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GEOLOGY OF SOUTHEASTERN AND SOUTH-CENTRAL
JEFFESON COUNTY, KANSAS

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by

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ABSTRACT

An area of approximately 175 square miles in the southeastern and south-central part of Jefferson County, Kansas has a topography dominated by east-facing cuestas. Outcropping strata in the area consist of approximately 350 feet of alternating shale and limestone formations of Pennsylvanian age unconformably overlain by approximately 110 feet of unconsolidated glacial till and alluvial deposits of Quaternary age. The Pennsylvanian rocks dip to the northwest at approximately 15 feet per mile. The surface rocks locally outline gentle anticlinal folds with closures of less than 20 feet. Mineral resources of the area consist of oil, gas, limestone, shale, sand, gravel, and ground-water.

INTRODUCTION

Location of Area

This report pertains to an area of approximately 175 square miles in the southeastern and south-central part of Jefferson County, Kansas (fig. 1). The area is bounded on the east by the Leavenworth County line, on the south by the Douglas County line, on the north by township 9 S. (near lat 39°13' N.), and on the west by range 17 E. (near long 95°28' W.). U. S. Highways 24 and 59, State Highways 16 and 92, and a paved county road give access to the area. Supplementing the paved roads are many well-maintained county roads that either follow or run parallel to section lines. In this part of Jefferson County probably no point is more than one mile distant from an all-weather road.

Geography of Area

Climate. Mean monthly temperatures range from 29° F. for January to 79° F. for July. The annual precipitation ranges from 30 to 35 inches; most of it occurs during the spring and summer months. The average annual number of clear days is 160. The normal crop-growing season lasts 190 days.

Agriculture. Agriculture is by far the most important industry in the area. The farming is a diversified type in which livestock and

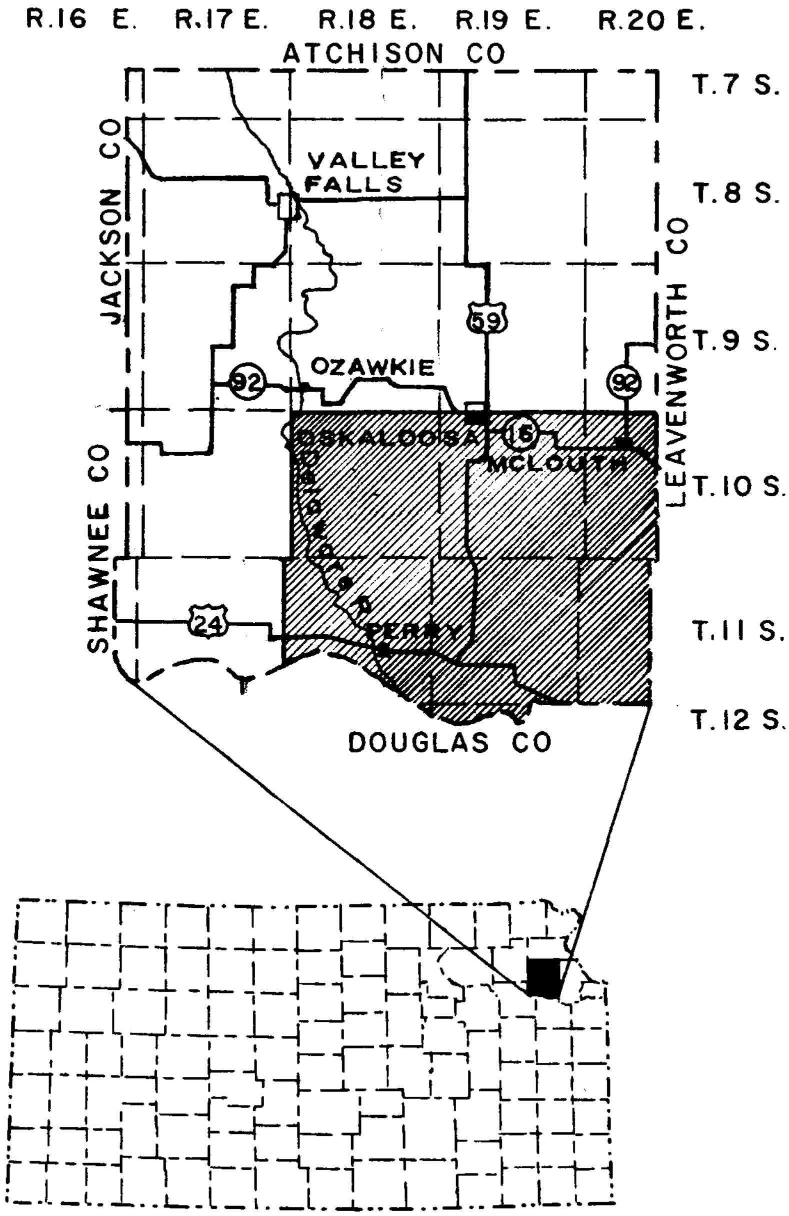

FIG. 1. Index map of southeastern and south-central Jefferson County, Kansas.

livestock products account for almost three-fourths of the total farm income. Corn is the dominant crop; other important crops are wheat, hay, oats, and soybeans.

Population. The largest towns in the area are McLouth, population 477, and Perry, population 399 (U. S. Census, 1950). Lying partly within the area is Oskaloosa, the county seat; its population is 721. The dispersed rural population has a density of less than 15 persons per square mile.

Topography of Area

The area lies partly within the Kansas Drift Plain and partly within the Attenuated Drift Border, defined by Schoewe (1949, pp. 289-291) as subdivisions of the Dissected Till Plains section of the Central Lowland physiographic province as classified by Fenneman (1938, pp. 588-605, pl. 6).

The maximum relief is approximately 380 feet. The highest point, slightly more than 1190 feet above mean sea level, is near McLouth in the northeast part of the area. The lowest point, slightly less than 820 feet above sea level, is in the Kansas River channel in the southernmost part of the county.

The area is effectively drained by the Kansas River system. The streams have a dendritic drainage pattern which developed on a glacial till plain and is superimposed on underlying bedrock. Flowing eastward along the south boundary of the county is the Kansas River. Its main tributary, the Delaware River, flows southward near the west boundary of the area. Stream action has formed three distinctive types of topography within the area.

Floodplain deposits make up a lowland with slight relief in the comparatively wide valleys of the Kansas and Delaware rivers. Along the sides of the valleys are remnants of alluvial terraces representing older, higher floodplains.

North and east of the Kansas and Delaware valleys a fairly steep slope marks the boundary of an upland which constitutes most of the area mapped. The average altitude of the upland surface is approximately 150 feet above that of the river floodplains. The upland consists of bedrock overlain by unconsolidated glacial till. Small tributaries of the rivers have removed most of the glacial till from about four-fifths of the upland area. Exposed here are alternating shale and limestone formations which are tilted slightly to the northwest. Differential erosion has formed a series of east-facing cuestas with prominent limestone-capped escarpments and gentle backslopes. The greatest local relief is in this part of the upland. Possibly some of the relief on the bedrock surface existed before the area was glaciated (Fenneman, 1938, pp. 592-594).

In the vicinity of Oskaloosa and McLouth the topography is dominated by gently rolling hills. The upland surface is highest in this part of the area which is farthest from the major streams. The surface is underlain by glacial till. The larger creeks of the area head in this part of the upland.

Purpose of Investigation

The purpose of this investigation is: (1) to describe the rocks exposed in southeastern and south-central Jefferson County; (2) to prepare a geologic map showing in detail the areal distribution of Pennsylvanian and Quaternary formations.

Previous Investigations

The Pennsylvanian rocks exposed in eastern Kansas were first studied by Meek and Hayden (1859). Other early studies were made by Mudge (1866) and Swallow (1866). Later investigations were conducted by: Haworth (1894); Adams, Girty, and White (1903); Haworth and Bennett (1908).

More recent investigations were made by: Moore (1920, 1932, 1936, 1949); Moore and Landes (1937); Bowsher and Jewett (1943); Moore, Frye, and Jewett (1944); Jewett (1945); Moore and Thompson, (1949); Moore and others (1951).

The Pleistocene geology of Kansas has been described by Frye and Leonard (1952).

Studies of the subsurface and structural geology of eastern Kansas were made by Fath (1920), Holl (1932), Kellett (1932), Ockerman (1935), Lee (1939, 1940, 1943), Jewett (1951), and Lee and Merriam (1954).

Reports concerning oil and gas developments have been made by Moore and Haynes (1917), Jewett and Abernathy (1945), Jewett (1949, 1954), Ver Wiebe and others (1955), and Goebel and others (1956).

Only two studies apply specifically to parts of the area investigated for this report. One is a report on the McLouth gas and oil field by Lee and Payne (1944). The other is a report on the geology and ground-water resources of the Kansas River Valley by Davis and Carlson (1952). Much useful information was derived from these two reports.

Methods of Investigation

The field work for this report was done intermittently between July, 1956 and September, 1957. The geology was mapped on U. S. Department of Agriculture aerial photographs (scale 1:24,000). U. S. Geological Survey topographic maps were used for checking elevations. A Focalmatic projector was used to transfer the geology from the aerial photographs to a base map (scale 1:40,000) adapted from a U. S. Soil Conservation map.

At selected localities rock exposures were studied. Lithology, weathering characteristics, and other properties of the rocks were noted. The Rock-color Chart of the Geological Society of America was used to determine colors. Specimens were collected for laboratory study.

Acknowledgements

Most of the materials, facilities, and transportation expenses required for this investigation were furnished by the State Geological Survey of Kansas. The writer has benefited from the counsel of the project advisers, Dr. L. F. Dellwig of the Department of Geology of the University of Kansas and Dr. J. M. Jewett of the State Geological Survey. Valuable field assistance and suggestions were contributed by Mr. Robert O. Kulstad, Mr. Stanton J. Ball, and Mr. Howard G. O'Connor of the State Geological Survey, and Mr. J. Rex Reynolds and Mr. William G. Brown of the Department of Geology, University of Kansas. Mr. John D. McNeal and other personnel of the Geology Section, State Highway Commission of Kansas made available to the writer all their pertinent records. The writer is also indebted to many Jefferson County residents who, without exception, readily gave information and allowed their property to be entered.

STRATIGRAPHY

General Statement

In southeastern and south-central Jefferson County the oldest subsurface rocks are Precambrian granite or gneiss (Lee, 1943, p. 19). The Precambrian rock surface is tilted northwestward, its depth ranging from approximately 1800 feet below mean sea level in southeast Jefferson County to about 2200 feet below sea level in the northwest part of the area mapped (Farquhar, 1957, pl. 1). The other subsurface rocks are approximately 2750 feet of sedimentary rocks ranging in age from Late Cambrian to Late Pennsylvanian. In the sequence are many unconformities; however, the only system not represented is the Silurian (Lee & Payne, 1944).

The oldest subsurface sedimentary rocks belong to the Arbuckle Group of Cambro-Ordovician age. They are approximately 700 feet thick. Above the Arbuckle Group are Ordovician formations averaging 220 feet in total thickness. Ordovician strata are overlain by approximately 175 feet of Devonian rocks. Next upward is the Chattanooga Shale of Devonian or Mississippian age, its thickness averaging 75 feet. Above the Chattanooga Shale are Mississippian rocks which have an aggregate thickness of about 335 feet. Overlying the Mississippian beds are approximately 1240 feet of Pennsylvanian rocks which are not exposed in Jefferson County. The unexposed section of Pennsylvanian rocks includes the Cherokee Group of Desmoinesian age at the base and part of the Douglas Group of Virgilian age at the top. Missing from the sequence is the Pedee Group of Missourian age.

The exposed bedrock consists of approximately 350 feet of northwestward-dipping, alternating shale and limestone formations of the Douglas and Shawnee Groups of the Virgilian Series, Pennsylvanian System. Unconformably overlying the sedimentary rocks are unconsolidated sediments of Quaternary age. These sediments consist of Pleistocene glacial till which is overlain by alluvial deposits of Pleistocene and Recent age. The maximum aggregate thickness of the Quaternary deposits is approximately 180 feet; the estimated average thickness is 110 feet. The areal distribution of formations is shown on the accompanying geologic map (pl. 1). A generalized columnar section of the outcropping strata is shown in figure 2.

The stratigraphic descriptions presented here pertain only to the strata exposed within the area. The units are described in the order of their deposition.

Pennsylvanian System

Virgilian Series

The Virgilian Series was named from Virgil, a town in Greenwood County, Kansas (Moore, 1932). All Pennsylvanian strata exposed in the

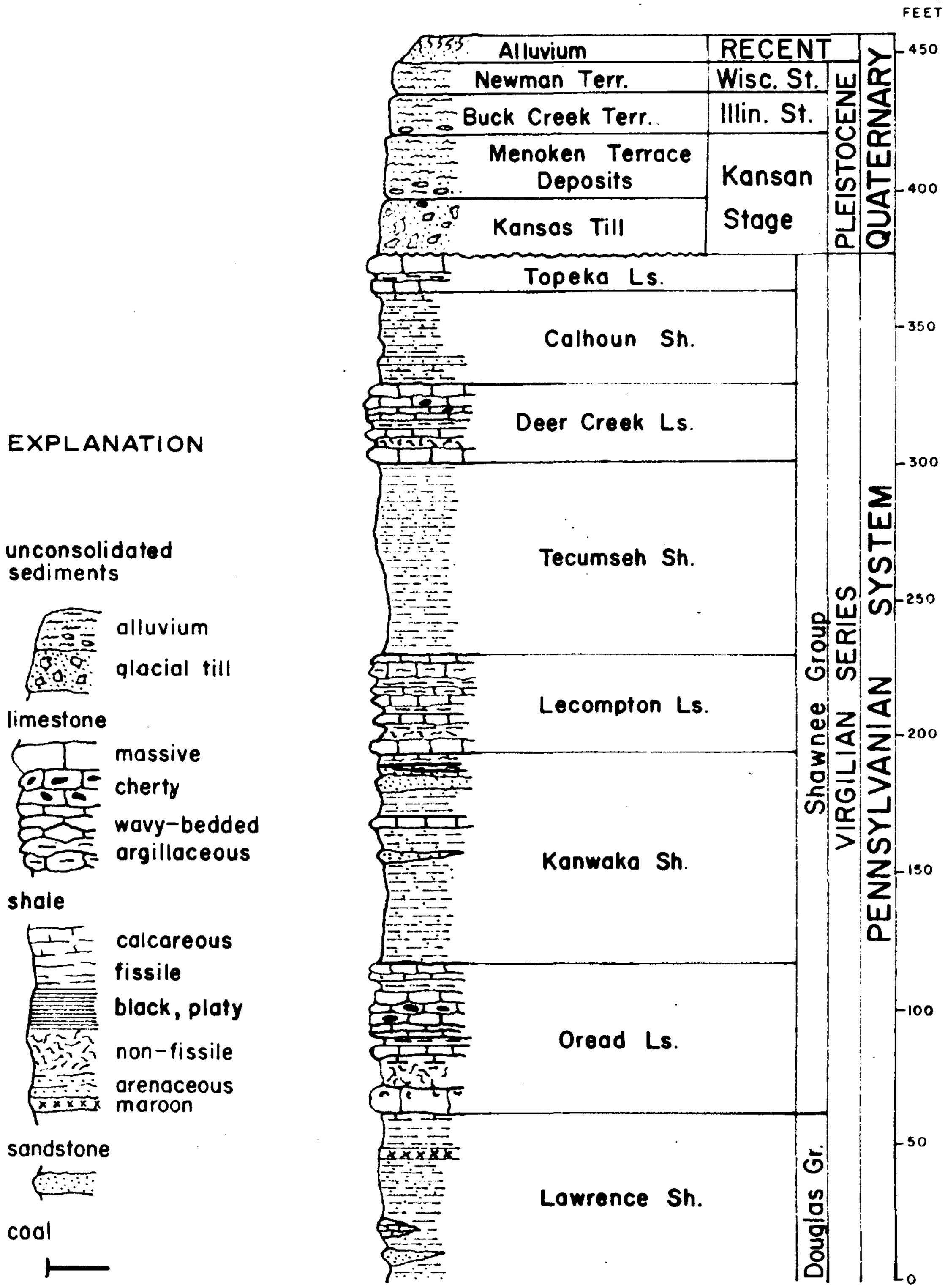

FIG. 2. Generalized columnar section of rocks exposed in southeastern and south-centeral Jefferson County, Kansas.

area are part of this series. Classified as Virgilian in age in this region are three groups (in upward order): the Douglas, Shawnee, and Wabaunsee Groups. Only the lower and middle groups are found in this area.

Douglas Group

The term "Douglas" was first used by Haworth (1898, p. 93) as a formation name for strata typically exposed in Douglas County, Kansas. Haworth applied the name to beds lying between the Stanton Limestone and Kanwaka Shale. The Douglas unit was given the rank of group by Moore (1932, p. 93) when he restricted its boundaries to include only the strata between the post-Missourian unconformity and the base of the Oread Limestone. As now classified the Douglas Group consists of the Stranger Formation and the overlying Lawrence Shale. Only about 60 feet of the Douglas strata crop out in Jefferson County. The exposures are limited to the upper half of the Lawrence Shale which crops out only in the southeastern part of the county.

Lawrence Shale

The upper formation of the Douglas Group, the Lawrence Shale, was named from Lawrence, Kansas (Haworth, 1894, p. 122). The lower limit of the formation was redefined by Moore and Newell (Moore, 1936, p. 154).

The upper half of the Lawrence Shale is the oldest rock exposed in Jefferson County.

The lowermost exposures of the Lawrence formation consist of light olive gray clayey silt shale. Sandstone lenses are irregularly distributed in the shale.

At one outcrop on the Jefferson-Leavenworth County line (NE 1/4, NE 1/4, NE 1/4 sec. 9, T. 11 S., R. 20 E.) the formation contains a 5.2 feet thick section of light-gray argillaceous and arenaceous limestone. The limestone is unevenly and thinly bedded. Its fossils include both conispiral and planispiral gastropods, pelecypods, spinose brachiopods, bryozoans, and many unidentified shell fragments. The limestone is not persistent southwestward along strike. Possibly it is correlative with the formation's Amazonia Limestone member, typically exposed in Andrew County, Missouri (Hinds & Greene, 1915, p. 31). In the only outcrop found in Jefferson County the top of the limestone is about 40 feet below the top of the Lawrence Shale.

The uppermost 40 feet of the Lawrence formation is primarily olive gray in color although greenish-gray, bluish-gray, and gray shales are common. It is mainly a silt shale which is sandy at some levels. Interbedded with the shale are thin layers of gray, silty sandstone which weathers to a light-brown color. Approximately 15 feet below the top of the formation is a maroon shale in a bed averaging about 2 feet cuestas. The limestone formations are generally well-exposed on the escarpment slopes. The shale formations are for the most part covered although the upper beds of the shales are normally exposed on escarpments below the limestones.

The Shawnee strata are cyclic deposits. Beds of various lithologies are arranged in a characteristic sequence which is repeated many times in the stratigraphic section. The term "cyclothem" has been used to define the series of beds deposited during a single sedimentary cycle. Each cyclothem consists mainly of shale overlain by limestone; both types of rocks were formed in oscillating marine waters. A few of the cyclothems are distinctive in that they contain non-marine deposits below the marine beds. The non-marine deposits are widely spaced stratigraphically, occurring in about every fifth cyclothem. The thick section ranging from the base of one non-marine deposit to the base of the next succeeding one has been defined by Moore (1936, p. 29) as a megacyclothem. At least three of the megacyclothems are represented in the outcropping Douglas and Shawnee rocks.

In this area approximately 290 feet of the Shawnee Group is exposed. The formations (from base upward) are: the Oread Limestone, Kanwaka Shale, Lecompton Limestone, Tecumseh Shale, Deer Creek Limestone, Calhoun Shale, and Topeka Limestone.

in thickness. From the base of the maroon shale upward the formation is predominantly clay shale although some of it is sandy silt shale. The clay shale contains many carbonized land plant fossils. At one location on the west side of Buck Creek (NW 1/4, SE 1/4 sec. 15, T. 11 S., R. 19 E.) a thin coal seam lies a few feet below the top of the formation. The coal seam is not persistent. In the beds immediately below the overlying Oread Limestone brachiopods, pelecypods, and crinoid stems are fairly common fossils.

Approximately 60 feet of the Lawrence Shale is exposed.

Shawnee Group

Above the Douglas Group is the Shawnee Group, named from Shawnee County, Kansas. Haworth (1898, p. 93) originally used the term "Shawnee" as a formation name applied to the strata ranging from the base of the Kanwaka Shale to the top of the Scranton Shale. Later the unit was advanced to the rank of group (Fath, 1921, pp. 39, 42). Moore (1936, p. 159) redefined the limits of the group as now recognized to include the beds from the base of the Oread Limestone to the top of the Topeka Limestone.

The Shawnee Group is composed of alternating limestone and shale formations. Exposures of the group consist of a series of east-facing

Oread Limestone

Conformably overlying the Lawrence Shale is the lowermost formation of the Shawnee Group, the Oread Limestone, named from Mount Oread at Lawrence, Kansas (Haworth, 1894, p. 123; 1895, p. 461). As redefined by Moore (1936, p. 161) the formation consists of four limestone and three shale members. The Oread Limestone is noticeably thicker than the other limestones of the Shawnee Group. Another feature which is useful for identification and tracing of the formation is its topographic expression as a high escarpment with two distinct ledges.

The average thickness of the Oread Limestone is 54 feet. The seven members of the formation (in ascending order) are: the Toronto Limestone, Snyderville Shale, Leavenworth Limestone, Heebner Shale, Plattsmouth Limestone, Heumader Shale, and Kereford Limestone.

Toronto Limestone member. The basal member of the Oread formation, the Toronto Limestone, was named from a town in Woodson County, Kansas (Haworth & Piatt, 1894, p. 117). The Toronto member is a medium-gray limestone altered by weathering to a light-brown or medium-brown color. The limestone is somewhat shaly and ferruginous; consequently the brown weathering zone extends far beneath the rock surface. The limestone is commonly massive but in some places it is separated into two thick beds by thin shale layers. The uppermost 5 feet of the member contains chert nodules in some outcrops. The most conspicuous fossils in the limestone are crinoid stems. Brachiopods and fusulinids are found in all parts of the member. In some places the uppermost part contains algae. The thickness of the member ranges from 9 to 12 feet.

Snyderville Shale member. The lowermost shale member of the Oread formation is the Snyderville. Its name is derived from a town in southeastern Nebraska (Condra, 1927, p. 38). The Snyderville member is an olive gray, silty clay shale which weathers to a medium-gray color. The shale is only slightly fissile and is essentially nodular in structure. At the top of the member is a thin layer of tan shale containing brachiopods (Chonetes) and unidentified pelecypods. The shale is otherwise nonfossiliferous. The thickness range of the member is from 8.9 to 11.3 feet.

Leavenworth limestone member. Immediately above the Snyderville Shale is the Leavenworth Limestone, typically exposed near Leavenworth, Kansas (Condra, 1927, p. 38). The Leavenworth member is a bluish-gray, finely-crystalline, hard limestone. Weathered exposures of the limestone are either yellowish-brown or yellowish-gray in color. The weathering discoloration is limited to a very shallow zone. The unit is a single massive bed which has an even upper surface and a wavy lower surface. The bed has well-developed vertical jointing. Weathered exposures of the limestone consist principally of large blocks that have pseudorectangular faces and rounded edges. The limestone is fossiliferous, containing fusulinids, brachiopods, gastropods, and crinoid stems. The member has a thickness ranging from 1.5 to 1.9 feet.

Heebner Shale member. Above the Leavenworth Limestone is the Heebner Shale member (fig. 3), named from a locality in southeastern Nebraska (Condra, 1927, p. 37). The Heebner Shale consists of two units. The lower unit is a black carbonaceous platy shale. In many places the black shale contains numerous small phosphate nodules of an oblate spheroid shape. Small pyrite crystals are common in the shale. The faunal content of the lower unit is probably restricted to conodonts. Its thickness ranges from 1.9 to 4.5 feet.

The upper unit of the Heebner member grades from a medium-gray micaceous silt shale in the lower part to a yellowish-orange clay shale at the top. The lower part is only slightly fossiliferous, containing small spinose brachiopods (probably Marginifera). The upper part of the shale is more fossiliferous, containing brachiopods, horn corals, and crinoid stems. All of the fossils are small. The thickness of the upper unit ranges from 1.8 to 2.6 feet.

The average thickness of the Heebner Shale member is 5.4 feet.

Plattsmouth Limestone member. Overlying the Heebner Shale is the Plattsmouth member, the thickest limestone unit of the entire Shawnee Group. The Plattsmouth Limestone was named from a town in

FIG. 3. Heebner Shale outcrop on Buck Creek, SW 1/4, SE 1/4 sec. 3, T. 11 S., R. 19 E. Line shows contact with overlying Plattsmouth limestone, 6 feet above water level (compare with outcrop shown in figure 4). Camera faces south, downstream.

FIG. 4. Plattsmouth Limestone outcrop on Buck Creek about 0.1 miles south of outcrop shown in figure 3. Entire thickness (20 feet) of member is shown. Limestone base here is one foot above water level. Comparison of elevation of base of Plattsmouth member with that shown in figure 3 indicates local south dip varying from regional northwest dip. Camera faces southeast.

Nebraska (Keyes, 1899, p. 306; Condra, 1927, p. 37). The member is a medium-gray, finely-crystalline limestone. Its weathered surface is either yellowish-gray or grayish-orange. Bedding ranges from thin to medium thickness (fig. 4). Interbedded with the limestone are many laminae of calcareous shale. After prolonged exposure the limestone beds weather into well-rounded and fairly smooth-surfaced slabs.

Some of the Plattsmouth beds are very cherty. The lower half of the member has scattered chert nodules with some concentration in a zone approximately 9 feet above the base. In the upper half of the member chert nodules are concentrated in one bed about 13 feet above the base of the member. Many of the chert nodules contain fossils.

All of the Plattsmouth strata are fossiliferous. The most numerous fossils, fusulinids, are especially abundant in some beds in the upper half of the member. Brachiopods are represented in the fauna by at least eight different genera. Bryozoans are fairly common, especially so in the cherty beds. Large planispiral gastropods, Bellerophon, are prominent fossils in the upper beds. Locally the topmost beds contain algae. Other fossils in the Plattsmouth member are the horn coral Lophophyllidium, pelecypods, and crinoid stems.

The maximum measured thickness of the Plattsmouth member is 19.9 feet. The average thickness is 18 feet.

Heumader Shale member. The uppermost shale member of the Oread formation is the Heumader Shale, named from a quarry near St. Joseph, Missouri (Moore, 1932, p. 96). The Heumader member is medium-gray, silty clay shale. It is slightly carbonaceous and is apparently non-fossiliferous. The member has a fairly uniform thickness of approximately 2.4 feet.

Kereford Limestone member. The uppermost member of the Oread formation is the Kereford Limestone. Its name was derived from a quarry at Atchison, Kansas (Condra, 1927, p. 45). The Kereford member is a light olive gray limestone altered by weathering to a purple-tinted reddish-brown color. The purple tint in the coloring is persistent and is particularly useful for distinguishing between the Kereford and Plattsmouth members of the Oread formation. The Kereford Limestone is shaly and ferruginous. It contains small chert nodules in one outcrop in the southeastern part of Jefferson County. The limestone has irregular beds. The lower one-third has thin beds that weather into rough-surfaced slabs. The upper two-thirds has comparatively thicker beds which tend to weather into blocky boulders.

The Kereford member is extremely fossiliferous. Significant features of its faunal assemblage are: the great numbers of fusulinids (*Triticites*) and fenestrate bryozoans; the large percentage of *Dielasma* (exceeded only by *Composita*) among its brachiopods; the abundance of shell fragments in the lower one-third of the member. Gastropods are the most abundant of the other fossils in the rock.

The Kereford Limestone in some places is exposed only on the dip slope of the Oread cuesta although in most places it crops out near the Plattsmouth scarp because of the thinness of the intervening Heumader Shale member. The Kereford member has an average thickness of 6.3 feet.

Kanwaka Shale

Conformably overlying the Oread Limestone is the Kanwaka Shale, named from a township in Douglas County, Kansas (Adams, 1903, p. 45). The lower half of the shale forms a very gentle slope, in many places covered. The upper half of the shale forms a steeper slope, partly because of the presence of a limestone member and two sandstone beds that are resistant to erosion. The formation ranges from 70 to 85 feet in thickness. The Kanwaka Shale is composed of three members (from base upward): the Jackson Park Shale, Clay Creek Limestone, and Stull Shale.

Jackson Park Shale member. The basal Jackson Park Shale member of the Kanwaka formation was named from a park in Atchison, Kansas (Moore, 1932, p. 96). The lower and major part of the Jackson Park member is a light olive gray, micaceous silt shale. Thin layers of sandy siltstone are interbedded with the shale at higher levels. Land plant fossils are associated with the siltstone layers.

The uppermost 10 feet of the Jackson Park member commonly is a bluish-gray, sandy silt shale. At one location is has a thin coal seam near the top. In some outcrops the bluish-gray shale overlies a bed of medium-gray, fine-grained, friable sandstone that weathers deeply to a yellowish-brown color. Stratification within the bed is very irregular. The average thickness of the bed is 2.5 feet.

The Jackson Park member ranges from 50 to 55 feet in thickness.

Clay Creek Limestone member. The middle member of the Kanwaka Shale is the Clay Creek Limestone. Its name was derived from a creek near Atchison, Kansas (Moore, 1932, p. 96). The member is composed of medium dark-gray to bluish-gray, finely-crystalline limestone. It weathers shallowly to a yellowish-orange color. Normally the Clay Creek member is one massive bed of limestone. The bed has a wavy lower surface, a fairly smooth upper surface, and rather well-developed vertical jointing. Weathered outcrops have irregular horizontal fractures in the upper part of the bed. At some places a thin, platy limestone bed lies below the massive unit.

The limestone is very fossiliferous. Fusulinids (Triticites) are especially abundant. Gastropods, brachiopods, and crinoid stems are conspicuous forms. The upper part of the member is characterized by an abundance of shell fragments, a general decrease in numbers of fusulinids upward, and algal remains locally at the top. Large planispiral gastropods are somewhat concentrated in the middle one-third of the member. The thin discontinuous limestone bed at the base of the member has a fauna resembling that of the upper part of the massive bed. It contains brachiopods, crinoid stems, and many small shell fragments.

The Clay Creek member has an almost uniform thickness of 2.6 feet.

Stull Shale member. Above the Clay Creek Limestone is the Stull Shale, typically exposed in Douglas County, Kansas (Moore, 1932, p. 96). At many places the entire Stull member is clearly exposed. The lower two-thirds of the member is a light olive gray, sandy silt shale that is micaceous and slightly carbonaceous. Upward the shale becomes more sandy and commonly is interbedded with thin layers of sandy siltstone. At most exposures the silt shale is overlain by a bed of medium-gray, fine-grained, friable sandstone. The sandstone is cross-bedded. The sandstone bed is variable in thickness, the maximum being approximately 5 feet.

The upper half of the Stull member is a medium-gray, silty clay shale. Land plant fossils occur in thin laminae throughout the shale. Approximately one foot below the top of the shale is a very carbonaceous zone. Within this zone is a coal seam ranging from 0.2 to 0.5 feet in thickness. In some places the zone has two thin coal seams.

The Stull Shale member has a variable thickness ranging from 22 to 29 feet.

Lecompton Limestone

Conformably overlying the Kanwaka Shale is the Lecompton Limestone, named from a town in eastern Kansas (Bennett, 1896, p. 116). The Lecompton formation has four limestone and three shale members. Shale constitutes approximately half the thickness of the strata. Some of the beds in the uppermost two limestone members are easily weathered, hence the Lecompton Limestone forms an escarpment which lacks the abruptness of the Oread and Deer Creek escarpments. The outcrop belt of the Lecompton formation in some places is very wide. The lower boundary of the formation is clearly revealed throughout the area. The upper boundary in some localities is not sharply defined.

The Lecompton Limestone is easily identified by its paleontologic and lithologic features. Distinctive faunal assemblages occur in two of its limestone members. Useful lithologic criteria are weathering characteristics and the absence of chert.

The average thickness of the Lecompton Limestone is 35 feet. The seven members of the formation (from base to top) are: the Spring Branch Limestone, Doniphan Shale, Big Springs Limestone, Queen Hill Shale, Beil Limestone, King Hill Shale, and Avoca Limestone.

Spring Branch Limestone member. The lowermost member of the Lecompton Limestone is the Spring Branch Limestone, typically exposed near Lecompton, Kansas (Condra, 1927, p. 47). The lower and major part of the Spring Branch member is a dark medium-gray, finely-crystalline limestone that weathers deeply to a yellowish-brown color. It occurs in one or two massive, vertically-jointed beds ranging from 2.5 to 5.6 feet in total thickness. The fauna in the unit is dominated by fusulinids (Triticites) which blanket the surface of the rock in many places where they have weathered out in relief. Other fossils include brachiopods, gastropods, echinoid spines, and crinoid columnals. Aside from a general increase in numbers of fusulinids upward there is no apparent zonation of fossils in the unit.

In some places the top part of the member is a massive bed of light-gray, soft shaly limestone. Where it is exposed in stream channels the bed has an intricate network of irregular horizontal and vertical fractures. After prolonged exposure the bed is weathered into blocky or nodular-shaped rubble. When weathered it either retains its original color or alters to a tan or yellow color. Possibly the bed is partly algal in origin; otherwise, it is unfossiliferous. The maximum thickness of the bed does not exceed 2 feet.

The maximum thickness of the Spring Branch member is approximately 7 feet. Its average thickness is 5 feet.

Doniphan Shale member. Above the Spring Branch Limestone is the Doniphan Shale member. Its type locality is in Doniphan County, Kansas (Condra, 1927, p. 47). The lower part of the Doniphan member is a tan, almost non-fissile clay shale. At some outcrops the tan shale is overlain by a dark-gray, carbonaceous shale approximately one foot in thickness. The uppermost part of the member consists of approximately one foot of light-gray, calcareous clay shale. In the lower part of the calcareous shale are one or two thin beds of shaly limestone. Some fusulinids occur in both the shale and limestone layers of the upper part of the member. The Doniphan shale is variable in thickness; the average is 7 feet.

Big Springs Limestone member. Overlying the Doniphan Shale is the Big Springs Limestone, named from a town in eastern Kansas (Condra, 1927, p. 47). The member is composed of a bluish-gray, very finely-crystalline limestone which when weathered is light yellowish-brown or yellowish-gray on the surface. The limestone consists of a single massive bed with a smooth upper surface and an uneven lower surface. Vertical joining is well-developed. Fusulinids are the most numerous of the fossils in the limestone. Other forms include brachiopods, crinoid stems, and a few gastropods. In its physical properties and faunal assemblage the Big Springs member is almost identical to the Leavenworth member of the Oread Limestone. The thickness of the Big Springs Limestone ranges from 1.7 to 2.4 feet.

Queen Hill Shale member. Lying above the Big Spring Limestone is the Queen Hill Shale, typically exposed in Nebraska (Condra, 1927, p. 46). The lower two-thirds of the Queen Hill member is a black, platy shale which, except for conodonts, is lacking in fossils. The shale has small pyrite crystals. The upper one-third of the member is a gray, unfossiliferous clay shale. The Queen Hill Shale has a lithology remarkably similar to that of the Heebner member of the Oread Limestone. The Queen Hill Shale, however, is more uniform in its thickness, averaging 3.5 feet.

Beil Limestone member. In sequence above the Queen Hill Shale is the Beil Limestone, named from a locality in southeastern Nebraska (Condra, 1930, p. 20). The Beil member consists of interbedded shaly limestone and very calcareous shale. The limestone and shale beds are a light olive gray color when unweathered. Weathering alters the color of both to a very light gray (almost white) color at most outcrops. The lower and thicker part of the Beil Limestone is composed of two thick beds of shaly limestone separated by a bed of limy clay shale. The upper 2.5 feet of the member consists of numerous thin beds of alternating shaly limestone and calcareous clay shale. At some places the top limestone bed contains algae. Stratification of the Beil member is very irregular from base to top. The unit is very susceptible to weathering and erosion and in most places it forms a gently sloping surface along its outcrop belt. Good outcrops of the member were found in stream valleys.

The outstanding feature of the Beil Limestone is its varied and copious faunal assemblage. Many fossils in excellent condition were found weathered out of the rock. The large horn coral Caninia torquia is abundant and is an excellent criterion for identification of the unit. Another abundant coral is Syringopora. The fauna commonly includes at least ten different genera of brachiopods ranging in size from small Hustedia to large Dictyoclostus. The more numerous of the brachiopods are Chonetes, Marginifera, and Composita. Other common fossils are gastropods, both fenestrate and ramose types of bryzoans, pelecypods, echinoid spines, and large crinoid columnals. Fusulinids (Triticites) are abundant, especially so in the upper, more shaly beds where in some places they are concentrated into clusters.

The average thickness of the Beil Limestone is 6.3 feet.

King Hill Shale member. The uppermost shale member of the Lecompton Limestone is the King Hill Shale, typically exposed in Nebraska (Condra, 1927, p. 45). The King Hill member is a dark greenish-gray, laminated, slightly silty clay shale that weathers to a light olive gray color. No fossils were found in the shale. The member is persistently thin throughout the area with an average thickness of 1.5 feet.

Avoca Limestone member. The uppermost member of the Lecompton formation is the Avoca Limestone, typically exposed in Otoe County, Nebraska (Condra, 1927, p. 45). The basal part of the Avoca member is a massive bed of light-gray, shaly, ferruginuous limestone that weathers deeply to a yellowish-orange or yellowish-brown color. The weathered rock is soft and earthy in appearance; it has a nodular surface. No fossils were found in this unit. Its thickness ranges from 1.7 to 5.6 feet.

Overlying the lower bed is a gray, calcareous, clayey silt shale. In some places a thin nodular bed of gray shaly limestone occurs near the middle of the shale unit. The upper part of the shale contains brachiopods. The shale is variable in its thickness, the maximum being approximately 3.9 feet.

The upper part of the Avoca member is a bluish-gray, finely-crystalline limestone, the surface of which is altered by weathering to a yellowish-orange color. It is a single massive bed with an even top surface, wavy lower surface, and vertical jointing. Fossils in the rock include abundant fusulinids, and smaller quantities of gastropods, brachiopods, and crinoid stems. Except for a greater concentration of fusulinids in the lower one-third of the bed there is no appreciable zonation of the fossils. The unit is persistent and has a fairly uniform thickness ranging from 2.4 to 2.8 feet. This top bed closely resembles the Clay Creek member of the Kanwaka Shale.

The average thickness of the Avoca Limestone is 8 feet.

Tecumseh Shale

The Lecompton Limestone is conformably overlain by the Tecumseh Shale, named from a village in Shawnee County, Kansas (Beede, 1898, p. 28). A one foot thick basal section of tan, laminated silt shale is the only exposure of the lower one-third of the Tecumseh Shale. The upper two-thirds of the formation is exposed at some places. It consists mainly of medium-gray, micaceous, sandy silt shale containing a few land plant fossils. Upward the shale changes gradually; a few feet below the overlying Deer Creek Limestone the strata consist of bluish-gray, calcareous shale that is less sandy and more clayey than the underlying shale. The thickness of the Tecumseh Shale ranges from 65 to 78 feet.

Deer Creek Limestone

The Deer Creek Limestone was named from outcrops in eastern Shawnee County, Kansas (Bennett, 1896, p. 117). The outstanding feature of the Deer Creek Limestone as a unit is its topographic expression. The exposure forms an escarpment which is conspicuously abrupt and well-defined (fig. 5). The upper member of the formation is a fairly thick, weathering-resistant limestone. Typically

FIG. 5. Escarpment of Deer Creek Limestone. Camera faces north along U. S. Highway 59 in SW 1/4 sec. 32, T. 10 S., R. 19 E.

all the members of the Deer Creek formation are exposed on the escarpment face, and once the formation has been identified its outcrop can be traced accurately for many miles. Its boundaries in most places are obvious on aerial photographs.

The Deer Creek Limestone is composed of five members with an aggregate thickness of approximately 27 feet. The five members (from bottom to top) are: the Ozawkie Limestone, Oskaloosa Shale, Rock Bluff Limestone, Larsh-Burroak Shale, and Ervine Creek Limestone.

Ozawkie Limestone member. The basal member of the Deer Creek formation conformably overlies the Tecumseh Shale, It is typically exposed near Ozawkie in Jefferson County, Kansas (Moore, 1936, p. 182). The Ozawkie member is a massive bed of gray limestone. When weathered it is brown on the surface and is speckled with brown in a thick zone below the surface. The limestone has a persistent oolitic texture. The ooids are concentrically-banded spheroids that are indiscriminately cut by fractures. The limestone after prolonged exposure weathers into well-rounded, blocky boulders. At some places the boulders have smooth-walled solution pits. These solution pits are found only in the Ozawkie member.

The Ozawkie member is less fossiliferous than most of the other limestones in the area. Its faunal assemblage includes brachiopods, planispiral gastropods, echinoid spines, crinoid stems, and fusulinids.

The average thickness of the Ozawkie Limestone is 3.8 feet.

Oskaloosa Shale member. Above the Ozawkie Limestone is the Oskaloosa Shale. It was named from the county seat of Jefferson County (Moore, 1936, p. 184). Most of the Oskaloosa member is a medium-gray, blocky clay shale lacking fossils. The uppermost 0.4 feet of the member is a grayish-orange, calcareous clay shale with a molluscan fauna. The Oskaloosa Shale is approximately 6.5 feet thick.

Rock Bluff Limestone member. Overlying the Oskaloosa Shale is the Rock Bluff Limestone, typically exposed in southeastern Nebraska (Condra, 1927, p. 50). The Rock Bluff member is a single bed of bluish-gray, very finely-crystalline limestone. Exposed surfaces of the rock weather to a yellowish-gray or yellowish-brown color. The bed has a smooth upper surface, an uneven lower surface, and prominent vertical jointing. The limestone is fossiliferous, containing fusulinids, brachiopods, crinoid stems, and planispiral gastropods.

No criterion (other than stratigraphic position) was found by which the Rock Bluff Limestone could be distinguished from the Leavenworth member of the Oread Limestone and the Big Springs member of the Lecompton Limestone. The average thickness of the Rock Bluff Limestone is 1.9 feet.

Larsh-Burroak Shale member. The uppermost shale of the Deer Creek formation is the Larsh-Burroak member. It is considered to be the equivalent of shale units typically exposed in Nebraska and Iowa (Condra, 1927, p. 49; Condra & Reed, 1943, p. 48). The lower half of the Larsh-Burroak member is a black, platy, carbonaceous shale containing few fossils other than conodonts. Upward this unit grades into a dark-gray, fissile shale as its carbonaceous content diminishes. The upper half of the Larsh-Burroak member is a medium-gray, unfossiliferous, silty clay shale. The average thickness of the Larsh-Burroak shale is 2.9 feet.

Ervine Creek Limestone member. The uppermost member of the Deer Creek formation is the Ervine Creek Limestone, named from exposures in southeastern Nebraska (Condra, 1927, p. 50). The Ervine Creek member is a light-gray, hard limestone altered by weathering to a yellowish-orange or light-brown color. On the basis of differences in lithology and faunal content the member is divisible into three units.

The lowermost and thickest unit of the Ervine Creek member is found at all outcrops. It is a finely-crystalline limestone that appears to be massive at fresh exposures. Weathered outcrops however reveal thin beds of limestone separated by sinuous and discontinuous laminae of clay shale. The beds weather into slabs, each of which is characterized by a knobby surface and irregular thickness. Clear to translucent calcite veinlets are fairly common in the rock. Mottled yellowish-gray and yellowish-orange chert nodules are local features. Fossils in the unit include small horn corals and the bryozoan, Fistulipora, both of which commonly weather out in relief on the surface. Less conspicuous forms are brachiopods, gastropods, fusulinids, and crinoid stems. A good specimen of the chambered sponge, Amblysiphonella, was found in the uppermost bed. The thickness of the lower unit is approximately 9 feet.

The middle unit of the Ervine Creek member is an "oatmeal"-textured fragmental limestone in a massive bed slightly more than one foot in thickness. Algae (Osagia), small gastropods, small brachiopods (especially Composita), crinoid stems, and large pelecypods are common fossils in the bed. Fusulinids are very rare in this unit.

The uppermost unit of the Ervine Creek member is a massive bed of finely-crystalline limestone approximately 1.5 feet thick. Fusulinids are common, occurring in clusters at the top of the bed. Several genera of brachiopods are represented: these include Composita, Neospirifer, and an abundance of Derbyia. Fenestrate and ramose types of bryozoans are other common fossils.

The middle and upper units of the Ervine Creek member probably are not persistent within the area. Where all three units are present the Ervine Creek Limestone is approximately 12 feet thick.

Calhoun Shale

Conformably overlying the Deer Creek Limestone is the Calhoun Shale, typically exposed at Calhoun Bluffs a few miles northeast of Topeka, Kansas (Beede, 1898, pp. 27-34). The Calhoun formation is a gray, micaceous, sandy silt shale. About 12 feet above the base of the shale is a bed of medium-gray, very calcareous and well-lithified sandstone. The bed is approximately 0.6 feet thick. The persistency of the bed could not be determined because the lower part of the Calhoun Shale is not exposed in many places. The shale is quite sandy in the upper half. Here are beds of bluish-gray, medium-grained, friable sandstone. Cross-bedding and irregular lower surfaces of some of the sandstone beds indicate that they are channel sands. The average thickness of the Calhoun Shale is 37 feet.

Topeka Limestone

The Calhoun Shale is conformably overlain by the Topeka Limestone, named from the Kansas State capital (Bennett, 1896, p. 117).

The Topeka Limestone caps the higher land surfaces in the south-central part of Jefferson County. The exposed part of the formation includes only its two lowermost limestone members and an intervening shale member, a sequence that forms a low but nevertheless distinct escarpment (fig. 6).

The Topeka Limestone is composed of nine members (in upward order): the Hartford Limestone, Iowa Point Shale, Curzon Limestone, Jones Point Shale, Sheldon Limestone, Turner Creek Shale, Du Bois Limestone, Holt Shale, and Coal Creek Limestone. The aggregate thickness of the three lowermost members is approximately 12 feet.

Hartford Limestone member. The basal member of the Topeka formation is the Hartford Limestone, named from a town in Coffee County, Kansas (Kirk, 1896, p. 80). The Hartford member consists mainly of medium-gray, very finely-crystalline limestone. A very thin outer zone of the limestone is altered by weathering to a yellowish-orange or yellowish-brown color. The shallowness of the weathering zone is a good criterion for identification of the Topeka formation, for the other limestone formations of the Shawnee Group have basal members in which the secondary weathering color extends deeper below the surface.

In some outcrops the basal unit of the Hartford member is a shaly limestone bed ranging from a feather edge to 0.6 feet in thickness.

FIG. 6. Escarpment of Topeka Limestone. Picture taken near easternmost extension of escarpment. Camera faces northeast in NW 1/4 sec. 28, T. 10 S., R. 19 E.

Small brachiopods, crinoid stems, and shell fragments are found in the unit. The bed is not persistent; where it occurs it is overlain by a thin bed of gray, fossiliferous shale.

The major unit of the Hartford member is a massive bed of hard, weathering-resistant limestone; its average thickness is 2.2 feet. Large brachiopods (Dictyoclostus) are prominent forms in its faunal assemblage. The chambered sponge, Amblysiphonella, was found in the basal part of this bed in three separate outcrops. Crinoid stems, fenestrate bryozoans, and horn corals are fairly common fossils. Fusulinids are present but not abundant.

The uppermost unit of the member is variable in lithology, faunal content, and thickness. At some places it consists of alternating shale and limestone in thin lenticular layers overlain by a somewhat thicker bed of hard limestone. The thin strata are only moderately fossiliferous. The top bed is more fossiliferous; it contains brachiopods (Marginifera), gastropods, and fusulinids. In other outcrops the uppermost unit is a limestone that tends to weather into slabs. Algae and ramose types of bryozoans are common fossils. The thickness of the upper unit ranges from 0.6 to 1.5 feet.

The Hartford member has a thickness ranging from 3.6 to 4.3 feet.

Iowa Point Shale member. The member lying above the Hartford Limestone is the Iowa Point Shale. It is typically exposed in northeastern Doniphan County, Kansas (Condra, 1927, p. 51). The Iowa Point member consists mainly of gray clay shale which is altered by weathering to a tan color. Approximately 0.4 feet above the base of the shale is a 0.4 feet thick section of thin-bedded, sandy limestone containing small fragments of shell. The Iowa Point Shale member averages 1.8 feet in thickness.

Curzon Limestone member. Overlying the Iowa Point Shale is the Curzon Limestone. Its type locality is east of Curzon Station in Holt County, Missouri (Gallaher, 1898, p. 57; Condra, 1927, p. 52). The Curzon member is a medium-gray limestone which commonly weathers to a dark yellowish-orange color on the surface. Below the surface it weathers deeply to a moderate yellowish-brown color. The limestone has massive bedding. Fractures develop parallel to bedding in the exposed rock and it weathers into thin smooth-surfaced slabs. Fossils commonly do not weather loose from the rock but many are revealed clearly in relief on the rock surface. The fossils include large brachiopods (Dictyoclostus), both fenestrate and ramose types of bryozoans, crinoid stems, and echinoid spines.

A complete section of the Curzon Limestone was not found. At all outcrops the upper part of the member is either weathered away or covered by mantle. The Curzon member has a minimum exposed thickness of 5.9 feet.

Quaternary System

Pleistocene Series

Unconsolidated Pleistocene deposits are irregularly distributed on the beveled edges of the Pennsylvanian formations. The Pleistocene deposits consist mainly of glacial till in the upland and glacial outwash in terraced valley train deposits in the lowland. The thickness of the series is quite variable, averaging approximately 110 feet. Represented in the sequence are (from oldest to youngest): the Kansan, Illinoian, and Wisconsin Stages.

Kansan Stage

Kansas Till

In the upland area the Kansas glacial till overlies the beveled Pennsylvanian rocks. The main constituent of the till is clay; also included are fragments of all the sizes ranging up to and including boulders. Of the larger fragments pink quartzite is probably the most conspicuous. Weathered granite, dark-colored igneous and metamorphic rocks, chert, and limestone are also found in large fragments. The till is unconsolidated, unsorted, and unstratified. Where it is unweathered the till is gray; however, most of it has been altered to a reddish-brown color by weathering.

Although all of the Pennsylvanian formations are in some places overlain by remnants of the till it is shown on the geologic map (pl. 1) only where it is sufficiently thick to prevent tracing of the Pennsylvanian rocks. The average thickness of the Kansas Till is 30 feet.

Lower Pleistocene Deposits

Overlying the Kansas Till are Lower Pleistocene unconsolidated alluvial deposits that form the Menoken Terrace, the oldest and highest terrace in the Kansas and Delaware valleys (Davis & Carlson, 1952, p. 225, pl. 1). The deposits are mainly silt but contain substantial amounts of sand, gravel, and clay. The sediments are stratified; in general the grain sizes become smaller upward. Lithologic similarities indicate that the alluvium was derived from the Kansas Till.

Areal distribution of Lower Pleistocene deposits as shown on the geologic map (pl. 1) accompanying this report agrees substantially with the distribution shown by Davis and Carlson, especially in the area with which they were primarily concerned (the Kansas River valley proper). One area where the maps do not agree is on the east side of the Delaware River in the northern half of T. 11 S, R. 20 E.

The geologic map included with this report shows Pennsylvanian rocks lying nearer to Delaware River than was shown by Davis and Carlson. In the same general area Lower Pleistocene deposits are shown along the east side of the valley. Davis and Carlson defined this strip as undifferentiated middle Pleistocene deposits. Alluvial deposits at comparable altitudes in an outlier near the middle of Delaware River valley (NW 1/4 sec. 9, T. 11 S., R. 20 E.) and in strips farther south on both sides of the valley were classified as Lower Pleistocene by Davis and Carlson. Their identification of the outlier was based partly on study of samples from a test hole drilled in the outlier.

Davis and Carlson have shown the undifferentiated middle Pleistocene deposits in small isolated outcrops in tributary stream valleys east of the Delaware River. Pennsylvanian rocks crop out in most of these areas. Differential erosion of the Pennsylvanian beds causes benches to develop. Where covered by mantle or slope wash the bench could be mistaken for an alluvial terrace.

The Lower Pleistocene deposits average 35 feet in thickness.

Illinoian Stage

Upper Pleistocene Deposits

Above the Menoken Terrace deposits are Upper Pleistocene alluvial deposits of Illinoian age (Davis & Carlson, 1952, p. 213).

The deposits are definitely identified only where Buck Creek enters the Kansas River valley. Here are unconsolidated, stratified, floodplain deposits of clayey and sandy silt which underlie the Buck Creek Terrace. The deposits are approximately 20 feet thick.

Wisconsin and Recent Stages

Newman Terrace Deposits

The youngest terrace in the area is the Newman Terrace. It was named from a small village in south-central Jefferson County (Davis & Carlson, 1952, p. 213). The deposits underlying the terrace grade laterally from medium sand on the natural levee along the scarp to silty clay near the sides of the river valleys (Davis & Carlson, 1952, p. 229). The sediments are unconsolidated stratified floodplain deposits ranging from Wisconsin to Recent age. The Newman terrace deposits commonly range from 10 to 20 feet in thickness.

Recent Alluvium

The youngest sediments in the area include the floodplain deposits of the Kansas and Delaware Rivers and the alluvium being deposited in the valleys of the small tributary streams. The floodplain deposits are chiefly sandy silt derived mainly from sources west and north of the area. In the smaller valleys the alluvium consists of poorly sorted particles derived from local sources.

STRUCTURAL GEOLOGY

Structural History

From studies of the stratigraphic relationships of subsurface rocks Lee (1943) interpreted in detail the structural history of northeastern Kansas. Lee's interpretations are the main source of information for the brief summary presented here.

In late Cambrian time subsidence in the central Ozark region of Missouri and contemporaneous uplift in southeastern Nebraska caused the exposed Precambrian basement rock surface of Jefferson County to be tilted to the southeast. The Jefferson County land surface was submerged and deposition began in the area. The surface was alternately submergent and emergent until the end of Arbuckle time when the entire region was uplifted and subjected to erosion. After the erosional period the area subsided and the St. Peter Sandstone was deposited on strata of Early Ordovician age.

From post-St. Peter time to the end of Chattanooga time the area in Jefferson County was again intermediate between positive and negative regions. The crustal movements were reversed, however, resulting in development of the Ozark Dome to the southeast and the North Kansas Basin to the northwest. Two angular unconformities indicate that maximum elevations of the land surface to the southeast occurred in late Silurian time and in the time immediately preceding deposition of the Chattanooga Shale.

During Mississippian time the North Kansas Basin continued to subside. However, a narrow belt of rocks trending slightly east of north through the basin began to rise. In early Pennsylvanian time the belt was strongly uplifted, forming the Nemaha Anticline and dividing the old basin into the Salina Basin to the west and an unnamed structural basin to the east. The history of the unnamed basin is obscure because of the absence of lower Pennsylvanian deposits in the region. In Desmoinesian time the surface east of the Nemaha Anticline subsided to form the Forest City Basin in northeastern Kansas and the Cherokee Basin in southeastern Kansas. Separating the basins was the Bourbon Arch, a low narrow platform trending northwestward. Continued regional subsidence caused burial of the Bourbon Arch before the end of Desmoinesian time. At this time the Forest City Basin became a northward extension of the larger Cherokee basin.

Deposition in the Forest City basin was interrupted by an uplift of regional proportions accompanied by westward tilting of the strata in eastern Kansas. This movement formed the Prairie Plains Monocline. Its exact date of origin is unknown because erosion has removed the upper part of the Forest City Basin deposits. The Prairie Plains Monocline is probably post-Permian and is definitely pre-Cretaceous in age. It is the youngest regional structure in northeastern Kansas. Kansas Cretaceous and Cenozoic rocks are only slightly deformed although they have been greatly elevated above sea level.

Present Structure

In Jefferson County the exposed Pennsylvanian sedimentary rocks strike northeastward and dip northwestward approximately 15 feet per mile. All of the bedrock now exposed was deposited on the southeast flank of the Forest City Basin and was subsequently tilted to its present structural attitude during development of the Prairie Plains Monocline. In the area mapped there are local minor variations in the direction of strike and the amount of dip. The dip ranges from 10 to 20 feet per mile. In the vicinity of the McLouth oil field the surface rocks have anticlinal folding with less than 20 feet of closure. The amount of closure increases with depth (Lee & Payne, 1944, p. 66). Gentle flexures were found in surface rocks in other parts of the area but at no place did the amount of closure exceed 10 feet. No faults were found in the surface rocks. Subsurface faulting has been reported by Lee and Payne (1944, p. 78).

ECONOMIC GEOLOGY

Mineral resources of the area include oil and gas, limestone, shale, sand, gravel, and ground-water.

Oil and Gas

All of the oil and gas produced in the area has come from the McLouth gas and oil field which was discovered in 1939. Maximum annual production was obtained from the field in 1943. Since that time the field production has gradually declined and during the past few years none has been reported. At the present time part of the field is being used for storage of natural gas. Although the discovery of the McLouth field resulted in the drilling of many wildcat wells in Jefferson County, no new fields have been discovered.

Limestone

Limestone taken from the area is used chiefly as road metal for highway and road construction. The Plattsmouth Limestone member is the unit best suited for such purposes. At the present time the only large scale quarrying is in the Plattsmouth Limestone about one-half mile northeast of the junction of U. S. Highways 24 and 59. At other locations in southeast Jefferson County the limestone is sufficiently thick and the overburden sufficiently thin to make quarrying economically feasible.

Shale

In the area is an abundance of shale, some of which could possibly be used in the manufacture of ceramic products and cement. None of it is being used at the present time.

Sand and Gravel

Sand and gravel is abundant in the floodplain deposits in the Kansas and Delaware River valleys. Small amounts occur in the glacial drift on the upland. There is no commercial production from the sand and gravel deposits. Individuals extract small amounts for local use.

Ground-water

The alluvial deposits in the Kansas and Delaware River valleys have an abundant supply of ground-water. In the upland small to moderate quantities of ground-water are derived from sandstone and limestone beds of Pennsylvanian age and from Recent alluvium in small streat valleys. An excellent study of the ground-water resources of the Kansas River valley has been made by Davis and Carlson (1952). The southern part of Jefferson County is included in the area covered by their investigation.

SUMMARY

Southeastern and south-central Jefferson County, Kansas, an area of approximately 175 square miles, is in the Dissected Till Plains section of the Central Lowland physiographic province. Most of the area is an upland. In the upland prominent east-facing cuestas have formed where bedrock is exposed and gently rolling hills have formed where glacial till underlies the surface. Along the river valleys there is a lowland. The Kansas River system effectively drains the area.

The exposed bedrock is Pennsylvanian in age. It consists of northwestward-dipping, alternating shale and limestone formations of the Douglas and Shawnee Groups, Virgilian Series. The strata consist of cyclic deposits. Each shale formation contains both marine and non-marine sediments. Each limestone formation is composed of alternating limestone and shale members of marine origin. The oldest outcropping rock is the Lawrence shale, the upper formation of the Douglas group. All the formations of the Shawnee group are exposed.

Unconformably overlying the Pennsylvanian rocks are unconsolidated deposits of Quaternary age. The oldest of these is the Pleistocene Kansas Till. Overlying the till is alluvium of Kansan age forming the Menoken Terrace. Above the Menoken Terrace are the Buck Creek Terrace alluvial deposits of Illinoian age. Overlying the Illinoian deposits are the Newman Terrace alluvial deposits of Wisconsin and Recent age. Alluvium is being deposited in present-day stream floodplains.

The first structural movement recorded in the area consisted of subsidence with southeastward tilting of the strata. It began in late Cambrian time and was terminated by a general uplift in Middle Ordovician time. From Middle Ordovician to the end of Paleozoic time subsidence was accompanied by northwestward tilting of the strata. Unconformities show that important uplifts occurred in

Late Silurian, Late Devonian, and Early Pennsylvanian time. In Desmoinesian time the Forest City Basin formed. Its southeast flank was the place of deposition of the Pennsylvanian rocks now exposed. The last major diastrophism occurred between Permian and Cretaceous time when the region was elevated and tilted westward to form the Prairie Plains Monocline. The outcropping Pennsylvanian formations strike northeastward and dip to the northwest at an average 15 feet per mile. Locally the strata have small gentle folds with closures of less than 20 feet. No faults were found in the surface rocks.

Mineral resources of the area consist of oil, gas, limestone, shale, sand, gravel, and ground-water.

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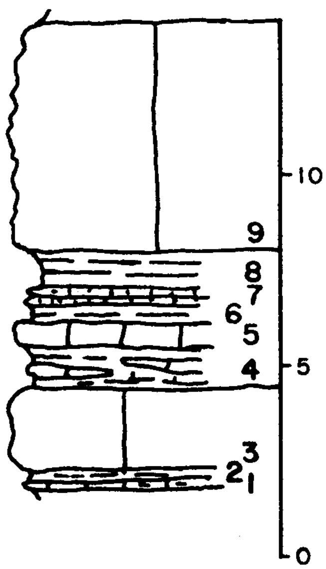
APPENDIX

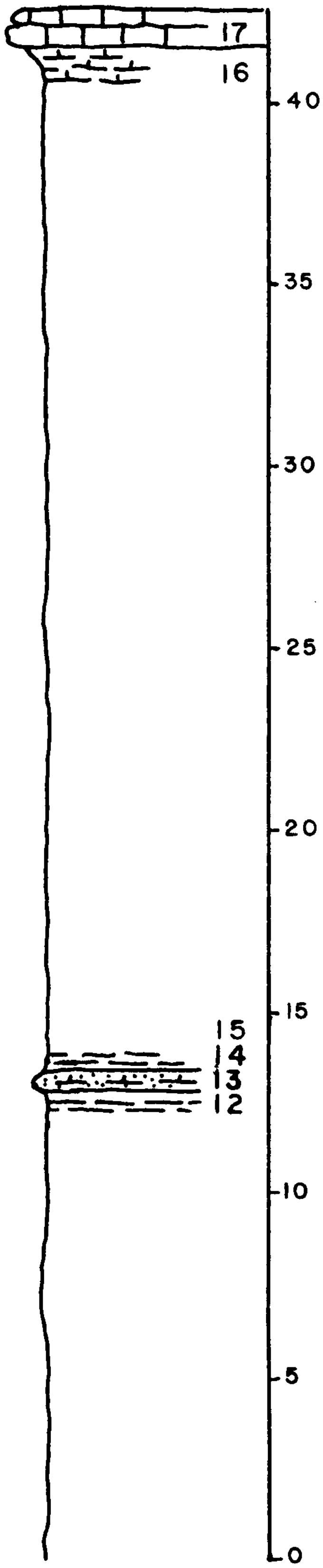
<u>Stratigraphic Sections of Virgilian Rocks Exposed in Jefferson County</u>



SE 1/4 NE 1/4 sec. 12, T. 10 S., R. 18 E along north side of east-west county road.

Shawnee Group
  Topeka Limestone (12.0 feet)
    Curzon Limestone member (5.9 feet)

9.	Limestone, medium-gray, weathers deeply to yellowish-orange color, ferruginous, massive, contains *Dictyoclostus*, echinoid spines, crinoid stems and calices, fenestrate and ramose types of bryozoans	5.9
	Iowa Point Shale member (1.8 feet)	
8.	Shale, tan	1.0
7.	Limestone, gray, platy, sandy in upper portion	0.4
6.	Shale, tan, laminated	0.4
	Hartford Limestone member (4.3 feet)	
5.	Limestone, olive gray, compact, fossiliferous, *Marginifera*, gastropods, fusulinids	0.7
4.	Clay shale, gray, with interbedded thin lenticular layers of limestone ...	0.9
3.	Limestone, medium light-gray; weathers to yellowish-brown in thin surficial zone, finely-crystalline, massive, fossiliferous, contains *Dictyoclostus*, crinoid stems and calices, fusulinids present but not abundant	2.2
2.	Shale, gray, laminated	0.3
1.	Limestone, gray, shaly	0.2



Top of section at extreme SE corner of sec. 10, T. 10 S., R. 18 E. Section extends northward along county road for approximately 1/2 mile.

Shawnee Group
Topeka Limestone (1.1 feet)
Hartford Limestone member (1.1 feet)

17.	Limestone, medium-gray, weathers shallowly to light-brown, finely-crystalline, contains *Dictyoclostus*, *Amblysiphonella*, horn corals, crinoid stems	1.1

Calhoun Shale (45.3 feet)

16.	Clay shale, gray, silty, laminated	1.0
15.	Covered interval	26.4
14.	Silt shale, gray, laminated	0.5
13.	Sandstone, medium-gray, well-lithified, very calcareous	0.6
12.	Silt shale, gray, laminated	0.5

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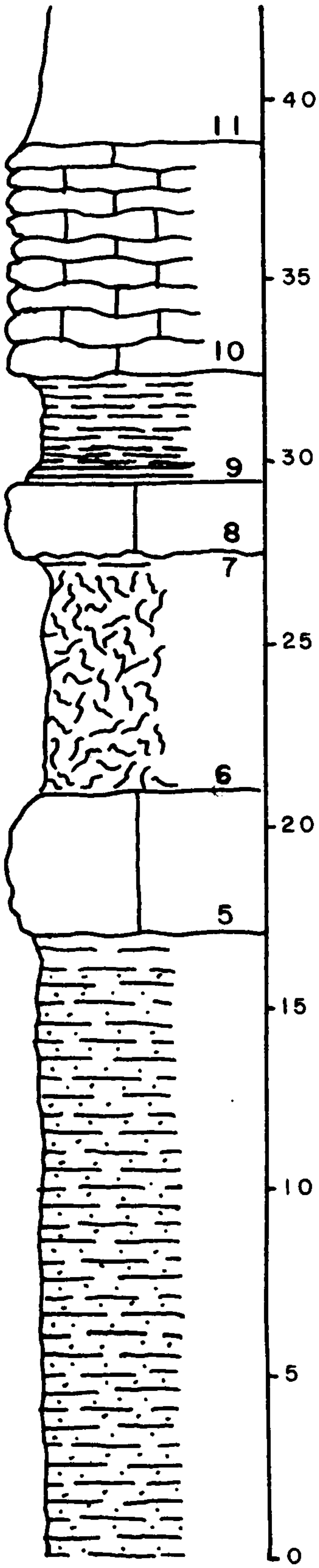

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11. Covered interval 15.2

Deer Creek Limestone (21.6 feet)

Ervine Creek Limestone member (6.4 feet)

10. Limestone, light-gray, weathers to light-brown, finely-crystalline, hard, ferruginous, fossiliferous, contains Hustedia, Neospirifer, Chonetes, Derbyia, horn corals, planispiral gastropods, fenestrate bryozoans, Fistulipora, fusulinids 6.4

Larsh-Burroak Shale member (2.9 feet)

9. Silt shale, grades from medium-gray at top to black color at base, clayey and laminated at top, carbonaceous and platy at base 2.9

Rock Bluff Limestone member (1.9 feet)

8. Limestone, bluish-gray, weathers shallowly to yellowish-brown, very finely-crystalline, massive, even upper surface, uneven lower surface, vertically jointed, fossiliferous, contains fusulinids, crinoid stems, brachiopods..................... 1.9

Oskaloosa Shale member (6.5 feet)

7. Shale, light-gray, laminated, calcareous, contains mollusks 0.4

6. Silt shale, medium-gray, nodular, laminated........................ 6.1

Ozawkie Limestone member (3.9 feet)

5. Limestone, gray, weathers to brown on surface and brown and gray spotted color far beneath surface, ferruginous, massive, oolitic texture from base to top, surface pitted when well-weathered, fossiliferous, contains crinoid stems, brachiopods, echinoid spines, fusulinids......................... 3.9

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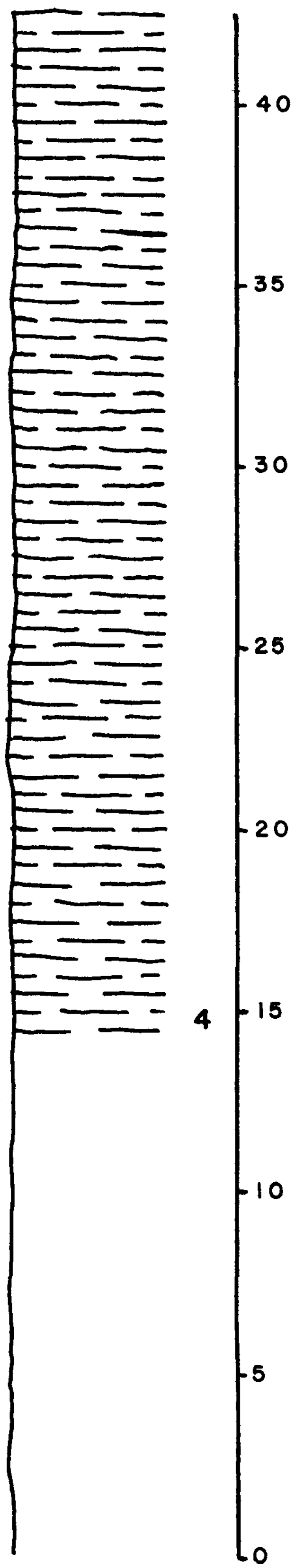

Tecumseh Shale (78.0 feet)

4. Silt shale, medium-gray, sandy, micaceous, somewhat clayey in uppermost part, laminated, iron oxide stain in bedding planes, contains leaves and other land plant remains 44.7

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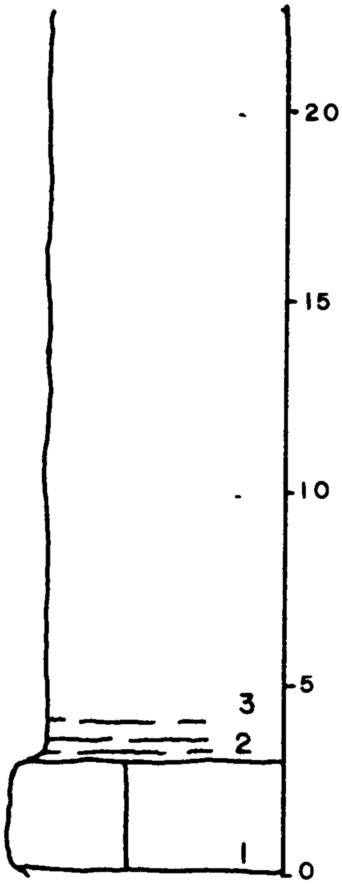

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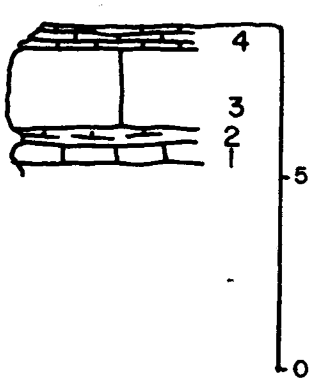
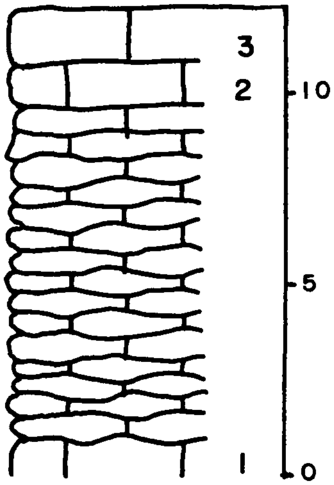
3. Covered interval 32.3
2. Silt shale, tan, clayey, laminated .. 1.0

Lecompton Limestone (2.8 feet)
Avoca Limestone member (2.8 feet)
1. Limestone, bluish-gray, finely-crystalline, massive, fossiliferous, contains fusulinids, crinoid stems, brachiopods...................... 2.8



SW 1/4 SE 1/4 SW 1/4 sec. 4, T. 10 S., R. 18 E. on north side of section road.

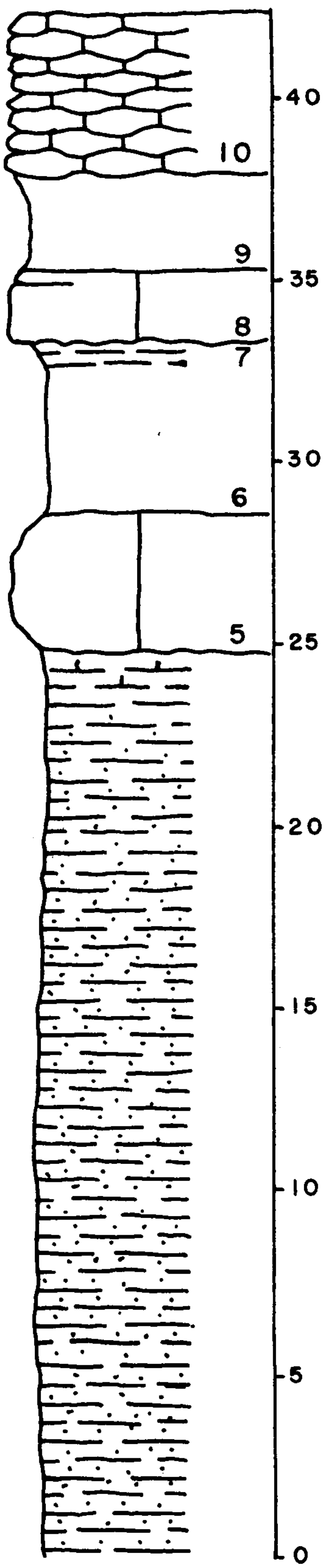
Shawnee Group
Topeka Limestone (3.6 feet)
Hartford Limestone member (3.6 feet)
4. Limestone, medium-gray; weathers shallowly to yellowish-orange color, weathers into slabs, contains ramose type bryozoans and algae (probably Osagia)........................... 0.6
3. Limestone, medium-gray, weathers shallowly to yellowish-orange color, finely-crystalline, massive, contains Dictyoclostus, crinoid stems, fenestrate type bryozoans, horn corals, fusulinids, algae (Ottonosia ?)....... 2.2
2. Clay shale, gray, weathers to dark yellowish-orange color............. 0.2
1. Limestone, gray, weathers to pale yellowish-brown, contains small crinoid stems..................... 0.6



SE 1/4 SE 1/4 sec. 6, T. 10 S., R. 18 E. in abandoned quarry west of county road.

Shawnee Group
  Deer Creek Limestone (11.4 feet)
    Ervine Creek Limestone member (11.4 feet)

3. Limestone, light-gray, weathers to yellowish-orange color, finely-crystalline, hard, massive, fossiliferous, many fusulinids in clusters at top of bed, *Neospirifer*, *Composita*, many *Derbyia*, ramose and fenestrate types of bryozoans, gastropods 1.5
2. Limestone, light-gray, weathers to yellowish-orange color, has an "oatmeal" texture, massive, fossiliferous, many algae (*Osagia* ?), small brachiopods (*Composita*), small gastropods, crinoid stems, large pelecypods, very few fusulinids 1.2
1. Limestone, light-gray, weathers to yellowish-orange color, finely-crystalline, hard, thin to medium-bedded, wavy-bedded, has calcite veinlets, fossiliferous, fusulinids, brachiopods, *Fistulipora*, horn corals, crinoid stems, chambered sponge *Amblysiphonella* found in upper part of top bed. Basal part of unit not exposed in quarry 8.7



Sec. 28. T. 10 S., R. 18 E. along north-south county road between SE 1/4 and SW 1/4.

Shawnee Group
Deer Creek Limestone (17.4 feet)
Ervine Creek Limestone member (4.5 feet)
10. Limestone, light-gray, weathers to light-brown, finely-crystalline, hard, thin to medium-bedded, wavy-bedded, brachiopods, horn corals, bryozoans, crinoid stems 4.5
Larsh-Burroak Shale member (2.5 feet)
9. Covered interval 2.5
Rock Bluff Limestone member (2.0 feet)
8. Limestone, bluish-gray, weathers to yellowish-gray in thin surficial zone, massive, even upper surface, wavy lower surface, vertically-jointed, fossiliferous, contains fusulinids, planispiral gastropods (Bellerophon ?) 2.0
Oskaloosa Shale member (4.7 feet)
7. Shale, gray, laminated............. 0.4
6. Covered interval 4.3
Ozawkie Limestone member (3.7 feet)
5. Limestone, medium-gray, weathers to light-brown on surface and gray and brown spotted color below surface, ferruginous, massive, oolitic texture, solution-pitted on surface, fossiliferous, contains crinoid stems, brachiopods, fusulinids 3.7

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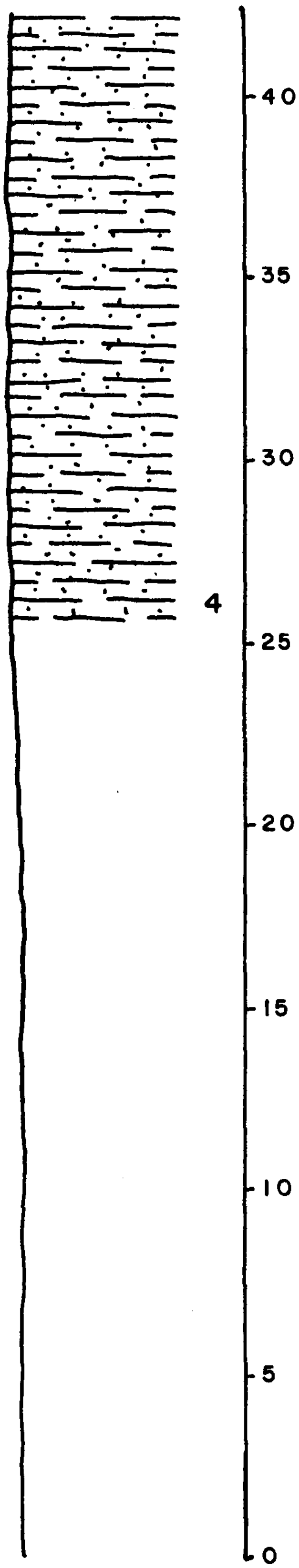

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Tecumseh Shale (82.2 feet)

4. Silt shale, medium-gray, laminated, micaceous, sandy, contains land plant fossils, upward becomes less sandy and color grades to bluish-gray 41.0

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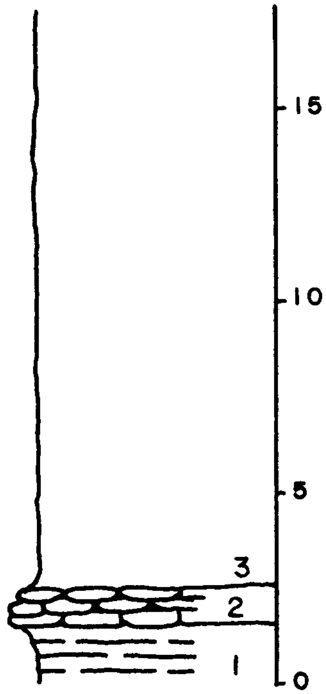

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3. Covered interval 41.2

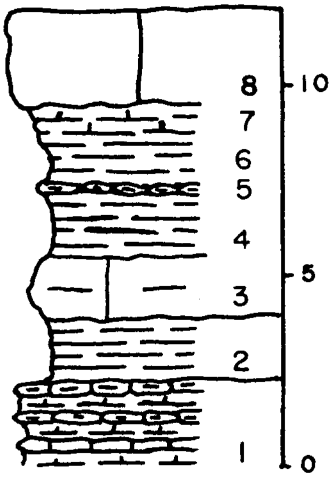
Lecompton Limestone (3.0 feet)

Avoca Limestone member (1.0 feet)

2. Limestone, dark-gray, weathers to yellowish-brown, shaly, nodular, unfossiliferous 1.0

King Hill Shale member (2.0 feet)

1. Clay shale, light-gray, laminated... 2.0



SW 1/4 NE 1/4 sec. 31, T. 10 S., R. 20 E. in west ditch of north-south county road.

Shawnee Group
Lecompton Limestone (11.9 feet)
Avoca Limestone member (8.0 feet)

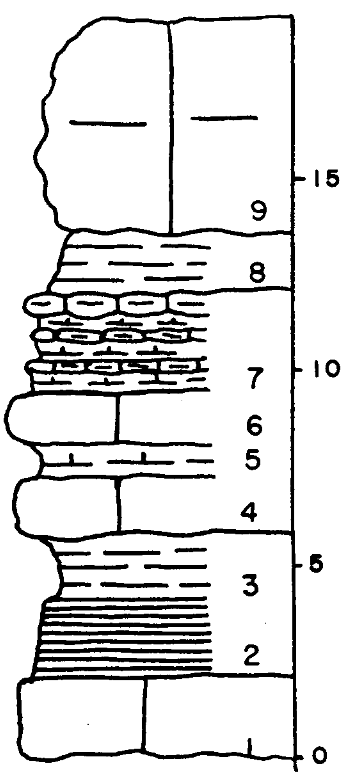
8. Limestone, medium-gray, weathers pale yellowish-orange, finely-crystalline, massive, even top, wavy bottom, vertically-jointed, very fossiliferous, many fusulinids especially in lower one-third, Chonetes, Marginifera, gastropods, crinoid stems 2.4
7. Silt shale, dark-gray, calcareous, has brachiopods 1.1
6. Silt shale, pale olive, clayey, laminated 0.9
5. Limestone, gray, shaly, nodular ... 0.3
4. Silt shale, medium-gray, clayey, laminated 1.6
3. Limestone, light-gray, massive, shaly, nodular, unfossiliferous 1.7

King Hill Shale member (1.6 feet)

2. Clay shale, dark greenish-gray, silty, laminated, no fossils 1.6

Beil Limestone member (2.3 feet)

1. Limestone, light gray, interbedded with limy shale, thin-bedded, wavy-bedded, extremely fossiliferous..... 2.3



SW 1/4 NW 1/4 sec. 17, T. 10 S., R. 18 E. stream cut on NE trending abandoned road.

Shawnee Group
Lecompton Limestone (18.9 feet)
Avoca Limestone member (5.6 feet)

9. Limestone, gray, weathers to yellowish-brown, massive, shaly, nodular, non-fossiliferous 5.6

King Hill Shale member (1.4 feet)

8. Clay shale, light olive gray, laminated, unfossiliferous 1.4

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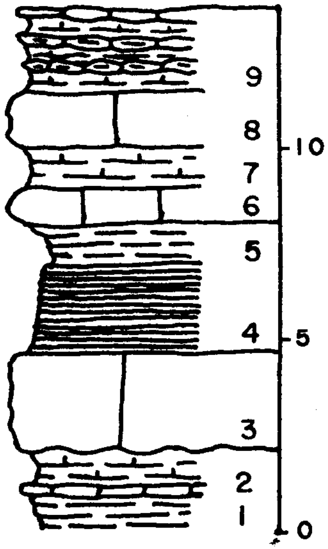
Beil Limestone member (6.3 feet)		
7.	Limestone, light-gray, weathers to very light-gray, shaly, thinly and irregularly-bedded, alternating with light-gray limy clay shale, extremely fossiliferous, Triticites, Chonetes, Composita, Dielasma, Marginifera, Dictyoclostus, Neospirifer, Caninia Torquia, Aulopora, crinoid stems and calyces	2.6
6.	Limestone, light olive gray, massive, brachiopods, fusulinids	1.4
5.	Clay shale, light-gray, calcareous, laminated, fossiliferous, crinoid stems, fusulinids, brachiopods	0.8
4.	Limestone, light olive gray, massive, fossiliferous, fusulinids, brachiopods, crinoid stems	1.5
Queen Hill Shale member (3.6 feet)		
3.	Clay shale, light olive gray, laminated	1.5
2.	Silt shale, black, platy, carbonaceous	2.1
Big Springs Limestone member (2.0 feet)		
1.	Limestone, bluish-gray, very finely-crystalline, massive, even top, wavy bottom, fossiliferous, abundant fusulinids	2.0



NW 1/4 NE 1/4 sec. 34, T. 10 S., R. 19 E. west back of creek crossing east-west section road

Shawnee Group

Lecompton Limestone (13.4 feet)

Beil Limestone member (5.5 feet)

9. Limestone, light-gray, shaly, thin-bedded, wavy-bedded, interbedded with limy clay shale, very fossiliferous, Triticites in clusters, Caninia Torquia, Chonetes, Marginifera, Composita, crinoid stems 2.0
8. Limestone, light-gray, massive, contains fusulinids, brachiopods, crinoid stems 1.4
7. Clay shale, light-gray, limy, laminated, contains fusulinids 1.1
6. Limestone, light-gray, massive, contains fusulinids 1.0

Queen Hill Shale member (3.3 feet)

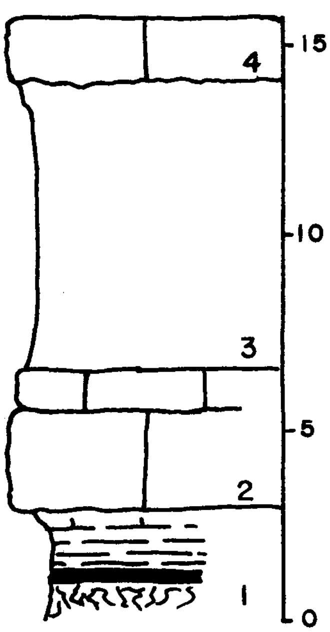
5. Clay shale, gray, laminated, unfossiliferous 1.0
4. Silt shale, black, carbonaceous, platy, brittle 2.3

Big Springs Limestone member (2.4 feet)

3. Limestone, bluish-gray, surface weathers to yellowish-orange color, massive, even top, wavy bottom, vertical jointing, fossiliferous, fusulinids, brachiopods 2.4

Doniphan Shale member (2.2 feet)

2. Shale, gray, limy, overlying thin bed of shaly limestone, fusulinids in shale and limestone 1.2
1. Shale, very dark-gray, platy 1.0



NW 1/4 NE 1/4 sec. 12, T. 11 S., R. 19 E. along east-west section road.

Shawnee group

Lecompton Limestone (12.7 feet)

Big Springs Limestone member (1.7 feet)

4. Limestone, bluish-gray, very finely-crystalline, massive, even top, wavy bottom, vertical jointing, fusulinids, brachiopods..................... 1.7

Doniphan Shale member (7.4 feet)

3. Covered interval 7.4

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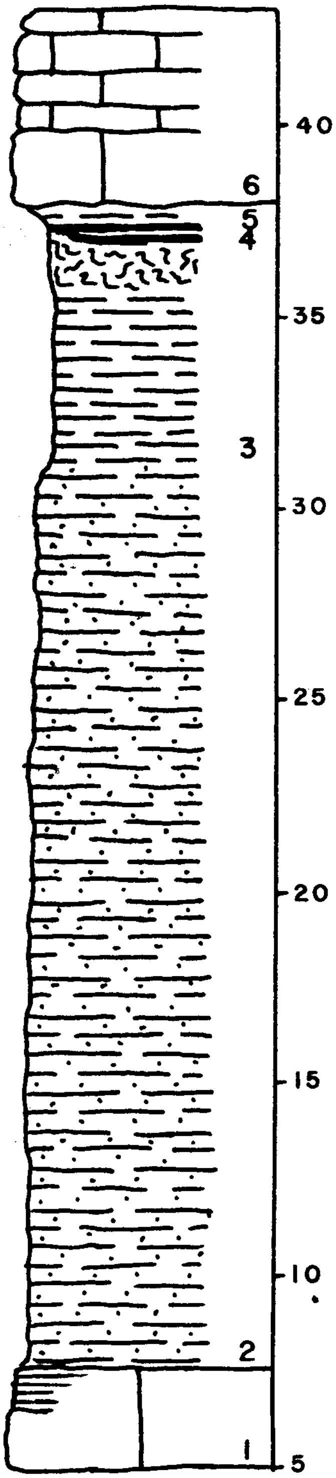

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Spring Branch Limestone member (3.6 feet)

2. Limestone, medium-gray, weathers deeply to light brown, massive, many fusulinids, brachiopods 3.6

Kanwaka Shale (Stull Shale member)

1. Shale, gray, and thin coal seam ... 1.8

SE 1/4 SE 1/4 sec. 36, T. 10 S., R. 19 E. along east-west section road.

Shawnee Group

Lecompton Limestone (5.1 feet)

Spring Branch Limestone member (5.1 feet)

6. Limestone, medium-gray, weathers deeply to yellowish-brown, medium to thick-bedded, fossiliferous, fusulinids (very abundant in upper part), Marginifera, Neospirifer, echinoid spines, fenestrate bryozoans, crinoid stems 5.1

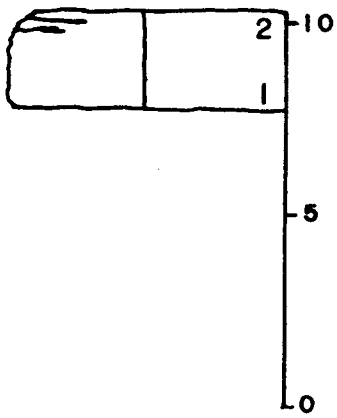
Kanwaka Shale (32.7 feet)

Stull Shale member (30.1 feet)

5. Clay shale, medium-gray, carbonaceous, laminated 0.9
4. Clay shale, very carbonaceous, contains coal seams 0.5
3. Clay shale, light-gray, contains carbonaceous laminae throughout, stratification poor toward top 5.4
2. Silt shale, light olive gray, sandy, micaceous, contains land plant fossils 23.3

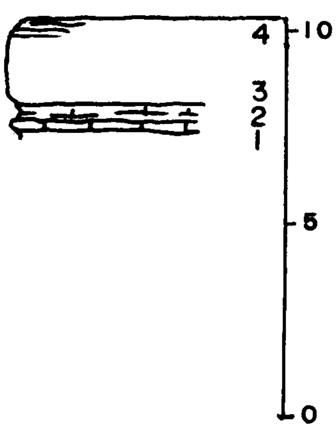
Clay Creek Limestone member (2.6 feet)

1. Limestone, medium dark-gray, weathers shallowly to moderate yellowish-orange color, massive, horizontal fractures in upper part, fossiliferous, fusulinids from base to top, Chonetes, planispiral gastropods, ramose types of bryozoans, crinoid stems 2.6



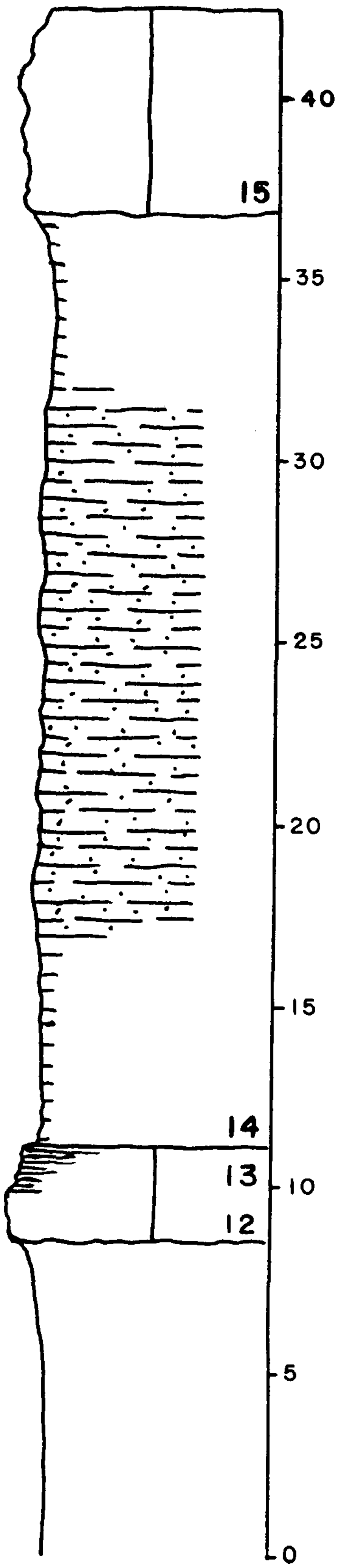
SE 1/4 SW 1/4 sec. 18, T. 11 S., R. 19 E. on north side of east-west section road.
Shawnee Group
Kanwaka Shale (2.6 feet)
Clay Creek Limestone member (2.6 feet)

2. Limestone, medium dark-gray, weathers shallowly to yellowish-orange color, weathers into thin irregular slabs, fossiliferous, fusulinids not abundant, ramose and fenestrate types of bryozoans, echinoid spines, brachiopods, crinoid stems, many shell fragments 0.6
1. Limestone, medium dark-gray, thin surficial zone weathers to yellowish-orange color, massive, fossiliferous, fusulinids abundant, especially in uppermost 0.2 feet of bed, Planispiral gastropods (Bellerophon ?) especially numerous in uppermost 0.8 feet of bed, other fossils include brachiopods and crinoid stems 2.0



SE 1/4 SW 1/4 sec. 29, T. 10 S., R. 20 E. in creek bed west of north-south county road.
Shawnee Group
Kanwaka Shale (2.8 feet)
Clay Creek Limestone member (2.8 feet)

4. Limestone, dark-gray, weathers to yellowish-orange color, weathers into slabs, shaly, fossiliferous, contains crinoid stems, brachiopods, many shell fragments 0.4
3. Limestone, dark-gray, weathers shallowly to yellowish-orange color, massive, fossiliferous, fusulinids, brachiopods, crinoid stems, planispiral gastropods (Bellerophon ?) concentrated in upper 0.8 feet of bed 1.7
2. Shale, tan, calcareous 0.5
1. Limestone, dark-gray, shaly, platy, fossiliferous, contains many small shell fragments, crinoid stems, brachiopods 0.2



NW 1/4 SW 1/4 sec. 14, T. 11 S., R. 19 E. along east-west county road.

Shawnee Group

Lecompton Limestone (5.6 feet)

Spring Branch limestone member (5.6 feet)

15. Limestone, medium dark-gray, weathers deeply to moderate yellowish-brown, finely-crystalline, massive, fossiliferous, fusulinids (very abundant in upper part), brachiopods, crinoid stems, brachiopods 5.6

Kanwaka Shale (78.3 feet)

Stull Shale member (25.4 feet)

14. Silt shale, light olive gray, sandy, micaceous, iron oxide stains, very thin beds of sandy siltstone in upper half, contains land plant fossils (top and basal portions mostly covered).. 25.4

Clay Creek Limestone member (2.6 feet)

13. Limestone, medium dark-gray, weathers to moderate yellowish-orange color, weathers into thin slabs, few fusulinids (none found near top), small gastropods, crinoid stems, small shell fragments 1.2

12. Limestone, medium dark-gray, weathers shallowly to moderate yellowish-orange color, finely-crystalline, massive, contains fusulinids (base to top), ramose type bryozoans, <u>Chonetes</u>, crinoid stems 1.4

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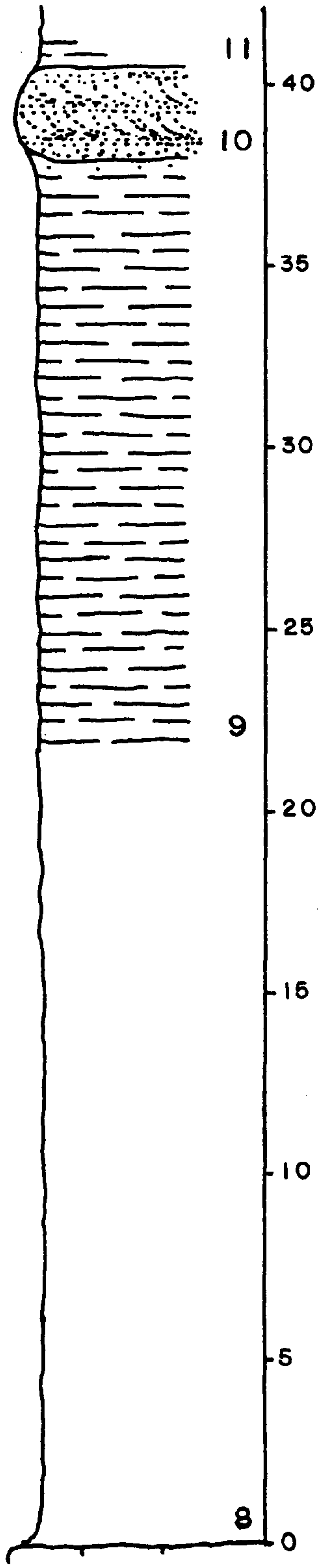

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Jackson Park Shale member (50.3 feet)

11.	Covered interval	10.0
10.	Sandstone, medium-gray, weathers deeply to moderate yellowish-brown, fine-grained, friable, cross-bedded, massive	2.5
9.	Silt shale, light olive gray, sandy, micaceous, iron oxide stains, laminated, contains laminae and thin beds of sandy siltstone, contains land plant leaves in upper part	16.2
8.	Covered interval	21.6

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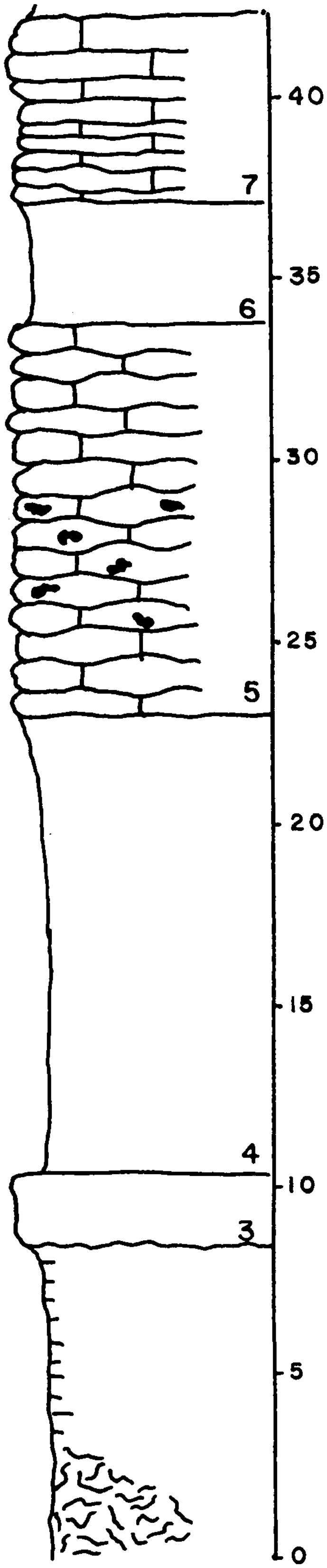

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Oread Limestone (48.0 feet)

Kereford Limestone member (4.7 feet)

7. Limestone, light olive gray, weathers deeply to moderate reddish-brown, weathered surface purple-tinted, finely-crystalline, ferruginous, thin-bedded, wavy-bedded, extremely fossiliferous, many fossils weather out of rock, large fusulinids, fenestrate bryozoans, many *Composita*, many *Dielasma*, *Marginifera*, *Hustedia*, gastropods, crinoid stems 4.7

Heumader Shale member (3.2 feet)

6. Covered interval 3.2

Plattsmouth Limestone member (10.8 feet)

5. Limestone, medium-gray, weathers to grayish-orange color, finely-crystalline, thin to medium-bedded, wavy-bedded, chert nodules in mid-portion, fossiliferous, fusulinids, *Marginifera*, *Hustedia*, *Dictyoclostus*, *Composita*, crinoid stems 10.8

Heebner Shale member (12.5 feet)

4. Covered interval 12.5

Leavenworth Limestone member (1.9 feet)

3. Limestone, bluish-gray, weathers shallowly to moderate yellowish-brown, very finely-crystalline, massive, even top, uneven bottom, vertically-jointed, fossiliferous, fusulinids, brachiopods, crinoid stems, conispiral gastropods 1.9

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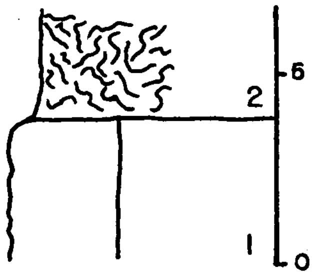


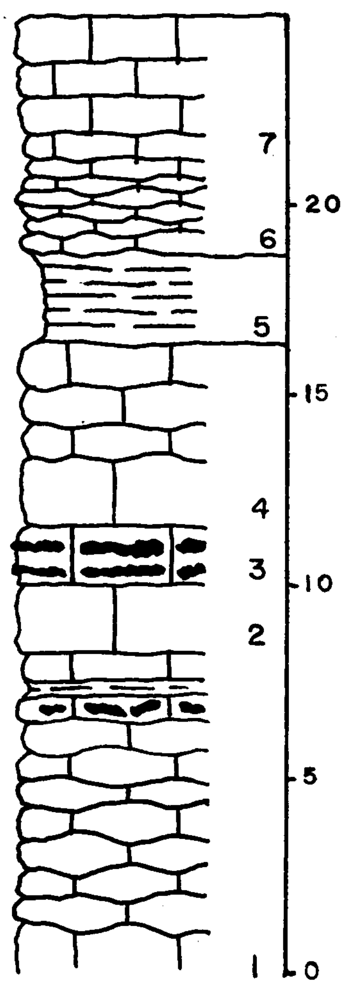
Snyderville Shale member (11.3 feet)

2. Clay shale, light olive gray, slightly silty, nodular, upper part mostly covered 11.3

Toronto Limestone member (3.6 feet)

1. Limestone, light-gray, weathers deeply to dark yellowish-orange color, finely-crystalline, massive, many fusulinids, crinoid stems, Hustedia, fenestrate type bryozoans, basal part of member not exposed 3.6

SW 1/4 NE 1/4 sec. 29, T. 11 S., R. 19 E. in N. R. Hamm Quarry



Shawnee Group

Oread Limestone (24.6 feet)

Kereford Limestone member (6.3 feet)

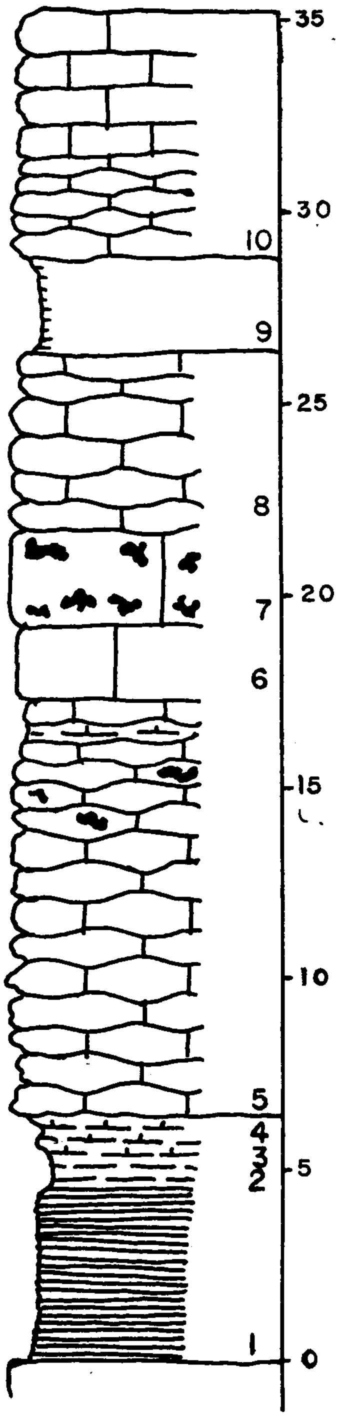
7. Limestone, light olive gray, weathers deeply to reddish-brown, medium-bedded, bedding moderately uneven, weathers into nodular blocks, moderately fossiliferous, fusulinids, brachiopods 4.3
6. Limestone, light olive gray, weathers deeply to purple-tinted reddish-brown, thin-bedded, wavy-bedded, extremely fossiliferous, many fusulinids, Composita, Dielasma, bryozoans 2.0

Heumader Shale member (2.3 feet)

5. Clay shale, medium light-gray, silty, laminated, probably slightly carbonaceous 2.3

Plattsmouth Limestone member (16.0 feet)

4. Limestone, light-gray, medium to thick-bedded, wavy-bedded, contains fusulinids, Composita, crinoid stems, Bellerophon 4.9
3. Limestone, light-gray, has two chert layers, fossiliferous 1.4
2. Limestone, light-gray, massive, fusulinids abundant 1.8
1. Limestone, light-gray, thin to medium-bedded, wavy-bedded, large chert nodules and thin shale bed in upper part, many fossils (some in chert nodules), fusulinids, crinoid stems, Hustedia, Chonetes, fenestrate bryozoans (basal part of member not exposed) 8.0



SW 1/4 SE 1/4 sec. 3, T. 11 S., R. 19 E. on west bank of Buck Creek

Shawnee Group

Oread Limestone (35.2 feet)

Kereford Limestone member (6.5 feet)

10. Limestone, light olive gray, weathers to purple-tinted reddish-brown, thin to medium-bedded, wavy-bedded, shaly, very fossiliferous, large fusulinids, ramose and fenestrate bryozoans, Dielasma, Composita, Bellerophon, echinoid spines, crinoid stems 6.5

Heumader Shale member (2.5 feet)

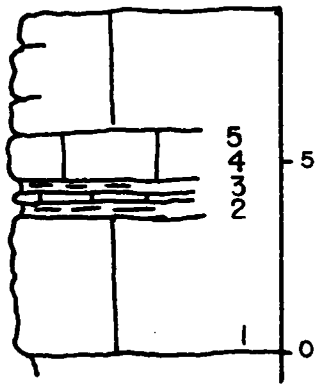
9. Covered interval 2.5

Plattsmouth Limestone member (19.9 feet)

8. Limestone, light-gray, thin to medium-bedded, wavy-bedded, fusulinids and large Bellerophon very abundant upper part, Neospirifer and other brachiopods 4.6
7. Limestone, light-gray, massive, chert nodules abundant, fusulinids in limestone and chert, bryozoans conspicuous, shell fragments 2.5
6. Limestone, light-gray, massive, many fusulinids in clusters 1.9
5. Limestone, light-gray, thin to medium-bedded, wavy-bedded, thin shale bed and chert nodules in upper part, chert contains brachiopods and crinoid stems, fossils include Enteletes (in zone about 7.6 feet above base), Hustedia, Derbyia, Dictyoclostus, fenestrate bryozoans, Lophophyllidium, fusulinids 10.9

Heebner Shale member (6.3 feet)

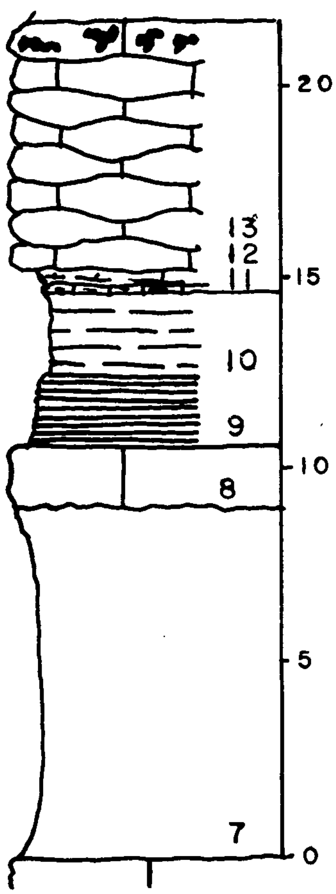
4. Silt shale, yellowish-orange, limy, laminated, small fossils, horn corals, Composita 0.3
3. Silt shale, medium light gray, micaceous, clayey, nodular 0.4
2. Silt shale, medium-gray, limy, micaceous, contains many small Marginifera .. 1.1
1. Silt shale, black, carbonaceous, platy, contains pyrite crystals, many phosphate nodules of oblate spheroid shale .. 4.5



SW 1/4 NW 1/4 sec. 19, T. 11 S., R. 20 E. on north side of east-west county road.

Shawnee Group
  Oread Limestone (9.0 feet)
    Toronto Limestone member (9.0 feet)

5.	Limestone, medium light-gray, weathers deeply to light-brown, thick to massive bedding, fossiliferous, contains crinoid stems, Hustedia, fusulinids	4.5
4.	Silt shale, gray, clayey	0.2
3.	Limestone, gray	0.4
2.	Silt shale, gray, clayey	0.2
1.	Limestone, medium-gray, weathers deeply to moderate brown, fossiliferous, contains Hustedia, fusulinids, many crinoid stems	3.7



NE 1/4 SE 1/4 sec. 31, T. 11 S., R. 20 E. on west side of north-south section road.

Shawnee Group
  Oread Limestone (34.0 feet)
    Plattsmouth Limestone member (7.1 feet)

13.	Limestone, very light-gray, weathers to grayish-orange color, thin to medium-bedded, wavy-bedded, upper part cherty, fossiliferous, contains crinoid stems, Neospirifer, Marginifera, fusulinids	6.6
12.	Clay shale, gray, limy	0.3
11.	Limestone, light-gray, shaly	0.2

    Heebner Shale member (4.0 feet)

10.	Shale, light medium-gray, laminated	2.1
9.	Silt shale, black, platy, carbonaceous	1.9

    Leavenworth Limestone member (1.6 feet)

8.	Limestone, bluish-gray, weathers shallowly to brownish-gray, very finely-crystalline, massive, even upper surface, wavy lower surface, vertically-jointed, fusulinids, brachiopods	1.6

    Snyderville Shale member (8.9 feet)

7.	Covered interval	8.9

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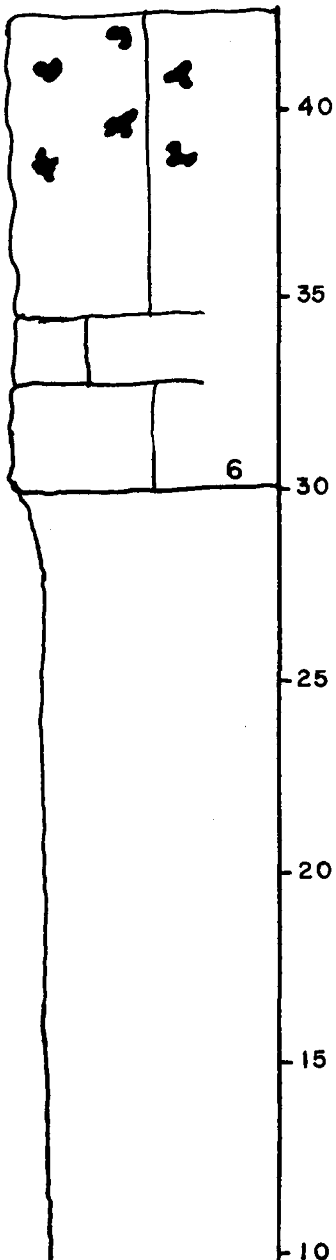

Toronto Limestone member (12.4 feet)

6. Limestone, medium light-gray, weathers deeply to light-brown, massive to thick-bedded, chert nodules in uppermost 5 feet, fossiliferous, crinoid stems, Hustedia, fusulinids 12.4

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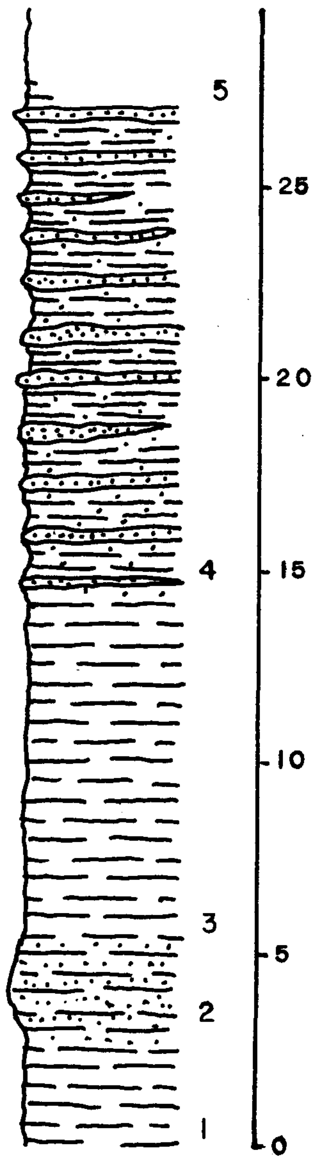

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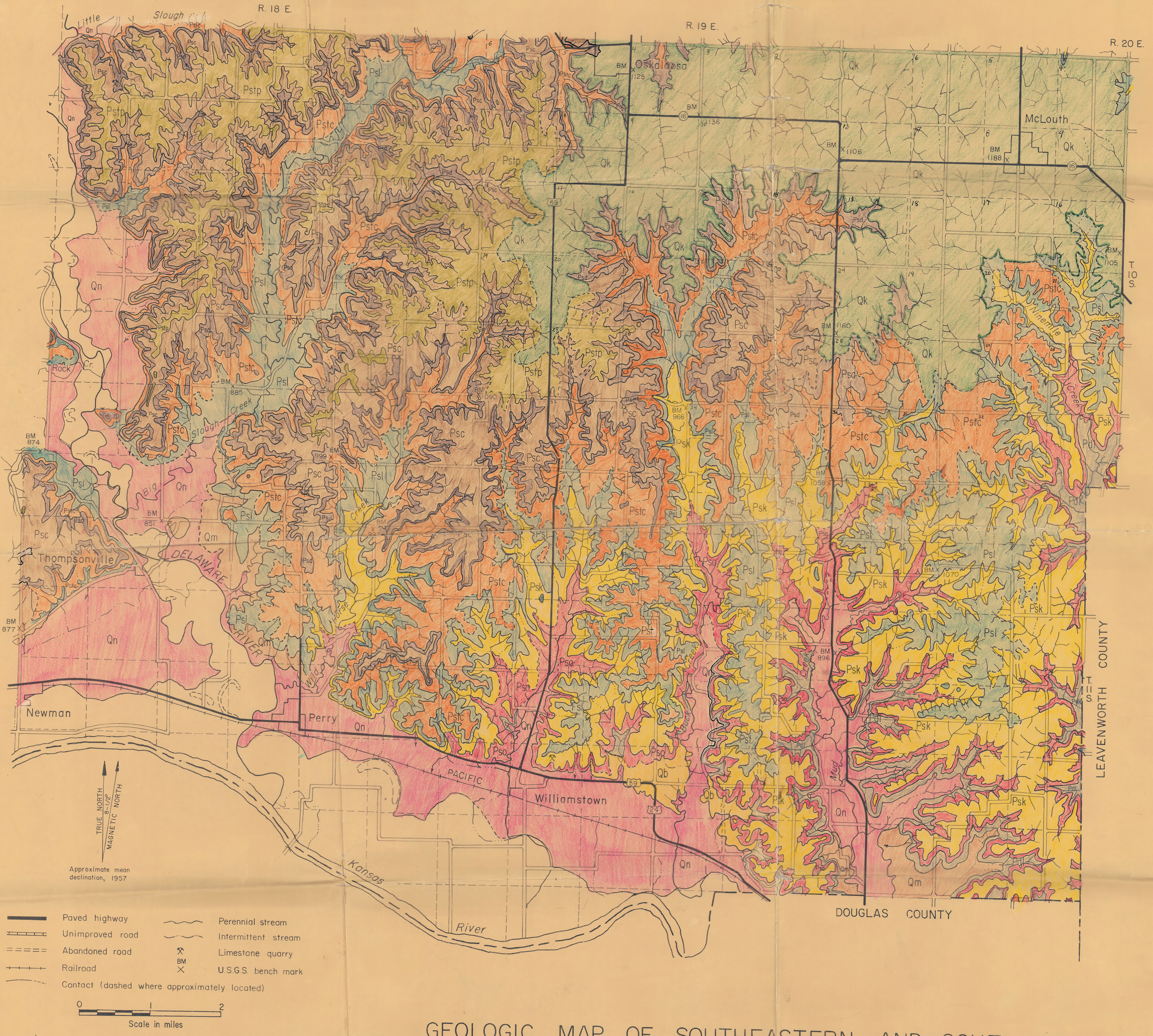
Douglas Group

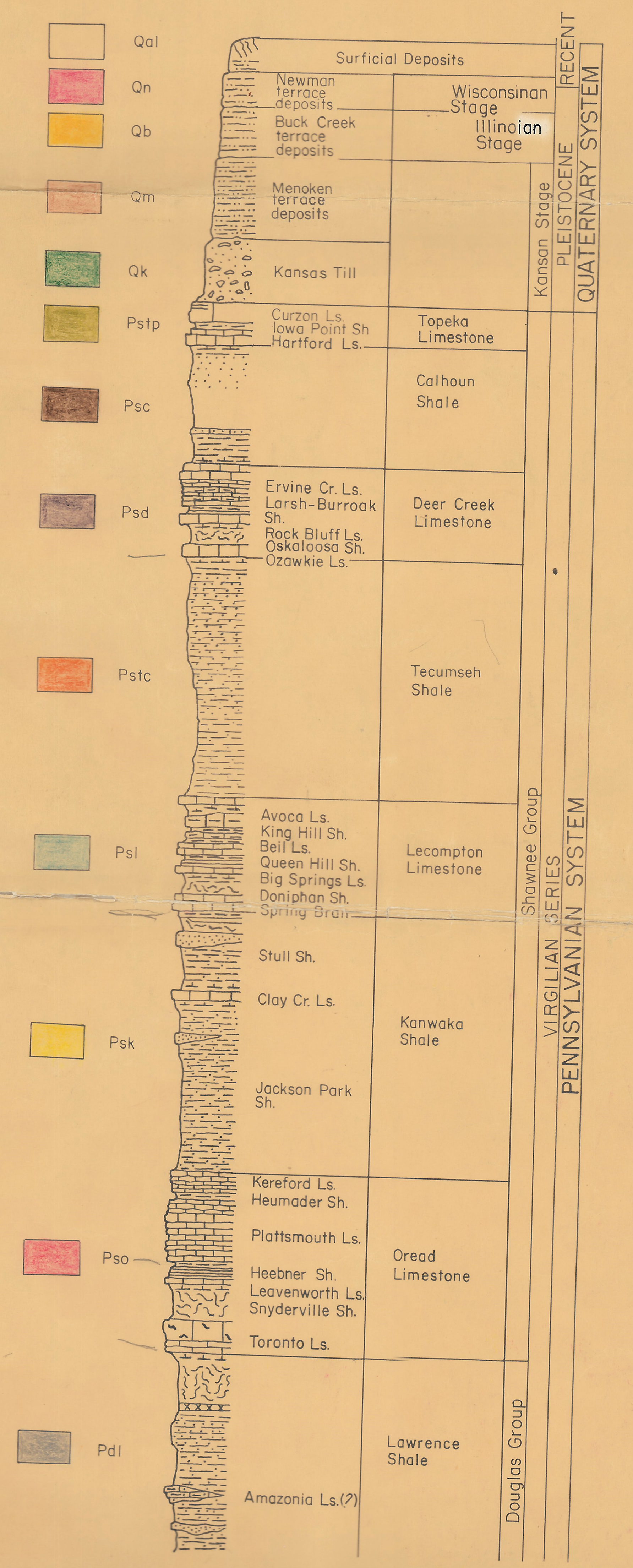
Lawrence Shale (59.2 feet)

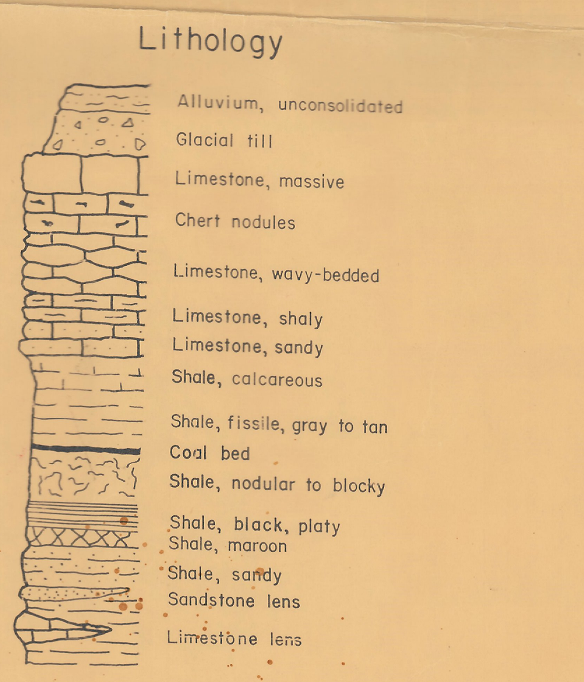
5.	Covered interval	32.4
4.	Silt shale, light olive gray, laminated, contains thin beds of gray shaly sandstone at irregular intervals	12.3
3.	Silt shale, light olive gray, clayey, laminated	9.3
2.	Silt shale, light olive gray, sandy, slightly platy	2.2
1.	Silt shale, light olive gray, clayey, laminated	3.0



GEOLOGIC MAP OF SOUTHEASTERN AND SOUTH-CENTRAL JEFFERSON COUNTY, KANSAS

GEOLOGY BY
DARRELL E. DAVIS





Kansas Geological Survey
Open-file Report 59-3
[Plate 1]