUNTY, OKLAHOMA

### T. 29 N., R. 10 E.

| | Feet |
|---|---|
| I. SE 1/4 sec. 19. Measured on the west side of a steep canyon on the north side of the road. | |
| OREAD FORMATION: | |
| Plattsmouth limestone: | |
| Limestone, sandy, medium crystalline, pinkish-brown, has crinoid fragments and weathers brick-red | 2.5 |
| Sandstone, calcareous, light gray. Grades into sandy limestone with a few fossil fragments | 3.0 |
| Limestone, dense, finely crystalline, light gray, limonitic, wavy bedded, and contains numerous Triticites | 6.0 |
| Heebner shale: Covered | 55.0 |
| Leavenworth limestone: | |
| Limestone, dark gray, dense, brittle, has fossil fragments and few Triticites. Weathers dirty yellow | 1.5 |
| II. SW 1/4 sec. 19. Measured in road cut along north side of road. | |
| KANWAKA SHALE: | |
| Sandstone, not measured. | |
| Shale, yellow-gray, sandy, limonitic. About | 5.0 |
| Sandstone, brown, medium grained, cross-bedded. | 2.0 |
| Shale, yellow-gray, sandy, limonitic. About | 4.0 |
| Sandstone, brown, medium grained, impure, cross bedded | 30.0 |
| Shale, mostly covered. Sandy, clayey, yellow-gray. Varies in thickness | 17.0 |

| | Feet |
|---|---|
| OREAD FORMATION: | |
| Plattsmouth limestone: | |
| Limestone, highly variable in lithology, fossils, and thickness. Is sandy, shaly, gray-brown, and packed with Triticites. Base grades into a porous, shaly, calcareous sandstone..... | 3.5 |
| Heebner shale: | |
| Shale, clayey, sandy, limonitic streaks. Contains many fine-grained limonitic sandstone nodules and remains of plants..... | 60.0 |
| Leavenworth limestone: | |
| Limestone, dense, brittle, medium crystalline, dark gray, and vertically jointed. Lower half and very top are most fossiliferous. Many Neospirifer, Chonetes, crinoid stems, and Triticites present. Weathers dirty yellow. | 2.0 |
| Shale, calcareous, fossiliferous, yellow-gray at top. Grades into a clayey, maroon shale at base..... | 15.0 |

T. 29 N., R. 9 E.

III. Measured in the east-central part of sec. 14, along the road and in the canyon west of the road.

| | |
|---|---|
| KANWAKA SHALE: | |
| Sandstone, top covered. Brown, impure, medium grained, cross-bedded..... | 15.0 |
| Covered interval, probably shale. About..... | 15.0 |
| Sandstone, same as above..... | 20.0 |
| Covered interval, probably shale..... | 4.0 |
| OREAD FORMATION: | |
| Plattsmouth limestone: | |
| Limestone, sandy, ferruginous, and grades into a calcareous sandstone. Weathers to a chocolate brown. Often covered with lichen and has a purple tinge in spots..... | 2.5 |
| Limestone, slabby, wavy bedded, sandy, buff to brown, finely crystalline to medium crystalline, and limonitic in places. Towards the base it becomes less impure and more dense. The basal part is fossiliferous and contains many Triticites..... | 17.0 |
| Heebner shale, covered at top. Basal part is gray to yellow-gray and extremely fossiliferous. About..... | 60.0 |
| Leavenworth limestone: | |
| Limestone, dense, brittle, dark gray-brown, | |

| | Feet |
|---|---|
| finely crystalline and fossiliferous. Very top is packed with Triticites, Neospirifer, Chonetes and crinoid fragments. Weathers dirty yellow..... | 1.8 |
| Shale: | |
| Shale, clayey, gray and buff..... | 11.0 |
| Sandstone, resistant, laminated, buff, fine-grained calcareous, finely cross bedded.... | 4.0 |
| Shale, clayey, maroon with buff streaks..... | 10.0 |
| Sandstone, brown, medium grained, cross bedded. | 8.0 |
| Covered interval, probably shale. About..... | 20.0 |
| Sandstone, tan, fine-grained, finely cross bedded and resistant..... | 3.0 |
| IV. Center sec. 15. In canyon that is immediately west of central power unit shed by the road in the SE 1/4 of the section. | |
| Lecompton limestone: (Avoca) | |
| Limestone, dense, shaly, dark gray and contains many Triticites and few Caninia torquia. It weathers to a dirty yellow surface..... | 0.8 |
| King Hills, covered..... | 4.0 |
| Lecompton limestone: (Bell) | |
| Limestone, impure, wavy bedded, light blue-gray, and weathers to a rough, light gray surface. Contains many large Caninia torquia and numerous Triticites. Approximately..... | 9.0 |
| KANWAKA SHALE: | |
| Shale, yellow-gray at top and grades into maroon shale at base..... | 13.0 |
| Sandstone, brown, impure, medium grained, sub-angular to sub-rounded, and cross-bedded... | 12.0 |
| Covered interval..... | 10.0 |
| Limestone, impure, gray, and very fossiliferous. Contains many Chonetes granulifer. Thin bedded..... | 0.6 |
| Covered interval..... | 4.0 |
| Sandstone, very similar to above sandstone..... | 21.0 |
| Covered interval, probably shale..... | 16.0 |
| Sandstone, similar to above sandstone..... | 18.0 |
| Shale, similar to above shale..... | 21.0 |
| Sandstone, similar to above sandstone..... | 25.0 |
| Shale, dark gray, platy..... | 6.0 |
| Covered interval..... | 18.0 |
| OREAD FORMATION: | |
| Plattsmouth limestone: | |
| Limestone, dense, gray, wavy bedded. Dark gray shale stringers come in between the limestone | |

| | Feet |
|---|---|
| beds at the base. This exposure of the Platts-mouth greatly resembles the Deer Creek..... | 23.0 |
| V. SW 1/4 sec. 22, along side of the road. | |
| Covered interval, not measured. | |
| Sandstone, cross-bedded, tan, medium to fine-grained..... | 3.0 |
| Limestone, impure, conglomeratic, algal, weathers to a dirty buff with blue spots..... | 0.5 |
| Covered interval..... | 2.5 |
| Limestone, dense, brittle, limonitic, brown, and packed with fossil fragments. Has a few Triticites. Badly slumped..... | 2.5 |
| Shale, yellow-brown with gray streaks..... | 10.0 |
| Lecompton limestone: (Beil) | |
| Limestone, gray, sandy, ferruginous, medium crystalline, and soft. Contains Triticites... | 1.2 |
| Limestone, slabby, wavy bedded, tan, and contains many fusulinids..... | 0.9 |
| Limestone, light blue-gray, wavy bedded, dense, weathers to a rough, light gray surface and contains many Caninia torquia and a few Triticites. About..... | 8.0 |
| KANWAKA SHALE: | |
| Shale, clayey, gray and buff with maroon streak near the base..... | 17.0 |
| Sandstone, thin-bedded at top and cross bedded at the base. Tan, impure, medium grained.. | 14.0 |
| Shale, sandy, yellow-gray, and clayey..... | 14.0 |
| Sandstone, thin bedded, tan, medium grained.... | 1.5 |
| Shale, buff and gray..... | 6.0 |
| Sandstone, thin-bedded, medium to fine grained. Weathers brown with limonitic stains..... | 15.0 |
| Shale, buff and gray..... | 11.0 |
| Sandstone, massive, tan, impure, medium to fine-grained..... | 36.0 |
| OREAD FORMATION: | |
| Plattsmouth limestone: | |
| Limestone, sandy, tan, limonitic, irregularly bedded at the top. It becomes less impure towards the base which is light blue gray, and wavy bedded. Fossils are numerous..... | 14.0 |
| Shale, clayey, yellow-gray, and sandy..... | 4.0 |
| T. 29 N., R. 8 E. | |
| VI. Center of sec. 17. Measured along east side of the stream. | |

| | Feet |
|---|---|
| STONEBREAKER FORMATION: | |
| Reading limestone: | |
| Limestone, dense, finely crystalline, dark gray-brown, contains many Triticites and numerous "Cryptozoon". Weathers to rust color. About | 1.7 |
| Covered interval, probably shale..... | 0.5 |
| Limestone, dense, brittle, dark gray-brown, finely crystalline. Weathers yellow-brown. Contains many Triticites. About..... | 1.5 |
| Covered interval, probably shale..... | 4.5 |
| Limestone, shaly, gray-brown, fossil fragments, and algal spots. Weathers dirty yellow.... | 1.6 |
| AUBURN SHALE: | |
| Shale, sandy, limonitic, and contains plant remains. Grades into micaceous siltstone at places. Often covered..... | 6.0 |
| Sandstone, base covered. Is fine grained, buff, micaceous, finely cross-bedded. It becomes calcareous at the top and darkens to brown near the base. This is a very persistent sandstone and forms a small ledge. Exposed | 5.0 |
| Covered interval, probably shale..... | 6.0 |
| Limestone, thin, sandy, gray, and full of branching bryzoans. Not measured. | |
| Covered interval, probably shale..... | 4.0 |
| Limestone, thin, dense, lithographic, light blue, and contains a few Myalina, bryzoans and brachiopods. Not measured. | |
| Covered interval, probably shale..... | 5.0 |
| Limestone, thin shaly, dark gray. Weathers light blue-gray with yellow splotches. Contains many Myalina and a few small gastropods. Not measured. | |
| Covered interval, probably shale..... | 10.0 |
| WAKARUSA LIMESTONE: | |
| Limestone, shaly, brown, and weathers to a rough, nodular, yellow surface with blue-gray splotches. Appears to be of algal origin and has a thin shale parting near the middle..... | 2.0 |
| Shale, grayish-yellow, calcareous, clayey, and fossiliferous..... | 7.0 |
| Limestone, shaly, dull gray, contains numerous Myalina, and weathers to a dirty yellow.... | 0.9 |
| Shale, grayish-yellow, calcareous, clayey, and fossiliferous..... | 9.0 |
| Limestone, dense, brittle, dull gray and contains many "Cryptozoon". Weathers tan with a few limonitic streaks..... | 0.9 |

| | Feet |
|---|---|
| Covered interval, probably shale..... | 0.3 |
| Limestone, dense, brittle, dark gray turning brown near the top, and contains numerous large Triticites. Weathers to a dirty yellow | 2.0 |
| Covered interval, probably shale. About..... | 4.0 |
| BURLINGAME LIMESTONE: | |
| Limestone, light gray, medium crystalline, and full of fine fossil fragments..... | 1.2 |
| Covered interval, probably shale..... | 3.3 |
| Limestone, dense, impure, brown, weathers to a brownish-yellow. Few fossil fragments of larger size than in above limestone and few bryzoan..... | 1.5 |
| Covered interval. About..... | 5.0 |
| Sandstone, micaceous, calcareous, fine-grained. | 0.6 |
| Limestone, coquinoid, tan..... | 0.4 |
| Shale, gray, has small concretions of limestone | 0.5 |
| Limestone, brown to gray, dense, impure, weathers to bright brownish-yellow. Contains numerous Myalina, gastropods, and a few cephalopods and brachiopods. Forms a distinct ledge at this exposure. Is slightly conglomeratic at the top..... | 3.0 |
| SILVER LAKE SHALE: | |
| Siltstone, gray and buff, micaceous, plant remains..... | 4.0 |
| Sandstone, tan, shaly, fine to medium grained.. | 1.5 |
| Siltstone, same as above but with a few shale lenses..... | 18.0 |
| RULO LIMESTONE: Dark gray, dense, pebbly, and shaly. | 0.7 |
| CEDAR VALE SHALE: | |
| Coal (Elmo), thin, smutty, disappears in places | 0.1 |
| Shale and siltstone, gray and buff, sandy, micaceous. Base not exposed..... | 15.0 |

VII. SE 1/4 sec. 26. Measured along Smith Creek.

| | |
|---|---|
| PAWHUSKA FORMATION: | |
| Pearsonia limestone: | |
| Limestone, dense, brittle, dark gray, weathers reddish-brown to a dirty yellow. Few fossils Vertically jointed..... | 2.9 |
| Shale: | |
| Shale, grayish-yellow, sandy, fossiliferous.... | 14.0 |
| Limestone, gray-brown, sandy, thin shale partings packed with Triticites. Very persistent..... | 2.0 |
| Shale, same as above..... | 10.0 |
| Limestone, sandy, shaly, gray, and contains | |

| | Feet |
|---|---|
| algal and fusulinids. Weathers light blue-gray to tan..... | 2.8 |
| Covered interval..... | 9.0 |
| Little Hominy limestone: | |
| Limestone, slabby, wavy bedded, gray to tan, slightly sandy, and splotched with rust.... | 7.0 |
| Shale: | |
| Covered interval, probably shale..... | 6.0 |
| Limestone, dense, brittle, dark gray-brown, weathers to a dirty yellow and gray and contains a few "Cryptozoon". Is blocky and resembles the Plummer limestone below..... | 1.5 |
| Covered interval, probably shale..... | 10.5 |
| Deer Creek limestone: | |
| Limestone, slabby, wavy bedded, dense, gray to tan, sandy at the top. Contains Triticites at places and forms a distinct escarpment.. | 14.0 |
| Shale: Dark gray to black, platy..... | 3.5 |
| Plummer limestone: | |
| Limestone, dense, brittle, dark gray, finely crystalline, weathers to a yellowish-gray and contains a few "Cryptozoon". Breaks up into sharp edged, angular blocks..... | 2.0 |
| Shale: | |
| Covered interval, probably shale..... | 11.0 |
| Limestone, sandy, shaly, nodular, slightly conglomeratic. May be of algal origin..... | 2.3 |
| Covered interval, probably shale..... | 8.0 |
| Sandstone, calcareous, tan, medium grained..... | 0.8 |
| Shale, clayey, gray-blue, maroon tinges at places | 7.0 |
| Lecompton limestone: (Beil) | |
| Limestone, poorly exposed, soft, impure, gray.. | 1.0 |
| Covered interval, probably shale..... | 0.5 |
| Limestone, wavy bedded at top and grades into a more massive bedding in the lower part. Dense, gray, slightly sandy, and weathers to a rough, light gray surface. Numerous Caninia torquia. Not measured. | |

VIII. West-central part of sec. 32. Measured along Buck Creek.

| | |
|---|---|
| BURLINGAME LIMESTONE: | |
| Limestone, lower bed of Burlingame. Top part is dense, brown, shaly, and weathers yellow-brown. Contains numerous gastropods. The base is dense, shaly, gray, and weathers to a light gray. Contains many fossil fragments | 3.0 |
| Covered interval..... | 19.0 |

| | Feet |
|---|---|
| Sandstone, tan, soft, medium grained..... | 1.5 |
| Covered interval..... | 18.0 |
| HAPPY HOLLOW LIMESTONE: | |
| Limestone, poorly exposed. Is gray, shaly, sandy, soft, and weathers to a light blue-gray. Top may be of algal origin..... | 1.5 |
| WHITE CLOUD SHALE: | |
| Shale, clayey, yellow-gray. Contains many marine fossils..... | 6.0 |
| Shale, maroon and gray..... | 8.0 |
| Sandstone, brown, shaly, medium grained, cross bedded..... | 7.0 |
| Shale, very sandy at top but grades downward into a yellow-gray shale which in turn grades downward into a blue-gray shale..... | 13.0 |
| Covered interval..... | 20.0 |
| BIRD CREEK LIMESTONE: | |
| Limestone, dense, dark gray, slightly shaly, and contains a few Triticites. Weathers to a dirty yellow..... | 0.8 |
| Shale, clayey, yellow..... | 1.5 |
| Limestone, dense, brittle, dark gray, weathers to a dirty yellow and contains a few Triticites. Resembles the above limestone..... | 1.7 |
| Shale: Only top part exposed. Is dark blue-gray and contains a dark, carboniferous streak near the top that contains plant remains..... | 6.0 |

IX. NE 1/4 sec. 36. Measured on bluff near stream.

| | |
|---|---|
| Lecompton limestone: (Bell) | |
| Limestone, gray, shaly, irregularly bedded, and packed with Triticites..... | 1.0 |
| Limestone, similar to above but is sandy and has many fossil fragments..... | 0.8 |
| Shale, clayey, yellow-gray, and has a buff and pink marl at the top..... | 1.2 |
| Limestone, gray, massive bedded, sandy, weathers to a rough, pitted, light blue-gray surface. Many Caninia torquia, Syringopora multattenuata, and Lophophyllidium occur at the base and diminish in number towards the top. Triticites are common near the middle and also diminish towards the top which is very sandy..... | 8.5 |
| KANWAKA SHALE: | |
| Shale, dark gray and platy..... | 2.0 |
| Sandstone, tan, medium, cross bedded..... | 2.0 |

T. 28 N., R. 9 E.

| | Feet |
|---|---|
| X. NE 1/4 sec. 5. Measured in small tributary of North Fox Creek. | |
| PAWHUSKA FORMATION: | |
| Shale: | |
| Covered interval. Not measured. | |
| Limestone, dense, brittle, finely crystalline, dark gray, few "Cryptozoon". Weathers to a dirty yellow. Similar to Plummer limestone | 1.5 |
| Covered interval. Probably shale..... | 13.0 |
| Deer Creek limestone: | |
| Limestone, dark gray-brown, medium crystalline, few Myalina and weathers to a yellow-brown. | 0.9 |
| Covered interval, probably shale..... | 0.5 |
| Limestone, dense, gray to tan, slabby, wavy-bedded, slightly sandy, splotched with rust, few Triticites..... | 14.0 |
| Covered interval, probably shale..... | 4.0 |
| Plummer limestone member: | |
| Limestone, dense, brittle, dark gray, vertically jointed with rhombohedral striations on its surface. Weathers dirty-yellow..... | 1.8 |
| Shale: | |
| Covered interval, probably shale..... | 11.0 |
| Limestone, sandy, shaly, algal spots..... | 2.5 |
| Covered interval, probably shale..... | 8.0 |
| Shale, clayey, maroon..... | 9.0 |
| Lecompton limestone: (Beil) | |
| Limestone, poorly exposed. Gray to brown, sandy, weathers yellow-brown..... | 2.5 |
| Covered interval, probably shale..... | 1.0 |
| Limestone, massive to wavy bedded, gray to buff, slightly sandy at top and weathers to a light-blue gray at the base and a yellow-brown at the top. Contains few Caninia torquia and Triticites..... | 9.0 |
| KANWAKA SHALE: | |
| Covered interval, probably shale..... | 6.0 |
| Sandstone, impure, medium grained, tan..... | 3.5 |
| Covered interval, probably shale..... | 3.0 |
| Sandstone, cross-bedded, limonitic, medium grained, brown..... | 18.0 |
| Covered interval, about..... | 5.0 |
| Limestone, gray, sandy, fossiliferous, platy... | 0.6 |
| Covered interval, about..... | 1.0 |
| Sandstone, similar to thick sandstone above.... | 30.0 |

| | Feet |
|---|---|
| XI. SE 1/4 sec. 15. Measured along the ranch road that goes to the top of the hill. | |
| PAWHUSKA FORMATION: | |
| Lecompton limestone: (Beil) | |
| Limestone, not measured. | |
| KANWAKA SHALE: | |
| Covered interval, probably shale | 9.0 |
| Sandstone, brown, medium grained, cross bedded. | 6.0 |
| Covered interval, probably shale | 6.0 |
| Sandstone, same as the above sandstone | 5.0 |
| Covered interval, probably shale | 19.0 |
| Sandstone, same as above sandstone | 3.0 |
| Covered interval, probably shale | 8.0 |
| Sandstone, same as above sandstone | 22.0 |
| Covered interval | 3.0 |
| Sandstone, same as above sandstone | 19.0 |
| Covered interval | 6.0 |
| OREAD FORMATION: | |
| Plattsmouth limestone: | |
| Limestone, shaly, dark gray-brown, packed with Triticites. Weathers light gray-brown | 2.5 |
| Heebner shale: | |
| Covered interval, probably shale | 7.5 |
| Sandstone, poorly exposed. Same as above | 4.0 |
| Covered interval | 36.0 |
| Sandstone, same as above sandstones | 3.0 |
| Covered interval, probably shale | 8.0 |
| Leavenworth limestone: | |
| Limestone, dense, dark gray, brittle, vertically jointed, and many Triticites. Weathers grayish-yellow | 1.7 |
| XII. NE 1/4 sec. 29. Measured in small tributary of Pond Creek. | |
| PAWHUSKA FORMATION: | |
| Plummer limestone: | |
| Limestone, dense, finely crystalline, dark gray-brown, and weathers yellow-gray. Outcrop marked by sharp edged blocks | 1.5 |
| Shale: | |
| Shale, clayey, blue-gray, fossiliferous | 12.0 |
| Sandstone, very calcareous, gray, weathers to a rough, ragged surface | 1.5 |
| Shale, clayey, maroon at base and gray at the top | 12.0 |
| Lecompton limestone: (Beil) | |
| Limestone, dense, impure, blue-gray to brown, and contains many Triticites and Caninia | |

| | Feet |
|---|---|
| torquia. Top weathers to a yellow-brown and base weathers to a light gray, pitted surface | 3.5 |
| Shale, clayey, blue-gray | 4.5 |
| Limestone, dense, impure, light blue-gray and contains many large Caninia torquia. Weathers to a rough, pitted light gray surface | 4.0 |
| Shale, clayey, blue-gray | 6.0 |
| Sandstone, calcareous, buff, fine to medium grained, laminated. Weathers yellow-buff | 1.0 |
| KANWAKA SHALE: | |
| Covered interval, probably shale | 11.0 |
| Sandstone, cross bedded, tan, ferruginous, medium grained. Base not exposed | 17.0 |

T. 28 N., R. 8 E.

XIII. NE 1/4 sec. 2. Measured along the stream in this area.

| | |
|---|---|
| PAWHUSKA FORMATION: | |
| Pearsonia limestone: | |
| Limestone, dense, silty, dark gray, platy at the top and weathers rust-brown | 2.9 |
| Shale: | |
| Shale, calcareous, fossiliferous, blue-gray with thin buff streaks | 13.0 |
| Limestone, gray-brown, shaly, and contains thin shale lentils. Packed with Triticites | 2.0 |
| Covered interval | 1.0 |
| Sandstone, calcareous, medium to fine grained | 1.5 |
| Covered interval, probably shale | 1.5 |
| Little Hominy limestone: | |
| Limestone, sandy, ferruginous, gray, weathers brown | 1.0 |
| Limestone, gray, slightly conglomeratic, sandy, and contains many small algal pellets | 1.5 |
| Limestone, dense, shaly, light blue-gray | 2.5 |
| Shale, yellow-gray, clayey | 7.0 |
| Limestone, wavy bedded, slightly sandy, gray, and splotched with rust. Weathers light gray | 12.0 |
| Shale: | |
| Shale, platy, black to dark gray | 2.0 |
| Limestone, dense, dark gray, and contains many Cryptozoon. Weathers dirty yellow | 1.2 |
| Covered interval, probably shale | 10.0 |
| Deer Creek limestone: | |
| Limestone, dense, dark gray, Myalina numerous, and weathers rust-brown | 0.9 |

| | Feet |
|---|---|
| Shale, clayey, gray | 2.5 |
| Limestone, slabby, wavy bedded, gray to tan, and splotched with rust. Becomes more massive bedded towards the base | 16.0 |
| Shale: Dark gray to black. Platy | 4.0 |
| Plummer limestone: | |
| Limestone, dense, dark gray, blocky, weathers yellow-gray | 1.8 |

XIV. Center sec. 2. Measured up side of bluff next to the stream in this area.

| | |
|---|---|
| Sandstone, blocky, ferruginous, medium grained, weathers brown | 2.0 |
| Covered interval, probably shale | 3.0 |
| PAWHUSKA FORMATION: | |
| Pearsonia limestone: | |
| Limestone, silty, dark gray, dense, blocky, platy at top, and weathers to a rust brown. | 2.8 |
| Shale: | |
| Covered interval, probably shale | 8.0 |
| Limestone, dark gray-brown, shaly and contains thin shale lentils. Packed with thin Triticites | 2.0 |
| Shale, clayey, yellow-gray, fossiliferous | 9.0 |
| Little Hominy limestone: | |
| Limestone, dense, sandy, shaly, brown at top changing to gray at base. The middle is very sandy and ferruginous, and the lower part is slightly conglomeratic and contains algae. | 8.0 |
| Shale, yellow-gray | 5.0 |
| Limestone, wavy bedded, slightly sandy, gray, and splotched with rust. Weathers light gray | 12.0 |
| Shale: | |
| Shale, platy, dark gray to black | 1.5 |
| Limestone, dense, dark gray, contains many "Cryptozoon" and weathers yellow-gray | 1.2 |
| Shale, yellow-gray, fossiliferous | 7.0 |

XV. Central part sec. 3. Measured along road in the area.

| | |
|---|---|
| BIRD CREEK LIMESTONE: | |
| Limestone, dense, brittle, dark gray, and weathers to a yellow-gray. Not measured. | |
| Covered interval, probably shale. About | 3.0 |
| Limestone, dense, brittle, dark gray, few Triticites, and weathers to yellow-gray | 1.8 |

| | Feet |
|---|---|
| SEVERY SHALE: | |
| Covered interval. About | 1.0 |
| Sandstone, cross bedded, tan, medium grained | 4.0 |
| Shale, sandy, yellow-gray | 15.0 |
| Sandstone, same as the above sandstone | 3.0 |
| Shale, sandy, yellow-gray | 44.0 |
| FAWHUSKA FORMATION: | |
| Turkey Run limestone: | |
| Limestone, platy, shaly, dull gray, fossiliferous weathers to yellow-gray | 0.9 |
| Shale: | |
| Shale, sandy, yellow-gray, fossiliferous | 6.0 |
| Limestone, gray, conglomeratic, algae remains, and numerous Myalina. Weathers yellow-gray | 1.5 |
| Shale, calcareous, gray-brown | 8.0 |
| Sandstone, blocky, tan, medium grained, weathers brown | 5.0 |
| Covered interval, probably shale | 10.0 |
| Pearsonia limestone: | |
| Limestone, slightly silty, dense, dark gray-brown platy at the top, and weathers to rust-brown | 2.5 |

XVI. Center sec. 18. Measured where Stonebreaker crosses South Buck Creek.

| | |
|---|---|
| STONEBREAKER FORMATION: | |
| Reading limestone: | |
| Covered interval. Not measured. | |
| Limestone, dense, dark gray-brown, and weathers to a rust color. Contains many bryzoans and "Cryptozoon" and a few Triticites | 0.4 |
| Shale, yellow-gray, fossiliferous | 0.2 |
| Limestone, dense, gray, blocky, and weathers yellow-gray. Numerous "Cryptozoon" and many Triticites occur in this bed | 1.2 |
| Shale, calcareous, gray, fossiliferous | 0.6 |
| Limestone, dense, blocky, gray, finely crystalline, and weathers yellow-gray. Contains numerous Triticites, especially in upper part | 3.2 |
| Shale, buff and gray | 1.6 |
| Coal, smutty | 0.3 |
| Shale, poorly exposed, yellow-gray | 1.5 |
| Limestone, shaly, nodular, gray-brown, weathers to yellow-brown. May be algal | 1.0 |

XVII. SE 1/4 sec. 15. Measured along road and up the side of the hill on the west side of the road.

| | Feet |
|---|---|
| STONEBREAKER FORMATION: | |
| Reading limestone: | |
| Limestone, dense, gray, weathers light blue-gray and contains numerous Triticites. Not measured. | |
| AUBURN SHALE: | |
| Covered interval | 6.0 |
| Sandstone, calcareous, fossiliferous at the top, fine grained, laminated, buff, resistant | 4.0 |
| Shale, sandy, yellow-gray | 30.0 |
| Limestone, dense, brittle, dark gray, full of Myalina fragments and weathers yellow-gray. | 1.2 |
| Shale, fossiliferous, yellow-gray | 10.0 |
| WAKARUSA LIMESTONE: | |
| Limestone, gray, medium crystalline, sandy, and full of crinoid and other fossil fragments. | 2.5 |
| Covered interval, probably shale | 13.0 |
| Limestone, dense, dark gray, brittle, few fossil fragments and many large "Cryptozoon". Weathers dirty yellow | 1.2 |
| Covered interval | 6.0 |
| BURLINGAME LIMESTONE: | |
| Limestone, gray, speckled with rust, finely ground fossil fragments | 2.5 |
| Covered interval, probably shale | 8.0 |
| Limestone, gray, shaly, thin bedded and packed with Myalina | 0.5 |
| Silverlake Shale: | |
| Calcareous, gray, full of Myalina | 11.0 |
| RULO LIMESTONE: | |
| Limestone, dense, brown, fossiliferous, and weathers yellow-brown | 1.5 |
| Shale: | |
| Covered interval, probably shale | 2.0 |
| Coal, smutty, impure | 0.2 |
| Limestone, conglomeratic, fossiliferous, sandy, shaly, limonitic, and contains numerous pieces of oxidized wood | 2.5 |
| Covered interval | 4.0 |
| Sandstone, blocky, impure, medium grained, calcareous in places, and weathers to brown | 4.0 |
| Shale, sandy, yellow-gray. Approximately | 10.0 |
| Covered interval, probably shale | 13.0 |
| Sandstone, similar to the above sandstone | 2.0 |
| Covered interval | 9.0 |
| BIRD CREEK LIMESTONE: | |
| Limestone, dense, dark gray, slightly fossiliferous, weathers yellow-gray. Not measured. | |

| | Feet |
|---|---|
| Covered interval, about..... | 3.0 |
| Limestone, dense, brittle, dark gray-brown, few Triticites, and weathers yellow-gray... | 1.5 |

XVIII. Measured along stream that runs through the southern part of sections 23 and 24.

| | |
|---|---|
| BURLINGAME LIMESTONE (?): | |
| Covered interval, not measured. | |
| Limestone, dense, brittle, gray and buff, slabby, weathers to a smooth, yellow-brown and gray surface. Contains numerous, well-preserved brachiopods, especially Composita subtilata | 3.0 |
| Covered interval. Approximately..... | 2.0 |
| Limestone, appears to be a short lentil. Thin bedded, dark gray, sandy, full of fine fossil fragments, and weathers yellow-gray | |
| Covered interval..... | 18.0 |
| RULO LIMESTONE (?): | |
| Limestone, dense, brittle, brown, and weathers to a rough, pebbly, gray surface. Contains a few large gastropods..... | 1.5 |
| Covered interval..... | 10.0 |
| Sandstone, cross bedded, tan, medium grained..... | 6.0 |
| Covered interval..... | 24.0 |
| BIRD CREEK LIMESTONE: | |
| Limestone, dense, blocky, dark gray, weathers to yellow-gray..... | 0.5 |
| Covered interval, probably shale..... | 1.0 |
| Limestone, dense, blocky, dark gray, contains a few "Cryptozoon" and Triticites. Weathers yellow-gray..... | 1.6 |
| SEVERY SHALE: | |
| Covered interval, probably shale..... | 16.0 |
| Sandstone, cross bedded, impure, medium grained, and weathers brown..... | 6.0 |
| Covered interval..... | 4.0 |
| Sandstone, same as above sandstone..... | 23.0 |
| Sandstone and shale. This part of the section is composed of thin alternating beds of sandstone and sandy gray and buff shale. It becomes sandier towards the top and more shaly towards the base..... | 7.0 |
| Shale, sandy, yellow-gray..... | 8.0 |
| Sandstone, blocky, impure, medium grained, tan. | 2.0 |
| Shale, gray and yellow-gray, clayey, fossiliferous, and contains many Chonetes granulifer, and crinoid fragments..... | 3.5 |

| | Feet |
|---|---|
| PAWHUSKA FORMATION: | |
| Turkey Run limestone: | |
| Limestone, dense, shaly, platy, dark gray, and contains numerous fossils and fossil fragments. Weathers yellow-gray..... | 0.8 |
| Shale: Dark gray to black at the top and grades downwards into a gray, calcareous shale near the middle. This in turn grades downwards into a clayey, maroon shale which at the very base, resembles the shale at the very top. | |
| Pearsonia limestone: | |
| Limestone, dense, brittle, blocky, platy at the top, dark gray-brown, and weathers to a yellow-tan..... | 3.0 |
| Shale: | |
| Shale, clayey, yellow-gray, fossiliferous..... | 10.0 |
| Limestone, shaly, gray-brown, thin shale lentils, slumps considerably, packed with Triticites | 1.5 |
| Covered interval, probably shale..... | 4.0 |
| Sandstone, brown, blocky, medium grained..... | 5.0 |
| Covered interval, probably shale..... | 6.0 |
| Little Hominy limestone: | |
| Limestone, shaly, gray and tan, pebbly, sandy and platy in places, and weathers to a light blue-gray and buff. Part of this unit appears to be of algal origin..... | 4.0 |
| Covered interval, probably shale..... | 6.0 |
| Limestone, slabby, irregularly bedded, gray, and splotched with rust. Weathers to a rough, light blue-gray surface. Numerous Triticites, "Cryptozoon", Amblysiphonella prosseri, and brachiopods are found near the base..... | 8.0 |
| Shale: | |
| Covered interval, probably shale..... | 10.0 |
| Limestone, dense, dark gray, blocky, contains many "Cryptozoans". Weathers dirty yellow. | 1.0 |
| Covered interval, probably shale..... | 2.5 |
| Deer Creek limestone: | |
| Limestone, dense, dark gray-brown, and contains many Myalina that have been replaced by coarsely crystalline calcite. Weathers to a dirty brown and yellow..... | 1.5 |
| Covered interval, probably shale..... | 2.5 |
| Limestone, sandy, limonitic, massive bedded, gray and contains a few gastropods and brachiopods..... | 6.0 |
| Limestone, slabby, wavy bedded, gray-blue, and splotched with rust. Fossils are scarce... | 6.0 |

| | Feet |
|---|---|
| Limestone, wavy to massive bedded, dense, blue-gray. Weathers light gray. *Triticites* are common | 7.0 |

XIX. NE 1/4 sec. 31. Measured along Sand Creek.

STONEBREAKER FORMATION:

Elmont limestone:

| | |
|---|---|
| Limestone, dense, brown, wavy bedded, and weathers to a bright yellow-brown. Contains numerous brachiopods, bryzoans, and crinoid stems near the base | 2.3 |
| Covered interval, probably shale | 6.0 |
| Limestone, shaly, gray, and weathers light blue-gray splotched with rust. Contains "*Cryptozoon*", *Triticites*, and fossil fragments | 0.5 |

Harveyville shale:

| | |
|---|---|
| Shale, calcareous, dark gray | 5.0 |
| Coal, impure | 0.2 |
| Clay, dark blue-gray, limonitic streaks, slightly shaly | 0.6 |
| Shale, calcareous, gray | 2.0 |

Reading limestone:

| | |
|---|---|
| Limestone, shaly, sandy, and weathers to a rough, pebbly surface. The upper part is a light blue-gray and the lower part is buff. Appears to be partially of algal origin and contains numerous fossil fragments | 1.0 |
| Covered interval, probably shale | 10.0 |
| Limestone, dense, vertically jointed, brown, and weathers to a gray surface splotched with rust. It contains numerous large *Triticites* and "*Cryptozoon*". A tendency was noted in the top 0.6 of a foot to be platy and to separate from the basal part | 2.0 |
| Shale, clayey, blue-gray | 0.5 |
| Limestone, dense, brittle, gray, slightly sandy, and contains finely ground fossil fragments. Weathers gray-buff | 1.5 |
| Shale, poorly exposed, dark blue-gray, and contains a thin, smutty coal bed near the middle | 2.0 |
| Limestone, slightly sandy, gray-brown, and is full of finely ground fossil fragments. Contains a few *Wyalina* and *Juresania nebrascensis* | 1.0 |
| Limestone, shaly, buff, and contains numerous blue-gray algal spots | 1.3 |

| | Feet |
|---|---|
| XX. Center sec. 32. Measured from the point that the Wakarusa crosses Sand Creek, westward, to the top of the hill. The section below the Wakarusa was measured in the SE 1/4 of the section. | |
| STONEBREAKER FORMATION: | |
| Reading limestone member: | |
| Limestone, badly slumped, not measured. | |
| AUBURN SHALE: | |
| Covered interval. Approximately..... | 12.0 |
| Sandstone, calcareous, buff, fine grained, laminated. Only the top is exposed..... | 3.0 |
| Covered interval..... | 16.0 |
| Limestone, dense, brittle, dark gray, and weathers yellow-gray. Contains numerous Myalina..... | 1.2 |
| Covered interval..... | 12.0 |
| Limestone, sandy, brown to tan, thin bedded, full of finely ground fossil fragments. Weathers to a dirty blue-gray with yellow blotches.. | 3.0 |
| Shale, clayey, maroon..... | 2.0 |
| Shale, yellow-gray, contains crinoids and brachiopods..... | 12.0 |
| WAKARUSA LIMESTONE: | |
| Limestone, dense, brittle, dull, dark gray, and weathers to a yellow-gray. Contains numerous Crurithyris planoconvexa, Triticites, and fossil fragments..... | 0.6 |
| Shale, clayey, dark gray..... | 0.3 |
| Limestone, dense, brittle, dark brown-gray, and weathers to a yellow-gray. Contains a few "Cryptozoon" near the middle..... | 1.1 |
| SOLDIER CREEK SHALE: | |
| Shale, blue-gray, sandy near the top..... | 1.0 |
| Coal, shaly, impure..... | 0.2 |
| Shale, clayey, blue-gray. Limonitic streaks... | 7.0 |
| BURLINGAME LIMESTONE: | |
| Limestone, poorly exposed, sandy, limonitic, dark gray on fresh surface but turns brown near the surface. Weathers to a yellow-brown and tan. Is full of finely ground fossil fragments and contains a few Myalina. Contains a few shale intervals..... | 6.0 |
| Covered interval..... | 20.0 |
| Sandstone: | |
| Sandstone, impure, cross bedded, medium grained | 4.0 |
| Shale, sandy, yellow-gray..... | 5.0 |
| Sandstone, same as the above sandstone but more shaly..... | 11.0 |

| | Feet |
|---|---|
| Shale, sandy, yellow-gray..... | 4.0 |
| Sandstone, only top exposed, same as the above. | 5.0 |

T. 27 N., R. 9 E.

XXI. South-central part of sec. 1. Measured in a canyon which runs east-west through this part of the area.

PAWHUSKA FORMATION:

Lecompton limestone: (Bell)

Limestone, poorly exposed, gray to brown, weathers yellow-brown. Contains few Triticites and Ganinia torquia. Not measured.

KANWAKA SHALE:

| | |
|---|---|
| Covered interval, probably shale..... | 4.0 |
| Sandstone, tan, impure, medium grained..... | 5.0 |
| Covered interval, probably shale..... | 6.0 |
| Sandstone, cross bedded, tan, medium grained and weathers brown..... | 8.0 |
| Covered interval..... | 2.0 |
| Sandstone, same as the sandstone just above it. | 1.0 |
| Covered interval..... | 17.0 |
| Sandstone, same as the above sandstone..... | 6.0 |
| Covered interval..... | 10.0 |
| Sandstone, same as the above, but slightly softer..... | 52.0 |
| Covered interval..... | 3.0 |
| Sandstone, thin bedded, medium grained, slightly calcareous, with dark gray shale separating the beds near the base..... | 15.0 |
| Covered interval. Approximately..... | 15.0 |
| Shale, sandy, yellow-gray..... | 30.0 |

OREAD FORMATION:

Leavenworth limestone:

| | |
|---|---|
| Limestone, dense, brittle, dark gray-brown, and weathers yellow-gray. Contains numerous Triticites..... | 1.5 |

XXII. NW 1/4 sec. 3, and NE 1/4 sec. 4. Measured along the stream that runs through this area.

PAWHUSKA FORMATION:

| | |
|---|---|
| Limestone, dark gray, dense, blocky, weathers dirty yellow. Contains a few Triticites and "Cryptozoon"..... | 1.0 |
| Covered interval..... | 3.0 |

Deer Creek limestone:

| | |
|---|---|
| Limestone, badly slumped, similar to the above limestone, but contains only fossil fragments..... | 1.0 |

| | Feet |
|---|---|
| Covered interval, probably shale..... | 1.0 |
| Limestone, slabby, wavy bedded, blue-gray, slightly sandy near the top, and the base is more massive bedded. Weathers to a light gray, rust splotched surface. Few Triticites found..... | 17.0 |
| Covered interval, probably shale..... | 7.0 |
| Plummer limestone: | |
| Limestone, dense, blocky, dark gray, weathers yellow-gray..... | 1.2 |
| Shale: | |
| Covered interval, probably shale..... | 7.0 |
| Sandstone, calcareous, tan and gray, fine grained to medium grained, and weathers to ragged surface. Varies in thickness..... | 6.0 |
| Shale, sandy, yellow-gray..... | 11.0 |
| Sandstone, thin, tan, medium grained. Not measured. | |
| Covered interval, probably shale..... | 5.0 |
| Lecompton limestone: (Bell) | |
| Limestone, shaly, sandy, brown, dense, fossil fragments, and weathers to a bright yellow. | 2.5 |
| Covered interval, probably shale..... | 1.0 |
| Limestone, dense, brown, contains many Triticites and large Caninia torquia. Weathers yellow and gray..... | 2.0 |
| Shale, top part is calcareous and yellow-gray; the lower part is a clayey maroon shale.... | 3.0 |
| Sandstone, tan, medium to fine grained..... | 0.6 |
| Shale, clayey, yellow-gray..... | 1.5 |
| Limestone, shaly, sandy, brown. Surface is highly pitted and weathers yellow-brown. | |
| KANWAKA SHALE: | |
| Shale, clayey, maroon..... | 5.0 |
| Covered interval..... | 16.0 |
| Sandstone, tan, medium grained, slightly shaly, cross bedded, weathers brown..... | 24.0 |

XXIII. NW 1/4 sec. 29. Measured along the sides of the small tributary running into Sand Creek.

| | |
|---|---|
| PAWHUSKA FORMATION: | |
| Deer Creek limestone: | |
| Limestone, slabby to platy, tan to blue-gray, wavy bedded, sandy at the top. Weathers to a yellow-brown at the top and the rest weathers to a light gray splotched with rust..... | 20.0 |
| Covered interval, probably shale..... | 9.0 |
| Plummer limestone: | |

| | Feet |
|---|---|
| Limestone, dense, blocky, dark gray, weathers yellow-gray..... | 1.0 |
| Shale: | |
| Covered interval, probably shale..... | 6.0 |
| Limestone, very sandy, tan and gray, weathers ragged..... | 3.0 |
| Covered interval, probably shale..... | 9.0 |
| Sandstone, blocky, tan, medium grained..... | 1.0 |
| Limestone, purple to maroon, full of Triticites and crinoid stems..... | 0.3 |
| Shale, clayey, maroon..... | 4.0 |
| Lecompton limestone: (Bell) | |
| Limestone, dense, shaly, gray, and weathers to a light blue-gray surface spotted with rust. Contains a few Triticites..... | 1.5 |
| Covered interval, probably shale..... | 0.2 |
| Limestone, dense, brown, and contains many Triticites and a few Caninia torquia. Weathers bright yellow-brown..... | 2.0 |
| Covered interval. Approximately..... | 5.0 |
| Limestone, badly slumped, dense, brown, weathers to a rust color. Contains many crinoid fragments and numerous Triticites..... | 0.6 |
| KANWAKA SHALE: | |
| Sandstone and shale. This is a very interesting zone in that cyclic sedimentation on a small scale is very obvious. Approximately five cycles are shown here. Each cycle consists of maroon shale at the top underlain by blue-gray shale which is underlain by a thin sandstone unit. Under this sandstone occurs some more blue-gray shale which marks the base of the cycle..... | 23.0 |
| Sandstone, tan, limonitic, cross bedded, medium grained. A thin, sandy, fossiliferous, gray limestone occurs in this sandstone ten feet down from the top..... | 30.0 |

T. 27 N., R. 8 E.

XXIV. NE 1/4 sec. 13. Measured along the stream in this area to the top of the hill in the north-central part of the section.

| | |
|---|---|
| PAWHUSKA FORMATION: | |
| Turkey Run limestone: | |
| Limestone, shaly, dark gray, thin bedded, fossiliferous, and weathers yellow-gray..... | 1.0 |
| Shale: | |

| | Feet |
|---|---|
| Shale, clayey, yellow-gray, grading into maroon shale at the base | 25.0 |
| Covered interval | 5.0 |
| Pearsonia limestone: | |
| Limestone, dense, brittle, dark gray-brown, and weathers to a rust color | 2.5 |
| Shale: | |
| Covered interval, probably shale | 9.0 |
| Limestone, gray-brown, thin bedded, shaly, and packed with slender Triticites | 1.5 |
| Covered interval, probably shale | 15.0 |
| Little Hominy limestone: | |
| Limestone, shaly, gray-blue, weathers light gray | 0.5 |
| Covered interval, approximately | 1.0 |
| Limestone, shaly, blue-gray and tan, pebbly surface, appears to be partly of algal origin | 3.0 |
| Covered interval, probably shale | 5.0 |
| Limestone, slightly shaly, gray, weathers buff and light gray | 2.0 |
| Covered interval, about | 14.0 |
| Deer Creek limestone: | |
| Limestone, slabby, wavy bedded, blue-gray, sandy at the top, weathers to a light gray, rust splotched surface, except for the very top, which is yellow-brown | 18.0 |
| Covered interval, probably shale | 4.0 |
| Plummer limestone member: | |
| Limestone, dense, brittle, blocky, dark gray, weathers yellow-gray | 0.9 |
| Shale: | |
| Covered interval, probably shale | 8.0 |
| Sandstone, very calcareous, fine grained to medium grained. Weathers to a ragged surface. | 2.0 |
| Covered interval, probably shale | 10.0 |
| Lecompton limestone: | |
| Limestone, dense, brown, weathers yellow-brown. Contains many Triticites and a few Caninia torquia | 3.5 |
| Covered interval. Approximately | 3.0 |
| Limestone, same as the limestone above but more blocky | 0.5 |

XXV. SW 1/4 sec. 14, to the NE 1/4 sec. 23. Measured along Dry Creek.

BIRD CREEK LIMESTONE, badly slumped, not measured.

SEVERY SHALE:

| | |
|---|---|
| Covered interval | 10.0 |

| | Feet |
|---|---|
| Sandstone, tan, medium grained, cross bedded, only the top part is exposed | 4.0 |
| Covered interval | 8.0 |
| Sandstone, same as the above sandstone | 10.0 |
| Covered interval | 38.0 |
| PAWHUSKA FORMATION: | |
| Turkey Run limestone: | |
| Limestone, gray, slightly conglomeratic, blue-gray algal spots, and thin bedded | 0.8 |
| Shale: | |
| Covered interval | 6.0 |
| Sandstone, cross-bedded, medium grained, tan | 6.0 |
| Covered interval | 18.0 |
| Pearsonia limestone: | |
| Limestone, dense, massive, dark gray, and weathers platy near the top. Weathered surface is reddish-brown and silty. Contains a few large brachiopods and gastropods | 2.8 |
| Shale: | |
| Shale, sandy, buff and gray, slightly fossiliferous | 8.0 |
| Limestone, shaly, thin bedded, gray-brown, slumps badly, and is packed with Triticites | 2.0 |
| Covered interval, probably shale | 13.0 |
| Sandstone, calcareous, tan, medium grained | 4.0 |
| Little Hominy limestone: | |
| Limestone, shaly, blue-gray to tan, pebbly surface. Top part appears to be of algal origin | 3.0 |
| Shale, yellow-gray, fossiliferous | 9.0 |
| Limestone, shaly, dark gray, weathers dirty yellow. Contains a few Triticites | 1.0 |
| Shale: | |
| Shale, sandy, yellow-gray, fossiliferous | 17.0 |
| Deer Creek limestone: | |
| Limestone, gray, sandy, thin bedded, limonitic, and contains many limonitic Myalina and gastropods | 2.0 |
| Limestone, massive bedded, gray, splotched with rust. Very few fossils | 2.0 |
| Limestone, very dense, almost lithographic, tan, platy | 6.0 |
| Limestone, slabby, wavy bedded, blue-gray, and splotched with rust. The top part contains many Triticites and the basal part contains a few corals, "Cryptozoon", and brachiopods | 10.0 |
| Shale: Only top part is exposed. Gray-buff at top and grades downwards into a dark blue-gray, very platy shale | 6.0 |

| | Feet |
|---|---|
| XXVI. Measured along Hickory Creek from the SW 1/4 sec. 16, to the SE 1/4 sec. 8. | |
| WAKARUSA LIMESTONE: | |
| Limestone, slightly sandy, gray, full of fossil fragments | 0.8 |
| Covered interval. Approximately | 0.2 |
| Limestone, dense, brittle, dark gray, many "Cryptozoon". Weathers yellow-gray | 1.2 |
| Covered interval | 10.0 |
| BURLINGAME LIMESTONE: | |
| Limestone, shaly, brown, limonitic, weathers rust-yellow with light blue spots | 1.5 |
| Covered interval | 11.0 |
| Limestone, shaly, gray, full Myalina fragments. | 1.0 |
| Silver Lake Shale: | |
| Covered interval, probably shale | 9.0 |
| Sandstone, calcareous, gray-brown, thin bedded. | 3.0 |
| Shale, gray, sandy, few limestone stringers | 5.0 |
| RULO LIMESTONE: | |
| Limestone, top part is brown, and weathers yellow and tan. Base is more dense, dark yellow brown, and contains numerous Neospirifer | 2.0 |
| CEDAR VALE SHALE: | |
| Shale, sandy, buff near the top. Middle is blue-gray, and base is a yellow and buff, shaly siltstone | 16.0 |
| Sandstone, shaly, tan, medium grained | 1.0 |
| Covered interval, probably shale | 5.0 |
| HAPPY HOLLOW LIMESTONE (?): | |
| Limestone, shaly, brown, weathers yellow-brown with light blue-gray spots | 1.0 |
| Covered interval | 3.0 |
| Limestone, shaly, gray, fossil fragments | 1.0 |
| WHITE CLOUD SHALE: | |
| Covered interval | 5.0 |
| Sandstone, cross bedded, tan, medium grained | 10.0 |
| Covered interval | 30.0 |
| BIRD CREEK LIMESTONE: | |
| Limestone, dense, brittle, dark gray-brown, platy near the top and is vertically jointed. Numerous Enteletes hemiplicata were found | 2.5 |
| XXVII. Measured in railroad cut in the south-central part of sec. 18. | |
| WAKARUSA LIMESTONE: | |
| Limestone, calcarenite, slightly sandy, cross-bedded, highly lenticular, gray-brown, and is full of crinoid fragments. Contains a few thin shale lentils | 12.0 |

| | Feet |
|---|---|
| Shale, gray-blue to yellow-gray. Varies in thickness | 1.5 |
| Limestone, dense, brittle, dark gray-brown, weathers yellow-gray. Contains numerous, large "Cryptozoon" | 1.2 |
| Shale: Clayey, blue-gray at top grading into yellow-gray in the lower part | 3.0 |
| BURLINGAME LIMESTONE: | |
| Limestone (Burlingame?), brown, impure, weathers to a rust color | 0.3 |
| Shale, yellow-gray | 7.0 |
| Limestone, shaly, sandy, brown, weathers yellow-brown | 2.0 |
| Covered interval | 33.0 |
| RULO LIMESTONE: | |
| Limestone, massive, dense, brittle, dark gray-brown at the base grading to brown near the top. Many fossils | 3.5 |
| CEDAR VALE SHALE (?): | |
| Shale, clayey, light blue-gray and buff | 3.0 |
| Coal, impure | 0.5 |
| Shale, sandy, light blue-gray and buff, base covered | 10.0 |

XXVIII. Measured in a canyon that occurs in the central part of sec. 19.

| | |
|---|---|
| STONEBREAKER FORMATION: | |
| Elmont limestone: | |
| Limestone, shaly, brown, weathers yellow-brown. Not measured. | |
| Covered interval | 9.0 |
| Limestone, dense, dark gray, weathers yellow-gray. Contains many large "Cryptozoon" | 1.0 |
| Harveyville shale: | |
| Covered interval, probably shale | 12.0 |
| Reading limestone: | |
| Limestone, shaly, gray and tan. Not measured. | |
| Shale, clayey, maroon | 7.0 |
| Limestone, dense, brittle, gray. Top is full of large Triticites and "Cryptozoon". The base contains only a few Triticites | 4.0 |
| Covered interval, probably shale. About | 1.0 |
| Limestone, badly slumped. Top is shaly, light gray-brown and weathers yellow-gray with blue spots (algal). Base is sandy, brown, and weathers to a bright rust color. About | 5.0 |
| AUBURN SHALE: | |
| Covered interval, probably shale | 25.0 |

| | Feet |
|---|---|
| Limestone, dense, brittle, dark gray, weathers yellow-gray and contains many Myalina..... | 1.0 |
| Sandstone, thin bedded, fine to medium grained, tan. Weathers brown..... | 3.0 |
| Shale, yellow-gray at the top, maroon near the middle, gray in the lower part, and dark gray at the base..... | 28.0 |
| WAKARUSA LIMESTONE: | |
| Limestone, dense, brittle, dark gray, weathers yellow-gray and contains many large "Cryptozoon"..... | 1.0 |
| Shale: Dark gray to black, bituminous..... | 4.0 |
| Covered interval..... | 8.0 |
| BURLINGAME LIMESTONE (?): | |
| Limestone, gray, finely ground fossil fragments weathers light gray..... | 1.0 |
| SILVER LAKE SHALE (?): | |
| Covered interval..... | 5.0 |
| Sandstone, tan, medium grained..... | 4.0 |
| Covered interval..... | 6.0 |
| RULO LIMESTONE: | |
| Limestone, massive, dense, pinkish-brown, weathers slabby and to a rust color..... | 2.0 |
| CEDAR VALE SHALE (?): | |
| Covered interval, probably shale..... | 1.0 |
| Coal, smutty..... | 0.2 |
| Covered interval, probably shale..... | 20.0 |
| HAPPY HOLLOW LIMESTONE (?): | |
| Limestone, gray-brown, weathers yellow-gray. Contains a few Triticites near the base and contains evidence of algal near the top.... | 2.5 |

XXIX. South-central part of sec. 20. Measured from the bed of North Bird Creek to the top of the hill south of the stream.

| | |
|---|---|
| AUBURN SHALE: | |
| Covered interval. Not measured. | |
| Limestone, dense, dark gray, weathers yellow-gray and full of Myalina..... | 1.0 |
| Covered interval..... | 4.0 |
| Sandstone, cross bedded, tan, medium grained... | 7.0 |
| Covered interval..... | 19.0 |
| WAKARUSA LIMESTONE: | |
| Limestone (Wakarusa?), slightly sandy, gray to brown, many fossil fragments..... | 3.0 |
| Covered interval..... | 12.0 |
| Limestone, dense, brittle, dark gray, few fossil fragments and many "Cryptozoon"..... | 1.5 |
| Covered interval..... | 10.0 |

| | Feet |
|---|---|
| Sandstone, cross bedded, tan, medium grained, impure. | 15.0 |
| Limestone, conglomeratic, spotted gray and buff..... | 0.5 |
| Covered interval..... | 5.0 |
| RULO LIMESTONE: | |
| Limestone, dense, brown, few fossils. Weathers to a dirty buff..... | 3.5 |
| CEDAR VALE SHALE: | |
| Covered interval, probably shale..... | 2.0 |
| Coal, smutty..... | 0.2 |
| Covered interval, probably shale..... | 15.0 |
| HAPPY HOLLOW LIMESTONE: | |
| Limestone, slabby, brown to tan, weathers buff on top part and blue-gray at base..... | 2.5 |
| WHITE CLOUD SHALE: | |
| Covered interval, probably shale..... | 5.0 |
| Sandstone, tan, medium grained..... | 3.0 |
| Covered interval..... | 7.0 |
| Sandstone, cross bedded, tan, medium grained... | 30.0 |
| Covered interval..... | 5.0 |
| BIRD CREEK LIMESTONE: | |
| Limestone, dense, massive, dark gray, blocky, weathers to a dirty yellow. Contains a few Enteletes hemiplicata..... | 3.0 |

XXX. SE 1/4 sec. 31. Measured from the bed of the small tributary, westward to the top of the hill.

| | |
|---|---|
| STONEBREAKER FORMATION: | |
| Reading limestone: | |
| Limestone, dense, gray, many Triticites. Badly slumped. Not measured. | |
| AUBURN SHALE: | |
| Covered interval. Estimated..... | 3.0 |
| Sandstone, tan, medium to fine grained, cross-bedded..... | 12.0 |
| Covered interval..... | 18.0 |
| Limestone, dense, brittle, dark gray, weathers yellow-gray. Contains many Myalina..... | 1.0 |
| Covered interval..... | 3.0 |
| Sandstone, cross bedded, medium grained, tan... | 7.0 |
| Covered interval..... | 5.0 |
| Sandstone, same as the above sandstone..... | 3.0 |
| Covered interval..... | 5.0 |
| WAKARUSA LIMESTONE: | |
| Limestone (Wakarusa?), slightly sandy, tan, weathers to light blue-gray. Contains a few brachiopods and is full of fossil fragments..... | 1.5 |

| | Feet |
|---|---|
| Covered interval, probably shale..... | 15.0 |
| Limestone, dense, brittle, blocky, dark gray, weathers dirty yellow and full of "Cryptozoon"..... | 1.0 |
| Covered interval..... | 5.0 |
| BURLINGAME LIMESTONE: | |
| Limestone, poorly exposed, tan, medium crystalline, fossil fragments. About..... | 0.5 |
| Covered interval..... | 7.0 |
| Limestone, shaly, brown, fossiliferous, weathers into gray slabs whose surface, at places, has an appearance of mud cracks. Is full of small gastropods, some Myalina, and a few light nodules of limestone (algal). | ? |
| Covered interval..... | 10.0 |
| RULO LIMESTONE (?): | |
| Limestone, dense, dark gray, brittle. Weathers into rough slabs of buff limestone. Contains a couple of thin shale intervals..... | 2.5 |

XXXI. Center sec. 36. Measured in the road cut on the west side of the road.

| | |
|---|---|
| PAWHUSKA FORMATION: | |
| Turkey Run limestone: | |
| Limestone, dark gray-brown, conglomeratic, weathers to a rough, light blue-gray and buff spotted surface (algal)..... | 0.9 |
| Shale: | |
| Covered interval..... | 4.0 |
| Sandstone, tan, medium grained, blocky..... | 6.0 |
| Covered interval, probably shale..... | 20.0 |
| Sandstone, similar to the above sandstone..... | 4.0 |
| Covered interval, probably shale..... | 5.0 |
| Pearsonia limestone: | |
| Limestone, dense, brittle, dark gray-brown. Lower part is massive bedded and the upper is wavy bedded and slabby. Weathers to a rust color..... | 3.0 |
| Shale: | |
| Shale, clayey, gray-brown. Fossiliferous..... | 6.0 |
| Limestone, slightly shaly, gray-brown, and weathers to a dirty buff. Packed with Triticites. | |
| Shale, maroon at base and grades upwards into a yellow-gray, fossiliferous shale..... | 14.0 |
| Little Hominy limestone: | |
| Limestone, dense, wavy bedded, light gray-brown, slightly sandy. Very top is spotted with | |

Feet

light gray and brown nodules (algal). Base is full of finely ground fossil fragments.. 6.0
Shale, yellow-gray and buff..... 10.0
Limestone, gray, dense, fossiliferous, weathers buff..... 1.5
Covered interval..... 18.0
Deer Creek limestone:
Limestone, gray, slightly sandy, weathers light gray. The surface is highly pitted due to solution cavaties..... 2.0
Limestone, slabby, wavy bedded, dense, gray, and splotched with rust. Triticites are numerous in certain zones..... 10.0
Limestone, similar to overlying limestone, but more compactly bedded. Weathers dirty gray 6.0

## Measured Sections Taken Outside the Area.

### T. 35 S., R. 10 E. (Kansas)

XXXII. Measured in valleys along side the road which is one mile north of Elgin, Kansas in sec. 10.

PAWHUSKA FORMATION:
Deer Creek limestone:
Limestone, slabby, wavy bedded, gray to tan, weathers to a rust splotched light gray surface. Several "Cryptozoon" and gastropods were found near the base. Not measured.
Covered interval, probably shale..... 3.0
Plummer limestone:
Limestone, blocky, dense, brittle, dark gray, weathers to a yellow-gray..... 2.0
Shale:
Covered interval, probably shale..... 7.0
Sandstone, cross bedded, slabby, medium to fine grained, impure..... 6.0
Limestone conglomerate, very sandy matrix, not present in places. Varies in thickness.... 0.5
Shale, maroon with thin lentils of sandy, buff shale and sandstone..... 18.0
Lecompton limestone:(Avoca)
Limestone, dull dark gray, dense, blocky, weathers yellow-gray. Contains numerous Triticites, Caninia torquia, "Cryptozoan", and Amblysiphonella prosseri. About..... 1.0
Covered interval..... 5.0
Lecompton limestone: (Beil)
Limestone (Beil?), shaly, nodular, manganese dendrites scattered throughout, weathers yellow, pitted..... 1.0

| | Feet |
|---|---|
| Covered interval..... | 3.0 |
| Limestone, gray, slightly sandy, bedding is thin but compact. Many Triticites and Caninia torquia found. Weathers to a light gray, rough, jagged surface splotched with rust..... | 7.0 |
| KANWAKA SHALE: | |
| Shale, gray-blue and platy at the top. Grades downwards into a yellow-gray shale..... | 13.0 |
| Sandstone, tan, medium grained..... | 2.0 |
| Shale, maroon at the base, and buff and sandy at the top..... | 5.0 |
| Sandstone, tan, medium to fine grained, shaly.. | 3.0 |
| Covered interval..... | 17.0 |
| Limestone, dark gray, conglomeratic, full of fossil fragments. Weathers dirty yellow... | 1.5 |
| Shale, clayey, yellow-gray at top. Maroon at the base..... | 5.0 |
| Sandstone, blocky, tan, medium grained..... | 2.0 |
| Shale, sandy and buff at the top. Maroon at the base..... | 6.0 |

T. 35 S., R. 9 E. (Kansas)

XXXIII. Measured along the Hewins, Kansas road in the western part of sec. 15, and along the stream in the SW 1/4 sec. 10.

| | |
|---|---|
| WHITE CLOUD SHALE: | |
| Covered interval, not measured. | |
| Sandstone, cross bedded, tan, medium grained, not measured. | |
| Covered interval..... | 3.0 |
| Sandstone, cross bedded, tan, medium grained... | 4.0 |
| Covered interval..... | 15.0 |
| BIRD CREEK LIMESTONE: | |
| Limestone, dense, brittle, dark gray, contains a few Triticites and fossil fragments. Weathers to a dirty yellow..... | 1.3 |
| Shale, clayey, yellow..... | 4.0 |
| Limestone, very similar to the above limestone, but contains less fossils, and weathers yellow-gray..... | 1.8 |
| Aarde shale member: (Howard formation of Kansas) | |
| Shale, clayey, yellow-gray..... | 2.0 |
| Coal (Modaway), smutty..... | 0.2 |
| SEVERY SHALE: | |
| Shale, clayey, yellow-gray..... | 1.5 |
| Sandstone, gray to tan, blocky, slightly calcareous, medium grained to fine grained.... | 0.5 |

| | Feet |
|---|---|
| Shale, clayey, yellow-gray..... | 6.0 |
| Sandstone, shaly, thin-bedded, medium to fine grained, tan, weathers brown..... | 24.0 |
| Shale, slightly sandy, yellow-gray..... | 30.0 |
| PAWHUSKA FORMATION: | |
| Turkey Run limestone: | |
| Limestone, full dark gray, dense, fossiliferous, weathers platy and yellow-gray..... | 1.0 |
| Shale: | |
| Covered interval, probably shale..... | 13.0 |
| Sandstone, blocky, tan, medium grained..... | 2.0 |
| Covered interval..... | 11.0 |
| Limestone, gray-brown, weathers buff. Contains many Triticites. Poorly exposed..... | 2.0 |
| Covered interval, probably shale..... | 1.0 |
| Pearsonia limestone: | |
| Limestone, dense, brittle, dark gray-brown, fossiliferous, weathers to a rust color.... | 2.5 |
| Shale: Clayey, blue-gray with few buff streaks, fossiliferous..... | 9.0 |
| Limestone, shaly, thin bedded, gray-brown, full of Triticites. Slumps badly..... | 2.5 |
| Shale, clayey, gray..... | 6.0 |
| Limestone, dark gray-brown, massive, fossil fragments, weathers buff..... | 1.5 |
| Limestone and shale. Limestone is sandy and silty, gray, fossiliferous, soft, weathers dirty buff..... | 6.0 |
| Limestone, shaly, dark gray, numerous Triticites, weathers buff..... | 1.0 |
| Covered interval..... | 4.0 |
| Limestone, thin bedded, dark gray, few "Cryptozoon" and Triticites. Weathers to a bright yellow-brown..... | 2.0 |
| Covered interval..... | 6.0 |
| Limestone, blocky, dense, dark gray, weathers yellow-gray, and contains many large "Cryptozoon". | 1.0 |

T. 27 N., R. 7 E.

XXXIV. Measured at the point where the Stonebreaker crosses North Bird Creek in the NW 1/4 sec. 12.

| | |
|---|---|
| WILLARD SHALE: | |
| Covered interval, not measured. | |
| Sandstone, cross bedded, tan, medium grained... | 5.0 |
| Covered interval..... | 10.0 |
| Sandstone, blocky, tan, medium grained..... | 1.0 |
| Covered interval..... | 14.0 |

| | Feet |
|---|---|
| Limestone, gray, very fossiliferous..... | 1.0 |
| Covered interval, probably shale..... | 10.0 |
| Coal, smutty, shaly..... | 0.3 |
| Clay, gray-blue, streaked with rust..... | 0.3 |
| Shale, yellow-gray, contains many Myalina and fragments of crinoids..... | 1.0 |
| STONEBREAKER FORMATION: | |
| Elmont limestone: | |
| Limestone, shaly, gray, weathers buff. Slightly platy near the top..... | 2.0 |
| Shale, yellow-gray, fossiliferous..... | 6.0 |
| Limestone, impure, gray, blocky, weathers buff. | 0.5 |
| Harveyville shale: | |
| Shale, dark gray with rust streaks at the top. The base is gray and calcareous..... | 2.0 |
| Coal, shaly, disappears at places..... | 0.1 |
| Shale, sandy, yellow-gray..... | 4.0 |
| Reading limestone: | |
| Limestone, shaly, pebbly surface, gray, weathers buff and light blue-gray. May be of algal origin..... | 2.0 |
| Shale, blue-gray at the top and maroon with green streaks at the base..... | 9.0 |
| Limestone, dense, gray-brown, vertically jointed, contains many Triticites and has numerous "Cryptozoon" near the top. Weathers yellow-gray and is splotched with rust and maroon in places..... | 2.0 |
| Shale, blue-gray, clayey..... | 0.4 |
| Limestone, dense, gray, brittle, weathers light gray and buff. Contains numerous Triticites..... | 2.2 |
| Shale, clayey, blue-gray..... | 1.3 |
| Coal, shaly..... | 0.1 |
| Shale, clayey, blue-gray, bituminous..... | 0.4 |
| Limestone, shaly, gray, pebby surface, weathers buff and gray with blue algal spots..... | 2.0 |

T. 26 N., R. 8 E.

XXXV. NE 1/4 sec. 2. Measured in railroad cut and along stream in this area.

| | |
|---|---|
| PAWHUSKA FORMATION: | |
| Deer Creek limestone: | |
| Limestone, gray to tan, slabby, wavy bedded, weathers to a rust splotched, light gray surface. Contains a few Triticites..... | 16.0 |
| Covered interval, probably shale..... | 5.0 |

| | Feet |
|---|---|
| Plummer limestone: | |
| Limestone, dense, blocky, dark gray, few fossil fragments, weathers dirty yellow..... | 1.0 |
| Shale: | |
| Covered interval, probably shale..... | 7.0 |
| Limestone, thin bedded, gray, shaly, and very sandy. Surface has a ragged appearance on weathering. Grades into a fine to medium grained sandstone near the base..... | 3.5 |
| Covered interval, probably shale..... | 4.0 |
| Limestone, purple to maroon, full of Triticites and crinoid stems..... | 0.2 |
| Shale, maroon..... | 5.0 |
| Lecompton limestone: (Beil) | |
| Limestone, dense, brown, weathers to a bright rust-yellow. Contains many Triticites and a few Caninia torquia..... | 1.5 |
| Covered interval, approximately..... | 3.0 |
| Limestone, similar to limestone above but contains few fossils. | |
| Covered interval..... | 4.0 |
| Sandstone, fine grained, gray-buff, calcareous, weathers rust-yellow. This bed changes into limestone farther north..... | 1.0 |
| KANWAKA SHALE: | |
| Covered interval..... | 5.0 |
| Sandstone, cross bedded, tan, medium grained, weathers brown..... | 20.0 |
| XXXVI. South-central part sec. 11. Measured in small tributaries, east of the road, that run into North Bird Creek. | |
| SEVERY SHALE: | |
| Covered interval, not measured. | |
| Limestone, soft, shaly, thin bedded, gray, fossiliferous..... | 2.0 |
| Shale, yellow-gray..... | 3.0 |
| PAWHUSKA FORMATION: | |
| Turkey Run limestone: | |
| Limestone, dense, brittle, blocky, dark gray, weathers yellow-gray. Contains a few "Cryptozoon", and numerous Crurithyris planoconvexas..... | 2.0 |
| Shale: | |
| Shale, clayey, gray-buff, with few maroon spots | 5.0 |
| Sandstone, blocky, tan, medium grained..... | 5.0 |
| Shale, same as the above shale..... | 11.0 |
| Sandstone, same as the above sandstone..... | 4.0 |
| Covered interval..... | 10.0 |

| | Feet |
|---|---|
| Pearsonia limestone: | |
| Limestone, dense, brittle, dark gray-brown, weathers yellow-gray..... | 1.5 |
| Shale: | |
| Covered interval, probably shale..... | 9.0 |
| Limestone, gray-brown, thin bedded, and packed with Triticites. Appears to be thinner, and more resistant here than in the exposures to the north. Outcrop marked by jagged pieces sticking up through the soil..... | 1.0 |
| Covered interval..... | 12.0 |
| Sandstone, calcareous, fine to medium grained, tan, weathers brown..... | 3.0 |
| Little Hominy limestone: | |
| Limestone, slightly sandy, tan to gray, wavy bedded, weathers to a pitted light gray surface. Poorly exposed. About..... | 5.0 |
| Shale, clayey, blue-gray, fossiliferous..... | 19.0 |
| Deer Creek limestone: | |
| Limestone, gray, slabby, wavy bedded. Base is more compactly bedded than top. The upper part is slightly sandy, and contains a thin, black limestone at the very top. Weathers to a light gray, rust splotched surface.... | 15.0 |
| Covered interval, probably shale..... | 11.0 |
| Plummer limestone member: | |
| Limestone (Plummer?), dense, blocky, brittle, dark gray, weathers dirty yellow. Contains many Crurithyris planoconvexa, and a few Triticites..... | 0.5 |
| Covered interval, probably shale..... | 6.0 |
| Limestone, dense, blocky, brittle, dark gray, weathers dirty yellow. Few fossil fragments | 1.0 |
| Shale: | |
| Covered interval, probably shale..... | 7.0 |
| Limestone, very sandy, light gray-brown, weathers to a ragged buff and light gray-blue surface..... | 2.0 |
| Covered interval..... | 5.0 |
| Sandstone, blocky, tan, medium grained..... | 5.0 |
| Covered interval..... | 6.0 |
| Lecompton limestone: (Beil) | |
| Limestone, dense, brown, weathers to a bright yellow-brown. Contains numerous Triticites | 3.0 |
| Shale, clayey, blue-gray..... | 4.0 |